National Renewable Energy Laboratory
Innovation for Our Energy Future

Appendices

Rebuilding Greensburg, Kansas, as a Model Green Community: A Case Study

NREL's Technical Assistance to Greensburg June 2007 – May 2009













Lynn Billman

Technical Report
NREL/TP-6A2-45135
November 2009

Link to Report

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Appendices

Rebuilding Greensburg, Kansas, as a Model Green Community: A Case Study

NREL's Technical Assistance to Greensburg June 2007 – May 2009

Lynn Billman

Technical Report
NREL/TP-6A2-45135
November 2009

National Renewable Energy Laboratory
1617 Cole Boulevard, Golden, Colorado 80401
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Contract No. DE-AC36-08GO28308

Prepared under Task No. IDKS.1070

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm


Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.

Acknowledgments

The report *Rebuilding Greensburg, Kansas, as a Model Green Community: A Case Study, NREL's Technical Assistance to Greensburg June 2007 – May 2009*, was written by Lynn Billman who was the project lead for the feasibility studies and technical assistance that NREL provided to advise the city of Greensburg on energy efficiency in buildings; district heating and cooling; renewable resources such as wind, solar, and biomass; and alternative transportation (vehicles, fuels, and infrastructure).

The appendices include supporting studies, presentations, and ordinances provided by many NREL employees and subcontractors who spent many hours and days in Kansas and Golden, Colorado, to conduct the studies including NREL employees: Mary Werner, Andy Walker, Ren Anderson, Shanti Pless, Paul Torcellini, Jim Green, Chris Gaul, Phillip Shepherd, Trudy Forsyth, and Gerry Harrow; and subcontractors: John Thornton, Consultant; Alex Lukachko, Building Science Consulting; Steve Bolibruck, IBACOS; Building Science Corporation; and Thomas A. Wind, Wind Utility Consulting.

NREL would also like to acknowledge the extensive help from the following organizations: Greensburg GreenTown, Greensburg, Kansas; Professional Engineering Consultants, Wichita, Kansas; Berkebile Nelson Immenschuh McDowell Architects, Kansas City, Missouri; BTI-Greensburg John Deere Dealership, Greensburg, Kansas; Sunflower Electric Power Corporation, Hays, Kansas; Southern Pioneer Electric Company, Ulysses, Kansas; U.S. Department of Agriculture, Rural Development; U.S. Department of Homeland Security, Federal Emergency Management Agency; and State of Kansas, Kansas Corporation Commission.

Rebuilding Greensburg, Kansas, as a Model Green Community: A Case Study

NREL's Technical Assistance to Greensburg
June 2007 – May 2009

Supporting Studies, Presentations, and Ordinances (All documents used with permission)

Page

Appendix A: Cross-Cutting Information 1

A.1 Presentation: Renewable Resource Availability in Greensburg
Mary Werner, NREL 2

A.2 Summary: Financial Incentives for Energy Efficiency and Renewable Energy
Lynn Billman, NREL 12

A.3 Presentation: Renewable Energy Screening, Town of Greensburg, Kansas
Andy Walker, NREL 25

Appendix B: Residential Construction 44

B.1 Presentation: Example Performance Targets and Efficiency Packages Greensburg, Kansas
Ren Anderson, NREL 45

B.2 Fact Sheet: Why Build an Energy Efficient Home?
Ren Anderson, NREL 58

B.3 Recommendation: Greensburg, Kansas Should Adopt the Best Green Housing Requirements in the U.S.
Ren Anderson, NREL 61

B.4 Fact Sheets: High Performance Housing
Building Science Corporation for the DOE Building America Program 62

B.5 Presentation: Building for Energy Efficiency – Part 1
Alex Lukachko, Building Science Consulting 83

B.6 Presentation: Building for Energy Efficiency – Part 2
Steve Bolibruck, IBACOS 120

B.7 Presentation: Building for Energy Efficiency – Part 3
Alex Lukachko, Building Science Consulting 136

B.8 Presentation: Building for Energy Efficiency – Part 4
Steve Bolibruck, IBACOS 174

B.9 House Plan: Plan 1 – Three Bedroom, Basement, Greensburg, Kansas
Building Science Corporation 185

B.10 Fact Sheet: Energy Efficient Homes are More Affordable than Conventional Homes
Ren Anderson, NREL 199

Appendix C: Commercial, Nonprofit, and Public Buildings 206

C.1 Presentation: Setting Goals and Implementing Energy Efficiency Strategies
Shanti Pless, Lynn Billman, NREL 207

C.2 Presentation: Setting Goals and Implementing Energy Efficiency Strategies for the Kiowa County Memorial Hospital
Paul Torcellini, Shanti Pless, Lynn Billman, NREL 220

C.3 Recommendation: Applying a Whole-Building Design Process for New Commercial Buildings in Greensburg
Shanti Pless, NREL 230

C.4 Recommendation: Greensburg, Kansas Should Adopt the Best Green Municipal Building Requirements in the United States
Shanti Pless, NREL 235

C.5 Recommendation: The City of Greensburg, Kansas, Should Encourage Green Commercial, Nonprofit, and Public Building Design to Align with the Community Master Plan
Shanti Pless, NREL 236

C.6 Recommendation: Metal Building Recommendations for Greensburg, Kansas
Shanti Pless, NREL 237

Appendix D: Power Generation 243

D.1 Summary: Electricity Supply for Greensburg, Kansas, as of December 2007
Lynn Billman, NREL 244

D.2 Presentation: Community Wind Options
Trudy Forsyth, NREL; Thomas A. Wind, Wind Utility Consulting 246

D.3 Presentation: Examples of Community Owned Wind Projects
Thomas A. Wind, Wind Utility Consulting 260

D.4 Analysis: Wind Generation Options for Greensburg, Kansas
Thomas A. Wind, Wind Utility Consulting 276

D.5 Analysis: Greensburg Municipal Utility Business Strategies to Become Green
Thomas A. Wind, Wind Utility Consulting; Lynn Billman, NREL 292

D.6 Presentation: Refined Wind Speed Maps for Greensburg
Trudy Forsyth, NREL; Thomas A. Wind, Wind Utility Consulting 362

D.7 Recommendation: Only Very Small Wind Turbines Should be Building Mounted and Primarily for Architectural Purposes, not Primarily for Energy-generation Purposes
Jim Green, NREL 369

D.8 Analysis: Photovoltaic Generation Options for Greensburg, Kansas
John P. Thornton, Consultant..... 370

D.9 Assessment: Greensburg, Kansas, Biomass Resource Assessment and Opportunities for Converting and Using Fuels from Biomass
Chris Gaul, NREL..... 408

D.10 Presentation: Biomass Pellet Options for Greensburg and Surrounding Regions
Scott Haase, NREL 417

D.11 Executive Summary: Assessment of Biomass Pelletization Options for Greensburg, Kansas
Scott Haase, NREL 447

D.12 Assessment: Greensburg, Kansas, Long Term Recovery Plan, Landfill Gas Potential
Phillip Shepherd, NREL..... 466

D.13 Assessment: Greensburg, Kansas, Downtown District Heating and Cooling Study
Chris Gaul, NREL..... 467

D.14 White Paper: Greensburg Recovery Program – The Feasibility and Benefits of Fuel Cell Cogeneration
Trudy Forsyth, NREL; Thomas A. Wind, Wind Utility Consulting 476

Appendix E: Alternative Transportation 487

E.1 Assessment: Options for Alternative Fuels and Vehicles in Greensburg, Kansas
Gerry Harrow..... 488

Appendix F: Green Building Codes and Standards..... 511

F.1 Presentation: Building Codes for Greensburg – Introductory Discussion
Lynn Billman, John Holton, Alex Dane, NREL 512

F.2 Presentation: Greensburg Green Building Codes
Alex Dane, Lynn Billman, John Holton, NREL 528

F.3 Presentation: Greensburg Green Building Program, Residential Recommendations
Alex Dane, Lynn Billman, John Holton, NREL 541

F.4 Recommendation: Greensburg Green Building Program
Alex Dane, John Holton, Lynn Billman, NREL 550

F.5 Memo: NAHB Green Commitment to City of Greensburg, Kansas
National Association of Home Builders 555

Appendix G: Electricity Generation Policies and Ordinances 557

G.1 Presentation: Information for Greensburg City Council on Proposed Changes Regarding Utility Customer Owned Renewable Energy Generation
Thomas A. Wind, Wind Utility Consulting 558

G.2 Recommendation: Proposed Interconnection Agreement for Greensburg (Draft)
Thomas A. Wind, Wind Utility Consulting 567

G.3 Recommendation: Proposed Net Billing Tariff for Greensburg (Draft)
Thomas A. Wind, Wind Utility Consulting 573

G.4 Recommendation: Proposed Small Wind Turbine Ordinance for Greensburg (Draft)
Thomas A. Wind, Wind Utility Consulting 575

G.5 Issue Discussion: Small Wind Zoning Ordinance for Greensburg, Kansas 577

G.6 Recommendation: Proposed Solar Ordinance for Greensburg (Draft)
Thomas A. Wind, Wind Utility Consulting 581

G.7 Resources: Selected Solar Access Information
John P. Thornton, Consultant 583

G.8 Agreement: Cooperation Agreement (Greensburg MOU) 603

Appendix H: Educational and Outreach Materials 607

H.1 Guidelines: Rebuilding After Disaster—Going Green from the Ground Up 608

H.2 Brochure: Greensburg, Kansas—A Better, Greener Place to Live 633

H.3 Fact Sheet: From Tragedy to Triumph—Rebuilding Green Homes after Disaster 642

H.4 Fact Sheet: From Tragedy to Triumph—Rebuilding Green Buildings after Disaster 647

H.5 Fact Sheet: From Tragedy to Triumph—Rebuilding with Renewable Energy after Disaster 652

H.6 Fact Sheet: From Tragedy to Triumph—Resources for Rebuilding Green after Disaster 657

H.7 Brochure: Rebuilding It Better—BTI-Greensburg John Deere Dealership 662

H.8 Brochure: Greensburg Kansas: Building a Model Green Community, How Would You Rebuild a Town Green? 667

Appendices are available for download online at:
www.eere.energy.gov/buildings/greensburg/publications.html.

Appendix A: Cross Cutting Information

A.1 Presentation: Renewable Resource Availability in Greensburg 2

A.2 Summary: Financial Incentives for Energy Efficiency and Renewable Energy 12

A.3 Presentation: Renewable Energy Screening, Town of Greensburg, Kansas 25

A.1 Renewable Resource Availability in Greensburg

Mary Werner
National Renewable Energy Laboratory

National Renewable Energy Laboratory

A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

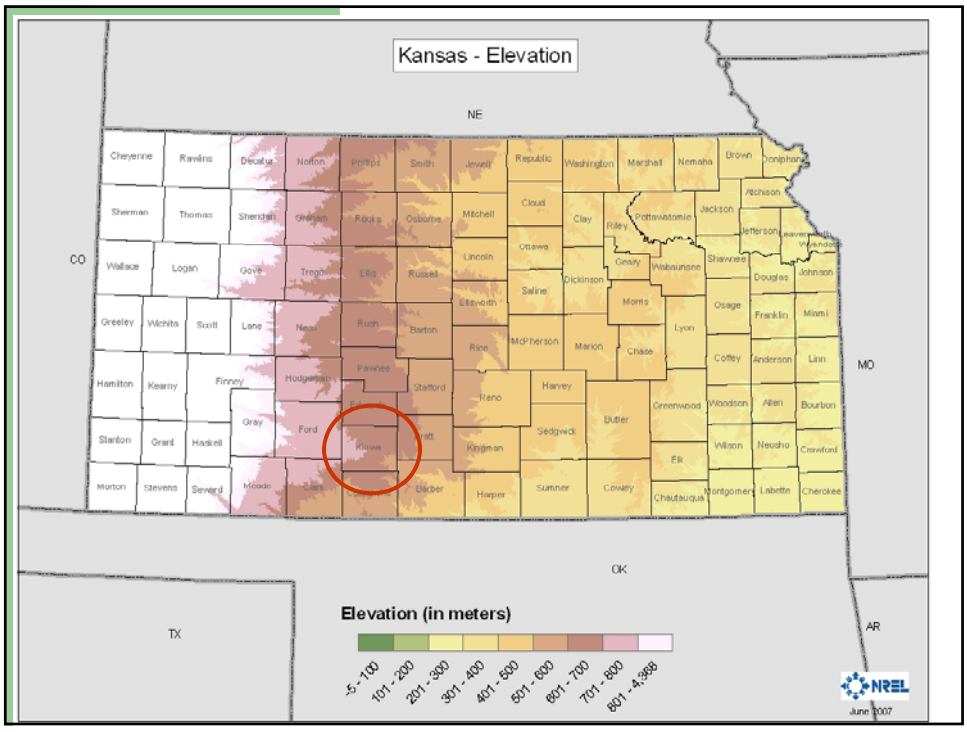
Innovation for Our Energy Future

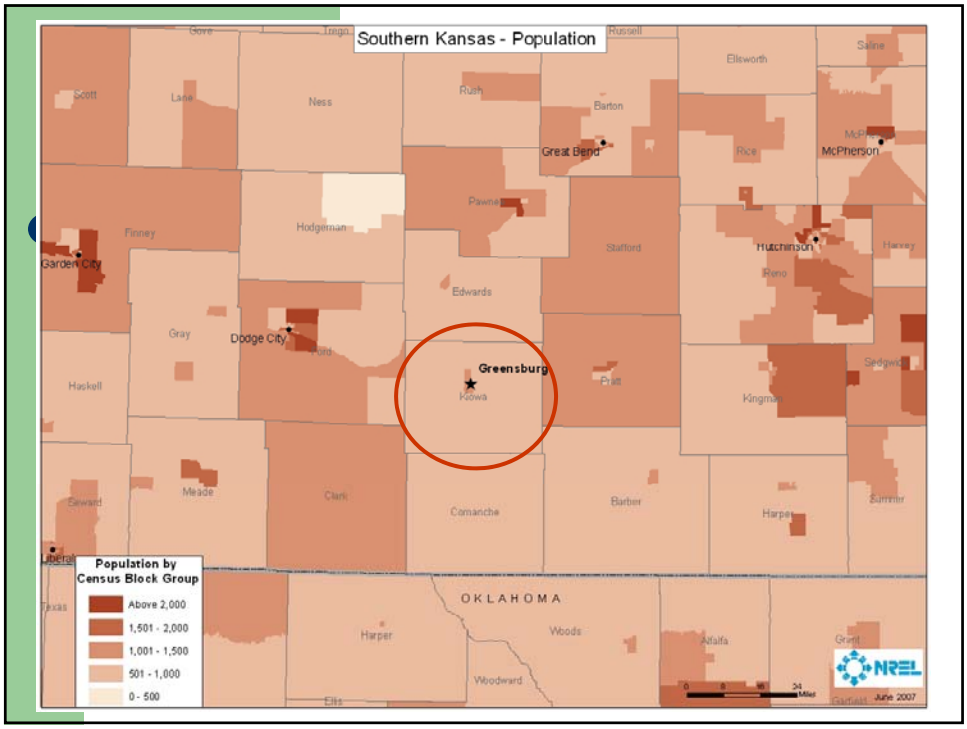
Renewable Resource Availability in Greensburg

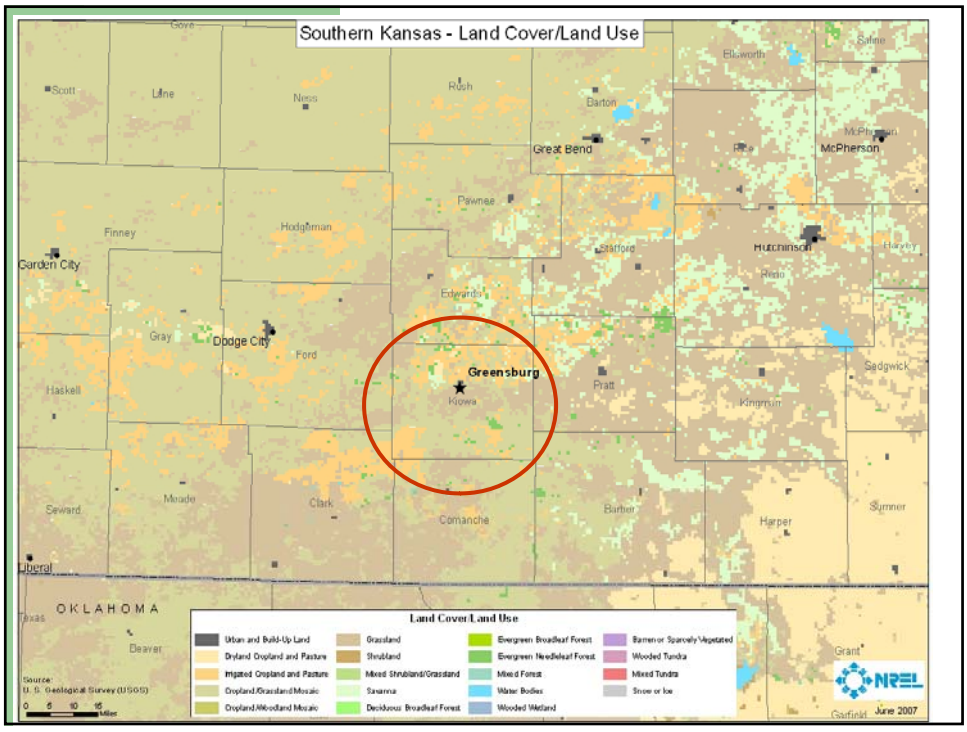
Prepared by the National Renewable Energy Laboratory (NREL)

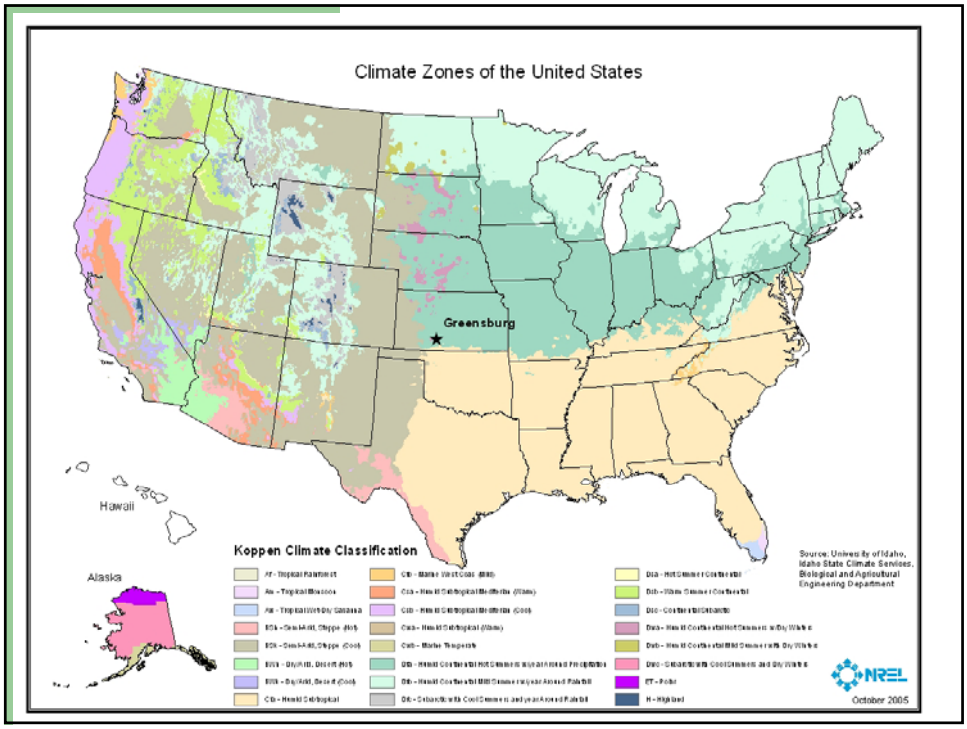
June 8, 2007

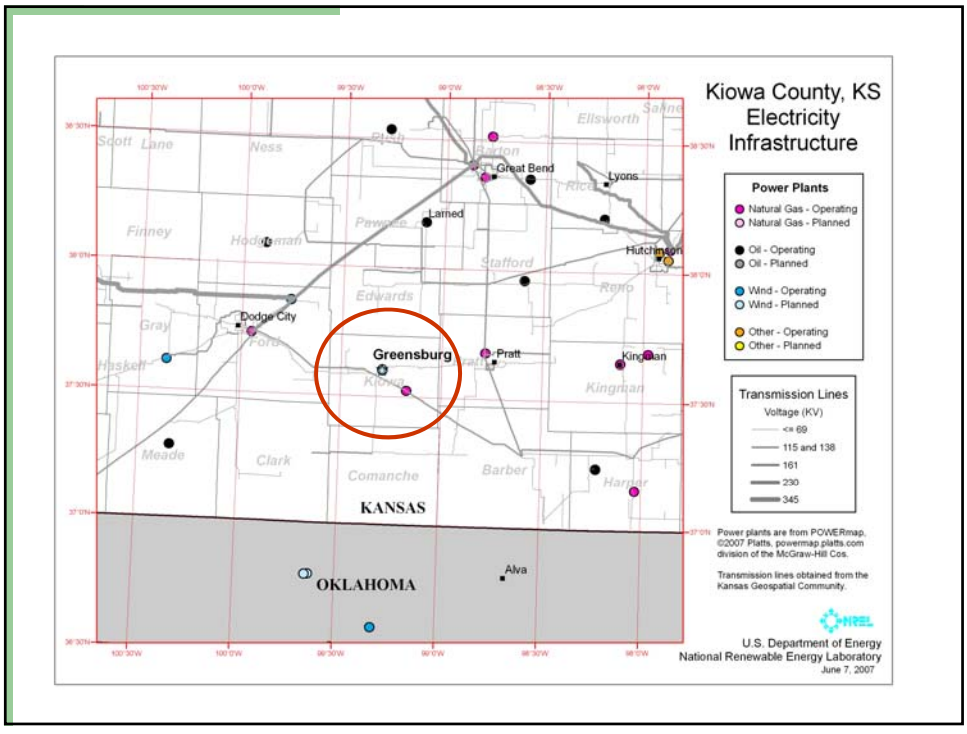
NREL is operated by Midwest Research Institute • Battelle

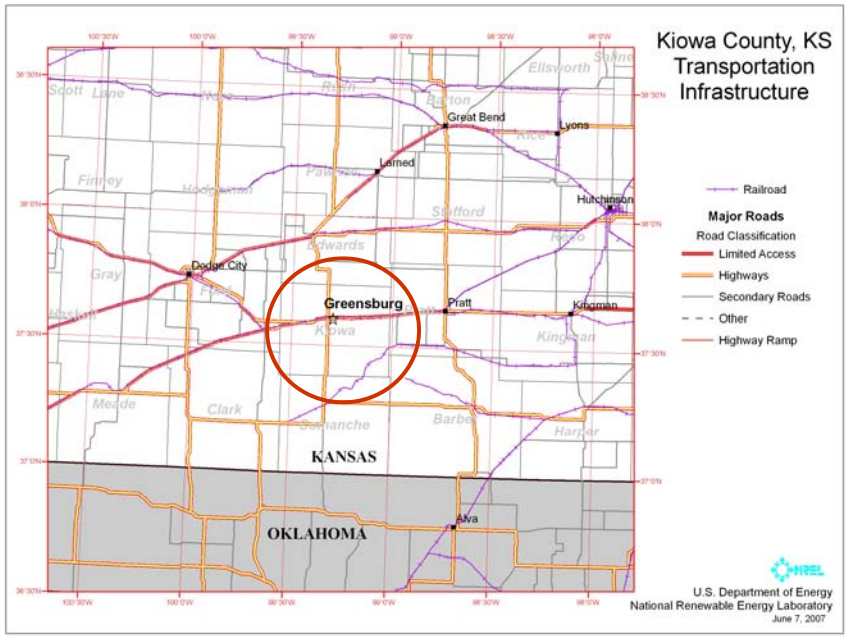



Southern Kansas - Population
Greensburg
Great Bend
McPherson
Hutchinson
Garden City
Dodge City
Liberal
OKLAHOMA
Population by Census Block Group
Above 2,000
1,501 - 2,000
1,001 - 1,500
501 - 1,000
0 - 500
NREL
June 2007

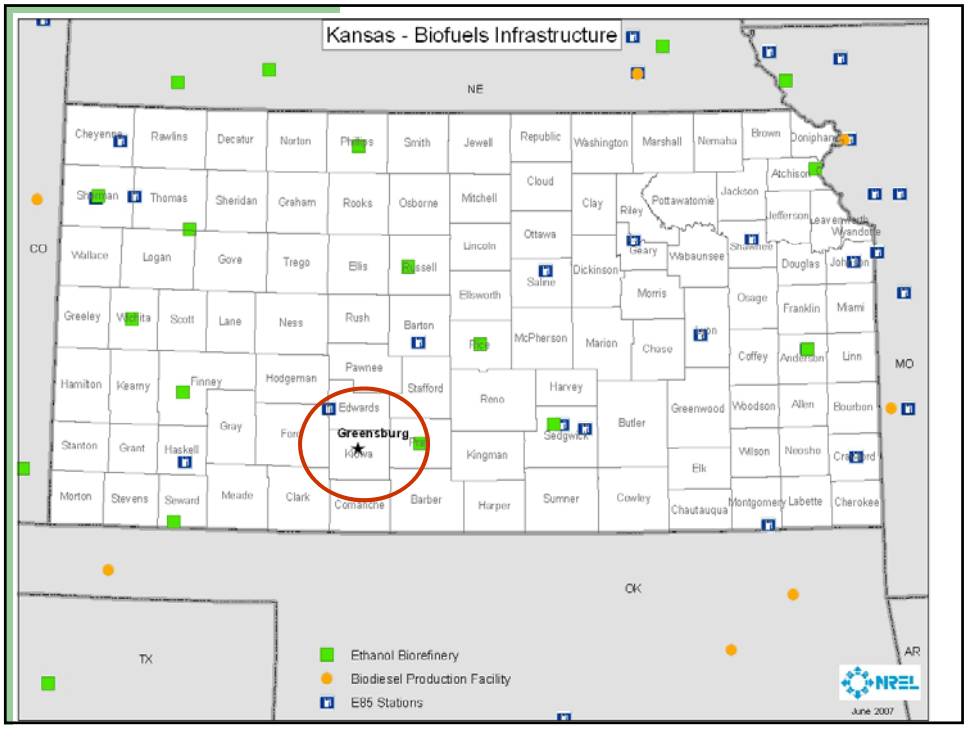

Southern Kansas - Land Cover/Land Use
Greensburg
Great Bend
McPherson
Hutchinson
Garden City
Dodge City
Liberal
OKLAHOMA
Land Cover/Land Use
Urban and Build-Up Land
Dryland Cropland and Pasture
Irrigated Cropland and Pasture
Cropland/Grassland Mosaic
Cropland/Woodland Mosaic
Grassland
Shrubland
Mixed Shrubland/Grassland
Savanna
Deciduous Broadleaf Forest
Evergreen Broadleaf Forest
Evergreen Needleleaf Forest
Mixed Forest
Water Bodies
Wooded Wetland
Barren or Sparsely Vegetated
Wooded Tundra
Mixed Tundra
Snow or Ice
Source: U.S. Geological Survey (USGS)
NREL
June 2007

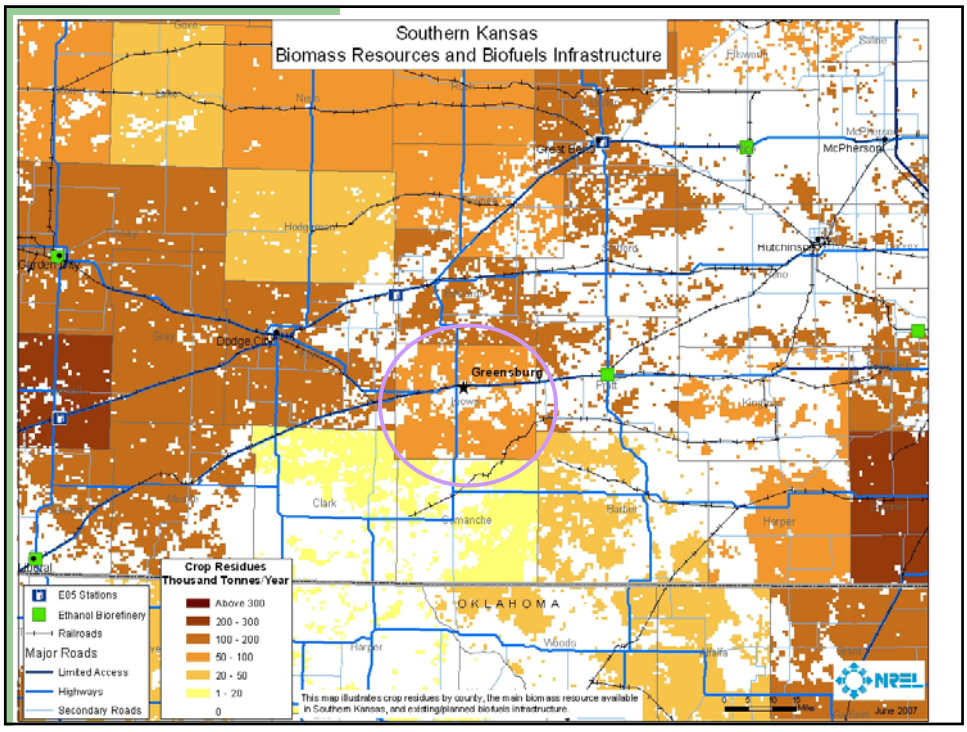

Climate Zones of the United States
Greensburg
Hawaii
Alaska
Koppen Climate Classification
Source: University of Idaho, Idaho State Climate Services, Biological and Agricultural Engineering Department
NREL
October 2005


Kiowa County, KS
Electricity
Infrastructure
Power Plants
Natural Gas - Operating
Natural Gas - Planned
Oil - Operating
Oil - Planned
Wind - Operating
Wind - Planned
Other - Operating
Other - Planned
Transmission Lines
Voltage (KV)
<= 69
115 and 138
161
230
345
Great Bend
Lyons
Larned
Hutchinson
Dodge City
Greensburg
Pratt
Kingman
KANSAS
OKLAHOMA
Alva
Power plants are from POWERmap, ©2007 Platts, powermap.platts.com division of the McGraw-Hill Cos.
Transmission lines obtained from the Kansas Geospatial Community.
U.S. Department of Energy
National Renewable Energy Laboratory
June 7, 2007



Biofuels / Biomass


Kansas - Biofuels Infrastructure
NE
CO
OK
TX
MO
AR
Greensburg
Ethanol Biorefinery
Biodiesel Production Facility
E85 Stations
June 2007


Southern Kansas
Biomass Resources and Biofuels Infrastructure
Greensburg
McPherson
Hutchinson
Dodge City
Clark
Comanche
Barber
Harper
OKLAHOMA
E85 Stations
Ethanol Biorefinery
Railroads
Major Roads
Limited Access
Highways
Secondary Roads
Crop Residues
Thousand Tonnes/Year
Above 300
200 - 300
100 - 200
50 - 100
20 - 50
1 - 20
0
This map illustrates crop residues by county, the main biomass resource available in Southern Kansas, and existing/planned biofuels infrastructure.
June 2007

County	Corn*	Corn Ethanol (Gal)*	Soybeans**	Biodiesel (Gal)	Cellulosic Biomass***	CRP Land****
Kiowa	23,500	2,608,500	12,500	562,500	60,135	53,337
Comanche	N/A	N/A	N/A	N/A	10,084	43010
Clark	1,000	111,000	600	27,000	16,777	52,114
Barber	2,300	255,300	6,600	297,000	32,690	21,018
Pratt	55,700	6,182,700	24,500	1,102,500	136,725	47,750
Ford	43,100	4,784,100	12,800	576,000	120,880	59,469
Edwards	56,300	6,249,300	22,100	994,500	124,295	34,101

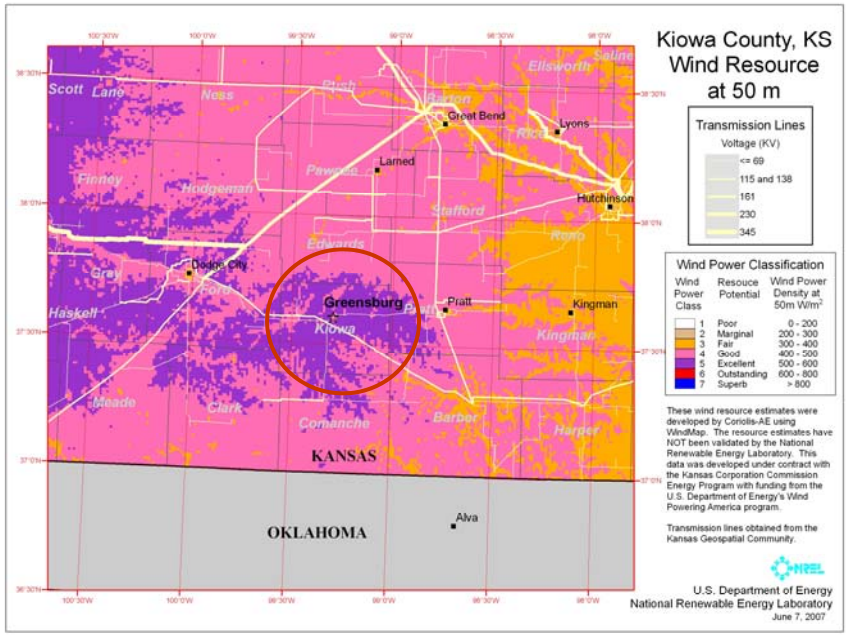
* Corn grain, harvested acres in 2006. Assuming 30% of grain is devoted to ethanol production.

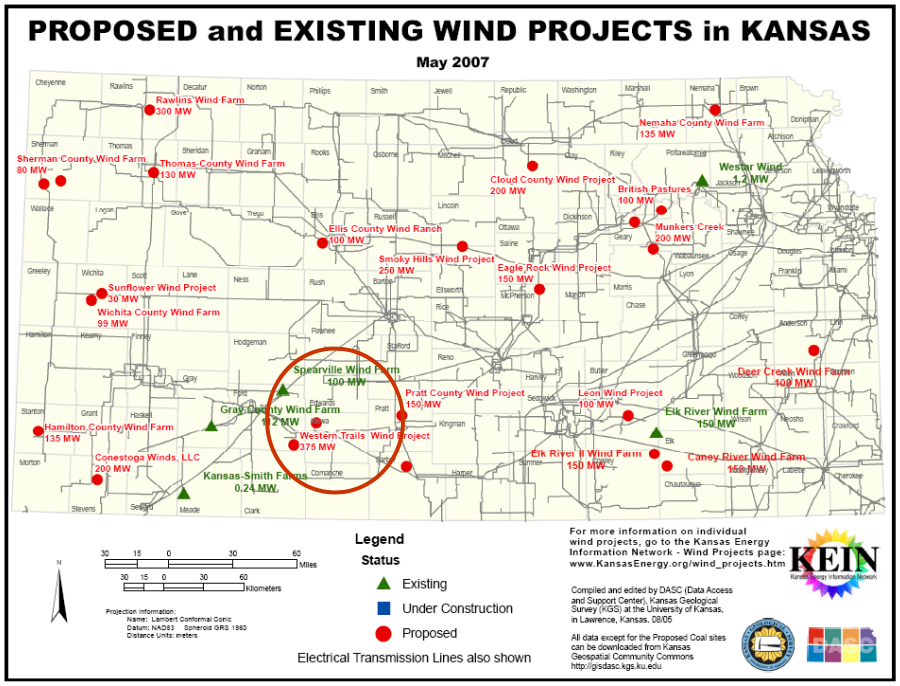
** Harvested acres in 2006

*** Crop residues (dry tonnes/year), 2002

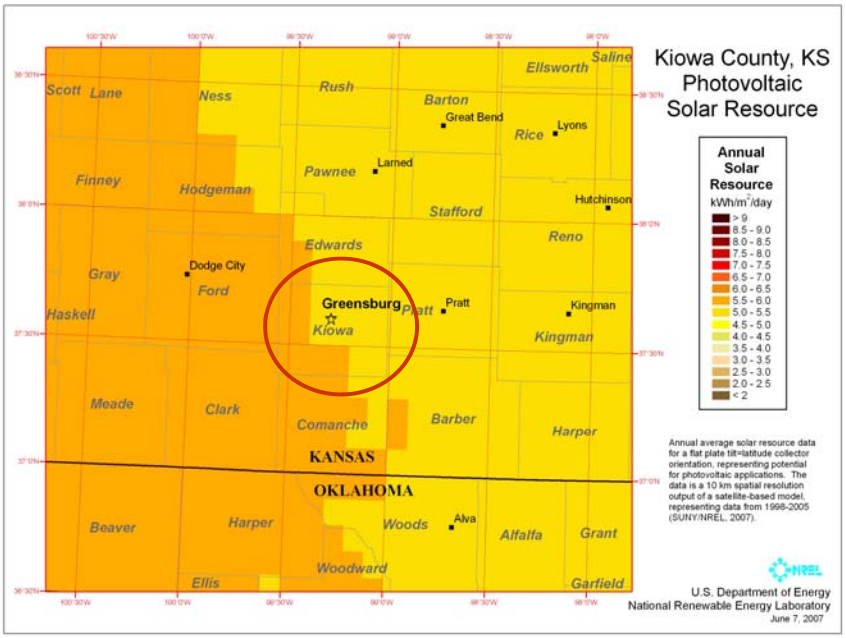
**** Conservation Reserve Program (CRP) land as of July 2003, in acres. Median estimated mature yield of switchgrass for this area is ~ 4.5 dry tons/acre/year

Wind

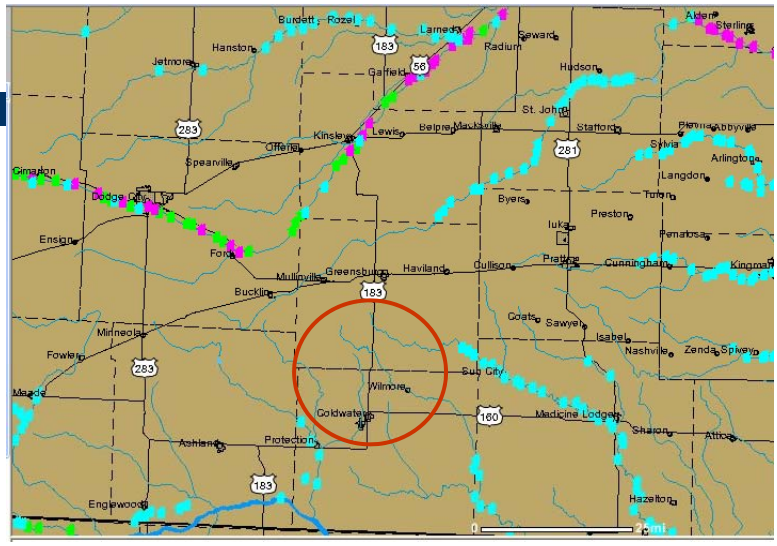

Kiowa County, KS
Wind Resource
at 50 m
Transmission Lines
Voltage (KV)
<= 69
115 and 138
161
230
345
Wind Power Classification
Wind Power Class
Resouce Potential
Wind Power Density at 50m W/m²
1 Poor 0 - 200
2 Marginal 200 - 300
3 Fair 300 - 400
4 Good 400 - 500
5 Excellent 500 - 600
6 Outstanding 600 - 800
7 Superb > 800
These wind resource estimates were developed by Coriolis-AE using WindMap. The resource estimates have NOT been validated by the National Renewable Energy Laboratory. This data was developed under contract with the Kansas Corporation Commission Energy Program with funding from the U.S. Department of Energy's Wind Powering America program.
Transmission lines obtained from the Kansas Geospatial Community.
U.S. Department of Energy
National Renewable Energy Laboratory
June 7, 2007
Great Bend
Lyons
Larned
Hutchinson
Dodge City
Greensburg
Pratt
Kingman
Alva
KANSAS
OKLAHOMA
Scott
Lane
Ness
Ellsworth
Saline
Finney
Hodgeman
Stafford
Reno
Edwards
Gray
Ford
Haskell
Kiowa
Meade
Clark
Comanche
Barber
Harper
Kingman


PROPOSED and EXISTING WIND PROJECTS in KANSAS
May 2007
Rawlins Wind Farm
300 MW
Sherman County Wind Farm
80 MW
Thomas County Wind Farm
130 MW
Nemaha County Wind Farm
135 MW
Cloud County Wind Project
200 MW
Westar Wind
1.2 MW
British Pastures
100 MW
Munkers Creek
200 MW
Ellis County Wind Ranch
100 MW
Smoky Hills Wind Project
250 MW
Eagle Rock Wind Project
150 MW
Sunflower Wind Project
30 MW
Wichita County Wind Farm
99 MW
Spearville Wind Farm
400 MW
Pratt County Wind Project
150 MW
Leon Wind Project
100 MW
Deer Creek Wind Farm
400 MW
Gray County Wind Farm
112 MW
Elk River Wind Farm
150 MW
Hamilton County Wind Farm
135 MW
Western Trails Wind Project
375 MW
Conestoga Winds, LLC
200 MW
Kansas Smith Farms
0.24 MW
Elk River II Wind Farm
150 MW
Caney River Wind Farm
150 MW
Legend
Status
Existing
Under Construction
Proposed
Electrical Transmission Lines also shown
For more information on individual wind projects, go to the Kansas Energy Information Network - Wind Projects page:
www.KansasEnergy.org/wind_projects.htm
KEIN
Compiled and edited by DASC (Data Access and Support Center), Kansas Geological Survey (KGS) at the University of Kansas, in Lawrence, Kansas. 08/05
All data except for the Proposed Coal sites can be downloaded from Kansas Geospatial Community Commons
http://gisdasc.kgs.ku.edu
Miles
Kilometers
Projection Information:
Name: Lambert Conformal Conic
Datum: NAD83 Spheroid GRS 1980
Distance Units: meters

Solar


Kiowa County, KS
Photovoltaic
Solar Resource
Annual
Solar
Resource
kWh/m²/day
> 9
8.5 - 9.0
8.0 - 8.5
7.5 - 8.0
7.0 - 7.5
6.5 - 7.0
6.0 - 6.5
5.5 - 6.0
5.0 - 5.5
4.5 - 5.0
4.0 - 4.5
3.5 - 4.0
3.0 - 3.5
2.5 - 3.0
2.0 - 2.5
< 2
Annual average solar resource data for a flat plate tilt=latitude collector orientation, representing potential for photovoltaic applications. The data is a 10 km spatial resolution output of a satellite-based model, representing data from 1998-2005 (SUNY/NREL, 2007).
U.S. Department of Energy
National Renewable Energy Laboratory
June 7, 2007
Scott
Lane
Ness
Rush
Barton
Great Bend
Ellsworth
Saline
Rice
Lyons
Finney
Hodgeman
Pawnee
Larned
Stafford
Hutchinson
Reno
Edwards
Gray
Dodge City
Ford
Haskell
Greensburg
Kiowa
Pratt
Kingman
Meade
Clark
Comanche
Barber
Harper
KANSAS
OKLAHOMA
Beaver
Harper
Woods
Alva
Alfalfa
Grant
Woodward
Ellis
Garfield

Hydro



In Summary

• Wind	Yes
• Solar	Maybe
• Ethanol Production	Likely
• Biodiesel Production	Maybe
• Geothermal – High Temp	Not likely
• Geothermal – Low Temp	Likely
• Hydro	Not likely

A.2 Summary: Financial Incentives for Energy Efficiency and Renewable Energy

Lynn Billman
National Renewable Energy Laboratory

Financial Incentives for Energy Efficiency and Renewable Energy: Introduction[1]

Updated 3-26-08

The attached charts summarize some essential information on financial incentives for energy efficiency and renewable energy at the Federal level and for the State of Kansas. While I believe this information is accurate and up-to-date as of March 26, 2008, financial incentives for energy are constantly changing.

The best source of information for federal and state financial incentives in energy efficiency and renewable energy is www.dsireusa.org. this database is maintained by the North Carolina State University Solar Center. Additional information on alternative fuel and vehicle incentives can be found at the Alternative Fuel Data Center website for the National Renewable Energy Laboratory: *www.eere.energy.gov/afdc/progs/fed_summary.php/afdc/US/0*.

The attached information also include a summary of information on energy savings performance contacts, which are applicable to energy efficiency and sometimes renewable energy project financing in all market sectors.

Lynn Billman
National Renewable Energy Laboratory
Lynn_billman@nrel.gov

[1] Best website for federal and state incentives on Energy Efficiency and Renewable Energy: www.dsireusa.org

Financial Incentives for Energy Efficiency and Renewable Energy: Residential Sector, Greensburg[1]

Updated 3-26-08

There are many sources of financing for residents in Greensburg (see USDA office, SBA, local bankers, Kansas Housing, etc.) These notes pertain ONLY to financial incentives for energy efficiency and renewable energy costs.

Type/Name	*Technologies*	*Amount / Maximum / Notes*	*Timing*
Residential Solar and Fuel Cell Federal Tax Credit	Solar photovoltaics, solar water heat, fuel cells	You can take a tax credit of 30% of the total costs of solar photovoltaic system up to a cap of $2000; same for a solar hot water system, and a person can take both. Also, you can take 30% of the total cost of a fuel cell system, up to a cap of $500 per 0.5 killowatt. http://www.irs.gov/pub/irs-pdf/f3468.pdf Tax Relief and Health Care Act of 2006 (H.R. 6111) under Title II Energy Tax Provisions	Valid on systems installed before December 31, 2008
Residential Energy Efficiency Federal Tax Credit	Water heaters, furnaces, boilers, heat pumps, air conditioners, building insulation, windows, doors, roofs	You can take a tax credit of 10% of the cost of building envelope improvements, up to a $500 limit; various details apply. http://www.irs.gov/newsroom/article/0,,id=154657,00.html	Valid on systems installed before December 31, 2008
Energy Efficient Mortgages (federal insured or conventional)	Energy efficiency measures	You can benefit from energy-efficient financing whether you're buying, selling, refinancing, or remodeling a home. If you're looking to buy an energy-efficient home, you can qualify for a better, more comfortable home because with lower utility costs, you can afford a slightly larger mortgage payment. You can also obtain financing to make energy-efficient improvements to an older home before moving in or to your existing home. You can apply for energy-efficient financing through a government-insured (USDA, HUD/FHA, or VA) or conventional loan program. There are two types of energy-efficient mortgages (EEMs): one for a new home and one for an existing home. With an EEM, you can purchase or refinance a home that is already energy efficient, or you can purchase or refinance a home that will become energy efficient after energy-saving improvements are made. Most energy-efficient financing programs offer both types of EEMs, as well as home-improvement loans for making energy-efficiency upgrades to your existing home. http://www.eere.energy.gov/consumer/your_home/designing_remodeling/index.cfm/mytopic=10380 http://www.fsec.ucf.edu/en/consumer/buildings/homes/ratings/eem/	n/a
Kansas Energy Efficiency Loan Program	Energy efficiency measures, including efficient appliances	For low-income homeowners, Kansas Housing Resources Corp will provide 50% of the loan amount needed to make energy efficient improvements, at zero interest, up to $7,500. Rest of the loan comes through Sunflower Bank. Lowers interest rate to make energy efficiency improvements more affordable. Also, weatherization grants available. http://www.kshousingcorp.org/programs/KEEP.shtml http://www.kshousingcorp.org/display/files/News%20Releases/08DOEWXGRANT.pdf	n/a

[1] Best website for federal and state incentives on Energy Efficiency and Renewable Energy: www.dsireusa.org

State Property Tax Exemption	Wind, solar thermal electric, photovoltaic, biomass, hydropower, geothermal, landfill gas	100% of investment is exempted from property taxes in Kansas. Does not apply to solar hot water. Kansas Statute KSA 79-102(11)	n/a

Financial Incentives for Energy Efficiency and Renewable Energy: Business Sector[1]

Updated 3-26-08

Type/Name	*Technologies*	*Amount / Maximum / Notes*	*Timing*
Federal Grant and Guaranteed Loan Program (USDA 9006)	Energy efficiency technologies, solar, wind, biomass, geothermal, hydrogen, fuel cells using renewable fuels	25% of eligible project costs (grants and guaranteed loans together, see below, cannot exceed 50% of eligible project costs). Maximum grant for renewable energy projects is $500,000; maximum grant for energy efficiency improvements is $250,000. http://www.rurdev.usda.gov/rbs/farmbill	Annual application process and competition. FY008 process has deadlines of April 15 and June 16, 2008.
Federal Tax Credit	Solar, some geothermal, fuel cells, microturbines	30% of the total costs of solar systems (photovoltaic electricity and hot water), solar hybrid lighting, and fuel cells, and 10% for geothermal electric, direct use geothermal, and microturbines. Excludes geothermal heat pumps. Other restrictions and requirements apply. http://www.irs.gov/pub/irs-pdf/f3468.pdf	Valid on systems installed before December 31, 2008
Federal Tax Credit	Wind, biomass, geothermal electric, landfill gas, others	2.0 ¢/kwh for wind, geothermal, closed-loop biomass; 1.0 ¢/kWh for landfill gas and others. Applies to first ten years of operation. http://www.irs.gov/pub/irs-pdf/f3468.pdf	Valid on systems installed before December 31, 2008
Federal Tax Credit	Energy efficient homes	$2,000 for homes certified to reduce energy consumption by 50% relative to the International Energy Conservation Code standard and meet minimum efficiency standards established by the Department of Energy. Rules are slightly different for manufactured compared to site-built homes. http://www.irs.gov/pub/irs-drop/n-06-27.pdf http://www.irs.gov/pub/irs-drop/n-06-28.pdf	Valid on homes occupied before December 31, 2008
Federal Tax Deduction	Energy efficiency measures	$0.30 to $1.80 per square foot of the building, depending on technology and amount of energy reduction. Applies to commercial buildings only. www.eere.energy.gov/buildings/info/tax_incentives.html	Valid on systems installed before December 31, 2008
Federal Corporate Depreciation (Modified Accelerated Cost-Recovery System)	Solar, wind, geothermal, fuel cells, microturbines, and solar hybrid lighting	Investments can be depreciated over five years. http://www.dsireusa.org ; see Federal incentives section.	
State Property Tax Exemption	Wind, solar thermal electric, photovoltaic, biomass, hydropower, geothermal, landfill gas	100% of investment is exempted from property taxes in Kansas. Does not apply to solar hot water. Kansas Statute KSA 79-102(11)	

[1] Best website for federal and state incentives on Energy Efficiency and Renewable Energy: www.dsireusa.org

Financial Incentives for Energy Efficiency and Renewable Energy: Public and Non-Profit Sector[1]

Updated 12-11-07

These notes pertain to public sector projects, including those owned by the city, a municipal utility, rural electric coop, state government, and tribal government. For other nonprofits, financial incentives for sustainability are hard to find. One possibly useful website is:
http://foundationcenter.org/pnd/tsn/tsn.jhtml?id=137700001 – why non-profits should be green
http://www.kresge.org/content/displaycontent.aspx?CID=59 -- grants from a foundation for the extra planning costs to design a green building for governments, historic, etc.

Type/Name	*Technologies*	*Amount / Maximum / Notes*	*Timing*
Clean Renewable Energy Bonds (CREBs) (Federal Loan Program)	Solar photovoltaics, wind, biomass, solar thermal electric, geothermal electric, landfill gas, others	For government entities, municipal cooperatives, tribes. CREBs are intended to provide governmental entities and electric cooperatives with the ability to obtain interest-free financing of certain renewable energy projects by providing the investors with a tax credit in lieu of interest. They deliver an incentive comparable to the production tax credit that is available to private renewable energy project developers and investor-owned utilities. The electric cooperative or bond issuer would issue the CREBs and sell them to bondholders. With a conventional bond, the Issuer must pay interest to the bondholder. But with a tax credit bond, the Issuer does not make interest payments. The federal government provides a tax credit to the bondholder in lieu of the Issuer paying interest to the bondholder. Projects are selected by the Treasury, with smaller projects given priority. http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US45F&State=federal&currentpageid=1&ee=1&re=1 http://www.elpc.org/energy/farm/crebs.php http://www.irs.gov/irb/2007-14_IRB/ar17.html http://www.nreca.org/documents/publicpolicy/cleanrenewableenergybonds.pdf	Was available once. Not certain this will be available again. Checking.
Renewable Energy Production Incentive (Federal grant)	Solar, wind, biomass favored	Financial payments for electricity produced and sold by new qualifying renewable energy generation facilities, for first ten years of operation. Annual payment depends on the size of the project, the number and size of the pool of applicants, and the federal appropriation for the year. For example, Lamar, Colo got ½ cent/kwh or $64,000 in 2006. http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US33F&State=federal&currentpageid=1&ee=1&re=1 http://www.eere.energy.gov/repi/	Available annually
Corporate Federal Tax Deduction for Your Builder	Energy efficiency measures	This is a tax deduction for your builder of $0.30 to $1.80 per square foot of the building, depending on technology and amount of energy reduction. www.eere.energy.gov/buildings/info/tax_incentives.html	Valid on systems installed before December 31, 2008

[1] Best website for federal and state incentives on Energy Efficiency and Renewable Energy: www.dsireusa.org

New Construction ESPC

ESPC can be used to incrementally improve the efficiency of planned and funded building construction projects without using capital appropriations to reimburse the ESCO.

First, the agency, ESCO, and architect (perhaps with the general contractor, if selected) meet and form a consensus about the baseline (non-improved) building design and energy use. At a minimum, the baseline building must meet existing energy codes and standards.

Then the ESCO "audits" the baseline design, perhaps through simulation in conjunction with review of any baseline equipment and building material selections. The ESCO suggests more energy efficient materials and systems (windows, insulation, chillers, boilers, air handling equipment, etc.), and the incremental costs and savings are presented.

All parties (ESCO and agency at a minimum) then negotiate and come to agreement on the incremental costs and savings, and confirm that the savings will pay for the incremental costs over a reasonable contract term. The new, more efficient equipment and materials become part of the building design, and their costs are allocated to the ESCO and the general contractor (GC).

The costs are allocated by comparing the total incremental cost increases to the costs of building systems and materials, and several items are identified for the ESCO (rather than the GC) to purchase and install. In this way, the ESCO might buy a complete chiller and several air-handling units, while the GC purchases more efficient windows and wall insulation. Although the building now costs more to construct than the inefficient building, the value of the GC's contract does not go up since some costs are borne by the ESCO. The ESCO coordinates the installation of its equipment with the GC in much the same manner as a GC subcontractor.

This process allows each party to buy complete systems, since one can't typically buy an incremental improvement (lower kW/ton for example) separate from the system (chiller, etc.). The ESCO uses its own funds to buy its systems, and is not paid any capital dollars.

Once the building is constructed and accepted, the ESCO is paid from the incremental savings of all energy efficiency upgrades to the baseline design. Extending the previous example, the ESCO would be paid for the incremental savings generated by the chiller, air-handling units, windows, and wall insulation. Although the ESCO did not purchase all those systems, it invested the equivalent money in the systems it purchased and installed. The ESCO is responsible for the performance (and usually the M&V) of all the systems and materials from which it derives payments. The building owner takes title to the ESCO-purchased equipment at the end of the ESPC term.

Financial Incentives for Alternative Fuels and Vehicles[1]

Updated 2-21-08

United States (Federal) Incentives and Laws

Alternative Fuel Infrastructure Tax Credit

Section 1342 of the Energy Policy Act of 2005 provides a tax credit equal to 30% of the of cost alternative refueling property, up to $30,000 for business property. Qualifying alternative fuels are natural gas, propane, hydrogen, E85, or biodiesel mixtures of B20 or more. Buyers of residential refueling equipment can receive a tax credit for $1,000. For non-tax-paying entities, the credit can be passed back to the equipment seller. The credit is effective on equipment put into service after December 31, 2005. It expires December 31, 2009 (hydrogen property credit expires in 2014).

This legislation also extends the Tax Deduction Timeline that was established by EPAct 1992, Section 179, and extended by the Working Families Tax Relief Act of 2004.

In May 2006, the Internal Revenue Service (IRS) published Form 8911, which provides a mechanism to claim the infrastructure tax credit. Owners who install qualified refueling property on multiple sites can utilize the credit for each property. The instructions define what is considered qualified property and the value of the credit. See IRS Form 8911 at http:///*www.irs.gov/pub/irs-pdf/f8911.pdf.*

Alternative Motor Vehicle Credit

Section 1341 of the Energy Policy Act of 2005 provides a tax credit to buyers of new alternative fuel vehicles placed in service as an alternative fuel vehicle after January 1, 2006. The legislation provides for a tax credit equal to 50% of the incremental cost of the vehicle, plus an additional 30% of the incremental cost for vehicles with near-zero emissions (SULEV or Bin 2 for vehicles <14,001 lb GVWR). The IRS has issued two notices to establish rules for manufacturers and qualified vehicle buyers to claim the credit. The Current Tax Credits table at *www.eere.energy.gov/afdc/vehicles/hybrid_electric_tax_credits.html* has information on certified vehicles and available credits.

The credit is available on the purchase of light-, medium, and heavy-duty vehicles and fuel-cell, hybrid, and dedicated natural gas, propane, and hydrogen vehicles. Light-duty lean burn diesel vehicles are also eligible.

Vehicles are subject to the following incremental cost limitations:

- $5,000: 8,500 GVWR or lighter
- $10,000: 8,501 - 14,000 GVWR
- $25,000: 14,001 - 26,000 GVWR
- $40,000: 26,001 GVWR and heavier

For non-tax-paying entities, the credit can be passed back to the vehicle seller. The tax credit can be applied to vehicle purchases made after December 31, 2005. The credit expires December 31, 2010.

IRS Notice 2006-9 (*www.irs.gov/pub/irs-drop/n-06-09.pdf*), issued in January 2006, establishes procedures for manufacturers to certify to the IRS that a vehicle meets requirements to claim the credit and the amount of the credit for which the vehicle is eligible.

IRS Notice 2006-54 (*www.irs.gov/pub/irs-drop/n-06-54.pdf*), issued in June 2006, extends the Qualified Alternative Fuel Motor Vehicle (QAFMV) tax credit to vehicle conversions. This IRS guidance states that new or used vehicles, placed in service as alternative fuel vehicles after January 1, 2006, qualify for the tax credit when the conversion system manufacturer has received a certificate of

[1] This information is taken directly from DOE's EERE Alternative Fuels & Advanced Vehicles Data Center at *www.eere.energy.gov/afdc/progs/fed_summary.php/afdc/US/0*.
Also check this complete database of incentives*: www.dsireusa.org*

conformity from the EPA or California Air Resources Board. This guidance also establishes that manufacturers (conversion system installers) must provide certification to the IRS that a vehicle is eligible for a tax credit. The IRS must then provide the manufacturer with acknowledgement that a vehicle qualifies for the credit. The credit is taken by the buyer of a vehicle, and IRS Form 8910 should be used to claim the credit. The credit cannot be sold or transferred but can be carried forward by the seller for use in later years.

This legislation replaces the Clean Fuel Vehicle Property Tax Deduction previously available to purchasers.

Hybrid Motor Vehicle Credit
Section 1341 of the Energy Policy Act of 2005 provides a tax credit for light-duty hybrid vehicles (<8,501 lb GVWR) based on their improved fuel economy and their life-time fuel savings potential. The IRS will certify vehicles for the credit and publish qualifying credit amounts as vehicles are certified. The Current Tax Credits table has the most recent information from the IRS.

The fuel economy portion of the credit is based on the following efficiency gains over model year 2002 baselines.

- 125%-149%: $400
- 150% -174%: $800
- 175%-199%: $1,200
- 200%-224%: $1,600
- 225%-249%: $2,000
- 250%+: $2,400

The conservation credit increases the fuel economy credit based on the following lifetime fuel savings:

- 1,200-1,799 gal: $250
- 1,800-2,399 gal: $500
- 2,400-2,999 gal: $750
- 3,000 gal+: $1,000

To qualify for the credits, the vehicles must meet at least Bin 5 standards if they are up to 6,000 lb GVWR, or Bin 8 standards if the vehicles are 6,001 lb-8,500 lb GVWR.

Heavy-duty hybrid vehicles are subject to the following incremental cost limitations:

- <14,001 GVWR: $7,500
- 14,001-26,000 GVWR: $15,000
- 26,001+ GVWR: $30,000

This tax credit replaces the tax deduction previously available to purchasers under the Clean Fuel Vehicle Property guidance. This tax credit expires December 31, 2010.

The IRS issued guidance to automobile manufacturers in January 2006. Specifically, this notice provides procedures for a vehicle manufacturer to certify to the Internal Revenue Service both that the vehicle meets certain requirements for the credit and information to calculate the amount of the credit allowable with respect to that vehicle. See Notice 2006-9 at *www.irs.gov/pub/irs-drop/n-06-09.pdf*.

Clean School Bus USA
Clean School Bus USA reduces operating costs and children's exposure to harmful diesel exhaust by limiting bus idling, implementing pollution reduction technology, improving route logistics, and switching to biodiesel. In fiscal year 2005, the program offered $7.5 million in cost-shared grants to help school districts upgrade their diesel fleets. The Energy Bill of 2005 utilizes this EPA program to grant up to 50% cost share (depending on the age and emissions of original bus) to replace school buses with ones that operate on alternative fuels or low-sulfur diesel, or up to 100% for retrofit projects. $55 million are authorized for both 2006 and 2007,

and "such sums as necessary" for 2008-2010. More information is available on the Clean School Bus USA site at *www.epa.gov/cleanschoolbus/index.htm.*

Biodiesel and Ethanol (VEETC) Tax Credit
The American Jobs Creation Act of 2004 (Public Law 108-357) created tax incentives for biodiesel fuels and extended the tax credit for fuel ethanol. The biodiesel credit is available to blenders/retailers beginning in January 2005. It also established the Volumetric Ethanol Excise Tax Credit (VEETC), which provides ethanol blenders/retailers with $.51 per pure gallon of ethanol blended or $.0051 per percentage point of ethanol blended (i.e., E10 is eligible for $.051/gal; E85 is eligible for $.4335/gal). The incentive is available until 2010.

Section 1344 of the Energy Policy Act of 2005 extended the tax credit for biodiesel producers through 2008. The credits are $.51 per gallon of ethanol at 190 proof or greater, $1.00 per gallon of agri-biodiesel, and $.50 per gallon of waste-grease biodiesel. If the fuel is used in a mixture, the credit amounts to $.0051 per percentage point ethanol or $.01 per percentage point of agri-biodiesel used or $.0050 per percentage point of waste-grease biodiesel (i.e. E100 is eligible for $.51 per gallon).

For more information, read IRS Form 637 (*www.irs.gov/pub/irs-pdf/f637.pdf*) and IRS publication 510 (*www.irs.gov/pub/irs-pdf/p510.pdf*).

Non-Urbanized Area Formula Program
The Non-Urbanized Area Formula Program assists in the maintenance, development, improvement, and use of public transportation systems in rural and small urban areas; helps people in non-urbanized areas get transportation to health care, shops, school, employment, pubic services, and recreation; assists in the development and support of intercity bus transportation; and more. The program provides funding for capital, operating, and administrative purposes to state and local governments, non-profit organizations, and public transit operators. For more information, read the Federal Transit Administration's FY 2007 Budget Request at *www.irs.gov/pub/irs-pdf/p510.pdf* or call the Federal Transit Administration's Office of Resource Management and State Programs at (202) 366-2053.

Kansas Incentives and Laws
Last Updated May 2007

The following information is taken directly from DOE's EERE Alternative Fuels & Advanced Vehicles Data Center and can be accessed by going to *www.eere.energy.gov/afdc/incentives_laws.html* and clicking on the state of Kansas on the map.

Kansas is the proud home of the Kansas City Regional Clean Cities Coalition (www.kcenergy.org/transportation.html). Coordinator contact information is listed below.

Alternative Fuel Refueling Infrastructure Tax Credit
The state offers an income tax credit for alternative fuel refueling stations placed in service after January 1, 2005, and before January 1, 2009. The tax credit, worth up to 40% of the total amount, may not exceed $160,000. For any refueling station placed in service after January 1, 2009, the amount may not exceed $100,000. This tax credit should be deducted from the taxpayer's income tax liability for the taxable year in which the expenditures are made. In the event the credit is more than the taxpayer's tax liability for that year, the remaining credit may be carried over for up to three years after the year in which the expenditures were made.
www.kcc.state.ks.us/energy/alt_fuels.htm

Renewable Fuel Retailer Incentive

Beginning January 1, 2009, a licensed retail motor fuel dealer may receive a quarterly incentive for selling and dispensing renewable fuels, including biodiesel. Qualified motor fuel dealers are eligible for up to $0.065 for every gallon of renewable fuel sold and up to $0.03 for every gallon of biodiesel sold, if the required threshold percentage is met. The threshold percentage for the incentive payment will increase on an annual basis from 10% for renewable fuel and 2% for biodiesel in 2009 to 25% beginning on January 1, 2024. Funds will be allocated from the Kansas Retail Dealer Incentive Fund.

'Biodiesel' is defined as a renewable, biodegradable, mono alkyl ester combustible liquid fuel derived from vegetable oils or animal fats that meets the specifications adopted by rules and regulations of the Secretary of Agriculture pursuant to current law. The specification must meet the American Society for Testing and Materials (ASTM) specification D6751-07 for biodiesel fuel (B100) blend stock for distillate fuels, but may be more stringent regarding biodiesel quality and usability. 'Renewable fuels' are defined as combustible liquids derived from grain starch, oil seed, animal fat, or other biomass; or produced from biogas source, including any non-fossilized, decaying, organic matter which is capable of powering spark ignition machinery.

Point of Contact

Cindy Mongold
Public Service Administrator II
Kansas Department of Revenue
Phone (785) 296-7048
Fax (785) 296-4993
cindy_mongold@kdor.state.ks.us
www.ksrevenue.org

Alternative Fuel Vehicle (AFV) Tax Credit

The state offers an income tax credit worth up to 40% of the incremental or conversion cost for qualified AFVs placed into service after January 1, 2005, as outlined in the chart below. Qualified AFVs include vehicles that operate on a combustible liquid derived from grain starch, oil seed, animal fat, or other biomass, or produced from a biogas source.

GVWR	Credit
Less than 10,000 lbs.	Up to $2,400
10,000 to 26,000 lbs.	Up to $4,000
Over 26,000 lbs.	Up to $40,000

Alternatively, a tax credit in an amount not to exceed the lesser of $750 or 5% of the cost of the AFV is available to a taxpayer who purchases an original equipment manufacturer AFV. This credit is allowed only to the first individual to take title of the vehicle. For motor vehicles capable of operating on E85, the individual claiming the credit must provide evidence of purchasing at least 500 gallons of E85 between the time the vehicle was purchased and December 31 of the next calendar year. This tax credit should be deducted from the taxpayer's income tax liability for the taxable year in which the expenditures are made. In the event the credit is more than the taxpayer's tax liability for that year, the remaining credit may be carried over for up to three years after the year in which the expenditures were made.
www.kcc.state.ks.us/energy/alt_fuels.htm

Biodiesel Production Incentive

A biodiesel fuel production incentive is available in the amount of $.30 per gallon of biodiesel fuel sold by a qualified Kansas biodiesel fuel producer. The incentive is payable to producers from the Kansas Qualified Biodiesel Fuel Producer Incentive Fund. Funding will be

made available for the production of biodiesel fuel beginning July 1, 2007.

Ethanol Production Incentive

The Kansas Qualified Agricultural Ethyl Alcohol Producer Fund enables qualified agricultural ethyl alcohol producers to apply for a production incentive with the Department of Revenue. If an ethyl alcohol producer who was in production prior to July 1, 2001, increases production capacity by an amount of 5,000,000 gallons over the producer's base sales, $0.075 may be collected for each gallon sold to an alcohol blender that is in excess of the producer's base sales (up to 15,000,000 gallons). Producers who start production on or after July 1, 2001, and who have sold at least 5,000,000 gallons to an alcohol blender may receive $0.075 for each gallon sold (up to 15,000,000 gallons).

Point of Contact
Patricia Platt
Public Service Administrator II
Kansas Department of Revenue
Phone (785) 291-3670
Fax (785) 296-2703
patricia_platt@kdor.state.ks.us

Regional Biofuels Promotion Plan

Kansas has joined Indiana, Iowa, Michigan, Minnesota, Ohio, South Dakota, and Wisconsin in adopting the Energy Security and Climate Stewardship Platform Plan (Platform), which establishes shared goals for the Midwest region, including increased biofuels production and use. Specifically, the Platform sets the following goals:

- Produce commercially available cellulosic ethanol and other low-carbon fuels in the region by 2012;
- Increase E85 availability at retail fueling stations in the region to 15% of stations by 2015, 20% by 2020, and 33% of all fueling stations in the region by 2025;
- Reduce the amount of fossil fuel that is used in the production of biofuels by 50% by 2025;
- By 2025, at least 50% of all transportation fuels consumed by the Midwest will be from regionally produced biofuels and other low-carbon transportation fuels.

The Platform also establishes a regional biofuels corridor program. The program directs state transportation, agriculture, and regulatory officials to develop a system of coordinated signage across the region for biofuels and advanced transportation fuels and to collaborate to create regional E85 corridors. The program requires standardized fuel product coding at fueling stations as well as increased education for retailers about converting existing fueling infrastructure to dispense E85. The state transportation, agriculture, and regulatory officials are required to report their corridor implementation plans to the Midwest Governors Association by April 1, 2008.

Idle Reduction Weight Exemption

Any vehicle or combination of vehicles equipped with idle-reduction technology may exceed the state's gross and axle weight limits by up to 400 pounds to compensate for the additional weight of the added idle reduction technology.

Point of Contact
Tom Whitaker
Executive Director
Kansas Motor Carriers Association
Phone (785) 267-1641
Fax (785) 266 -6551
tomw@kmca.org
www.kmca.org

E85 Tax Rate Reduction and Definition

Effective January 1, 2007, the motor vehicle fuel tax rate on E85 fuel is at least $0.17 per gallon, until July 1, 2020. On and after July 1,

2020, the tax on E85 fuel will be a minimum of $0.11 per gallon. E85 is defined as an alternative fuel that is a blend of denatured ethanol and hydrocarbon that typically contains 85% ethanol by volume, and must contain at least 70% ethanol by volume and complies with American Society for Testing and Materials (ASTM) specification D5798-99.

Biofuels Use

A 2% or higher blend of biodiesel must be purchased for use in state-owned diesel powered vehicles and equipment, where available, as long as the incremental price of biodiesel is not more than $0.10 per gallon as compared to the price of diesel fuel. Further, individuals operating state-owned motor vehicles must purchase fuel blends containing at least 10% ethanol, as long as these fuel blends are not $0.10 per gallon more than the current price per gallon of regular gasoline fuel.

Low-Speed Vehicle Access to Roadways

A low-speed vehicle is defined as any four-wheeled electric vehicle whose top speed is greater than 20 miles per hour (mph) but not greater than 25 mph and is manufactured in compliance with the national highway and traffic safety administration standards for low-speed vehicles in Title 49 of the Code of Federal Regulations Title 49, Part 571.500. Low-speed vehicles may only travel on roads with a posted speed limit of 40 mph or less and must be appropriately licensed.

A.3 Presentation: Renewable Energy Screening, Town of Greensburg, Kansas

Andy Walker
National Renewable Energy Laboratory

Renewable Energy Screening
Town of Greensburg, KS
National Renewable Energy Laboratory

Andy Walker
National Renewable Energy Laboratory

Optimization

- Identify the least cost combination of renewable energy technologies for Greensburg, KS

Renewable Energy Technologies Considered

- Photovoltaics (solar electricity)
- Wind Power
- Solar Ventilation Air Preheating
- Solar Water Heating
- Solar Thermal/Solar Thermal Electric
- Biomass Heat/Biomass Electric
- Daylighting

NREL National Renewable Energy Laboratory

Optimization Problem

Objective: Minimize Life Cycle Cost ($)

Microsoft Office Excel Spreadsheet function: SOLVER

- **Precision:** value of energy use 0.0 +/- 0.0001
- **Convergence:** change in life cycle cost less than $0.0001 for five iterations
- **Quadratic Extrapolation** to obtain initial estimates of the variables in one-dimensional search
- **Central Derivatives** used to estimate partial derivatives of the objective and constraint functions
- **Newtonian Search** Algorithm used at each iteration to determine the direction to search.

NREL National Renewable Energy Laboratory

Geographical Information System (GIS) Datasets

- NREL Datasets:
  - solar radiation 40x40 km grid
    - Horizontal, South-facing vertical, tilt=latitude
  - Wind Energy 200mx1000m grid
  - Biomass Resources
  - Illuminance for Daylighting
  - Temperature and Heating Degree Days
- Purchased Datasets
  - utility rates for each service territory (Platts)
  - State and utility incentives and utility policy (from DSIRE)
  - Temperature and Heating Degree Day (NREL)
  - City Cost Adjustments (RS Means & Co)
- Location Independent
  - Installed Hardware Costs from NREL technology databook
  - Economic Parameters (discount rate, inflation rate)

Selected Resource Information

Latitude	38.91667
Longitude	-111.7936
Heating Degree Days (65F)	4791
Cooling Degree Days (65F)	1628
Annual Average Solar tilt=lat (kWh/m2/day)	5.2
Annual Maximum Solar tilt=lat (kWh/m2/day)	6.3
Annual Average Solar horiz (kWh/m2/day)	4.6
Annual Average Wind Power Density (W/m2)	400
Annual Solar Vent Preheat Delivery (kWh/m2/yr)	557
Annual min Direct Solar on E/W 1-axis tracker (kWh/m2/day)	3
Biomass, total residues within 50 miles (tons/year)	1920000

Biomass Resource Breakdown

Within 50 mile radius:	
Crops	803000
Manure	432
Forest	1700
PrimMill	0
SecMill	750
Urban	10200
Landfill	2900
DWWT	135
Energy crops on CRP land	1101000
Total	**1920117**

Illuminance data for Daylighting Calculation

Illuminance Values (klux-hr)

March	9am	32
	11am	70
	1pm	85
	3pm	73
	5pm	38
June	9am	38
	11am	78
	1pm	102
	3pm	101
	5pm	77
Sept	9am	20
	11am	62
	1pm	87
	3pm	85
	5pm	58
Dec	9am	10
	11am	41
	1pm	53
	3pm	39
	5pm	8

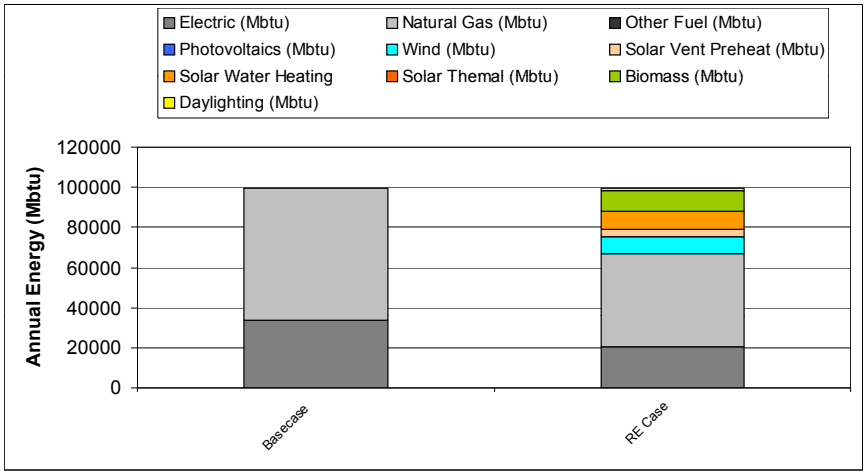
Economic Parameters

Discount Rate	4.6%	
Fuel Escalation Rate	2.0%	
Electric Escalation Rate	2.0%	

Results of Life Cycle Cost Optimization: Technology Sizes

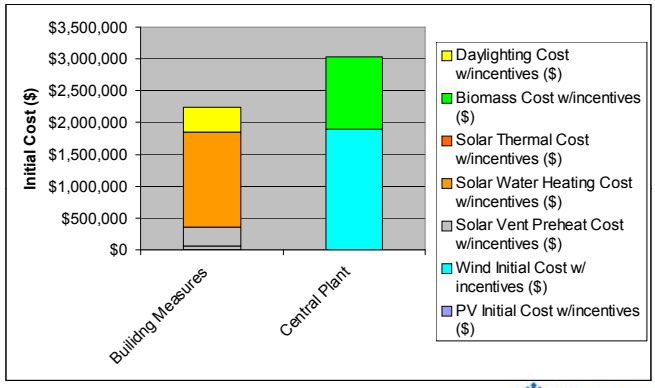
Photovoltaics Size (kW)	Wind Capacity (kW)	Solar Vent Preheat Area (ft2)	Solar Water Heating Area (ft2)	Solar Thermal Area (ft2)	Solar Thermal Electric (kW)	Biomass Boiler Size (M Btu/h)	Biomass Cogeneration Size (kW)	Daylighting Office Utility Skylight/Floor Area Ratio	Daylighting Warehouse Skylight/Floor Area Ratio
10	0	15258	29,179	0	0	0	0	3.968%	3.036%
0	957	0	0	0.00	0.00	1.34	101	0.000%	0.000%

Annual Energy from Each Technology (with Basecase)



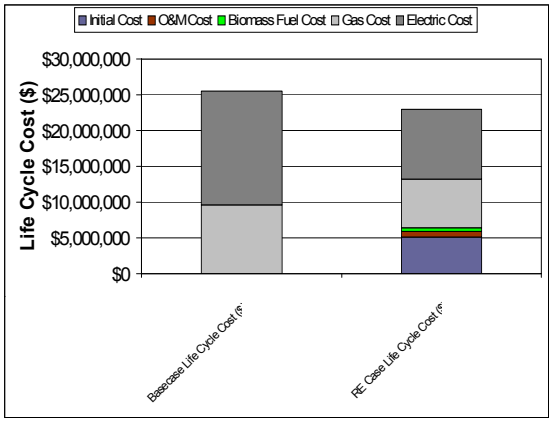
Initial Costs for Each Technology

	PV Initial Cost w/incentives ($)	Wind Initial Cost w/ incentives ($)	Solar Vent Preheat Cost w/incentives ($)	Solar Water Heating Cost w/incentives ($)	Solar Thermal Cost w/incentives ($)	Biomass Cost w/incentives ($)	Daylighting Cost w/incentives ($)	Total Initial Cost ($)
Builidng Measures	$59,216	$0	$305,167	$1,491,055	$0	$0	$388,709	$2,244,146
Central Plant	$1,238	$1,888,910	$0	$0	$0	$1,135,832	$0	$3,025,979
Total	$60,453	$1,888,910	$305,167	$1,491,055	$0	$1,135,832	$388,709	$5,270,126



Life Cycle Cost of Net Zero Case versus BaseCase

Name	Basecase Life Cycle Cost ($)	RE Case Life Cycle Cost ($)
Initial Cost	$0	$5,178,576
O&M Cost	$0	$689,759
Biomass Fuel Cost	$0	$575,533
Gas Cost	$9,579,065	$6,766,870
Electric Cost	$15,882,976	$9,690,919
Total	**$25,462,040**	**$22,901,657**



Photovoltaics



Photovoltaics
not cost effective
demonstration on school only

Building Name	Photovoltaics Size (kW)	PV Initial Cost w/incentives ($)	Net Metering up to (kW)	Avoided Cost ($/kwh)	PV Annual Energy Delivery (kWh/year)	Capacity Factor ()	PV Annual Utility Cost Savings ($)	PV Annual O&M Cost ($/year)
Courthouse	0	$0	100	0.03	0	0.0%	$0	$0
Library	0	$0	100	0.03	0	0.0%	$0	$0
sheriff	0	$0	100	0.03	0	0.0%	$0	$0
County Health Dept	0	$0	100	0.03	0	0.0%	$0	$0
County Extension Office	0	$0	100	0.03	0	0.0%	$0	$0
Hospital	0	$0	100	0.03	0	0.0%	$0	$0
Fairgrounds bldgs	0	$0	100	0.03	0	0.0%	$0	$0
Museum	0	$0	100	0.03	0	0.0%	$0	$0
City Hall	0	$0	100	0.03	0	0.0%	$0	$0
Fire/Police	0	$0	100	0.03	0	0.0%	$0	$0
High school	10	$59,216	100	0.03	14615	16.7%	$1,315	$88
Elem/Middle School	0	$0	100	0.03	0	0.0%	$0	$0
Gym and field bldgs	0	$0	100	0.03	0	0.0%	$0	$0
Post Office	0	$0	100	0.03	0	0.0%	$0	$0
USDA Service Center	0	$0	100	0.03	0	0.0%	$0	$0
Kansas State Hwy Office	0	$0	100	0.03	0	0.0%	$0	$0
USDA Housing Office	0	$0	100	0.03	0	0.0%	$0	$0
Mental Health Center	0	$0	100	0.03	0	0.0%	$0	$0
Twilight Theater	0	$0	100	0.03	0	0.0%	$0	$0
Assisted Living Residence	0	$0	100	0.03	0	0.0%	$0	$0
Senior Citizen housing	0	$0	100	0.03	0	0.0%	$0	$0
Residential	0	$0	100	0.03	0	0.0%	$0	$0
Commercial	0	$0	100	0.03	0	0.0%	$0	$0
Sum of Building Measures	**10**	**$59,216**		**0**	**14615**		**$1,315**	**$88**
Central Plant	**0**	**$0**	**100**	**0**	**0**	**0.0%**	**$0**	**$0**

NREL National Renewable Energy Laboratory

Technology Characteristics
Photovoltaics

Initial Cost	$8,730.00	$/kW	RS Means Green Building Project Planning and Cost Estimating, 2006
O$M	0.006	$/kWh	Renewable Energy Technology Characterizations, EPRI TR-109496, 1997.C185
BOS Efficiency	0.77		PVWatts documentation www.nrel.gov

NREL National Renewable Energy Laboratory

Wind Power



NREL National Renewable Energy Laboratory

Technology Characteristics
Wind Power

Wind Turbine Efficiency	35%	
Capital Cost	$926	$/m2 swept area
O&M Cost	7.9	$/year/kW
Power/Area	0.46	kW/m2
Capital Cost	2000	$/kW

http://www.eia.doe.gov/cneaf/solar.renewables/rea_issues/wind.html

http://www.pge.com/suppliers_purchasing/new_generator/incentive/avail

NREL National Renewable Energy Laboratory

Wind Energy

Building Name	Wind Capacity (kW)	Wind Annual Energy Delivery (kWh/year)	Capacity Factor (%)	Wind Annual Cost Savings ($)	Wind Annual O&M Cost ($/year)	Wind Payback Period (years)
Central Plant	957	2,533,894	30.23%	$276,194	$7,560	7.0

NREL National Renewable Energy Laboratory

Solar Ventilation Air Preheat



NREL National Renewable Energy Laboratory

Technology Characterization
Solar Ventilation Air Preheat

Initial Cost	20	$/sf			
O&M Cost	0				
	Warehouse Area (sf)	**Bldg Core Area (sf)**	**No-skylight area (sf)**	**Office Area (sf)**	**Utilities Area (sf)**
Ventilation Rate (cfm/sf)	0.12	0.12	0.12	0.12	0.12

NREL National Renewable Energy Laboratory

Solar Ventilation Air Preheating

Building Name	SVP Ventilation Rate (CFM)	Solar Vent Preheat Area (ft2)	Annual Gas Savings (therms/year)	Annual Utility Cost Savings ($/year)	Solar Vent Preheat Cost w/incentives ($)	Solar Vent Preheat Payback Period (years)
Courthouse	2,880	720.0	1,590	$1,288	$10,080	7.8
Library	505	126.3	279	$226	$1,769	7.8
sheriff	264	66.0	146	$118	$924	7.8
County Health Dept	204	51.0	113	$91	$714	7.8
County Extension Office	156	39.0	86	$70	$546	7.8
Hospital	10,800	2,700.0	5,961	$4,828	$37,800	7.8
Fairgrounds bldgs	2,100	0.0	0	$0	$0	#DIV/0!
Museum	1,200	300.0	662	$536	$4,200	7.8
City Hall	324	81.0	179	$145	$1,134	7.8
Fire/Police	420	105.0	232	$188	$1,470	7.8
High school	9,600	2,400.0	5,299	$4,292	$33,600	7.8
Elem/Middle School	5,880	1,470.0	3,245	$2,629	$20,580	7.8
Gym and field bldgs	1,920	480.0	1,060	$858	$6,720	7.8
Post Office	240	60.0	132	$107	$840	7.8
USDA Service Center	240	60.0	132	$107	$840	7.8
Kansas State Hwy Office	240	60.0	132	$107	$840	7.8
USDA Housing Office	240	60.0	132	$107	$840	7.8
Mental Health Center	1,320	330.0	729	$590	$4,620	7.8
Twilight Theater	1,080	0.0	0	$0	$0	#DIV/0!
Assisted Living Residence	2,520	630.0	1,391	$1,127	$8,820	7.8
Senior Citizen housing	13,080	3,270.0	7,220	$5,848	$45,780	7.8
Residential	116,220	0.0	0	$0	$0	#DIV/0!
Commercial	9,000	2,250.0	4,968	$4,024	$31,500	7.8
Sum of Building Measures	**180,433**	**15,258.3**	**33,688**	**$27,287**	**$213,617**	

NREL National Renewable Energy Laboratory

Solar Water Heating



NREL National Renewable Energy Laboratory

Technology Characterization
Solar Water Heating

Hot Water as Fraction of Total Building Energy		
Office	0.089506	
Education	0.21942	
Health Care	0.262063	
lodging	0.403771	
public assembly	0.153914	
food service	0.112016	
food sales	0.042623	
warehouse	0.052219	
other 15.3	0.08885	
all	0.152486	

source: DOE/OBT Energy Databook

SDHW Efficiency	0.4	
Cost	73	$/sf
O&M Cost	0.005	% of initial cost
Aux efficiency	0.8	

NREL National Renewable Energy Laboratory

Solar Water Heating

Building Name	Solar Water Heating Area (ft2)	Solar Water Heating Gas Savings (therms/year)	Solar Water Heating Annual Utility Cost Savings ($/year)	Solar Water Heating Cost w/incentives ($)	Solar Water Heating O&M Cost ($/year)	Solar Water Heating Payback Period (years)
Courthouse	0	0	$0	$0	$0	#DIV/0!
Library	0	0	$0	$0	$0	#DIV/0!
sheriff	45	134	$109	$2,280	$16	24.7
County Health Dept	34	104	$84	$1,762	$13	24.7
County Extension Office	26	79	$64	$1,347	$10	24.7
Hospital	1,825	5,492	$4,449	$93,262	$666	24.7
Fairgrounds bldgs	0	0	$0	$0	$0	#DIV/0!
Museum	0	0	$0	$0	$0	#DIV/0!
City Hall	55	165	$133	$2,798	$20	24.7
Fire/Police	71	214	$173	$3,627	$26	24.7
High school	1,622	4,882	$3,954	$82,900	$592	24.7
Elem/Middle School	994	2,990	$2,422	$50,776	$363	24.7
Gym and field bldgs	324	976	$791	$16,580	$118	24.7
Post Office	41	122	$99	$2,072	$15	24.7
USDA Service Center	41	122	$99	$2,072	$15	24.7
Kansas State Hwy Office	41	122	$99	$2,072	$15	24.7
USDA Housing Office	41	122	$99	$2,072	$15	24.7
Mental Health Center	223	671	$544	$11,399	$81	24.7
Twilight Theater	0	0	$0	$0	$0	#DIV/0!
Assisted Living Residence	426	1,282	$1,038	$21,761	$155	24.7
Senior Citizen housing	2,210	6,652	$5,388	$112,951	$807	24.7
Residential	19,640	59,102	$47,873	$1,003,604	$7,169	24.7
Commercial	1,521	4,577	$3,707	$77,718	$555	24.7
Sum of Building Measures	**29,179**	**87,808**	**$71,125**	**$1,491,055**	**$10,650**	

NREL National Renewable Energy Laboratory

Solar Thermal/Solar Thermal Electric



NREL National Renewable Energy Laboratory

Technology Characterization
Solar Thermal/Solar Thermal Electric

Solar Thermal cost	50	$/sf	
O&M cost	$0.127	$/therm/year	
Efficiency	0.33		
Cost of thermal storage	$1,465	$/therm	http://www.nrel.gov/csp/troughnet/pdfs/3516.pdf
Hours per day of solar collection	6		
Cogen Cost	1650	$/kW	
cogen Efficiency	0.3		
Boiler Capacity Factor	0.85		
Hx effectiveness	0.7		
Federal Production tax credit	0.01	$/kwh	

Solar Thermal/Solar Thermal Electric
…found not to be cost effective

Solar Thermal Area (ft2)	Solar Thermal Cogeneration Size (kW)	Solar Thermal Gas Savings (therms/year)	Solar Thermal Electric Delivery (kWh/year)	Solar Thermal Annual Utility Cost Savings ($/year)	Solar Thermal Cost w/incentives ($)	Solar Thermal O&M Cost ($/year)	Solar Thermal Payback Period (years)
0	0	0	0	0	$0	$0	#DIV/0!

Biomass Energy



NREL National Renewable Energy Laboratory

Technology Characterization
Biomass Energy

Biomass heating value	100	therms/ton
Boiler Cost	500000	$/MBH
Cogen Cost	1650	$/kW
Fuel Storage and Handling	250000	$/MBH
Boiler Efficiency	0.75	
cogen Efficiency	0.3	
Boiler Capacity Factor	0.85	
Hx effectiveness	0.7	
fixed cost per ton	20	
trucking cost	1	$/sq mile/ton
Federal Production tax credit	0.01	$/kwh
Biomass O&M Cost	15000	$/yr/Mmbtuh
http://www.eia.doe.gov/oiaf/analysispaper/biomass/index.html		

NREL National Renewable Energy Laboratory

Biomass Energy

Building Name	Biomass Boiler Size (M Btu/h)	Biomass Cogeneration Size (kW)	Biomass Gas Savings (therms/year)	Biomass Electric Delivery (kWh/year)	Biomass Capacity Factor	Biomass Annual Utility Cost Savings ($/year)	Tons of Fuel Used	per ton fuel cost ($/ton)	Biomass Cost w/incentives ($)	Biomass O&M Cost($/year)
Central Plant	1	101	78,769	754,248	85.0%	$139,228	1,330	$24.08	$1,135,832	$20,101

Daylighting



Daylighting at East Range Warehouse
Schofield Barracks, Hawaii

Technology Characterizations
Daylighting

	Lighting levels	
Office	30	fc
Warehouse	15	fc
Utility	30	fc
skylight transmittance	0.7	
lightwell transmittance	0.5	
Coefficient of Utilizatio	0.55	
Coefficient of Utilizatio	0.45	
Luminous Efficacy Ele	100	lumens/wat
Roof U-value	0.1	btu/hr/F
Skylight Uvalue	0.5	btu/hr/F
Cooling COP	3.5	
Heating Efficiency	0.8	
Skylight Cost	25	$/sf
Controls cost	0.25	$/sf floor ar

Daylighting

Building Name	Daylighting Office Utility Skylight/Floor Area Ratio	Daylighting Warehouse Skylight/Floor Area Ratio	Total Skylight Area (ft2)	Annual Electric Savings (kWh/year)	Annual Natural Gas Savings (therms/year)	Daylighting Cost w/incentives ($)	Daylighting Annual Cost Savings ($/year)	Daylighting Payback Period (years)
Courthouse	2.3%	3.4%	473.4	37,418.2	(272.1)	$16,634	$3,147	5.3
Library	4.6%	3.5%	137.2	5,243.8	(78.9)	$4,271	$408	10.5
sheriff	4.8%	3.6%	73.3	2,737.4	(42.2)	$2,273	$212	10.7
County Health Dept	4.8%	3.6%	57.0	2,114.8	(32.8)	$1,765	$164	10.8
County Extension Office	4.8%	3.6%	43.8	1,616.9	(25.2)	$1,355	$125	10.8
Hospital	4.8%	3.6%	3,031.0	111,942.4	(1,742.6)	$93,776	$8,663	10.8
Fairgrounds bldgs	3.8%	3.1%	481.5	21,907.8	(276.8)	$15,536	$1,747	8.9
Museum	4.3%	3.3%	303.7	12,481.4	(174.6)	$9,592	$982	9.8
City Hall	4.7%	3.6%	89.5	3,360.2	(51.5)	$2,777	$261	10.7
Fire/Police	4.7%	3.5%	114.9	4,357.1	(66.1)	$3,574	$339	10.6
High school	4.7%	3.5%	2,624.0	99,596.2	(1,508.6)	$81,600	$7,742	10.5
Elem/Middle School	4.7%	3.5%	1,607.2	61,002.7	(924.0)	$49,980	$4,742	10.5
Gym and field bldgs	3.9%	3.1%	449.3	20,018.0	(258.3)	$14,433	$1,592	9.1
Post Office	4.8%	3.6%	66.8	2,488.3	(38.4)	$2,071	$193	10.7
USDA Service Center	4.8%	3.6%	66.8	2,488.3	(38.4)	$2,071	$193	10.7
Kansas State Hwy Office	4.8%	3.6%	66.8	2,488.3	(38.4)	$2,071	$193	10.7
USDA Housing Office	4.8%	3.6%	66.8	2,488.3	(38.4)	$2,071	$193	10.7
Mental Health Center	4.2%	3.3%	329.8	13,735.0	(189.6)	$10,446	$1,083	9.6
Twilight Theater	4.3%	3.3%	276.7	11,228.8	(159.1)	$8,718	$882	9.9
Assisted Living Residence	3.6%	2.9%	549.8	26,326.0	(316.1)	$17,944	$2,113	8.5
Senior Citizen housing	0.0%	0.0%	0.0	0.0	0.0	$0	$0	#DIV/0!
Residential	0.0%	0.0%	0.0	0.0	0.0	$0	$0	#DIV/0!
Commercial	3.0%	1.1%	1,230.1	94,981.1	(707.2)	$45,753	$7,975	5.7
Sum of Building Measures	**4.0%**	**3.0%**	**12,139.5**	**540,020.9**	**(6,979.2)**	**$388,709**	**$42,949**	

Thank You!

Appendix B: Residential Construction

Page

B.1 Presentation: Example Performance Targets and Efficiency Packages, Greensburg, Kansas 45

B.2 Fact Sheet: Why Build an Energy Efficient Home? 58

B.3 Recommendation: Greensburg, Kansas, Should Adopt the Best Green Housing Requirements in the U.S 61

B.4 Fact Sheets: High Performance Housing 62

B.5 Presentation: Building for Energy Efficiency – Part 1 83

B.6 Presentation: Building for Energy Efficiency – Part 2 120

B.7 Presentation: Building for Energy Efficiency – Part 3 136

B.8 Presentation: Building for Energy Efficiency – Part 4 174

B.9 House Plan: Plan 1 - Three Bedroom, Basement, Greensburg, Kansas 185

B.10 Fact Sheet: Energy Efficient Homes are More Affordable than Conventional Homes 199

B.1 Example Performance Targets and Efficiency Packages Greensburg, Kansas

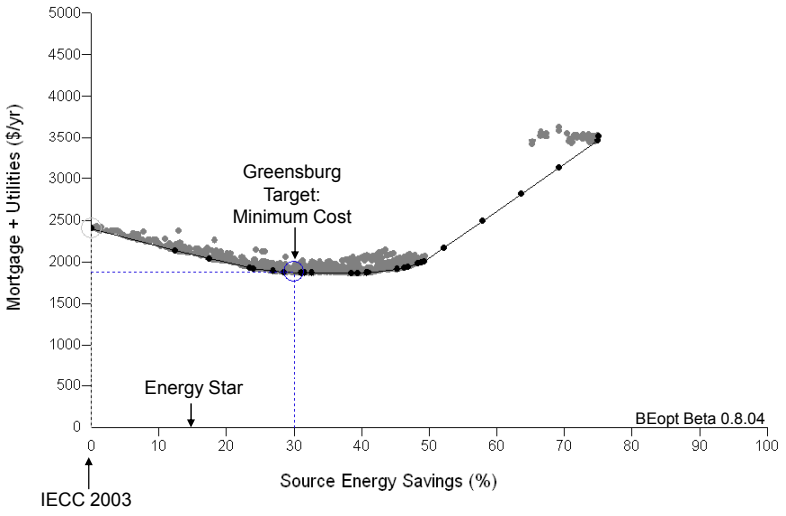
Ren Anderson
National Renewable Energy Laboratory

Mixed Humid Climate Region

Example Performance Targets and Efficiency Packages Greensburg, Kansas

Dr. Ren Anderson, NREL

30% Savings Target: Greensburg



(2000 ft2, 2-story, 16% window to floor area ratio), unconditioned basement

Example: Greensburg 30% Efficiency Package[1]

- 2x6 + R-19 batts (R14 wall assembly)
- R40 ceiling assembly
- R10 basement
- .0002 SLA (4 ACH_{50})
- Low e/low SHGC glazing (0.3 U-value, 0.37 SHGC)
- 50% CFL Lighting
- SEER 14 AC
- AFUE 90+ furnace
- Premium gas hot water, EF 0.61
- Tight ducts (Mastic, 5% Leakage), R-8
- BA QA (moisture control, …)

Estimated cost increase relative to standard home[2,3]: +$1.25-$2.00/ft2

Notes:
1. Equivalent packages may be substituted, based on specific builder preferences
2. Does not include costs associated with builder/contractor training and changes in business practices.
3. Incremental costs evaluated relative to minimum IECC 2003

NREL National Renewable Energy Laboratory

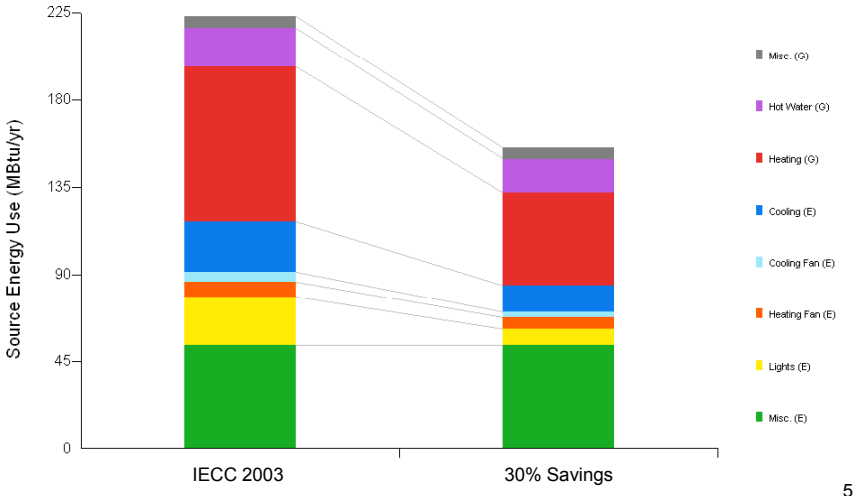
Estimated Annual Cost Savings: 30% Energy Savings Target

	Greensburg
Estimated Incremental First Cost Relative to Standard Practice[1]	$4,000
Annual Amortized Cost 7%, 30Year mortgage[2]	$211
Estimated Annual Utility Bill Savings	$723
Net Annual Savings	**$512**

(2000 ft2, 2-story, 16% window to floor area ratio, unconditioned basement)

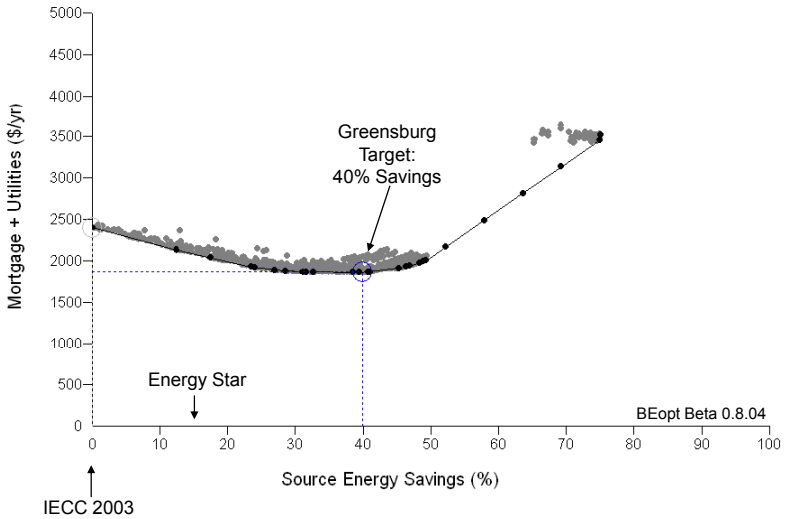
[1]Evaluated relative to minimum IECC 2003
[2] Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage.

Estimated Annual Energy Savings by End Use: 30% Target



5

40% Savings Target: Greensburg



(2000 ft2, 2-story, 16% window to floor area ratio, unconditioned basement)

6

NREL National Renewable Energy Laboratory

Example: Greensburg 40% Efficiency Package[1]

- 2x6 + R-21 batts (R15 wall assembly)
- R50 ceiling assembly
- R10 basement
- .0002 SLA (4 ACH_{50})
- Low e/low SHGC glazing, Argon Fill (0.28 U-value, 0.37 SHGC)
- 80% CFL Lighting
- SEER 18 AC
- AFUE 90+ furnace
- Premium gas hot water, EF 0.61
- Tight ducts (Mastic, 5% Leakage), R-8
- BA QA (moisture control, …)

Estimated cost increase relative to standard home[2,3]: +$3.00-$4.00/ft2

Notes:
1. Equivalent packages may be substituted, based on specific builder preferences
2. Does not include costs associated with builder/contractor training and changes in business practices.
3. Incremental costs evaluated relative to minimum IECC 2003

7

NREL National Renewable Energy Laboratory

Estimated Annual Costs: 40% Efficiency Target

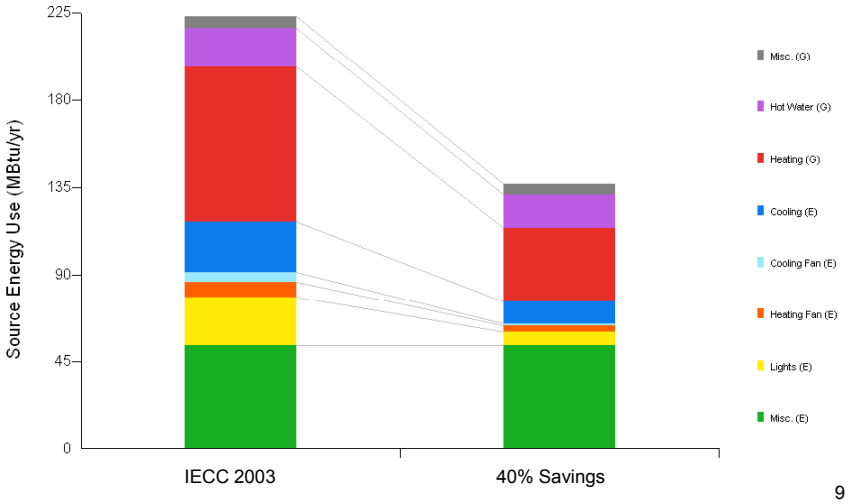
	Greensburg
Estimated Incremental First Cost Relative to Standard Practice[1,2]	$7,000
Annual Amortized Cost 7%, 30 Year mortgage[3]	$411
Annual Utility Bill Savings	$919
Net Annual Savings	**$508**

(2000 ft2, 2-story, 16% window to floor area ratio), unconditioned basement

[1]Evaluated relative to minimum IECC 2003. Cost does not include impact of $2000 tax credit.
[2]Qualifies for federal new home tax credit
[3]Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage.

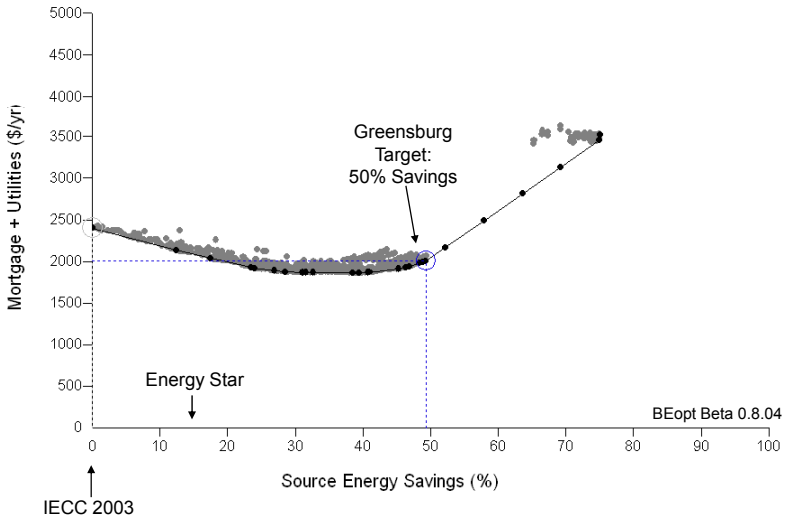
8

Estimated Annual Energy Savings by End Use: 40% Target



9

50% Savings Target: Greensburg



10

NREL National Renewable Energy Laboratory

Example: Greensburg 50% Efficiency Package[1]

- 2x6 + R-19 batts+ foam sheathing (R22 wall assembly)
- R50 ceiling assembly
- R10 basement
- .0001 SLA (2 ACH_{50})
- Low e/low SHGC glazing, Argon Fill (0.28 U-value, 0.37 SHGC)
- 80% CFL Lighting
- SEER 18 AC
- AFUE 90+ furnace
- Gas tankless hot water, EF 0.8+
- Tight ducts (Mastic, 5% Leakage), in conditioned space
- Energy Star Appliances
- BA QA (moisture control, …)

Estimated cost increase relative to standard home[2,3]: +$6.00-$8.00/ft2

Notes:
1. Equivalent packages may be substituted, based on specific builder preferences
2. Does not include costs associated with builder/contractor training and changes in business practices.
3. Incremental costs evaluated relative to minimum IECC 2003

NREL National Renewable Energy Laboratory

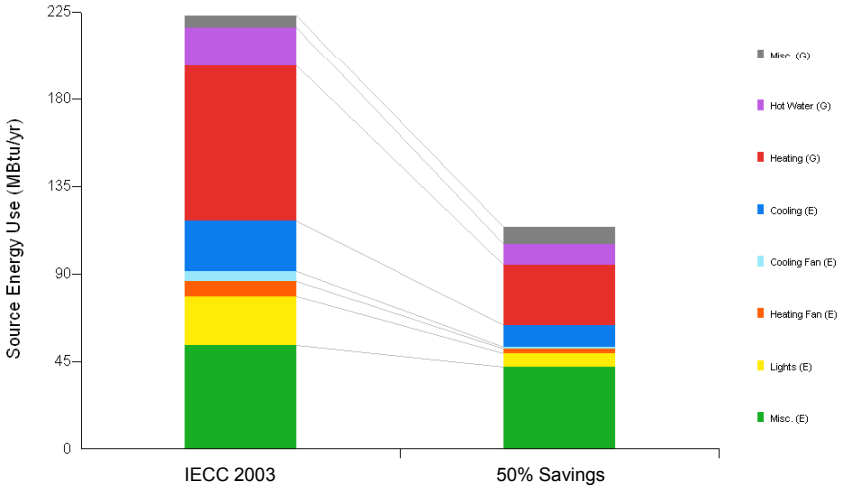
Estimated Annual Costs: 50% Efficiency Target

	Greensburg
Estimated Incremental First Cost Relative to Standard Practice[1,2]	$13,000
Annual Amortized Cost 7%, 30Year mortgage[3]	$706
Annual Utility Bill Savings	$1162
Net Annual Savings	**$456**

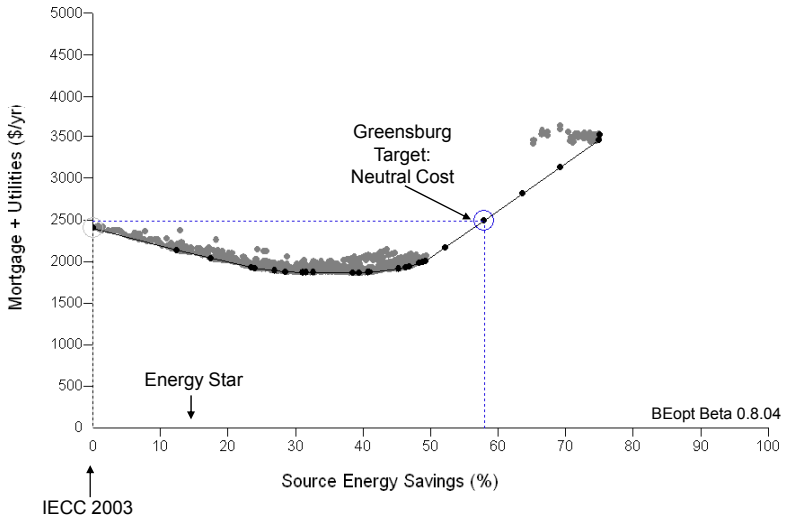
(2000 ft2, 2-story, 16% window to floor area ratio), unconditioned basement

[1]Evaluated relative to minimum IECC 2003
[2]Qualifies for federal new home tax credit
[3]Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage.

Estimated Annual Energy Savings by End Use: 50% Target



Neutral Cost Point: Greensburg



Example: Greensburg Neutral Cost Package[1]

- R22 wall assembly (2x6 + R-19 batts+ foam sheathing)
- R50 ceiling assembly
- R10 basement
- .0001 SLA (2 ACH_{50})
- Low e/low SHGC glazing, Argon Fill (0.28 U-value, 0.37 SHGC)
- 80% CFL Lighting
- SEER 18 AC
- AFUE 90+ furnace
- Gas tankless hot water, EF 0.8+
- Tight ducts (Mastic, 5% Leakage), in conditioned space
- Energy Star Appliances
- 1.5 kW_{DC} PV System
- BA QA (moisture control, …)

Estimated cost increase relative to standard home[2,3]: +$10.00-$13.00/ft2

Notes:
1. Equivalent packages may be substituted, based on specific builder preferences
2. Does not include costs associated with builder/contractor training and changes in business practices.
3. Incremental costs evaluated relative to minimum IECC 2003

15

NREL National Renewable Energy Laboratory

Estimated Annual Costs: Neutral Cost Target

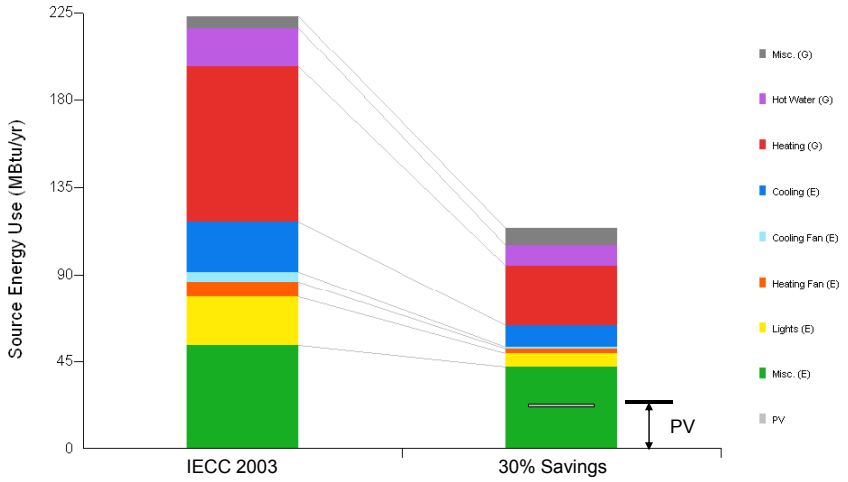
	Greensburg
Estimated Incremental First Cost Relative to Standard Practice[1,2]	$25,000
Annual Amortized Cost 7%, 30Year mortgage[3]	$1386
Annual Utility Bill Savings	$1386
Net Annual Savings	**$0**

(2000 ft2, 2-story, 16% window to floor area ratio), unconditioned basement

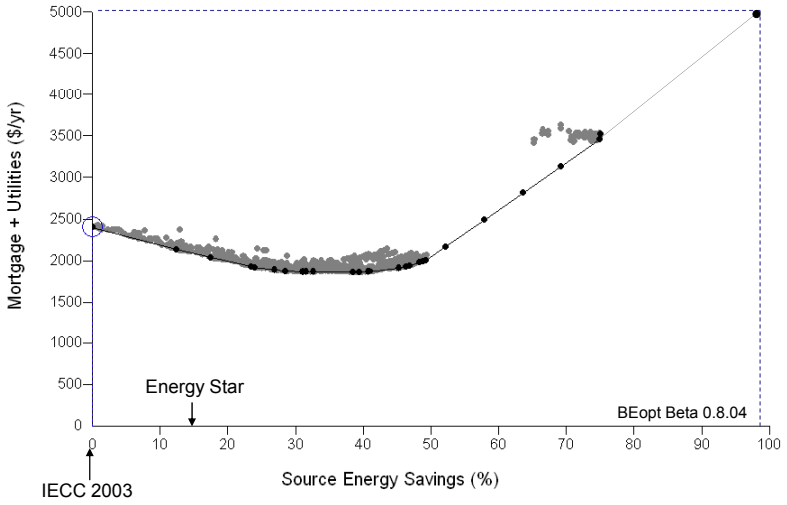
[1]Evaluated relative to minimum IECC 2003
[2]Qualifies for federal new home tax credit
[3] Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage.

16

Estimated Annual Energy Savings by End Use: Neutral Cost Target



Net Zero Energy Target: Greensburg



(2000 ft2, 2-story, 16% window to floor area ratio, unconditioned basement)

18

Example: Greensburg NZEH Package[1]

- R22 wall assembly (2x6 + R-19 batts+ foam sheathing)
- R50 ceiling assembly
- R10 basement
- .0001 SLA (2 ACH_{50})
- Low e/low SHGC glazing, Argon Fill (0.28 U-value, 0.37 SHGC)
- 80% CFL Lighting
- SEER 18 AC
- AFUE 90+ furnace
- Gas tankless hot water, EF 0.8+
- Tight ducts (Mastic, 5% Leakage), in conditioned space
- Energy Star Appliances
- 7 kW_{DC} PV System and solar hot water system
- BA QA (moisture control, …)

Estimated cost increase relative to standard home[2,3]: +$35.00-$40.00/ft2

Notes:
1. Equivalent packages may be substituted, based on specific builder preferences
2. Does not include costs associated with builder/contractor training and changes in business practices.
3. Incremental costs evaluated relative to minimum IECC 2003

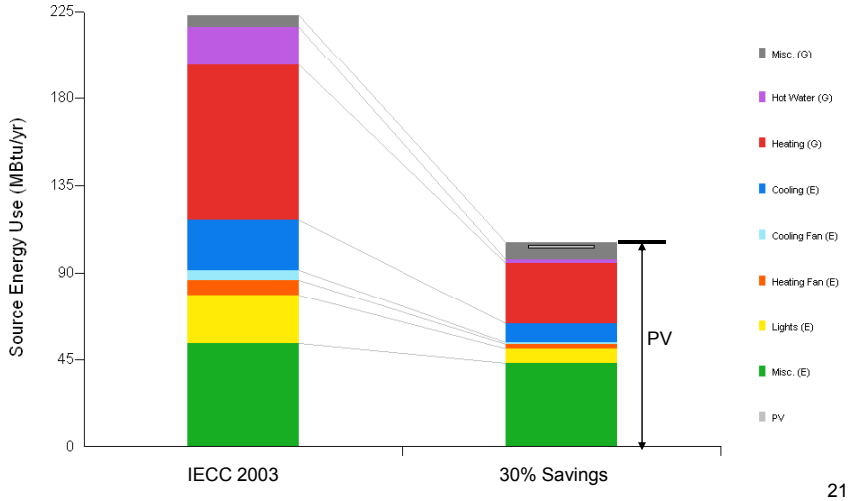
Estimated Annual Costs: Net Zero Energy Target

	Greensburg
Estimated Incremental First Cost Relative to Standard Practice[1,2]	$69,000
Annual Amortized Cost 7%, 30Year mortgage[2]	$4102
Annual Utility Bill Savings	$2306
Net Annual Savings	**-$1796**

(2000 ft2, 2-story, 16% window to floor area ratio), unconditioned basement

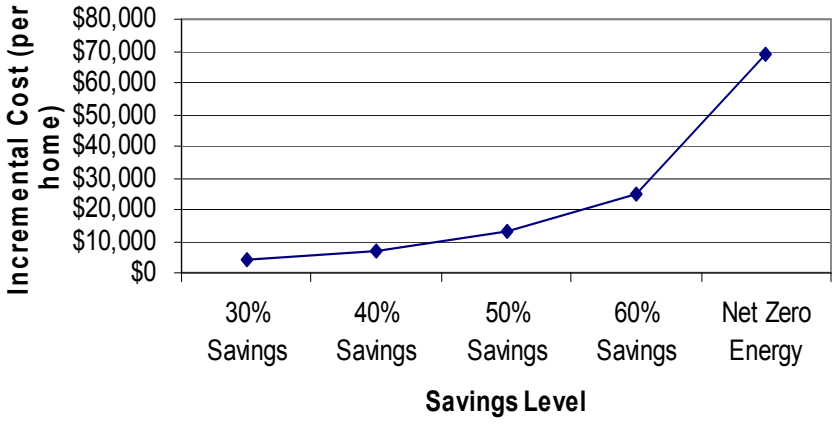
[1]Evaluated relative to minimum IECC 2003
[2]Qualifies for federal new home tax credit
[3]Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage.

Estimated Annual Energy Savings by End Use: Net Zero Energy Target



21

Cost of Energy Saving Upgrades



22

This work has been authored by an employee or employees of the Midwest Research Institute under Contract No. DE-AC36-99GO10337 with the U.S. Department of Energy. The United States Government retains and the publisher, by accepting the article for publication, acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for United States Government purposes.

B.2 Why Build an Energy Efficient Home?

Ren Anderson
National Renewable Energy Laboratory

Why Build an Energy Efficient Home?.....

It Saves You Money!

Upgraded Energy Savings Levels			
For a typical 2,000 sqft. home:	**Base Efficiency**	**High Efficiency**	**Premium Efficiency**
Estimated Incremental First Cost	$4,000	$7,000	$13,000
Savings on Monthly Utility Bill[1]	$60.25	$76.58	$96.83
Increase in Monthly Mortgage Payment[2]	$17.58	$34.25	$58.83
Net Monthly Savings	**$42.67**	**$42.33**	**$38.00**

[1] Evaluated relative to current Building Code - IECC 2003.
[2] Based on a 30 year mortgage at 7% APR with an increase in loan value of $4,000 for the 30% option (Base), $7,000 for the 40% option (High), and $13,000 for the 50% option (Premium).

You also get:

- Increased Durability
- Increased Comfort






What is Required to Own an Energy Efficient Home?.....

Simple Efficiency Upgrades Provided by Your Builder!

Energy Efficiency Upgrades

	Basic Efficiency Package	High Efficiency Package	Premium Efficiency Package
Insulation Walls Roof Basement	R-19 R-40 R-10	R-21 R-50 R-10	R-19 + R-5 Foam R-50 R-10
Windows U-Value Solar Rating	Double-glazed, low-e 0.30 0.37	Double-glazed, low-e, argon-filled 0.28 0.37	Double-glazed, low-e, argon-filled 0.28 0.37
Lighting % Compact Fluorescents	50%	80%	80%
Heating Efficiency Rating	90+%	90+%	90+%
Air Conditioning Efficiency Rating	14	18	18
Appliances	Standard	Standard	ENERGY STAR
Water Heater Energy Factor	Tank - gas 0.61	Tank - gas 0.61	Tankless - gas 0.80
Ventilation	Exhaust	Supply	Balanced

For more information, contact: Greensburg GreenTown (620-549-3275 or 620-723-2790) or Department of Energy / National Renewable Energy Laboratory representatives (620-210-0281)

B.3 Recommendation: Greensburg, Kansas, should Adopt the Best Green Housing Requirements in the United States

Ren Anderson
National Renewable Energy Laboratory

Requirement: All new residential construction is encouraged to be designed, contracted and built to achieve whole-house energy savings of at least 40% relative to minimum code using a "green building" approach. All existing residences and housing projects are encouraged to target maximum cost-effective energy savings

"Green building" is a whole-systems approach utilizing design and building techniques to minimize environmental impact and reduce the energy consumption and utility costs of a building while contributing to the health of its occupants and building durability. This requirement includes:

- Forty percent energy cost savings compared to a typical building built to code
- A healthy indoor environment
- Reduction in water use compared to a typical building
- Use of renewable energy generation wherever appropriate
- Use of locally available and recycled materials while minimizing construction waste
- Reducing the overall environmental impact from the site.

B.3.1. What are the Benefits of City Leadership Setting this Requirement?

By adopting this goal and green building approach the city will:

- Reduce homeowner utility costs
- Reduce peak electric demand and backup power requirements
- Substantially reduce negative environmental impacts and increase home durability
- Enhance building value and marketability
- Increase homeowner comfort
- Set the example for other housing projects and homeowners in Greensburg
- Receive extensive media coverage potentially leading to economic growth.

B.3.2 Cost Impacts Are Understood

- The best designed larger buildings have been documented to have NO increase in cost.
- Cost increases may be 3%-10% for Greensburg's smaller buildings, but will be more than compensated by lower utility bills.

12-03-07

B.4 High Performance Housing

Produced by: Building Science Corporation
for the DOE Building America Program

a. Foundations and Ground Water Control

b. Passive Radon Mitigation System

c. Controlled Ventilation System

d. Ductwork in Conditioned Space

e. Transfer Ducts and Grilles

f. Duct Sealing

g. Sealed Combustion Water Heaters

h. Basement Insulation

i. Wall Bracing Requirements for Insulating Sheathing

j. Insulating Sheathing Vapor Retarder Requirements

k. Cladding Attachment over Insulating Sheathing

l. Conditioned Attics

High Performance Housing — **Information Sheet 1**
for Greensburg, Kansas
Foundations and Groundwater Control

Water managed foundation systems rely on two fundamental principles:

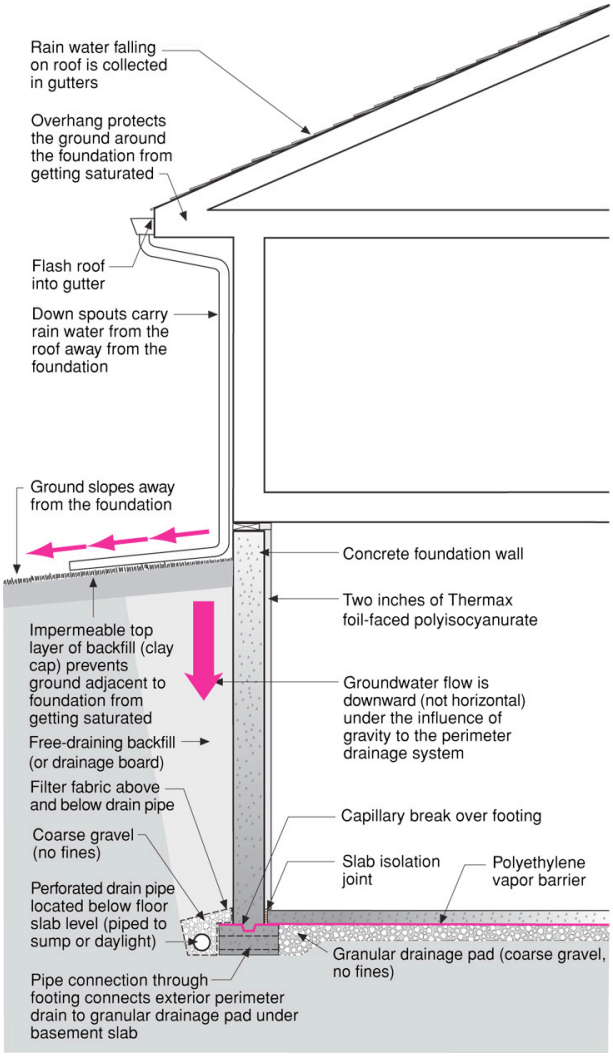
- keep rain water away from the foundation wall perimeter
- drain groundwater with sub-grade perimeter footing drains before it gets to the foundation wall

Water managed foundation systems are different from waterproofing systems. Waterproofing relies on creating a watertight barrier without holes. It can't be done. Even boats need pumps. Water managed foundation systems prevent the buildup of water against foundation walls, thereby eliminating hydrostatic pressure. No pressure, no force to push water through a hole. Remember, we know the foundation wall will have holes.

Mixing control joints with water management is a fundamental requirement for functional foundation systems that provide an extended useful service life. Dampproofing should not be confused with waterproofing. Dampproofing protects foundation materials from absorbing ground moisture by capillarity. Dampproofing is not intended to resist groundwater forces (hydrostatic pressure). If water management is used, waterproofing is not necessary. However, control of capillary water is still required (dampproofing). Dampproofing is typically provided by coating the exterior of a concrete foundation wall with a tar or bituminous paint or coating.

Draining groundwater away from foundation wall perimeters is typically done with free-draining backfill such as sand, gravel or other water-permeable material, or drainage boards or exterior foundation insulations with drainage properties.

Groundwater Control with Basements



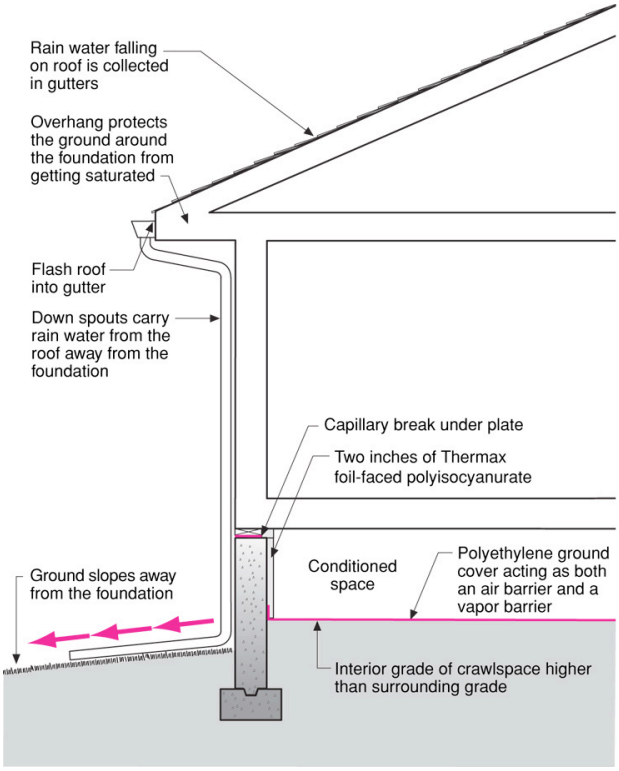
- Keep rain water away from the foundation perimeter
- Drain groundwater away in sub-grade perimeter footing drains before it gets to the foundation wall

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

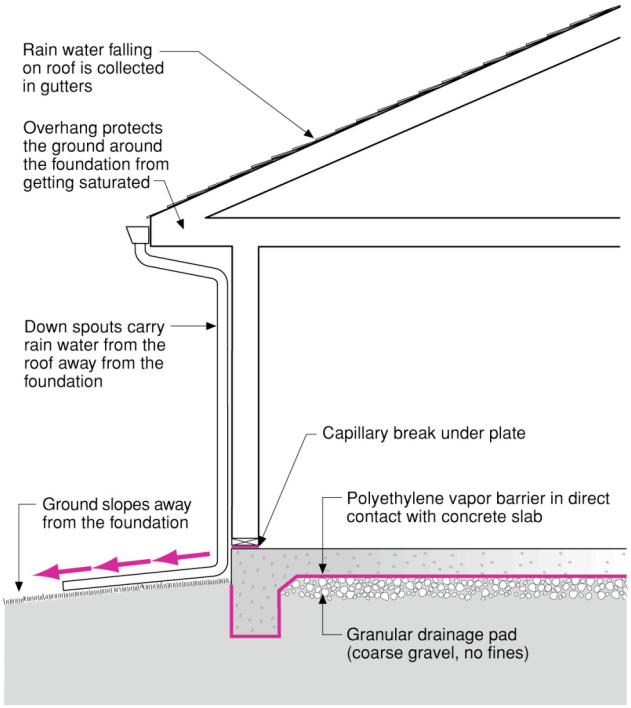
For more information about the Greensburg, Kansas project go to **buildingamerica-greensburg.com**

Groundwater Control with Crawlspaces



- Keep rain water away from the foundation perimeter
- If the interior crawlspace is lower than the exterior grade, a sub-grade perimeter footing drain is necessary as in a basement foundation
- The crawlspace in this configuration is conditioned space; it is part of the "interior" of the building and should be heated, cooled and ventilated as part of the building's heating, cooling and ventilating strategy

Groundwater Control with Slabs



- Keep rain water away from the foundation perimeter
- Do not place sand layer over polyethylene vapor barrier under concrete slab

High Performance Housing — **Information Sheet 10**
for Greensburg, Kansas
Passive Radon Mitigation System

Keeping soil gas (radon, water vapor, herbicides, termiticides, methane, etc.) out of foundations cannot be done by building hole-free foundations because hole-free foundations cannot be built. Soil gas moves through holes due to a pressure difference. Since we cannot eliminate the holes, the only thing we can do is control the pressure.

The granular drainage pad located under concrete slabs can be integrated into a sub-slab ventilation system to control soil gas migration by creating a zone of negative pressure under the slab. A vent pipe connects the sub-slab gravel layer to the exterior through the roof. This "passive" radon mitigation system is illustrated in the figure *Soil Gas Ventilation System—Basement Construction.*

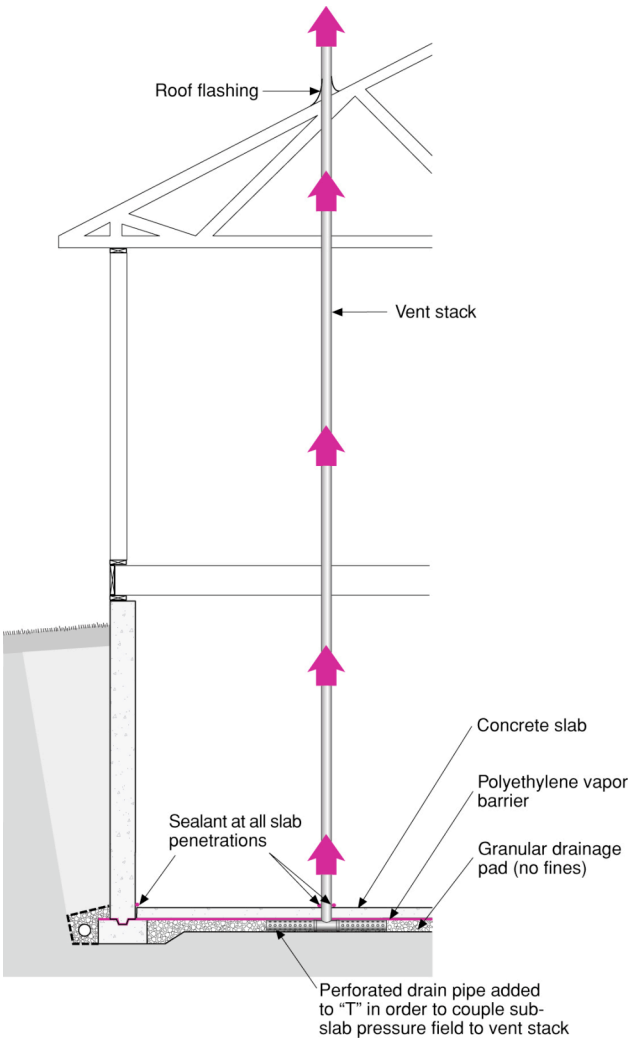
An exhaust fan can be added later, if necessary, to make this an "active" mitigation system.

More information about radon and radon resistance construction can be found on the Environmental Protection Agency's website at: www.epa.gov/iaq/radon/

See also the following EPA documents:

- "Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes"
- "Radon Resistant Construction Architectural Drawings"
- "Model Standards and Techniques for Control of Radon in New Residential Buildings"

Soil Gas Ventilation System—Basement Construction



- Granular drainage pad depressurized by active fan located in attic or by passive stack action of warm vent stack located inside heated space
- Avoid offsets or elbows in vent stack to maximize air flow

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

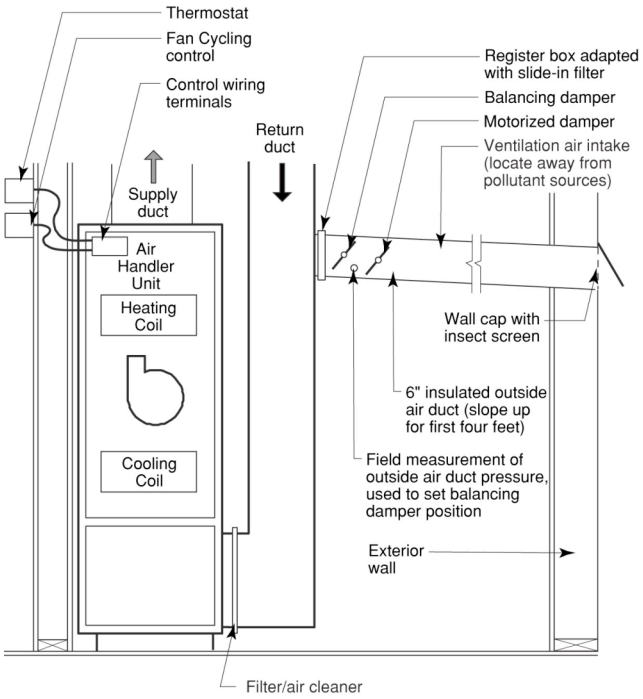
For more information about the Greensburg, Kansas project go to **buildingamerica-greensburg.com**

High Performance Housing — **Information Sheet 11**
for Greensburg, Kansas
Controlled Ventilation System

All buildings require controlled mechanical ventilation, or the controlled, purposeful introduction of outdoor air to the conditioned space. Building intentionally leaky buildings and installing operable windows does not provide sufficient outside air in a consistent manner. Building enclosures must be "built tight and then ventilated right." Why? Because before you can control air you must enclose it. Once you eliminate big holes it becomes easy to control air exchange between the inside and the outside.

With a tight building enclosure, both mechanical ventilation and pollutant source control are required to ensure that there is reasonable indoor air quality inside the house. These approaches are shown schematically in figure *Integrated Supply Ventilation System.*

The ventilation system for this house is designed as a central fan integrated system, which is made up of a 6-inch outdoor air intake duct connected to the return side of the air handler. This duct draws outdoor air in to the air distribution system and distributes it to the various rooms in the house. The intake duct has a motorized damper controlled by a fan cycling control to close the damper to prevent over ventilation of the house during times of significant space conditioning demands. An example of the central fan ventilation system with 6-inch motorized damper is shown in figure *Outdoor Air Duct Connected to the Return of the Air Handler.*



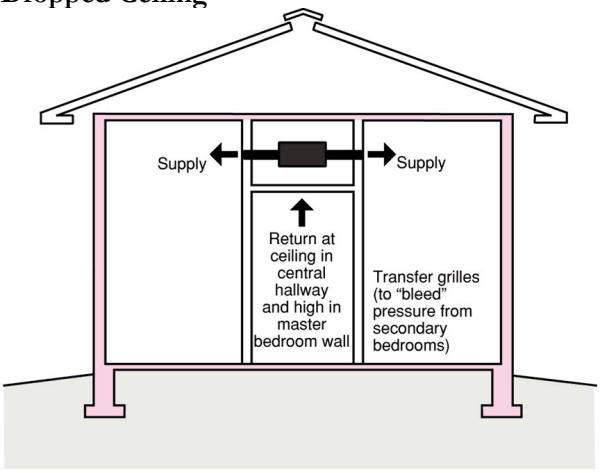
- Outside air duct should be insulated and positioned so that there is a fall/slope toward the outside to control any potential interior condensation. Avoid using long lengths of flex duct, which may have a dip and could create a reservoir for condensation
- Motorized damper allows control of ventilation air duty cycle (i.e., run time) separate from air handler duty cycle
- Controller can be mounted on the air handler, or in the main space near the thermostat
- Balancing damper adjusted to provide required flow
- Mixed return air temperatures (return air plus outside air) should not be allowed to drop below 50° Fahrenheit at the design temperature in order to control condensation of combustion gases on heat exchanger surfaces

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

For more information about the Greensburg, Kansas project go to **buildingamerica-greensburg.com**

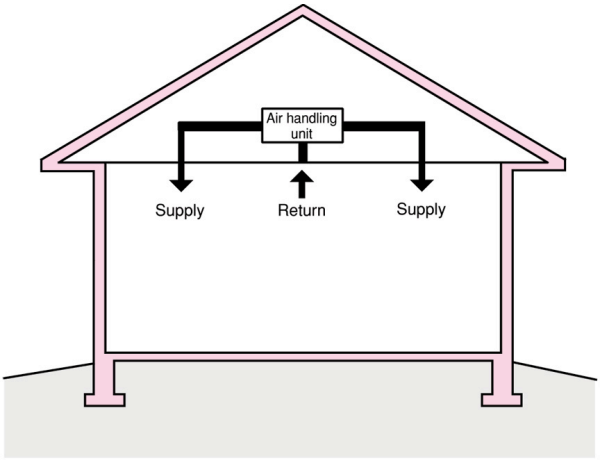
Vented and Unconditioned Attic with a Dropped Ceiling



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

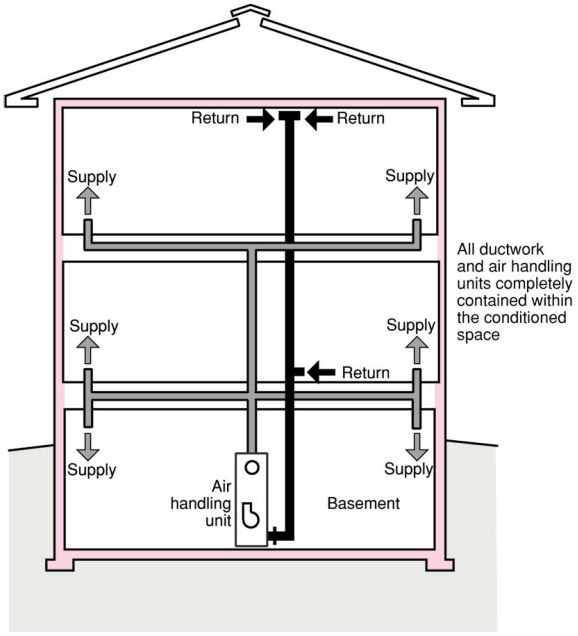
- In this approach, exterior wall heights are typically increased to 9-feet or more leaving hallway ceiling heights at 8-feet
- The air handling unit is located in an interior closet and the supply and return ductwork are located in a dropped hallway
- Transfer grilles "bleed" pressure from secondary bedrooms
- Ductwork does not have to extend to building perimeters when thermally efficient windows (low-E, spectrally selective) and thermally efficient (well-insulated 2x6 frome walls with 2" of insulating sheathing) building enclosure construction is used; throw-type registers should be selected
- Low efficiency gas appliances that are prone to spillage or backdrafting are not recommended in this type of application; heat pumps, heat pump water heaters or sealed combustion furnaces and water heaters should be used
- A hot water-to-air coil in an air handling unit can be used to replace the gas furnace/heat exchanger. The coil can be connected to a sealed combustion (or power vented) water heater located within the conditioned space.
- Ductwork is not located in exterior walls or in the vented attic

Vented and Conditioned Attic



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

Vented and Unconditioned Attic

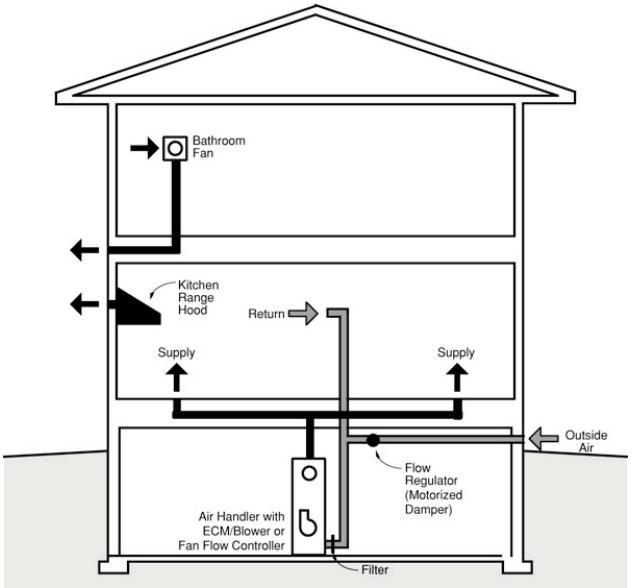


Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

- The air handling unit is located in a conditioned basement
- Low efficiency gas appliances that are prone to spillage or backdrafting are not recommended in this type of application; heat pumps, heat pump water heaters or sealed combustion furnaces and water heaters should be used
- A hot water-to-air coil in an air handling unit can be used to replace the gas furnace/heat exchanger. The coil can be connected to a sealed combustion (or power vented) water heater located within the conditioned space.
- Ductwork is not located in exterior walls or in the vented attic

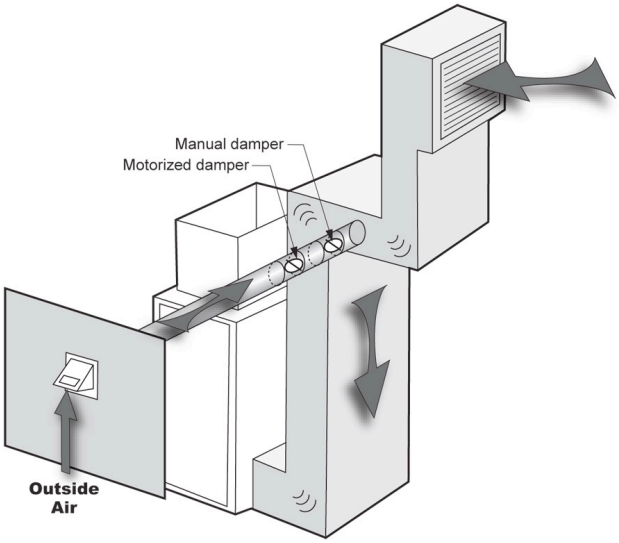
- The air handling unit is located in an unvented, conditioned attic; the attic insulation is located at or above the roof deck
- Low efficiency appliances that are prone to spillage or backdrafting are not recommended in this type of application; heat pumps, heat pump water heaters or sealed combustion furnaces and water heaters should be used
- A hot water-to-air in an air handling unit can be used to replace the gas furnace/heat exchanger. The coil can be connected to a sealed combustion (or power vented) water heater located within the conditioned space
- Ductwork is not located in exterior walls

Integrated Supply Ventilation System



- Air handler with ECM/blower runs continuously (or operated based on time of occupancy) pulling outside air into the return system
- A flow regulator (motorized damper) provides fixed outside air supply quantities independent of air handler blower speed
- House forced air duct system provides circulation and tempering
- Point source exhaust is provided by individual bathroom fans and a kitchen range hood
- In supply ventilation systems, and with heat recovery ventilation, pre-filtration is recommended as debris can affect duct and fan performance reducing air supply
- Kitchen range hood provides point source exhaust as needed
- Outside air duct should be insulated and positioned so that there is a fall/slope toward the outside to control any potential interior condensation. Avoid using long lengths of flex duct that may have a dip that could create a reservoir for condensation
- Mixed return air temperatures (return air plus outside air) should not be allowed to drop below 50° Fahrenheit at the design temperature in order to control condensation of combustion gases on heat exchanger surfaces

Outdoor Air Duct Connected to the Return of the Air Handler



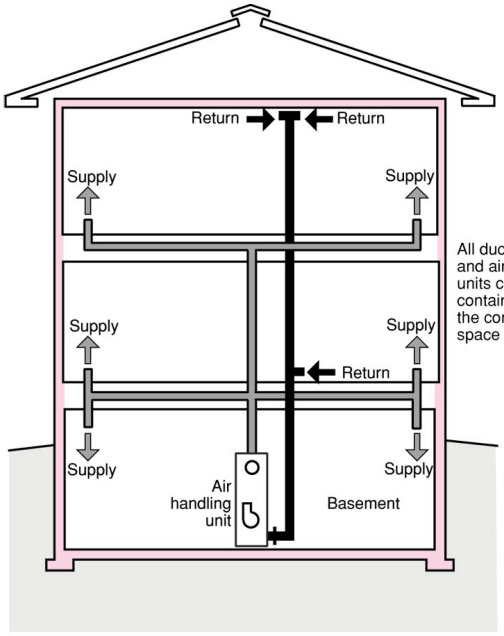
High Performance Housing — **Information Sheet 12**
for Greensburg, Kansas
Ductwork in Conditioned Space

The location of the duct system can have a significant impact on the overall performance of the system–both the utility use and the ability to provide comfort. The energy loss from the ducts for forced air heating and cooling systems can be significant, depending on the location of the ducts, and how well the ducts are sealed against air leakage. Though it is conceptually easy to imagine sealed duct systems, tight duct systems are unfortunately all too rare - duct leakage values of 20% of system flow are common. In many houses, the distribution duct work is located either in a vented crawlspace or in a vented attic – effectively outdoors. With the ducts located outside of the thermal envelope of the home, any leakage and conductive losses from the duct work is lost directly to the outside. Even worse, whenever air is leaking out or the ducts due to the system running, air is coming into the house to replace the lost air—resulting in forced air leakage whenever your furnace or air conditioner runs.

Moving the duct work and air handlers inside the thermal enclosure can be used to help prevent this energy loss to the exterior. Alternately, the thermal enclosure can be extended to include areas such as crawlspaces and attic as part of the conditioned space of the house.

In general, the placement of the mechanical equipment will depend on the design of the house. For houses with conditioned crawlspaces and basements, it is often logical to place the air handler or furnace in those locations. For slab on grade designs or elevated floors, available space can become a limitation. In these cases, unvented conditioned and semi-conditioned attics provide for a convenient location for the mechanical equipment and ducts. Otherwise, the equipment and / or ducts can be located in a dropped ceiling or in closets. Consideration for space requirements for the mechanical equipment should be made early in the design.

Vented and Unconditioned Attic



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

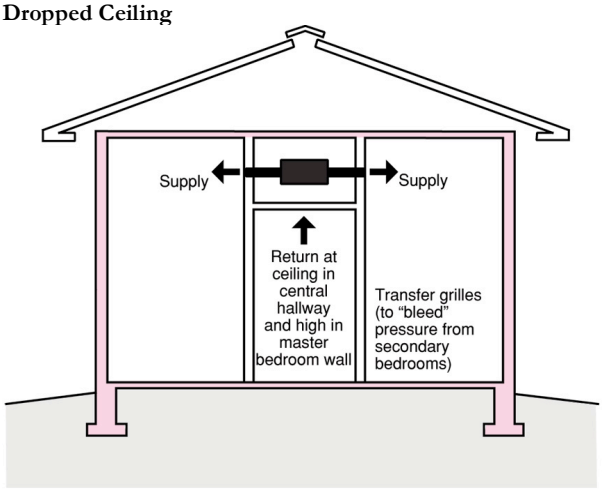
- The air handling unit is located in a conditioned basement
- Low efficiency gas appliances that are prone to spillage or backdrafting are not recommended in this type of application; heat pumps, heat pump water heaters or sealed combustion furnaces and water heaters should be used
- A hot water-to-air coil in an air handling unit can be used to replace the gas furnace/heat exchanger. The coil can be connected to a sealed combustion (or power vented) water heater located within the conditioned space.
- Ductwork is not located in exterior walls or in the vented attic

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

For more information about the Greensburg, Kansas project go to **buildingamerica-greensburg.com**

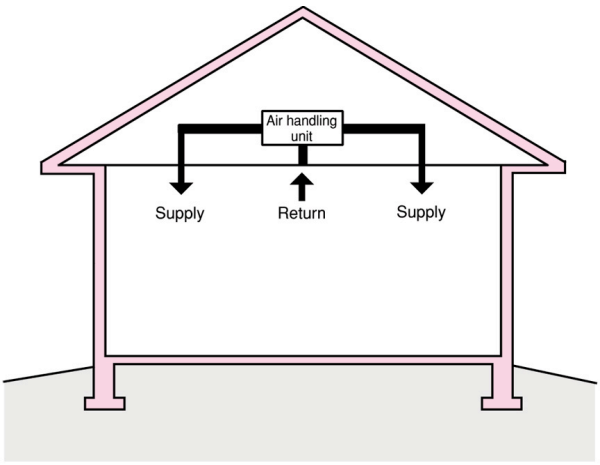
Vented and Unconditioned Attic with a Dropped Ceiling



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

- In this approach, exterior wall heights are typically increased to 9-feet or more leaving hallway ceiling heights at 8-feet
- The air handling unit is located in an interior closet and the supply and return ductwork are located in a dropped hallway
- Transfer grilles "bleed" pressure from secondary bedrooms
- Ductwork does not have to extend to building perimeters when thermally efficient windows (low-E, spectrally selective) and thermally efficient (well-insulated 2x6 frome walls with 2" of insulating sheathing) building enclosure construction is used; throw-type registers should be selected
- Low efficiency gas appliances that are prone to spillage or backdrafting are not recommended in this type of application; heat pumps, heat pump water heaters or sealed combustion furnaces and water heaters should be used
- A hot water-to-air coil in an air handling unit can be used to replace the gas furnace/heat exchanger. The coil can be connected to a sealed combustion (or pwer vented) water heater located within the conditioned space.
- Ductwork is not located in exterior walls or in the vented attic

Vented and Conditioned Attic



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

- The air handling unit is located in an unvented, conditioned attic; the attic insulation is located at or above the roof deck
- Low efficiency appliances that are prone to spillage or backdrafting are not recommended in this type of application; heat pumps, heat pump water heaters or sealed combustion furnaces and water heaters should be used
- A hot water-to-air in an air handling unit can be used to replace the gas furnace/heat exchanger. The coil can be connected to a sealed combustion (or power vented) water heater located within the conditioned space
- Ductwork is not located in exterior walls

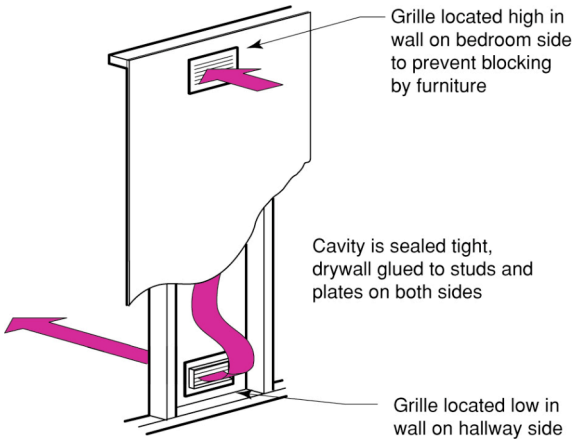
High Performance Housing — **Information Sheet 13**
for Greensburg, Kansas
Transfer Ducts and Grilles

The ductwork systems in these houses are designed to supply air to the individual rooms, and to have the air return to a central return grille. The Manual J (i.e. heating and cooling load) calculations typically yield the airflow requirements to the various rooms to meet those design loads. These airflow volumes are then used to size and lay out the ducts.

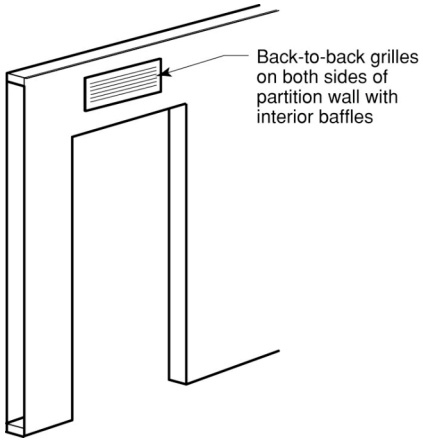
With any distribution system, there must be a return path for the energy distributing fluid. In the case of an air-based duct system, there is a central return that is open to the primary living space, with transfer means from bedrooms to the main space. The return path from the bedrooms needs to allow sufficient return flow to prevent room pressurization and prevent supply flow from being "choked" off. While undercutting doors can create part of the return air path, wall transfer grilles or jump ducts should be installed to prevent the return problems stated above.

All supply registers should have clear access to a return grille in order to prevent the pressurization of bedrooms and the depressurization of common areas. Bedrooms should either have a direct-ducted return or a transfer grille. Undercutting of bedroom doors rarely works and should not be relied upon to relieve bedroom pressurization. A central "hard" ducted return that is airtight and coupled with transfer grilles to relieve bedroom pressurization significantly outperforms a traditional return system, which has leaky ducted returns in every room, stud bays used as return ducts, and panned floor joists.

Transfer Grille

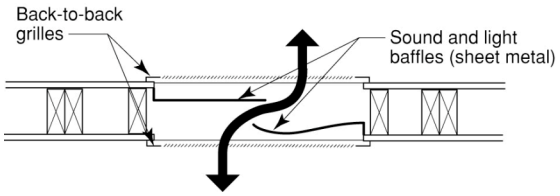


Transfer Grille—Over Door Opening



- Relieves pressure differences between spaces
- Interior baffles control sound and light transfer
- Door undercut of 1" minimum still required

Transfer Grille—Section



This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

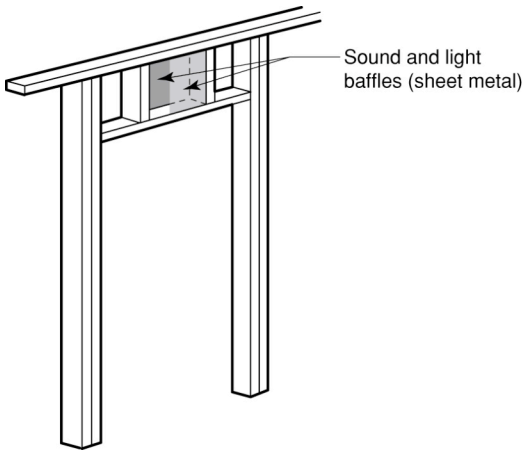
For more information about Building America go to **www.buildingamerica.gov**

For more information about the Greensburg, Kansas project go to **buildingamerica-greensburg.com**

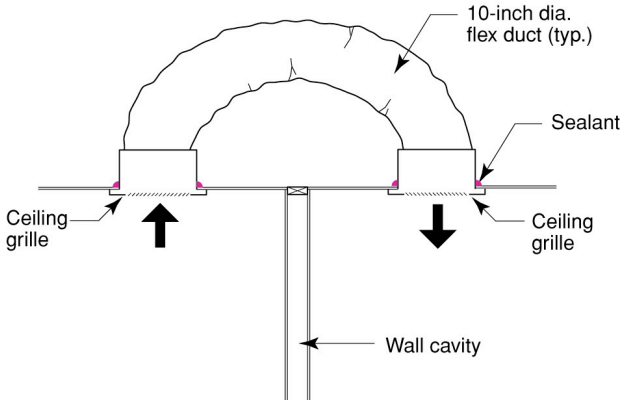




Transfer Grille—Construction



Jump Ducts



High Performance Housing — **Information Sheet 15**

Last updated on March 3, 2008

for Greensburg, Kansas

Duct Sealing

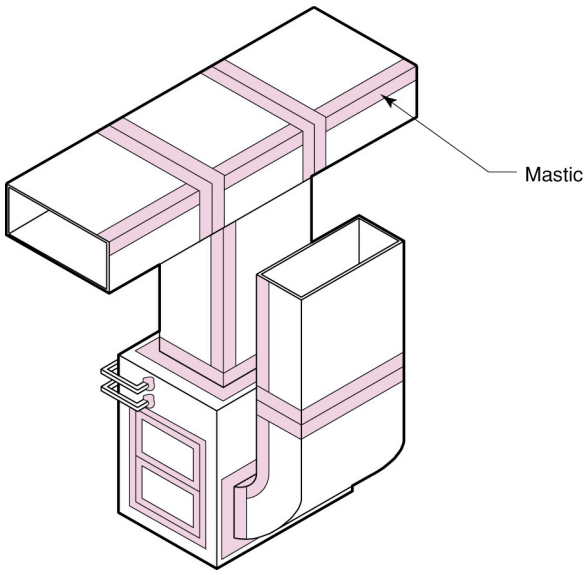
Ductwork, furnaces and air handlers should be sealed against air leakage. The only place air should be able to leave the supply duct system and the furnace or air handling unit is at the supply registers. The only place air should be able to enter the return duct system and the furnace or air handling unit is at the return grilles. A forced air system should be able to be pressure tested the way a plumber pressure tests a plumbing system for leaks. Builders don't accept leaky plumbing systems, so they should not accept leaky duct systems.

Supply systems should be sealed with mastic in order to be airtight. All openings (except supply registers), penetrations, holes and cracks should be sealed with mastic or fiberglass mesh and mastic. Tape, especially duct tape, does not work and should not be used. Sealing of the supply system includes sealing the supply plenum, its attachment to the air handler or furnace, and the air handler or furnace itself. Joints, seams and openings on the air handler, furnace or ductwork near the air handler or furnace should be sealed with both fiberglass mesh and mastic due to greater local vibration and flexure.

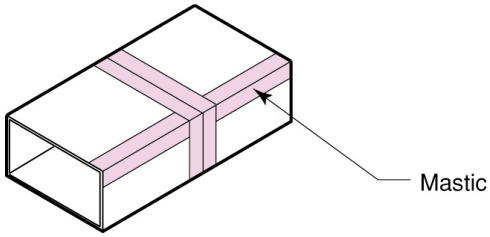
Return systems should be "hard" ducted and sealed with mastic in order to be airtight. Building cavities should never be used as return ducts. Stud bays or cavities should not be used for returns. Panned floor joists should not be used. Panning floor joists and using stud cavities as returns leads to leaky returns and the creation of negative pressure fields within interstitial spaces. Carpet dustmarking at baseboards, odor problems, mold problems and pollutant transport problems typically occur when building cavities are used as return ducts.

The longitudinal seams and transverse joints in sheet metal ducts should be sealed. The inner liner or insulated plastic flex duct should be sealed where flex ducts are connected to other ducts, plenums, junction boxes and boots/registers.

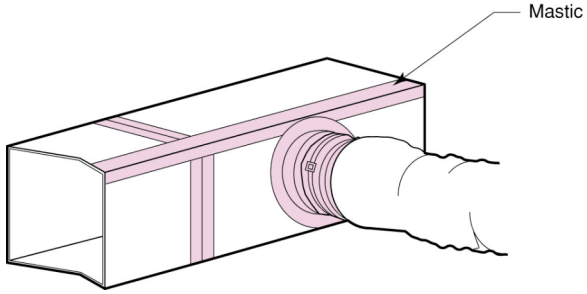
Air Handler Air Sealing



Rigid Duct Air Sealing



Flex Take-off from Rigid Air Sealing



This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

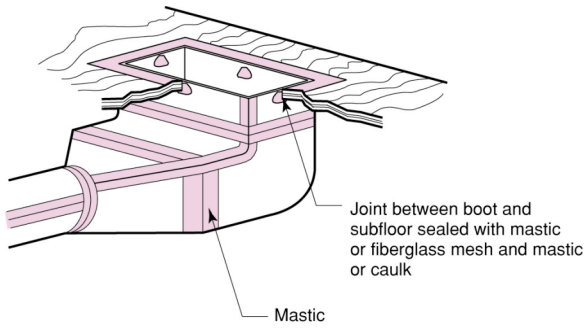
For more information about the Greensburg, Kansas project go to **buildingamerica-greensburg.com**

In flex duct installation, the outer liner and insulation should be pulled back and the inner liner attached to the collar with a tie. Fiberglass mesh tape (fabric) should be installed over the inner liner and collar such that at least 1 inch of fiberglass mesh tape covers the exposed collar. Mastic is then applied over the fiberglass mesh tape. The insulation and the outer liner is then pulled back over the connection and sealed with a second tie. When flex ducts are used, care must be taken to prevent restricting air flow by "pinching" ducts.

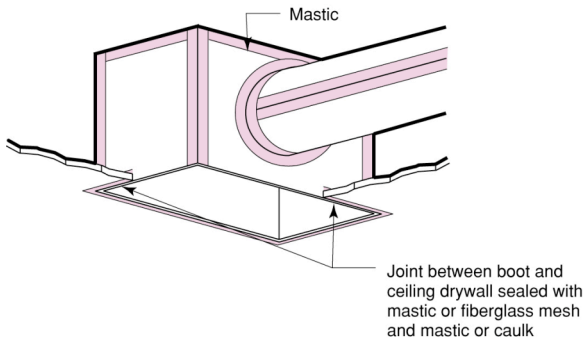
Connections between grilles, registers and ducts at ceilings, floors or knee walls typically leak where the boot does not seal tightly to the grille or gypsum board. Air from the attic, basement, or crawlspace can leak in or out where the ducts connect to the boot.

If the gap between boots and gypsum board opening or subfloor openings is kept to less than 3/8-inch, a bead of sealant or mastic may be used to seal the gap. Where gaps are larger than 3/8-inch, fabric and mastic should both be used. The optimum approach is to keep the gaps to less than 3/8-inch and use a bead of sealant. This requires careful coordination with the drywall contractor to make sure that the rough openings for the boots are cut no more than 3/8-inch bigger than the actual boot size on all sides.

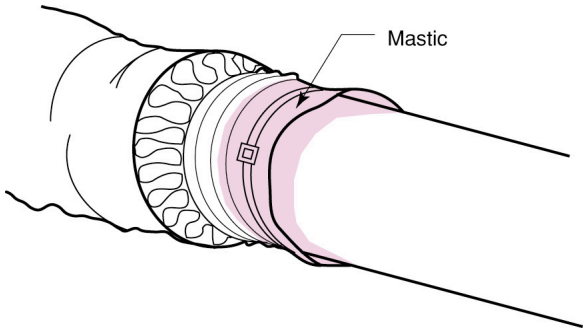
Floor Boot Air Sealing



Ceiling Boot Air Sealing



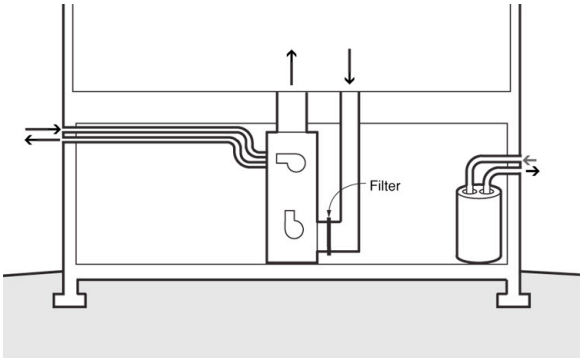
Rigid to Flex Air Sealing



High Performance Housing — **Information Sheet 17**
for Greensburg, Kansas
Sealed Combustion Water Heaters

In order to ensure good indoor air quality, all combustion appliances are recommended to be sealed combustion units, as opposed to naturally aspirated units. These systems are completely decoupled from the interior environment through the use of dedicated outdoor air intake and exhaust ducts connected directly to the unit. This change completely disconnects the combustion process from the interior environment, and eliminates concerns of back-drafting of the unit. In addition, it allows the elimination of the usual make-up air ducts. These make-up air ducts (required for naturally aspirated units) are a source of uncontrolled air leakage through the building enclosure, and therefore increase energy use. Finally, the sealed combustion appliances tend to be more efficient than the naturally aspirated units.

Spillage or backdrafting of combustion appliances is unacceptable. Only sealed combustion, direct vented, power vented or induced draft combustion appliances should be installed inside conditioned spaces for space conditioning or for domestic hot water. Traditional gas water heaters with draft hoods are prone to spillage and backdrafting. They should be avoided. Gas ovens, gas stoves or gas cooktops should only be installed with an exhaust range hood directly vented to the exterior. Wood-burning fireplaces or gas-burning fireplaces should be supplied with glass doors and exterior combustion air ducted to the firebox. Wood stoves should have a direct ducted supply of combustion air. Unvented (ventless) gas fireplaces or gas space heaters should never be installed. Sealed combustion direct vent gas fireplaces are an acceptable alternative. Portable kerosene heaters should never be used indoors.



- Water heater combustion air supplied directly to water heater from exterior via duct; products of combustion exhausted directly to exterior also via duct
- Furnace flue gases exhausted to the exterior using a fan; combustion air supplied directly to furnace from exterior via duct

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

For more information about the Greensburg, Kansas project go to **buildingamerica-greensburg.com**

High Performance Housing — **FAQ**

2006 IRC

Basement Insulation

Q: *What are the code recommendations for basement insulation? Does the building code allow me to leave my insulation exposed in the basement?*

A: For climate zones 4 through 8, the 2006 IRC requires that insulation be installed on the basement walls if the basement is conditioned, or if the basement is not conditioned insulation must be installed on the basement walls or in the floor separating the basement from the conditioned space above (*Section N1102.2.6 Basement Walls*).

The basement walls need to be insulated to a minimum value of R-10 for continuous insulation (such as foam plastic insulation) or R-13 for framing cavity insulation based on the component requirements of *Table N1102.1 Insulation and fenestration requirements by component*.

It is often recommended to insulate the basement walls with foam plastic insulation as the foam plastic insulations are not susceptible to deterioration when in contact with moisture (as can often be present in concrete basement walls). When using foam plastic insulation, the majority of products require a thermal barrier, usually ½" gypsum to be installed over the insulation (*Section R314.4 Thermal Barrier*) as a fire safety requirement. Certain foam plastic insulations such as DOW Thermax (*ICC-ES Legacy Report NER 681*) are rated to be left exposed on the interior of basement walls and do not need to be covered with a thermal barrier.

Applicable Code Sections:

2006 International Residential Code for One- and Two-Family Dwellings

- R314.3 Surface burning characteristics
- R314.4 Thermal barrier
- N1102 Building Thermal Envelope
- Table N1102.1 Insulation and fenestration requirements by component
- Table N1102.1.2 Equivalent U-factors
- N1102.2.6 Basement Walls

Additional References

- DOW Thermax ICC-ES Legacy Report NER 681

High Performance Housing — **FAQ**
2006 IRC
Wall Bracing Requirements for Insulating Sheathing

Q: *Can I install insulation board, in lieu of plywood, on the outside of an exterior wall?*

A: For some portion of, or for the entire exterior wall, the answer can be yes, depending on the design. The code provides options for houses that are in wind zones less than 110 mph.

Braced wall panels can be used instead of completely covering the entire building with plywood or OSB. While many types of braced wall panels are acceptable, the most common type of braced wall panels are: 1. A 4 foot wide sheet of plywood or OSB for outside walls and 2. Gypsum installed on interior walls. The various types of braced wall panels are described in *Section R602.10.3 Braced wall panel construction methods*. Standard braced wall panels need to a full 4 foot width with no cut outs from doors or window opening. Narrower panels can be used if the requirements of *Section R602.10.6 Alternate braced wall panels* are met.

A braced wall line and is made up of multiple braced wall panels on a wall. The number and location of the braced wall panels on a braced wall line depends on the wind speed, size and shape of the house, and number of stories. At minimum, braced wall panels are required at the corners and every 25 feet along the braced wall line; however the number may be increased depending on the shape and size of the house. This information can be found in *Table R602.10.1 Wall bracing*. This amount may need to be adjusted based on the weight of the roof assembly. The adjustment factors can be found in *Table R301.2.2.2.1 Wall bracing adjustment factors by roof covering dead load*.

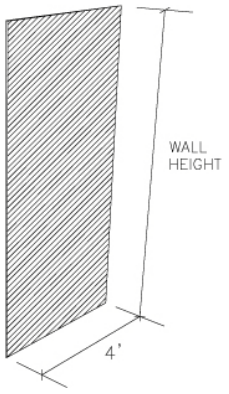


Figure 1: Braced wall panel

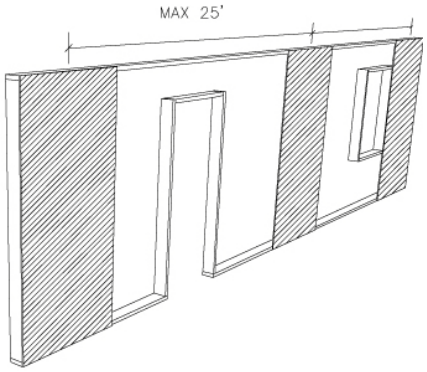


Figure 2: Braced wall line

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

For more information about the Greensburg, Kansas project go to **Greensburg.buildingscience.com**

Every house has multiple braced wall lines running in parallel directions. A braced wall line is commonly required every 35 feet; however there are some exceptions to this rule. Keep in mind that the braced wall lines must run in both directions on a house (front to back and side to side). The number and spacing of braced wall lines is given in *Section R602.10.1 Braced wall lines*.

Dwellings in wind zones greater than 110 mph are not covered under this section of the International Residential Code. In cases where the window zone is greater than 110 mph, the design and construction of the structural elements must be in accordance with accepted engineering practice (Section *R602.10.10 Design of structural elements*).

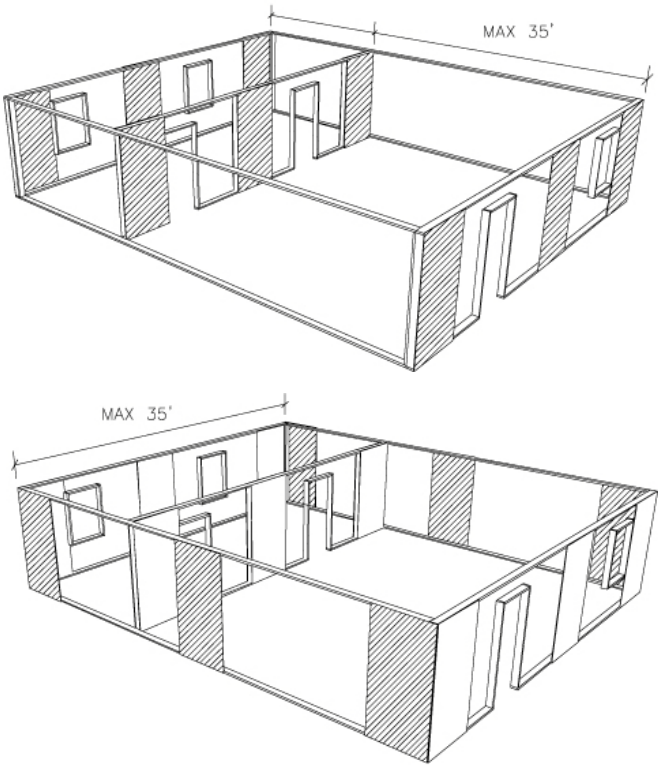


Figure 3: Braced wall lines spaced at 35 feet offsets in both directions

Applicable Code Sections:

2006 International Residential Code for One- and Two-Family Dwellings

- R301.2.2.2.1 Weight of materials
- Table R301.2.2.2.1 Wall bracing adjustment factors by roof covering dead load
- R602.3 Design and construction
- R602.10 Wall bracing
- R602.10.1 Braced wall lines
- R602.10.3 Braced wall panel construction methods
- R602.10.10 Design of structural elements

Available Resources:

- WFCM 110 mph Guide to Wood Construction in High Wind Areas
- WFCM section 3.4.4.2 Exterior Shear Walls

High Performance Housing — **FAQ**

2006 IRC

Insulating Sheathing Vapor Retarder Requirements

Q: *If insulation boards are installed on the outside of an exterior wall can the vapor retarder on the inside be removed?*

A: Yes, in certain cases. The addition of insulation boards on the exterior of the assembly helps reduce the potential for condensation occurring in the wall assembly. If enough insulation is added to the outside, then a vapor retarder on the inside is not necessary. Also, it is good practice to allow a wall assembly to be able to dry to at least one side, and since many insulation boards can be classified as vapor retarders, removing the vapor retarder from the inside allows increased drying of the assembly to the inside and improves the performance of the wall. The code recognizes this and addresses it in *Section N1102.5 Moisture Control* under Exception 3, which allows for the vapor retarder to be removed "where other means to control condensation are provided." However this still requires some calculations to demonstrate that the potential for condensation is managed in the proposed design.

The current 2007 Supplement to the International Residential Code (IRC) has made some changes to the definition and use of vapor retarders. These changes provide some clarity on vapor retarders, and can be used as guidance.

So what actually is a "vapor retarder"? The current 2006 IRC describes a vapor retarder as a material that has a permeance rating of 1.0 perms or less (*Section R202 Vapor retarder*). This seems simple enough, but there is in reality a large variation in performance between a product with a 1.0 perm rating and a product with a 0.1 perm rating. To address this, the International Code Council (ICC) added a new definition to Chapter 2 of the 2007 Supplement to the IRC for Vapor retarder class. The 2007 Supplement to the IRC currently defines vapor retarders under three classes:

Class I: 0.1 perm or less (Sheet polyethylene, non-perforated aluminium foil)

Class II: 0.1 perm <= 1.0 perm (Kraft faced fiberglass batts)

Class III: 1.0 perm <= 10 perm (Latex or enamel paint)

With the new definition for vapor retarder classes, new code language concerning the use for the new classes was also included. Class I and Class II vapor are needed to be installed on the warm in winter side of the insulation in Climate Zones 5, 6, 7, 8 and Marine 4 (*Section N1102.5 Vapor retarders*); however, Class III vapor retarders can now be used instead of Class I or II vapor retarders if the conditions of *Table 402.5.1 Class III vapor retarders* are met. In this table, provisions for using insulation boards are listed for various climate zones.

Applicable Code Sections:

2006 International Residential Code for One and Two-Family Dwellings

- R202 Vapor Retarder
- N1102.5 Moisture Control

2007 Supplement to the 2006 International Residential Code for One and Two-Family Dwellings

- R202 Vapor retarder Class
- N1102.5 Vapor retarders
- N1102.5.1 Class III vapor retarders
- N1102.5.2 Material vapor retarder class

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

For more information about the Greensburg, Kansas project go to **Greensburg.buildingscience.com**

High Performance Housing — **FAQ**
2006 IRC
Cladding Attachment over Insulating Sheathing

Q: *How do I attach my siding, if I don't use wood sheathing? Does the code allow for attachment back to studs at 24" centers?*

A: The Code provides specific prescriptive guidance on cladding attachment and allows you to attach cladding at 24" centers.

In the 2006 International Residential Code (IRC) cladding attachment requirements are covered in *Section R703 Exterior covering* with the majority of the requirements summarized in *Table R703.4 Weather-resistant siding attachment and minimum thickness*.

When sheathings other than wood or wood structural panels are used (such as foam plastic insulating sheathing), the code requires that the cladding be fastened back to the studs. The stud spacing is not specifically stated in *Table 5703.4 Weather-resistant siding attachment and minimum thickness* and therefore other sections of the code must be referenced for acceptability of stud spacing. This information is found in Section *R602.3.1 Stud size, height and spacing* in conjunction with *Table R602.3(5) Size, height and spacing of wood studs* listing that studs spaced at 24" centers are acceptable for certain walls.

Depending on the type of cladding, thickness of cladding, and type and thickness of sheathing different fasteners may be required. The penetration depth of the fastener into the stud is the basic requirement. For most claddings the fastener length is specified since the cladding and sheathing thickness is known, a minimum penetration depth is assumed. Where the sheathing thickness is variable (such as with foam plastic insulating sheathing), the fastener size needs to take into account the siding thickness and thickness of sheathing and still provide a minimum of 1" to 1.5" penetration (depending on the cladding type) into the stud.

In many cases furring strips are included in the design of the wall cladding to create a ventilation and drainage space behind the cladding. In this configuration it is often preferable to fasten the cladding to the furring strips instead of back to the studs. Unfortunately the code does not specifically cover this cladding system configuration so engineering may be required to design the cladding attachment to meet the cladding wind load requirements for the area.

Applicable Code Sections:

2006 International Residential Code for One- and Two-Family Dwellings

- R602.3.1 Stud size, height and spacing
- Table R602.3.1 Size, height and spacing of wood studs
- R703 Exterior covering
- Table R703.4 Weather-resistant siding attachment and minimum thickness

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

For more information about the Greensburg, Kansas project go to **Greensburg.buildingscience.com**

High Performance Housing — **FAQ**
2006 IRC
Conditioned Attics

Q: *I want to make my attic into living space by moving the insulation to the underside of the roof deck between the joists? How do I meet the roof venting requirements of the building code if I do this?*

A: There are two ways that this can be accomplished. You can insulate the rafter space provided that you leave a ventilation space between the top of the insulation (typically fiberglass batts or blown cellulose) and the underside of the roof sheathing (*Section R806.1 Ventilation required*). The minimum net free area of the ventilation space is described in *Section R806.2 Minimum area* and *Section R806.3 Vent and insulation clearance*.

Alternately, an unvented attic assembly can be created based on the requirements of *Section R806.4 Conditioned attic assemblies*. In essence two methods are available, install air impermeable expanding spray foam insulation to the underside of the roof deck or install rigid board foam plastic insulation above the roof deck. The language and various requirements that must be met are somewhat complicated to follow and require calculations to determine the minimum amount of insulation required to "*maintain the monthly average temperature of the condensing surface above 45F (7C)*".

To help clarify, the International Code Council (ICC) introduced new language into *Section R806.4 Unvented attic assemblies* of the 2007 Supplement to the International Residential Code (IRC). This section includes *Table R806.4 Insulation for condensation control*, which provides prescriptive requirements for minimum rigid board or air impermeable insulation R-values based on climate zone in order to manage the condensation potential in the assembly.

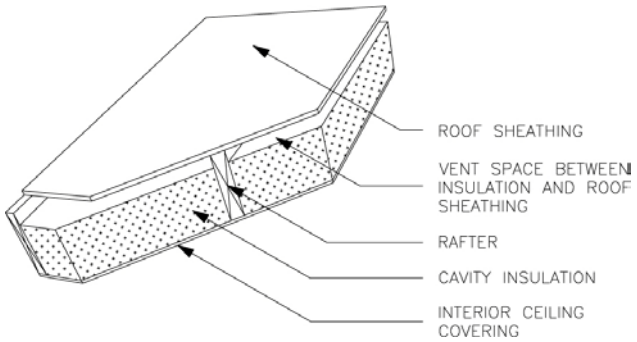


Figure 1: Vented cathedral roof assembly

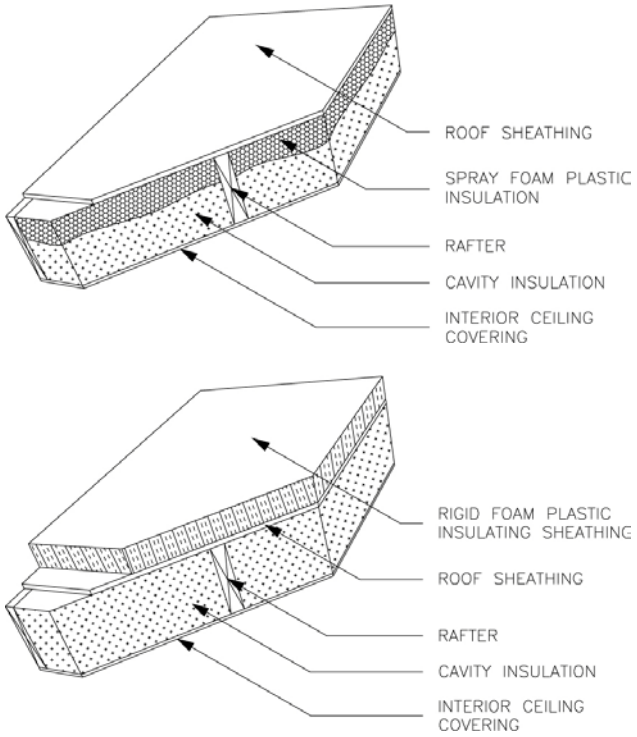


Figure 2: Unvented roof assemblies

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about Building America go to **www.buildingamerica.gov**

For more information about the Greensburg, Kansas project go to **Greensburg.buildingscience.com**

Applicable Code Sections:

2006 International residential Code for One- and Two-Family Dwellings

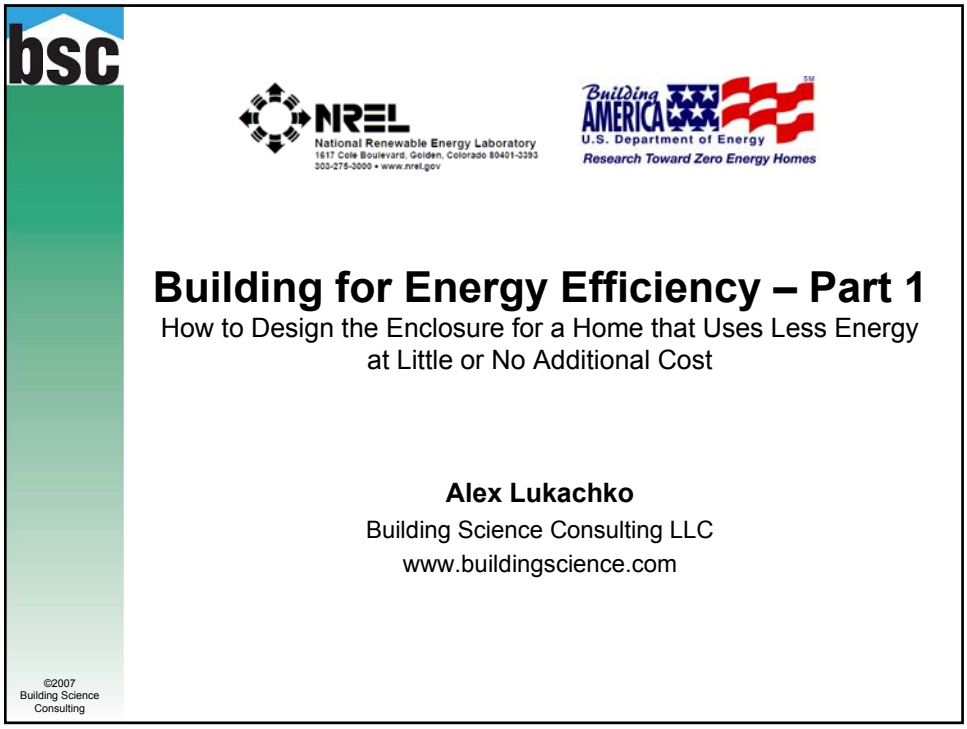
- R806.1 Ventilation required
- R806.2 Minimum area
- R806.3 Vent and insulation clearance
- R806.4 Conditioned attic assemblies

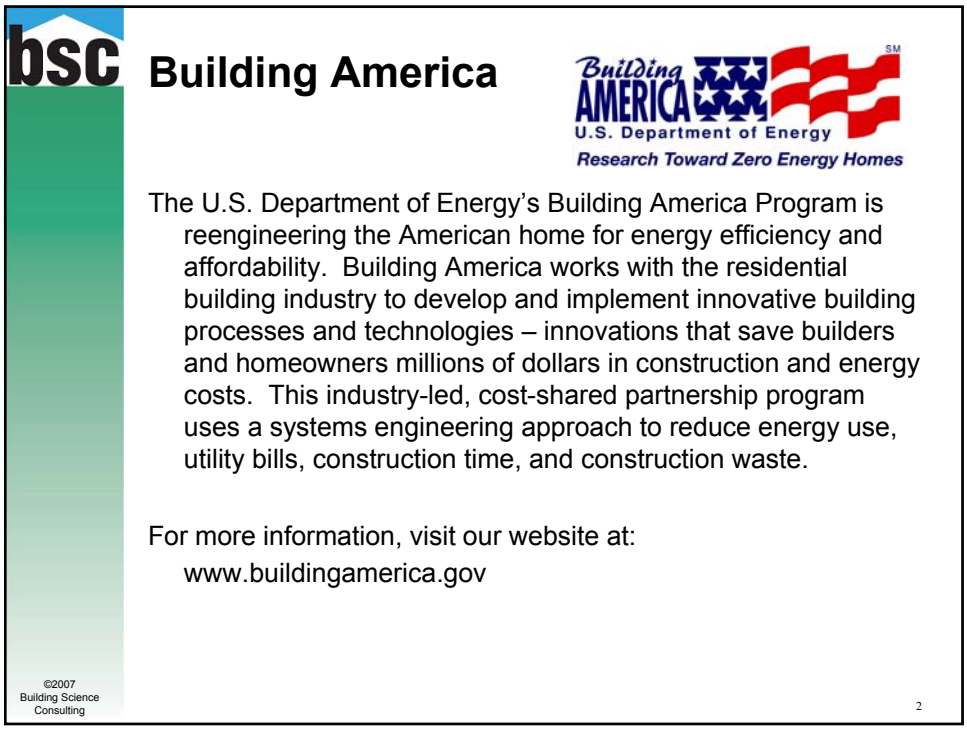
2007 Supplement to the International Residential Code

- R806.4 Unvented attic assemblies
- Table R806.4 Insulation for condensation control

B.5 Building for Energy Efficiency – Part 1

Alex Lukachko
Building Science Consulting


bsc
NREL
National Renewable Energy Laboratory
1617 Cole Boulevard, Golden, Colorado 80401-3393
303-275-3000 • www.nrel.gov
Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes
Building for Energy Efficiency – Part 1
How to Design the Enclosure for a Home that Uses Less Energy at Little or No Additional Cost
Alex Lukachko
Building Science Consulting LLC
www.buildingscience.com
©2007 Building Science Consulting


bsc
Building America
Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes
The U.S. Department of Energy's Building America Program is reengineering the American home for energy efficiency and affordability. Building America works with the residential building industry to develop and implement innovative building processes and technologies – innovations that save builders and homeowners millions of dollars in construction and energy costs. This industry-led, cost-shared partnership program uses a systems engineering approach to reduce energy use, utility bills, construction time, and construction waste.
For more information, visit our website at:
www.buildingamerica.gov
©2007 Building Science Consulting
2

Objectives for this morning . . .

1. **Help make decisions**
2. **Explain energy efficiency approach**
3. **Demonstrate business opportunities**

©2007
Building Science
Consulting

Why build energy efficient homes?

Consumers:

- Lower energy bills and maintenance costs
- More money for things other than energy
- Healthier, more comfortable, more durable homes

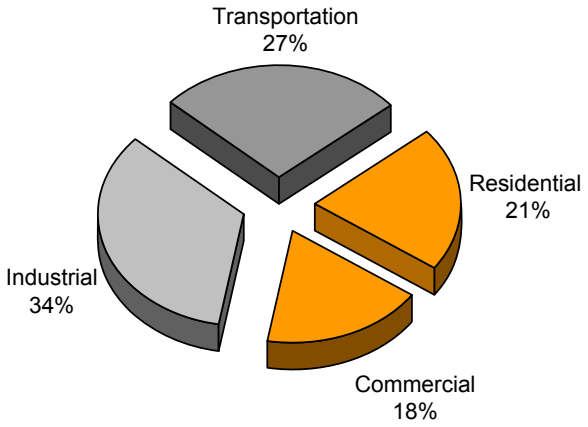
The nation:

- Wise use of resources through energy savings
- Greater energy security through the use of domestic resources
- A healthier environment through reduced emissions
- Increased use of onsite power and renewable energy systems

©2007
Building Science
Consulting

Assessing the Impact of US Buildings

Total Energy Consumption by Sector, 2001

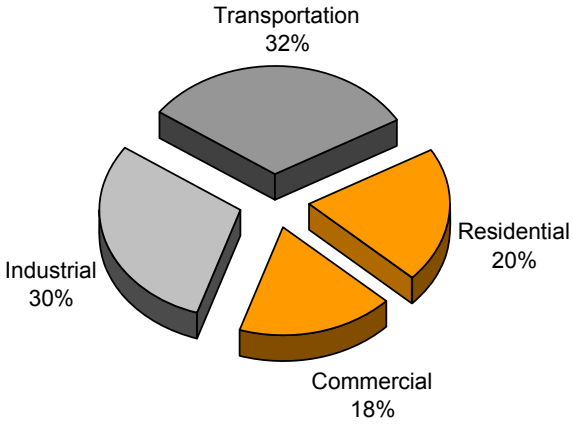


Source: EIA, Annual Energy Review, 2001 data - www.eia.doe.gov/emeu/aer

©2007
Building Science
Consulting

Contribution to Climate Change

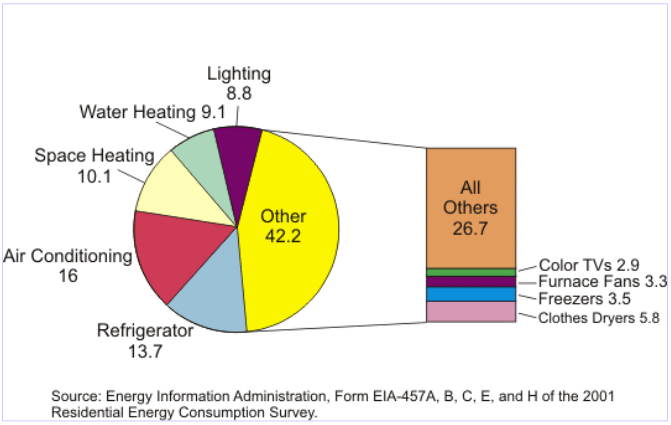
Carbon Dioxide Emissions from Energy Consumption by Sector, 2001



Source: EIA, Annual Energy Review, 2001 data - www.eia.doe.gov/emeu/aer

©2007
Building Science
Consulting

Background – Energy Use in the Home



Source: Energy Information Administration, Form EIA-457A, B, C, E, and H of the 2001 Residential Energy Consumption Survey.

©2007
Building Science
Consulting

7

Overview of the Design approach

Our approach follows three general steps:



Step 1: Reduce Enclosure Energy Use



Step 2: Reduce Mechanical System Energy Use

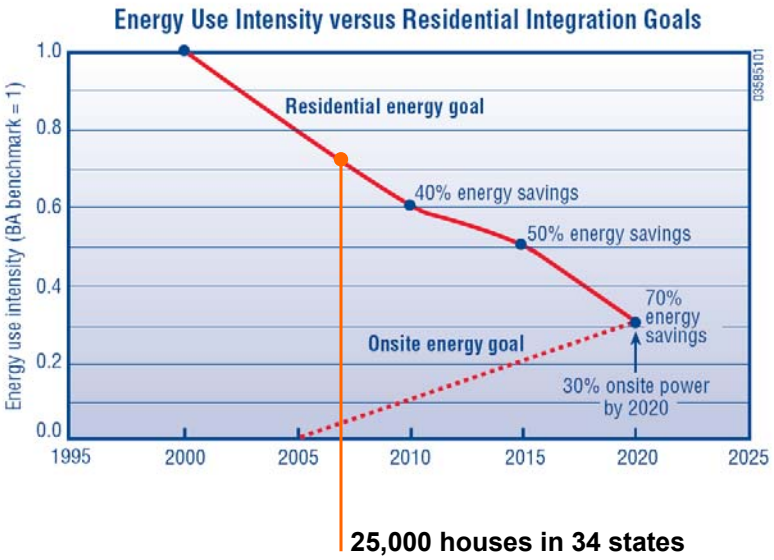


Step 3: Add Site Generated Energy

©2007
Building Science
Consulting

8

Building America Research Goals



25,000 houses in 34 states

©2007 Building Science Consulting

Systems Engineered for Zero Cost



Source: Building America. 1999. *Cost Saving System Trade-offs for Mixed Climates.* *U.S. Department of Energy*, Washington, D.C. www.buildingamerica.gov

©2007 Building Science Consulting

Looking long-term . . .

MIXED-HUMID CLIMATE CASE STUDY HOUSE

Richmond, VA

				TOTAL SOURCE ENERGY SAVINGS (heating, cooling, dhw, lighting, appliances, plug loads)				
STEP	DESCRIPTION OF STEP	Estimated Individual Cost of Change	Estimated Cumulative Cost of Change	over BA Benchmark	Incremental	Annual Energy Cost	Simple Payback (yr)	Incremental Payback (yr)
0	Benchmark	n/a	n/a	n/a	n/a	$1,288	n/a	n/a
1	Benchmark + Enclosure Upgrades	$400	$400	6.0%	6.0%	$1,210	5	5
2	Above + Mechanical Upgrades	$1,000	$1,400	21.9%	16.0%	$1,000	5	5
3	Above + Lights & Appliances	$350	$1,750	27.4%	5.4%	$929	5	5
4a	3 + 17 EER, 4 COP GSHP	$6,000	$7,750	33.3%	6.0%	$851	18	77
4b	3 + 40 sq ft SHW	$3,700	$5,450	38.5%	11.1%	$765	10	23
4c	3 + 2kW PV	$10,000	$11,750	41.7%	14.3%	$758	22	58
5	All Strategies	$19,700	$21,450	58.8%	31.4%	$516	28	48

- **Balance initial investment with long-term savings**
- **Add technology in a cost-effective manner**

©2007 Building Science Consulting

Overview of the Design approach

Top ten elements in the design of high performance homes:

1. Design for comfort with as little added energy as possible
2. Built tight
3. Ventilate
4. Use more insulation
5. Provide for durability by controlling moisture
6. Design a roof that is sloped to the south
7. Use the most efficient equipment the project can afford
8. Use efficient lighting, appliances and match to occupant needs
9. Reduce energy use 40-70% before adding onsite energy generation
10. Commission mechanical and onsite energy systems

©2007 Building Science Consulting

Overview of the Design approach

Top ten elements in the design of high performance homes:

1. Design for comfort with as little added energy as possible
2. Built tight
3. Ventilate
4. Use more insulation
5. Provide for durability by controlling moisture
6. Design a roof that is sloped to the south
7. Use the most efficient equipment the project can afford
8. Use efficient lighting, appliances and match to occupant needs
9. Reduce energy use 40-70% before adding onsite energy generation
10. Commission mechanical and onsite energy systems

©2007 Building Science Consulting

1. Design for comfort with as little added energy as possible

©2007 Building Science Consulting

Start with the building itself

1. **Siting** (choice of building site or position on it)
   - exposure to wind and rain
   - micro-climate: trees for shading, wind-blocks
2. **Orientation**
   - windows south, “service” rooms north
   - positioning and size of windows and doors
3. **Building form**
   - external features: overhangs, breezeways, porches
   - building size and shape

- **At each step there are opportunities to reduce the energy that the building will use**
- **These changes decisions can’t be made later**

©2007 Building Science Consulting

Breezeways and Porches



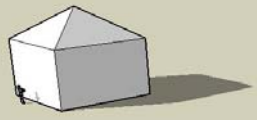
©2007 Building Science Consulting

Overhangs



©2007
Building Science
Consulting

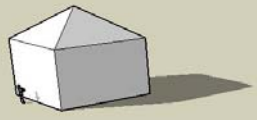
House size and form – Unvented Roof



Plan 'A'
30' x 30'
2 Stories
8:12 roof

©2007
Building Science
Consulting

House size and form – Unvented Roof

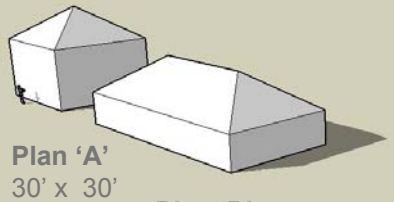


Plan 'A'
30' x 30'
2 Stories
8:12 roof

Floor Area	1800 sq ft
Surface Area	**4142** sq ft

©2007
Building Science
Consulting

House size and form – Unvented Roof



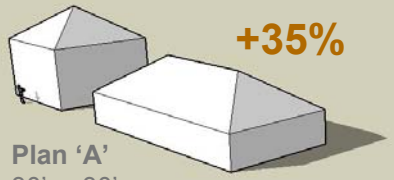
Plan 'A'
30' x 30'
2 Stories
8:12 roof

Plan 'B'
30' x 60'
1 Story
8:12 roof

Floor Area	1800 sq ft
Surface Area	**4142** sq ft

©2007
Building Science
Consulting

House size and form – Unvented Roof



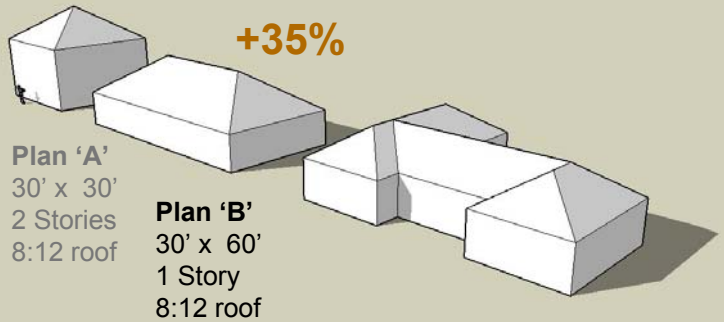
Plan 'A'
30' x 30'
2 Stories
8:12 roof

Plan 'B'
30' x 60'
1 Story
8:12 roof

Floor Area	1800 sq ft	1800 sq ft
Surface Area	**4142** sq ft	**5583** sq ft

©2007
Building Science
Consulting

House size and form – Unvented Roof



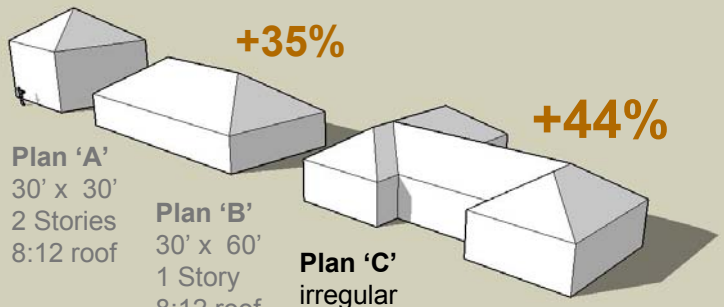
Plan 'A'
30' x 30'
2 Stories
8:12 roof

Plan 'B'
30' x 60'
1 Story
8:12 roof

Floor Area	1800 sq ft	1800 sq ft
Surface Area	**4142** sq ft	**5583** sq ft

©2007
Building Science
Consulting

House size and form – Unvented Roof

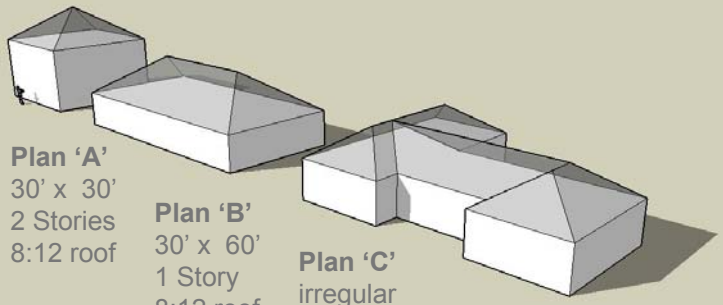


Floor Area	1800 sq ft	1800 sq ft	1800 sq ft
Surface Area	**4142** sq ft	**5583** sq ft	**5944** sq ft

©2007
Building Science Consulting

23

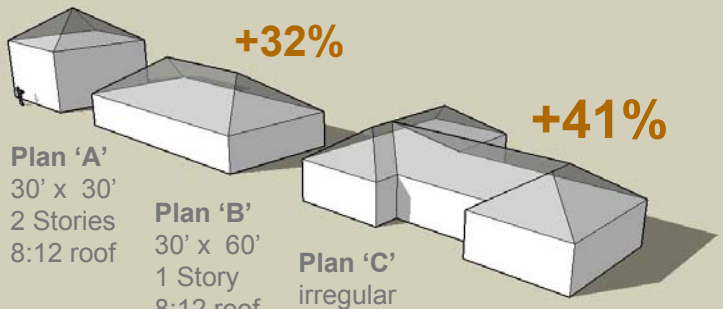
House size and form – Vented Roof



Floor Area	1800 sq ft	1800 sq ft	1800 sq ft
Surface Area	**3960** sq ft	**5220** sq ft	**5580** sq ft

24

House size and form – Vented Roof



Plan 'A'
30' x 30'
2 Stories
8:12 roof

Plan 'B'
30' x 60'
1 Story
8:12 roof

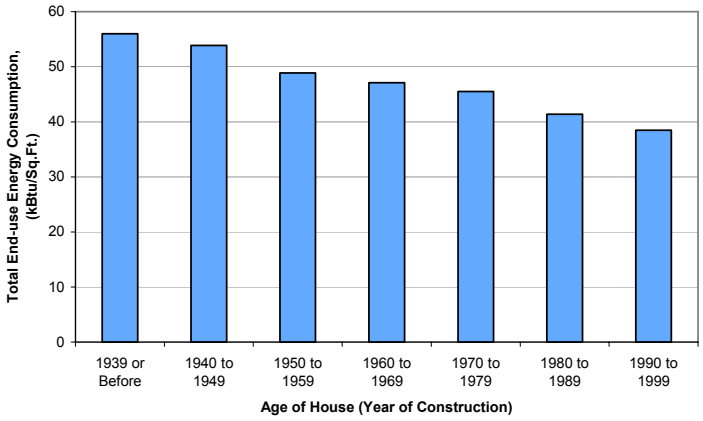
Plan 'C'
irregular
1 Story
8:12 roof

	Plan 'A'	Plan 'B'	Plan 'C'
Floor Area	1800 sq ft	1800 sq ft	1800 sq ft
Surface Area	**3960** sq ft	**5220** sq ft	**5580** sq ft
Volume	**16200** ft^3	**16200** ft^3	**16200** ft^3

25

Energy Efficient Construction is Catching on

Total End-Use Residential Energy Consumption in 2001 per Square Foot by Age of Construction

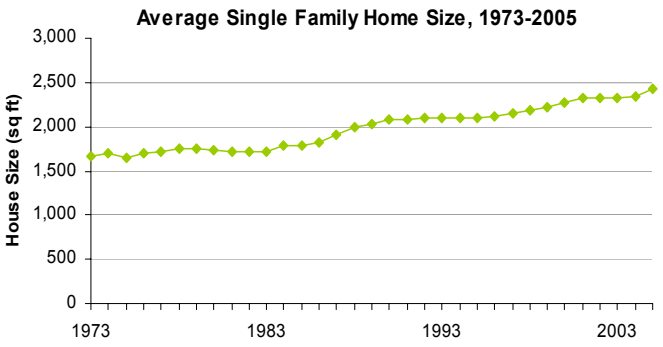


©2007
Building Science
Consulting

26

But size matters . . .

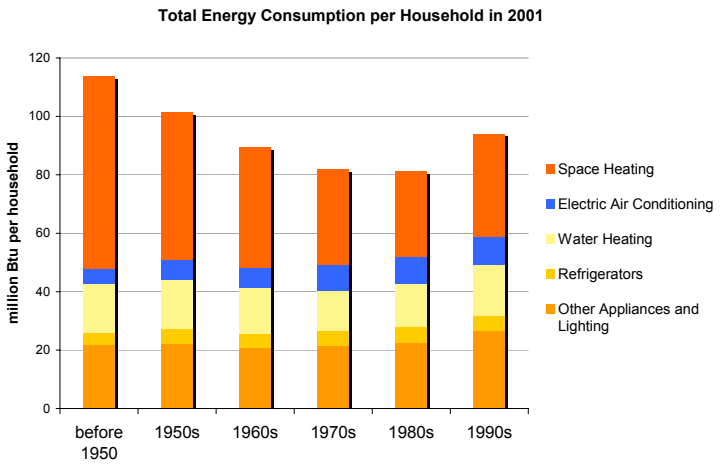
- Average House Size in **1940: ~1100 sq ft**[1]
- Average House Size in **1973: 1660 sq ft**[2]
- Average House Size in **2005: 2434 sq ft**



1. Wilson, Alex and Jessica Boehland "Small is Beautiful" *Journal of Industrial Ecology*, Vol 9, No 1-2. 2005
2. EIA, Annual Energy Review, 2001 data: www.eia.doe.gov/emeu/aer

©2007 Building Science Consulting

Total Energy Use is on the Rise

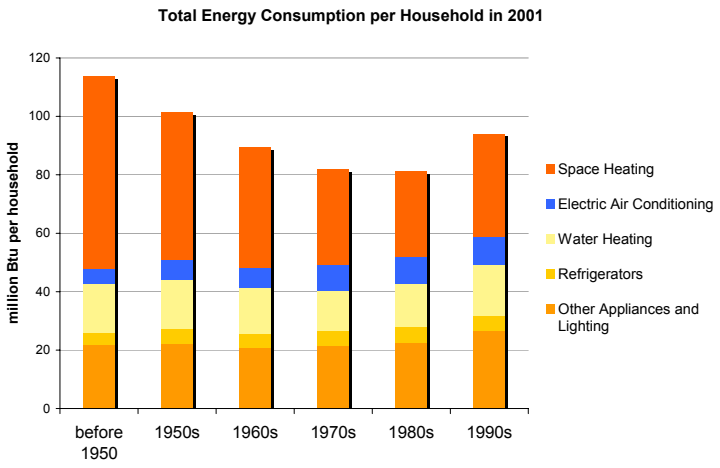


©2007 Building Science Consulting

2. Build tight

©2007
Building Science
Consulting

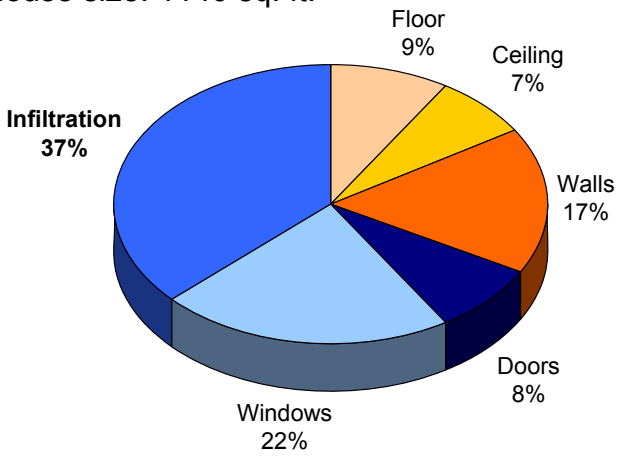
Total Energy Use is on the Rise



©2007
Building Science
Consulting

How the heating loads break down

House size: 1140 sq. ft.



Heating is the largest of all energy use, and infiltration is the biggest contributor to the heating load

©2007
Building Science
Consulting

Why airtight buildings?

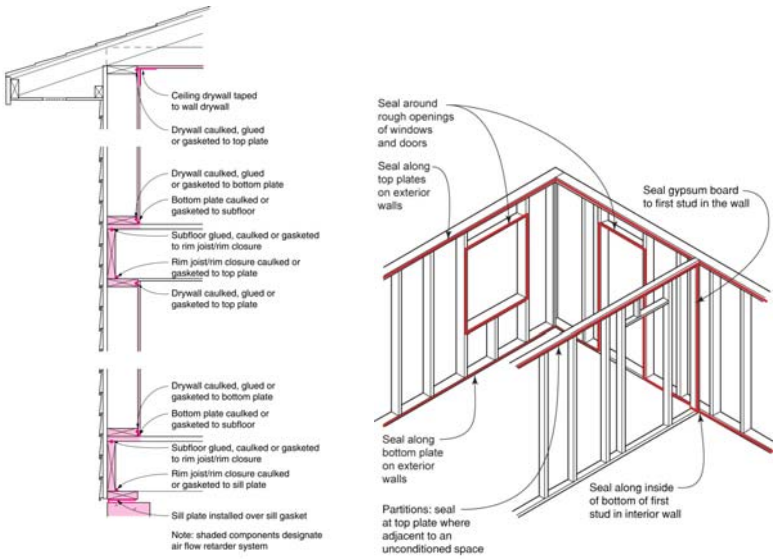
Reasons to control airflow:

- Energy - Heat loss/gain
- Durability - Air leakage condensation
- Occupant health - Pollution and odors
- Occupant comfort - Drafts, noise

Do this using an "AIR BARRIER SYSTEM"

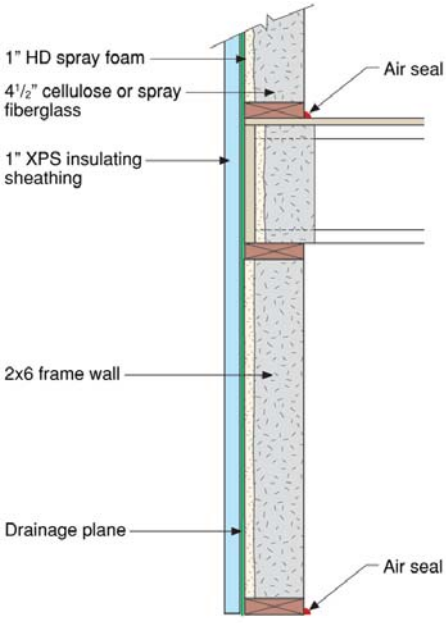
- Many materials are air impermeable, most systems are not

©2007
Building Science
Consulting



Interior Air Flow Retarder Using Drywall and Framing

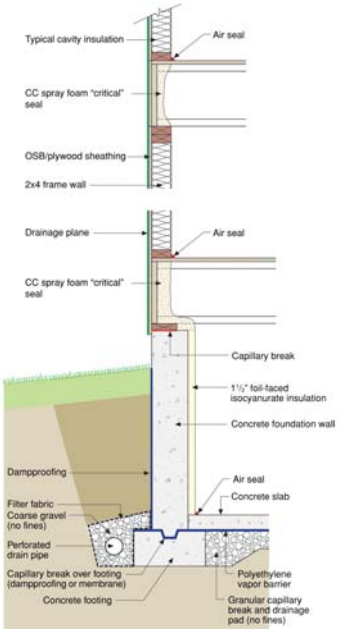
©2007 Building Science Consulting





©2007 Building Science Consulting





©2007 Building Science Consulting

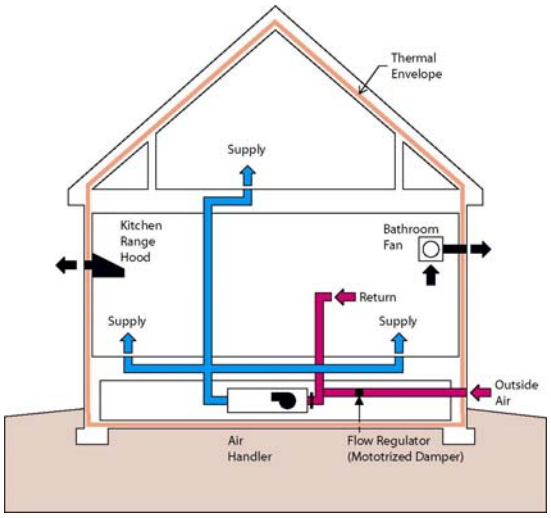
35

3. Ventilate

©2007 Building Science Consulting

36

Airtight Enclosure and Mechanical System



©2007 Building Science Consulting

37

Where should you put the holes?





bsc

Outside Air Intake

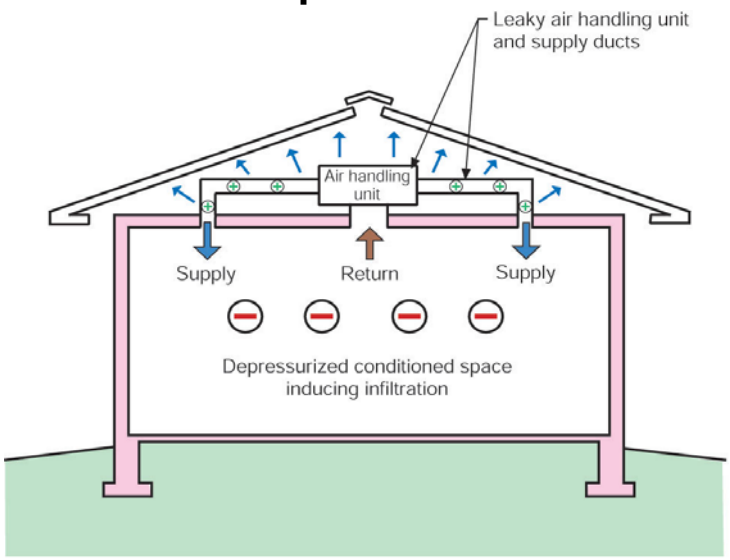


Direct vented to outside



©2007
Building Science
Consulting

Inadvertent Depressurization



Note: Colored shading depicts the building's thermal barrier and pressure boundary.
The thermal barrier and pressure boundary enclose the conditioned space.

©2007
Building Science
Consulting

42

Tight Ductwork and Sealed Combustion



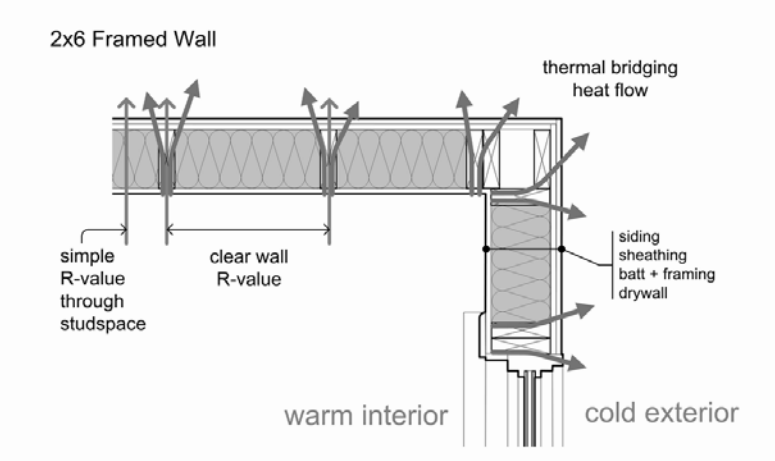


©2007
Building Science
Consulting

4. Use more insulation

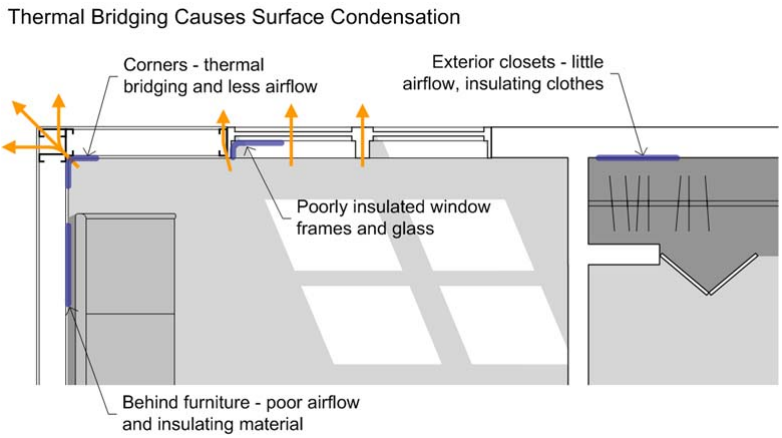
©2007
Building Science
Consulting

It's not just how much you use . . .



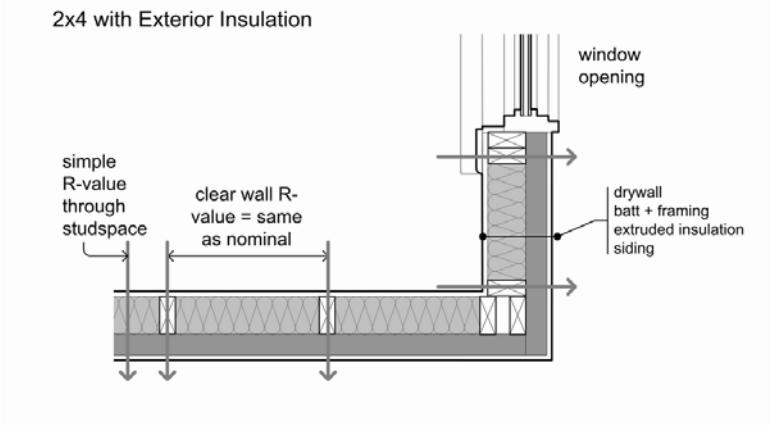
©2007
Building Science
Consulting

Surface temperature and condensation



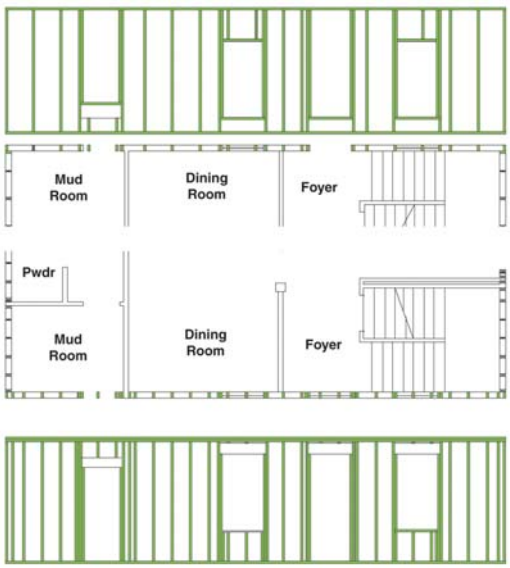
©2007
Building Science
Consulting

Eliminating thermal bridging



©2007 Building Science Consulting

Advanced Wall Framing



Wall 1 (2x6 24"o.c.)

Plate	36'-0"	2
Stud	8'-0"	20
Jack	7'-9¼"	6
Jack 2	6'-8½"	2
Cripple 2	1'-2¾"	2
Cripple 3	2'-1"	3

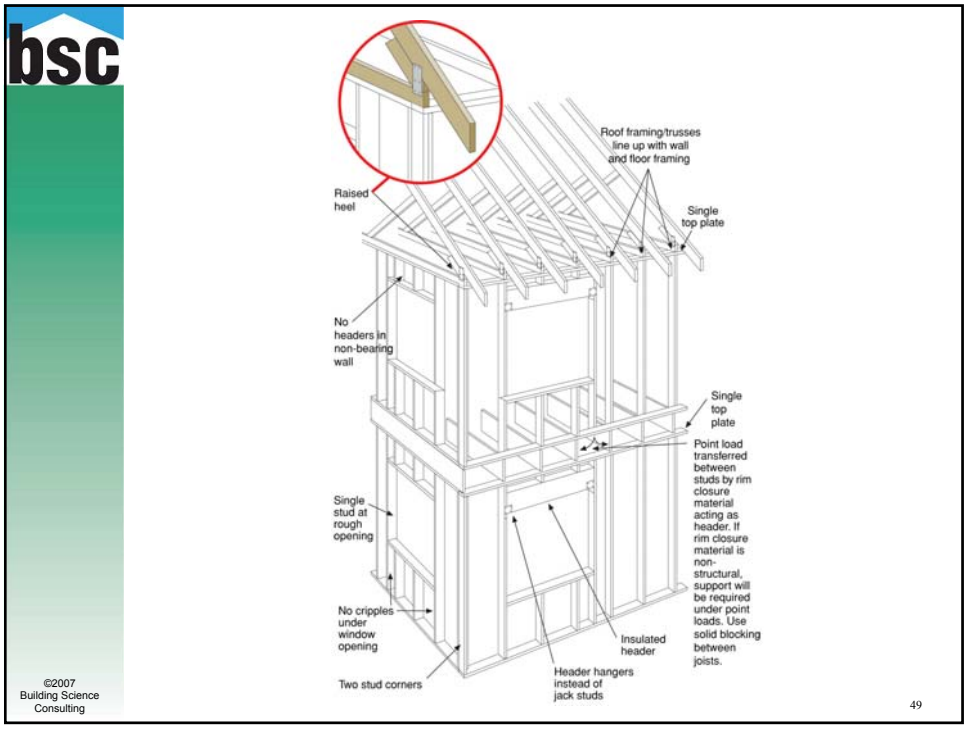
Gross wall area	327 ft²
Window area	74 ft²
Opaque area	45.17 ft²
Cavity area	207.83 ft²

Wall 1 (2x6 16"o.c.)

Plate	36'-0"	3
Stud	8'-8½"	29
Jack	7'-8½"	6
Jack 2	6'-8½"	2
Cripple 1	0'-2¾"	6
Cripple 2	1'-2¾"	2
Cripple 3	2'-1"	8

Gross wall area	327 ft²
Window area	74 ft²
Opaque area	65.60 ft²
Cavity area	181.40 ft²

©2007 Building Science Consulting


Roof framing/trusses line up with wall and floor framing
Raised heel
Single top plate
No headers in non-bearing wall
Single top plate
Point load transferred between studs by rim closure material acting as header. If rim closure material is non-structural, support will be required under point loads. Use solid blocking between joists.
Single stud at rough opening
No cripples under window opening
Insulated header
Header hangers instead of jack studs
Two stud corners
bsc
©2007 Building Science Consulting
49





bsc

5. Provide for durability by controlling moisture

©2007
Building Science
Consulting

Why control moisture?

1. Our efforts to save energy and reduce the flow of heat through building assemblies have **reduced drying potentials** and, therefore, increased the importance of controlling moisture flow through building assemblies.

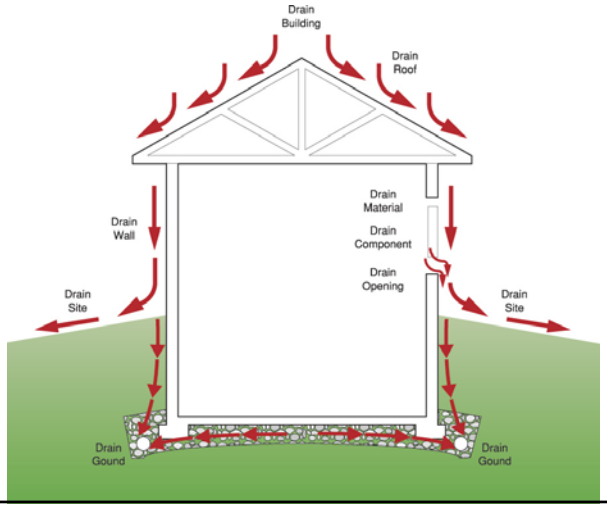
2. Building **materials last longer** when their faces are exposed to similar or equal temperature and humidity.

3. Three things destroy materials in general and wood in particular: **water**, **heat**, and **ultraviolet radiation**. Of these three, water is the most important by an order of magnitude.

©2007
Building Science
Consulting

How to control moisture?

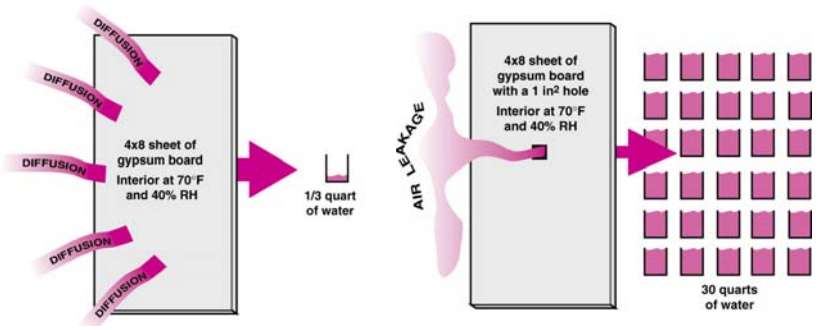
In moisture control, the priority is **liquid water first**, particularly when it comes in the forms of rain and groundwater. In these forms it is referred to as “bulk” water.



©2007
Building Science
Consulting

How to control moisture?

Following are **air-transported vapor** and then **diffusive vapor**, all other things being equal.



©2007 Building Science Consulting

Remember:

It's always a question of **quantities** and **rates**, of wetting and drying, and the tolerance of materials (individually and in combination) for each and all of the above.

- When the rate of wetting exceeds the rate of drying, **accumulation** occurs.
- When the quantity of accumulated moisture exceeds the storage capacity of the material or assembly, **problems** occur.
- The storage capacity of a material or assembly depends on **time**, **temperature**, and the **material** itself.

©2007 Building Science Consulting

Fungal growth = bad “green” building



57



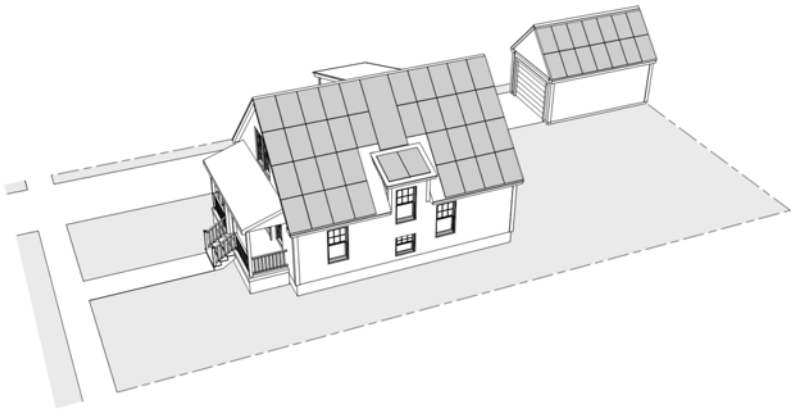
©2007
Building Science
Consulting

58

6. Design a roof that is sloped to the south

©2007
Building Science
Consulting

Plan to use the available solar resource



These two roofs total about 900 sq.ft. of south sloping roof and can accommodate about a 9 kW PV system and 40 sq. ft. of SHW panels . . . but the roof needs to face the right direction!

©2007
Building Science
Consulting

But the loads must be minimized first

Recall the three general steps:



Step 1: Reduce Enclosure Energy Use



Step 2: Reduce Mechanical System Energy Use



Step 3: Add Site Generated Energy

©2007 Building Science Consulting

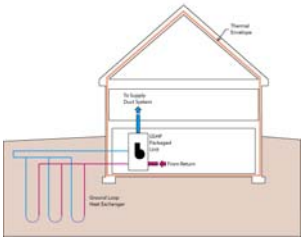


Roof area is a future resource

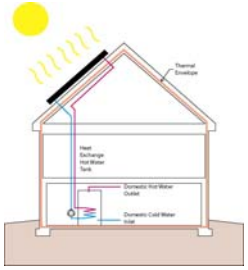


©2007
Building Science
Consulting

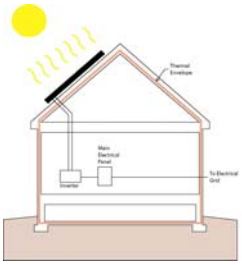
On-site Renewable Energy



GSHP Schematic



Solar Hot Water Schematic



Photovoltaic Schematic

©2007
Building Science
Consulting

Summary of the Design approach

Top ten elements in the design of high performance homes:

1. Design for comfort with as little added energy as possible
2. Built tight
3. Ventilate
4. Use more insulation
5. Provide for durability by controlling moisture
6. Design a roof that is sloped to the south
7. Use the most efficient equipment the project can afford
8. Use efficient lighting, appliances and match to occupant needs
9. Reduce energy use 40-70% before adding onsite energy generation
10. Commission mechanical and onsite energy systems

©2007 Building Science Consulting

Summary of the Design approach

Top ten elements in the design of high performance homes:

1. Design for comfort with as little added energy as possible
2. Built tight
3. Ventilate
4. Use more insulation
5. Provide for durability by controlling moisture
6. Design a roof that is sloped to the south
7. Use the most efficient equipment the project can afford
8. Use efficient lighting, appliances and match to occupant needs
9. Reduce energy use 40-70% before adding onsite energy generation
10. Commission mechanical and onsite energy systems

©2007 Building Science Consulting

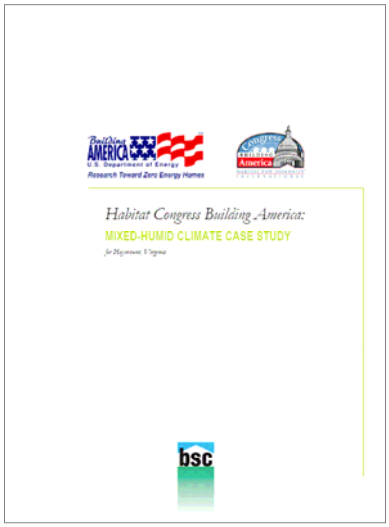
Resources

Building Science Corporation

Designs that Work – Mixed-Humid Climate Case Study

find this at:

www.buildingscience.com/dtw



©2007 Building Science Consulting

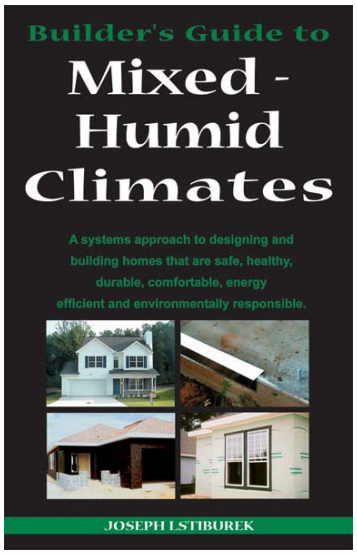
Resources

Building Science Corporation

Builder's Guide to Mixed-Humid Climates

find this at:

www.buildingsciencepress.com



©2007 Building Science Consulting

Resources

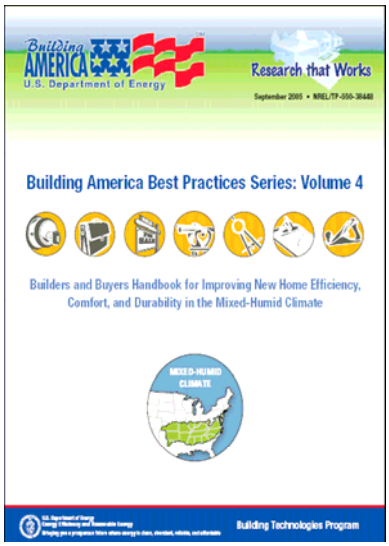
Building America

Mixed-Humid Climate Best Practices Guide

find this at:

www.buildingamerica.gov

(look for “publications”)



©2007 Building Science Consulting

Rebuilding Greensburg

A Seminar Series on Affordable, Energy Efficient Construction Techniques

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

Part 1: House Design and Foundation Systems

Date: September 8, 2007

- An overview of energy efficient and affordable house design
- Foundations and rainwater management

Part 2: Framing

- Advanced framing techniques
- Choosing the right windows and doors

Part 3: Mechanical Systems and Airtightness

- Build tight, ventilate right
- Mechanical system design and selection

Part 4: Enclosure

- Insulation – theory and installation practices
- Exterior cladding systems

Part 5: Finishes, Testing and Commissioning

- Measuring building performance
- Whole house commissioning and homeowner training

©2007 Building Science Consulting

Questions?

Before you go . . .

- **Sign up sheet for builders**

©2007
Building Science
Consulting

B.6 Building for Energy Efficiency – Part 2

Steve Bolibruck
IBACOS

IBACOS

Building for Energy Efficiency 2:

How to design the mechanical system for a home that uses less energy at little or no additional cost

Steve Bolibruck

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Session Objectives

- Understand the basic differences between the mechanical system in a standard home compared to a high performance home
- Learn the fundamentals of good residential air distribution system design in high performance homes
- Learn about air distribution system methods appropriate for high performance homes

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Introduction

- High performance homes have different space conditioning requirements
- Standard air distribution system design, selection, and installation practices don't address high performance homes fully
- Need to engineer and install the air distribution system for improved air delivery at lower cfm
- Design and installation of the mechanical system in a high performance home helps a builder stay cost neutral

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

High Performance Homes

- So what is different?
  - Improved thermal enclosure leads to reduced heating and cooling loads which results in smaller HVAC equipment
  - Used to use 400 sqft / ton as an estimation of size
  - Now 600 and up to 1000 sqft / ton
  - Improved thermal enclosure also reduces the need for perimeter air delivery
  - Reduced amount of airflow in the system
  - Standard to oversized ducts result in lower velocities
  - Lower velocities at diffusers reduce throw and mixing
  - Impact of duct leakage is amplified

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

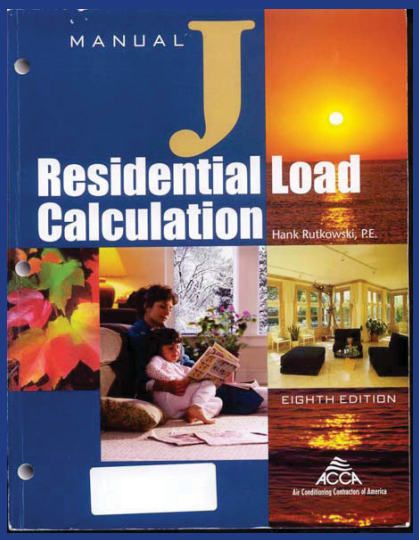
NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

Manual J 8th Edition

- Procedure used to estimate the heat loss and gain of conventional residential structures for the purpose of HVAC sizing
- Determine room-by-room loads

- Manual J examines:
  - Enclosure elements
  - Air leakage
  - System losses / gains
  - Sun position
  - Latent and internal gains



REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town
NREL
Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

Manual J – Heat Loss

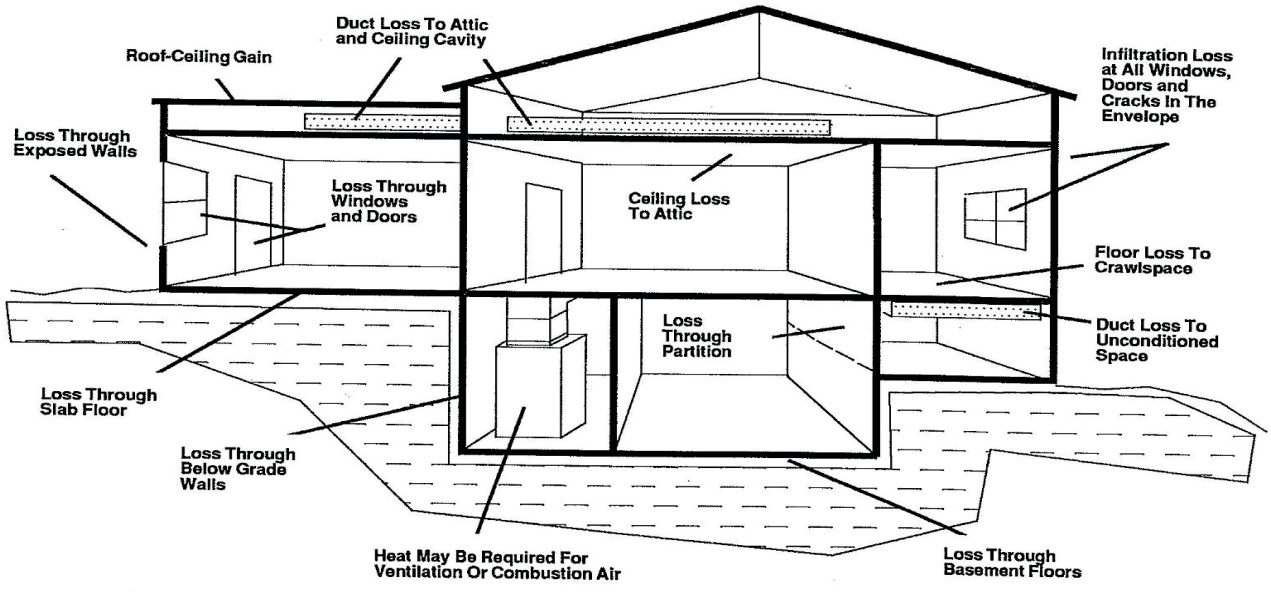


Figure 1-1

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town
NREL
Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

Manual J – Heat Gain

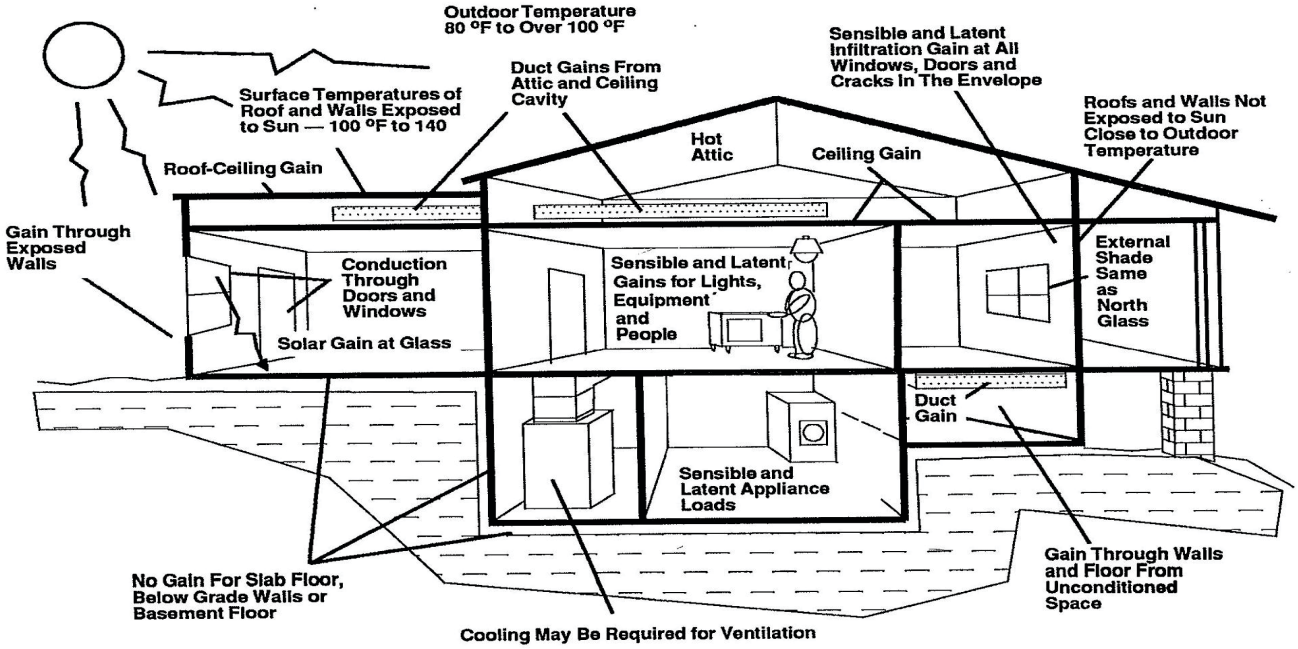


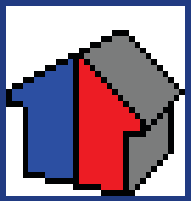
Figure 1-2

Load Calculation Software

- Highly recommended
  - Wrightsoft
  - Elite RHVAC
  - ASHRAE
- Easy to use
  - Enter data
  - Self calculating
  - Draw building and software tallies load
- Have to know the procedure and understand the process to trust the output.







REBUILDING GREENSBURG... as a healthy, energy efficient, affordable town
NREL
Building America U.S. Department of Energy Research Toward Zero Energy Homes

Manual S – Equipment Selection

- Bridge between Manual J and Manual D
- Obtain detailed manufacturer's information and review it to be sure you have what you need
  - Detailed capacities for heating & cooling equipment
  - Combination ratings for cooling & heat pumps
  - Evaporator coil info
  - Fan performance info at different speeds & external static pressures

Equipment Selection Example

Manual J

- Peak Heating and Cooling House Loads
- Room-by-Room Loads & Required Airflows

Manual J Loads	
Total required heating output	65,540
Required sensible cooling output	29,362
Required total cooling output	36,058

Newhouse **Manual J calculations** back of house facing east, inground basement, bay window options

	Peak Heating Load			Peak Cooling Load		
Room	BTUH	% of total	CFM	BTUH	% of total	CFM
Study	4,033	6.2%	82	1,033	2.9%	39
Rec Room	8,571	13.1%	175	1,878	5.2%	71
Bath	168	0.3%	3	94	0.3%	4
Storage	3,025	4.6%	62	563	1.6%	21
Family	6,722	10.3%	137	5,540	15.4%	210
Kitchen/Nk	4,201	6.4%	86	4,226	11.7%	161
Dining	4,705	7.2%	96	2,348	6.5%	89
Living	4,873	7.4%	99	2,441	6.8%	93
Foyer	1,512	2.3%	31	939	2.6%	36
Library	2,689	4.1%	55	1,409	3.9%	54
Pwdr	168	0.3%	3	188	0.5%	7
Mstr Suite	7,898	12.1%	161	4,319	12.0%	164
Dressing	1,849	2.8%	38	1,127	3.1%	43
W.I.C	1,344	2.1%	27	845	2.3%	32
Util	168	0.3%	3	188	0.5%	7
Bed2	4,033	6.2%	82	2,535	7.0%	96
Bath	672	1.0%	14	470	1.3%	18
Bed3	3,529	5.4%	72	2,348	6.5%	89
Hall	1,849	2.8%	38	1,221	3.4%	46
Bed 4	3,529	5.4%	72	2,348	6.5%	89
not used	0	0.0%	0	0	0.0%	0
Totals	65,540	100.0%	1,335	36,058	100.0%	1,370

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town
NREL
Building America U.S. Department of Energy Research Toward Zero Energy Homes

IBACOS

Equipment Efficiency

- Use the most efficient equipment the project can afford
  - Conduct iterative energy analysis to determine the impact of equipment efficiencies on energy savings
  - Translate the energy savings into cost reduction and look at the initial cost of the equipment upgrades

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Equipment Efficiency

- Common Industry Terminology:
  - Energy Efficiency Ratio (EER) = Btuh of cooling / watts used
  - Seasonal Energy Efficiency Ratio (SEER) = Btu cooling produced / watt-hour used
  - Annual Fuel Utilization Efficiency (AFUE) = The % of the amount of energy consumed that is actually converted to useful heat

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Standard Systems

- Standard thermal enclosure requires larger mechanical equipment that may even be oversized
- Multiple supply trunks with long branches routed to the perimeter of the thermal enclosure
- Poor return strategies
- Ductwork is not sealed and is therefore leaky
- More energy is consumed and less comfort is delivered

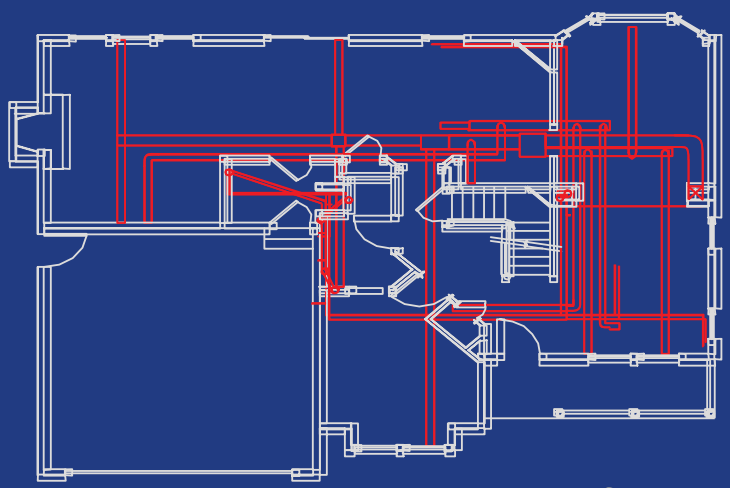
REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Standard Systems



- No integration with the other aspects of the house
- Perimeter delivery of supply air
- Room by room returns or worse

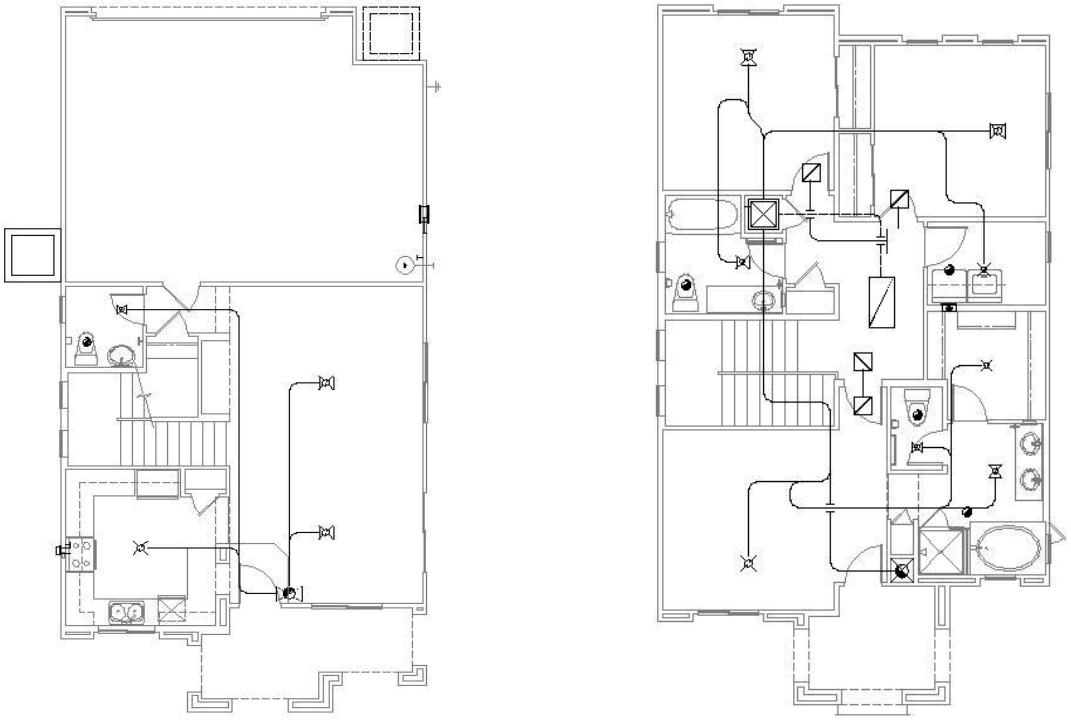
REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Standard Systems



REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

High Performance Air Distribution Design

- Use ACCA's Residential Duct System Manual D
- Integrate the distribution system into the floor plan of the house
- Locate equipment and ducts in conditioned space
- Size system for balanced air flows and quite operation
- Use central return systems
- Understand duct design is an iterative, back and forth process: velocity, friction, throw, diffuser…

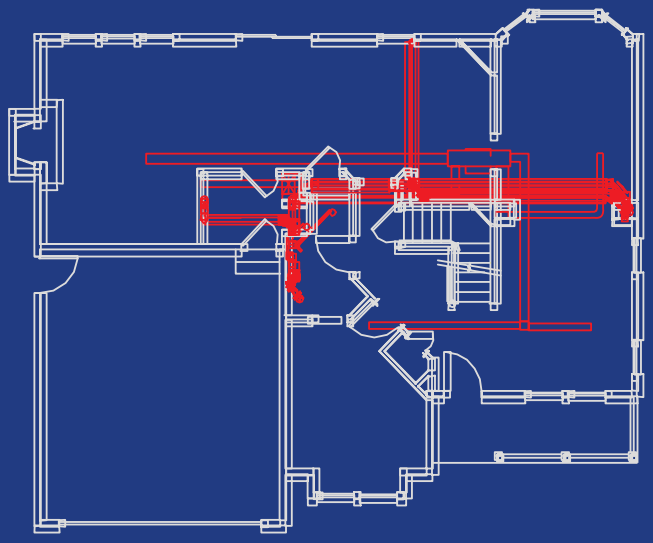
REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

High-Performance System



- Fully engineered and integrated design
- Centerline supply with high sidewall distribution
- Central return with jump ducts or transfer grilles

REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

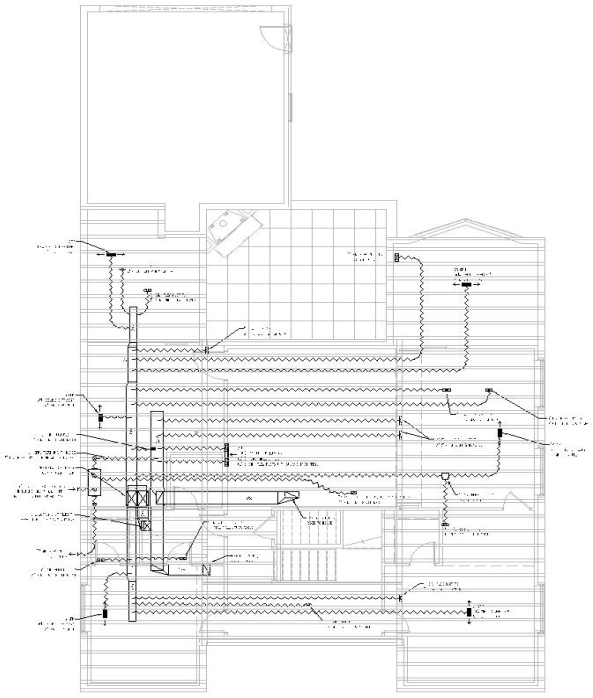
NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

High-Performance System

- Equipment and ductwork in conditioned space
- Short and efficient supply distribution
- Central returns
- Reduced total equivalent length utilizing shorter and more straight trunks and branches
- Right-sized ducts deliver air at needed velocities



REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

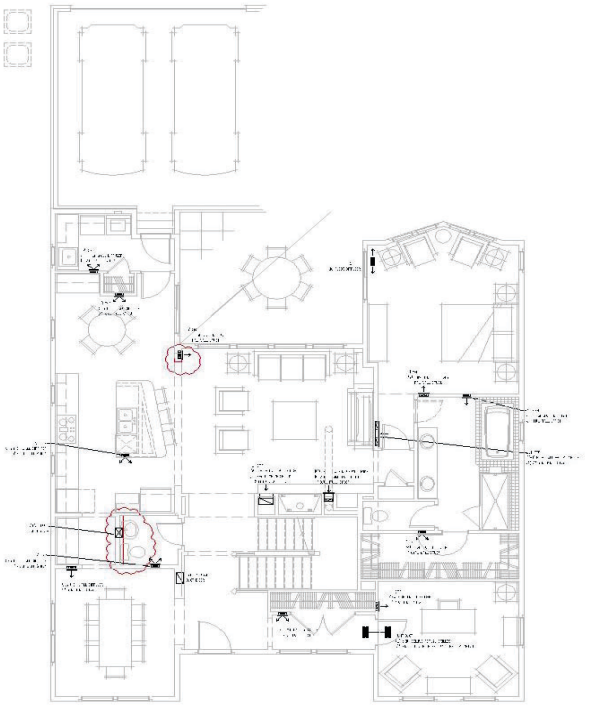
NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

High-Performance System

- Relatively open floor plan reduces the amount of wall space available
- Use of high sidewall diffusers more centrally located to reduce duct length
- Central return to optimize air distribution system
- Transfer grilles used to connect enclosed rooms



REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

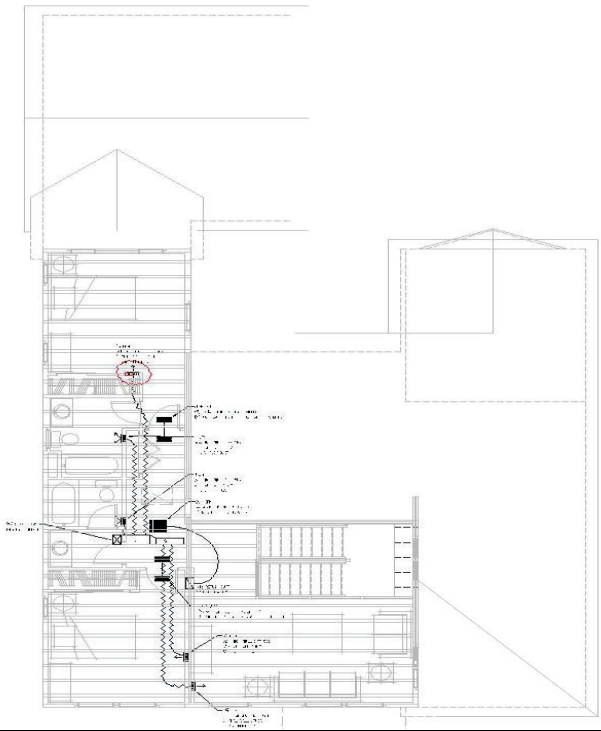
NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

High-Performance System

- Supply and return risers routed from the basement
- Short and compact supply trunk in the second floor structure.
- High sidewall diffuser locations to reduce the duct length as much as possible
- Central return with transfer grilles
- Right-sized ducts deliver air at needed velocities



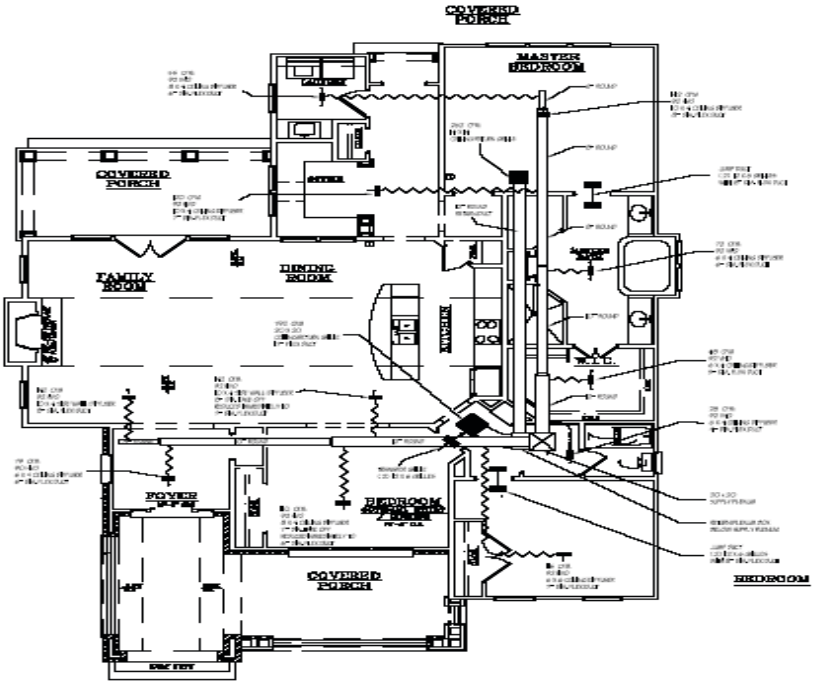
REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

High-Performance System



REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Duct Sealing

- No conventional duct tape
- Use of UL 181 rated duct mastic on all joints and seams
- Seal all ductwork even in conditioned space.



REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

What To Look For





REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Diffuser Selection and Design

Diffuser Comparisons

Room Designation	Throw Desired	CFM	Desired Selection VHO & HVO		Contractor Selection 6" x 10" & 6" x 12"		Generic Selection RZ682	
			Size	Throw	Size	Throw	Size	Throw
Laundry	4'	55	8 x 4	6.6'	6 x 10	3.6'	8 x 4	6.6'
Bedroom/Study	4.5'	110	8 x 4	13.3'	6 x 10	9.6'	6 x 10	9.1'
Family Rm	16'	142	10 x 4	15.8'	6 x 10	12.4'	6 x 10	9.1'
Family Rm	16'	142	10 x 4	15.8'	6 x 12	10.9'	6 x 10	9.1'
Mstr. Bath	7.5'	72	6 x 4	9.7'	6 x 10	6.3'	6 x 6	8.1'
Mstr. Bed	7.8'	142	10 x 4	12.3'	6 x 10	9.6'	8 x 8	11.2'
Office	7'	120	10 x 4	13.4	6 x 10	10.5'	12 x 4	11.5

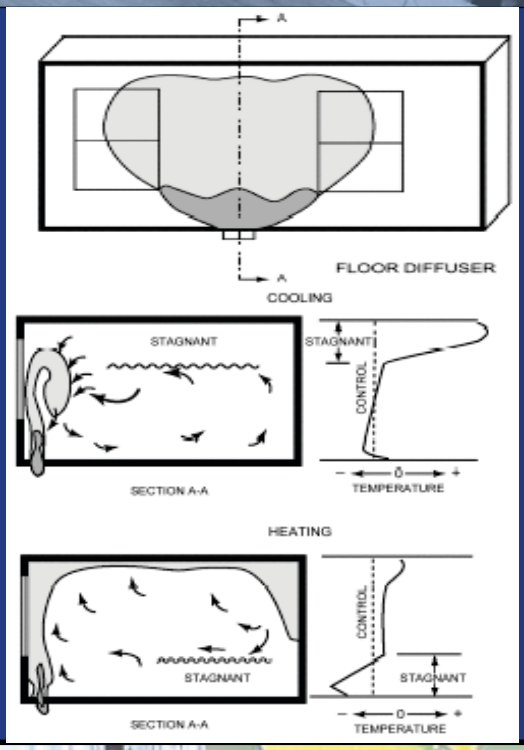
REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

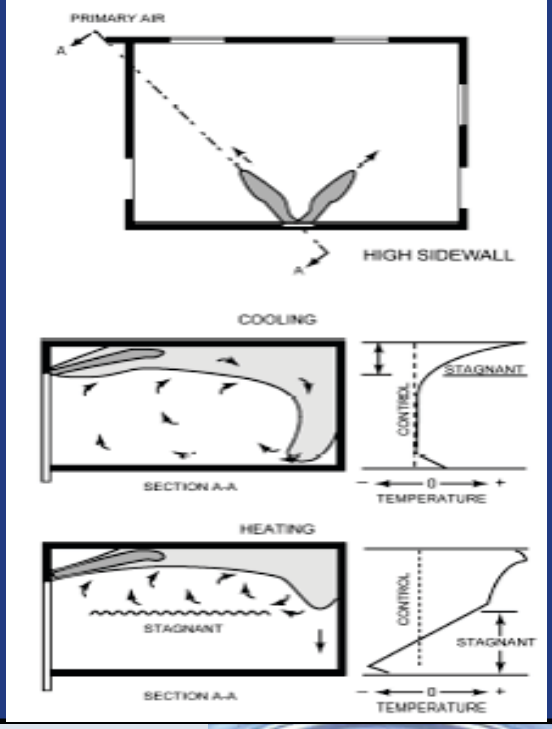
NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Diffuser Selection and Design





REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

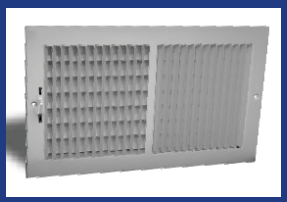
IBACOS

Diffuser Test Plan

Supply Outlets



Adjustable-Blade Single Deflection



Fixed-Blade 2-Way Throw



High-Velocity Slot



Adjustable-Blade Double Deflection

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

System Commissioning

- No conventional duct tape
- Use of UL 181 rated duct mastic on all joints and seams
- Seal all ductwork – even in conditioned space.
- Leakage of the system should be less than 5% of the fan capacity



REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

System Commissioning

Verify fan performance and system flows



REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

System Commissioning

Use flow hood measurements to balance, based off measured total flow



REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

System Commissioning

Measure adequacy of pressure balancing and return strategy



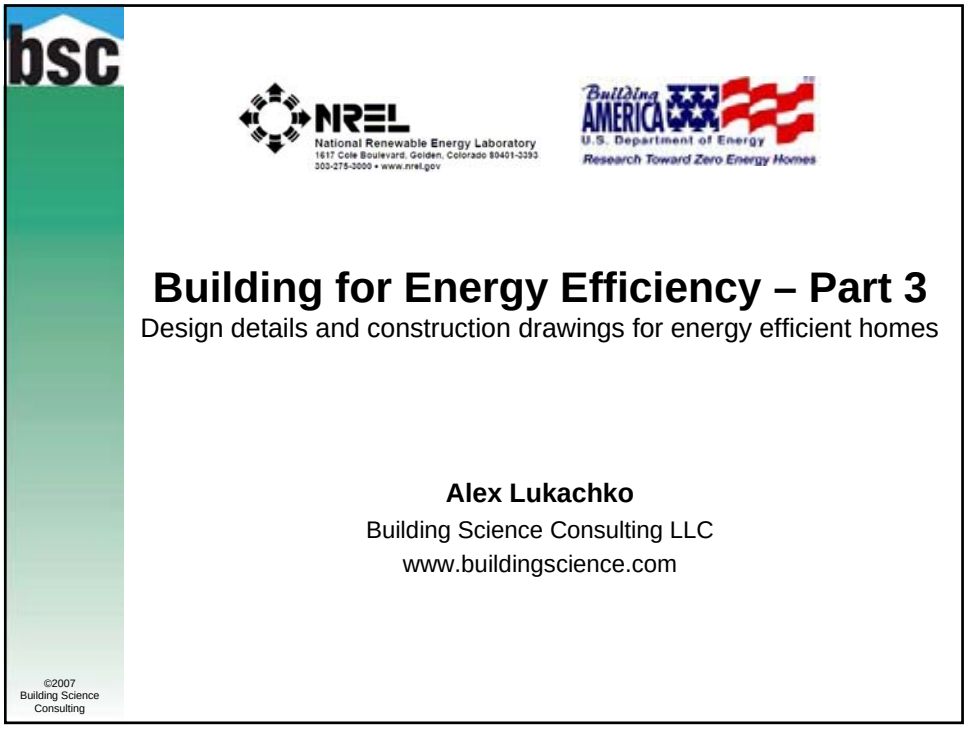
REBUILDING GREENSBURG…
as a healthy, energy efficient, affordable town

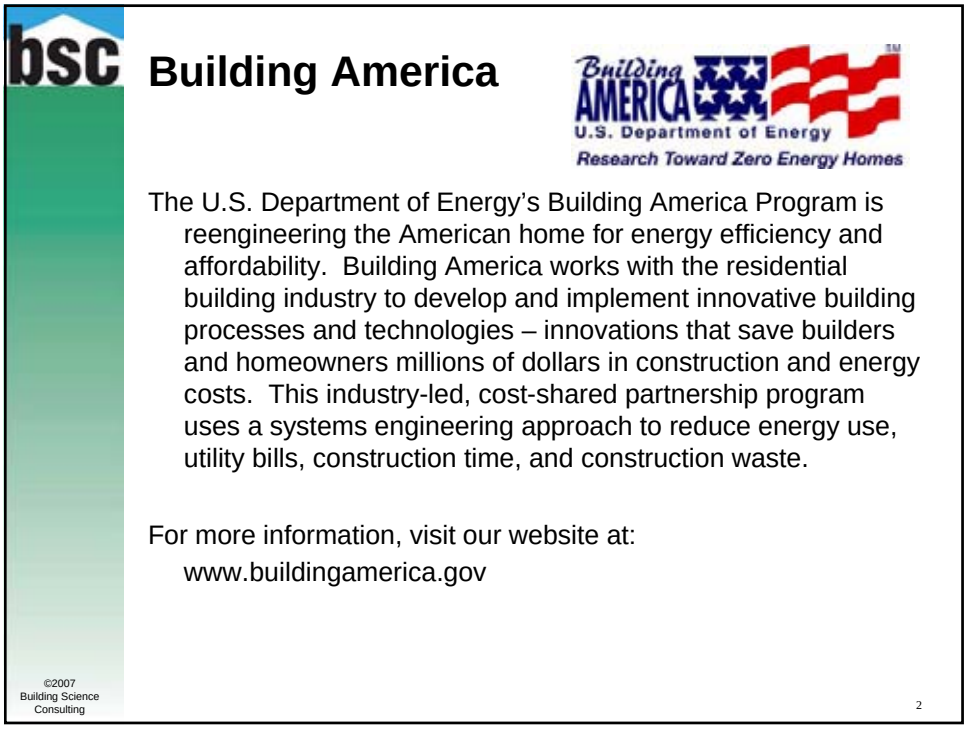
NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

B.7 Building for Energy Efficiency – Part 3

Alex Lukachko
Building Science Consulting


bsc
NREL
National Renewable Energy Laboratory
1617 Cole Boulevard, Golden, Colorado 80401-3393
303-275-3000 • www.nrel.gov
Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes
Building for Energy Efficiency – Part 3
Design details and construction drawings for energy efficient homes
Alex Lukachko
Building Science Consulting LLC
www.buildingscience.com
©2007
Building Science
Consulting


bsc
Building America
Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes
The U.S. Department of Energy's Building America Program is reengineering the American home for energy efficiency and affordability. Building America works with the residential building industry to develop and implement innovative building processes and technologies – innovations that save builders and homeowners millions of dollars in construction and energy costs. This industry-led, cost-shared partnership program uses a systems engineering approach to reduce energy use, utility bills, construction time, and construction waste.
For more information, visit our website at:
www.buildingamerica.gov
©2007
Building Science
Consulting
2

Objectives for this afternoon . . .

1. **"Show off" our house plans as examples of affordable, energy efficient, and durable construction**

2. **Explain applied building science principles through details and construction photos**

©2007 Building Science Consulting

Overview of the Design approach

Top ten elements in the design of high performance homes:

1. Design for comfort with as little added energy as possible
2. Built tight
3. Ventilate
4. Use more insulation
5. Provide for durability by controlling moisture
6. Design a roof that is sloped to the south
7. Use the most efficient equipment the project can afford
8. Use efficient lighting, appliances and match to occupant needs
9. Reduce energy use 40-70% before adding onsite energy generation
10. Commission mechanical and onsite energy systems

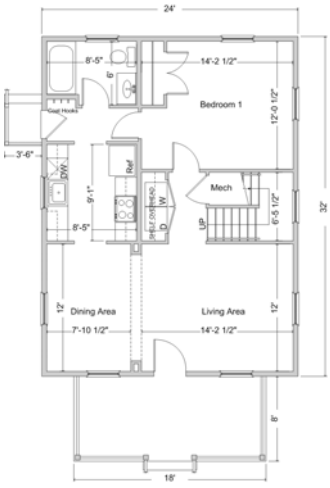
©2007 Building Science Consulting

Greensburg - Plan 1

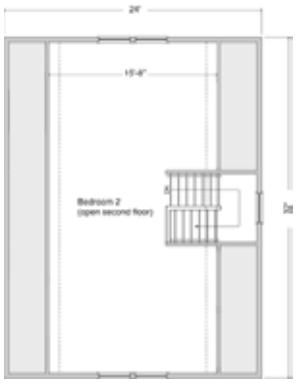


©2007
Building Science
Consulting

Greensburg Plan 1 – Floor Plans



First Floor Plan



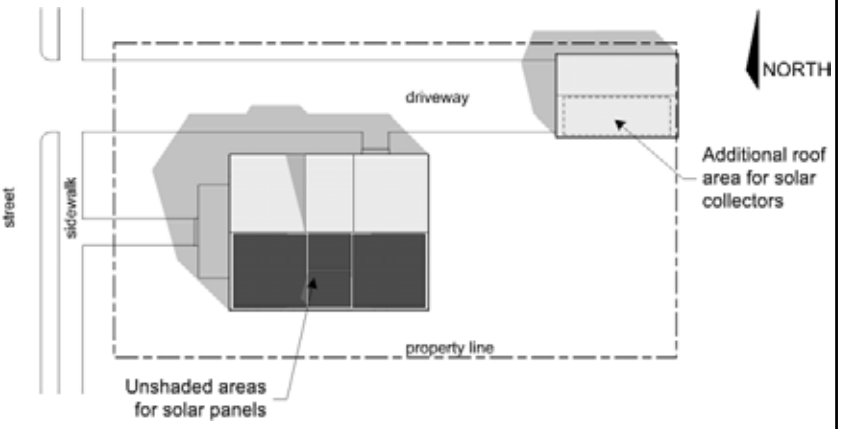
Second Floor Plan

(showing unfinished option,
Alt. 2 br, 1 bath with dormer)

1250 sq ft, 2-bedroom, 1.5 story single family home, with basement

©2007
Building Science
Consulting

Siting, Orientation and Solar Access



- Expansive south-facing roof for solar access
- Large overhangs and landscaping shade house to reduce summertime cooling loads

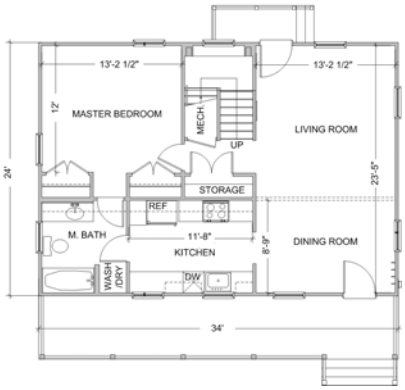
©2007 Building Science Consulting

Greensburg - Plan 2

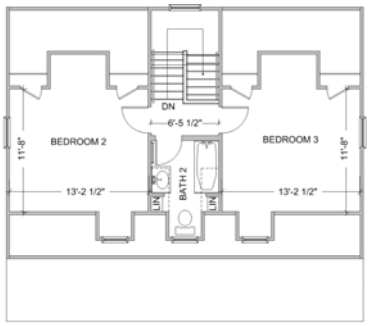


©2007 Building Science Consulting

Greensburg Plan 2 – Floor Plans



First Floor Plan

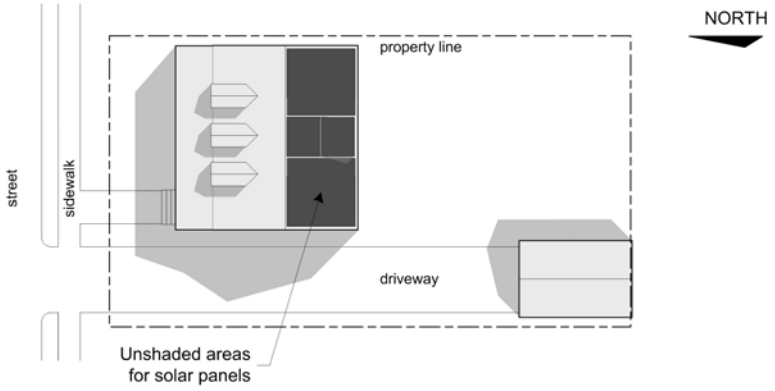


Second Floor Plan

1255 sq ft, 3-bedroom, 1.5 story single family home with basement

©2007
Building Science
Consulting

Siting, Orientation and Solar Access

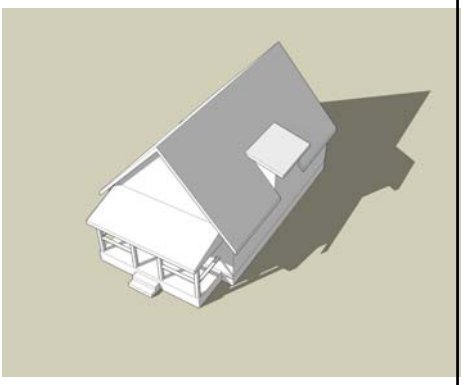


- Expansive south-facing roof for solar access
- Large overhangs and landscaping shade house to reduce summertime cooling loads

©2007
Building Science
Consulting

Adding to the Basic Plan

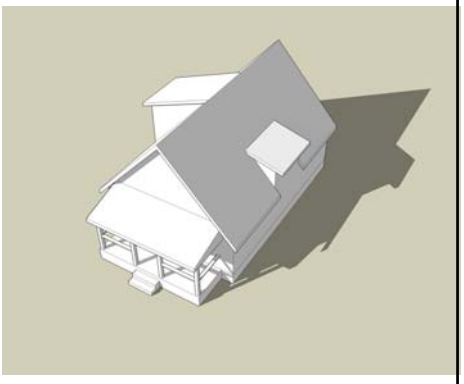
House Plan	**Greensburg Standard**	
Description	Two-bedroom house with living area on the main floor. Second floor can be divided into two bedrooms and bath.	
Living Area	Ground Floor	750 sq ft
	Second Floor	500 sq ft
	Total	**1250 sq ft**
Bedrooms	Ground Floor	1
	Second Floor	1
	Total	**2**
Number of Bathrooms		1



©2007 Building Science Consulting

Adding to the Basic Plan

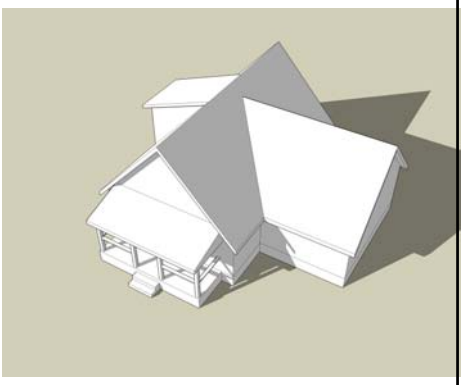
House Plan	**Greensburg Plus**	
Description	Three-bedroom version of the Standard with a second bathroom under a new dormer.	
Living Area	Ground Floor	750 sq ft
	Second Floor	500 sq ft
	Total	**1250 sq ft**
Bedrooms	Ground Floor	1
	Second Floor	2
	Total	**3**
Number of Bathrooms		2



©2007 Building Science Consulting

Adding to the Basic Plan

House Plan	**Greensburg "L"**	
Description	Three-bedroom house with "Great Room" and study on the ground floor, 3 bedrooms and second bath on the second floor.	
Living Area	Ground Floor	1050 sq ft
	Second Floor	800 sq ft
	Total	**1850 sq ft**
Bedrooms	Ground Floor	0
	Second Floor	3
	Total	**3**
Number of Bathrooms		2



©2007 Building Science Consulting

Examples: Royal Township, Michigan



©2007 Building Science Consulting



©2007
Building Science
Consulting

15



©2007
Building Science
Consulting

16

Examples: Carbondale, Colorado



©2007
Building Science
Consulting









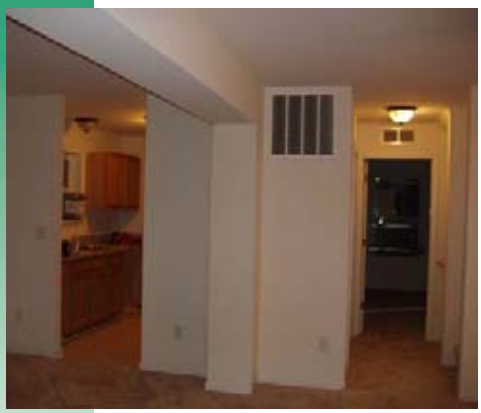
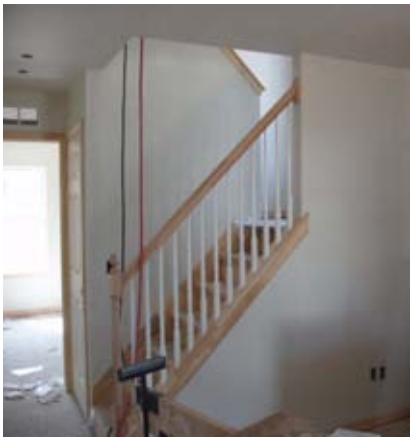
©2007
Building Science
Consulting






©2007
Building Science
Consulting

19

©2007
Building Science
Consulting

20



©2007
Building Science
Consulting

21





©2007
Building Science
Consulting

22





©2007
Building Science
Consulting

REBUILDING GREENSBURG HOUSING FAIR

Greensburg, KS

PLAN 1 - THREE BEDROOM - BASEMENT

PROJECT DESCRIPTION

These plans describe an affordable, energy-efficient, and durable 1250 sq ft single-family home. The drawing set and specifications were developed by Building Science Corporation through the Department of Energy's Building America Program for the "Rebuilding Greensburg" Housing Resource Fair on July 15-21, 2007. The plans provide an example of how homes in Greensburg could be rebuilt as part of a healthy, energy efficient and affordable town. During project planning and construction, all efforts should be made to meet the goals of this project.

SQUARE FOOTAGES

BASEMENT	816 SQ FT
FIRST FLOOR	816 SQ FT
SECOND FLOOR	444 SQ FT

LIST OF DRAWINGS

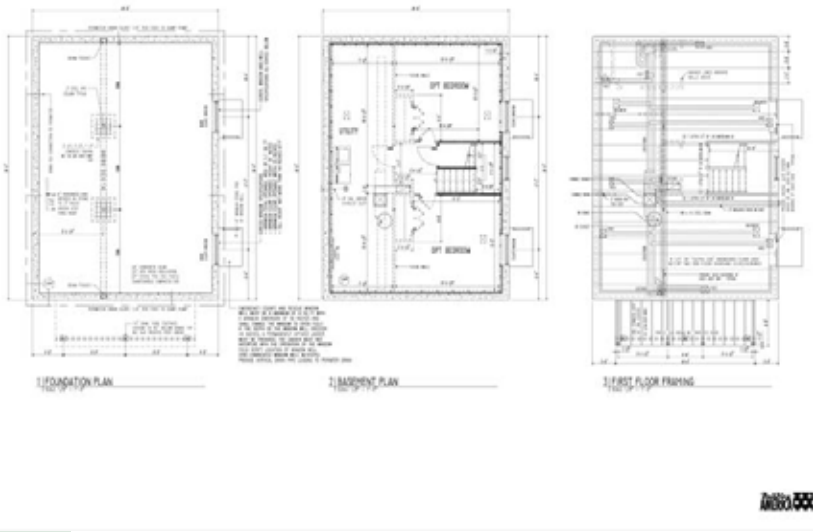
A-1 FOUNDATION / BASEMENT / FIRST FLOOR FRAMING PLANS
A-2 FIRST AND SECOND FLOOR PLANS / WALL FRAMING ELEVATIONS
A-3 SECOND FLOOR FRAMING / ROOF FRAMING / ROOF PLANS
A-4 BUILDING SECTION AA
A-5 BUILDING SECTION BB / WALL SECTION
A-5 BUILDING ELEVATIONS
A-6 DETAILS
M-1 MECHANICAL PLANS
E-1 ELECTRICAL PLANS



DATE: 19 JULY 2007

BUILDING SCIENCE CORPORATION

©2007
Building Science
Consulting



©2007
Building Science
Consulting

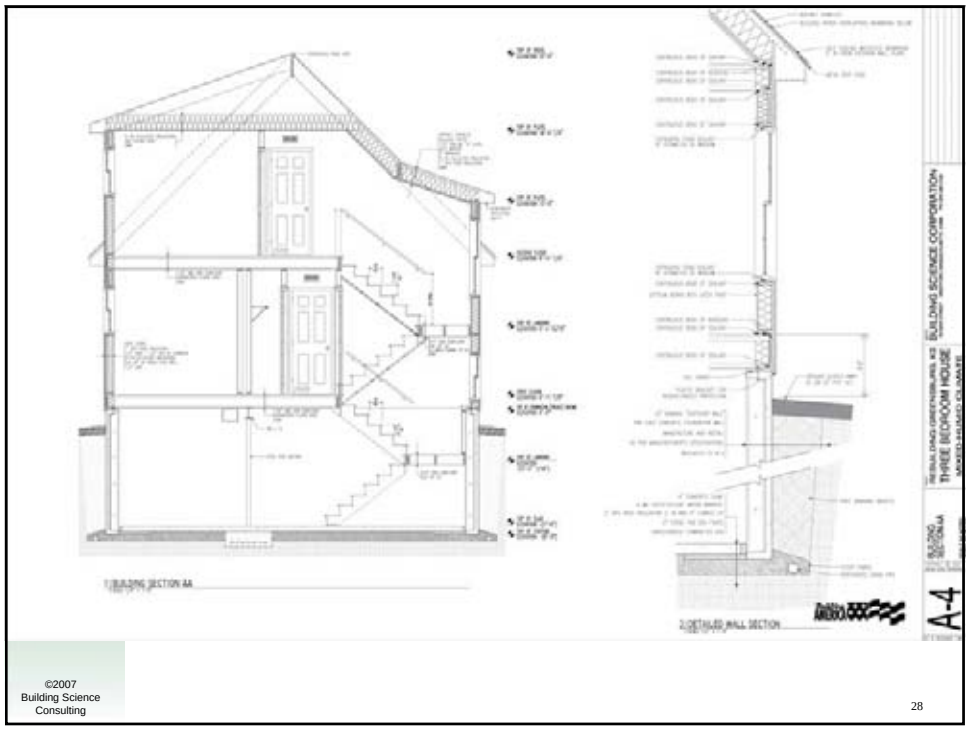


©2007
Building Science
Consulting



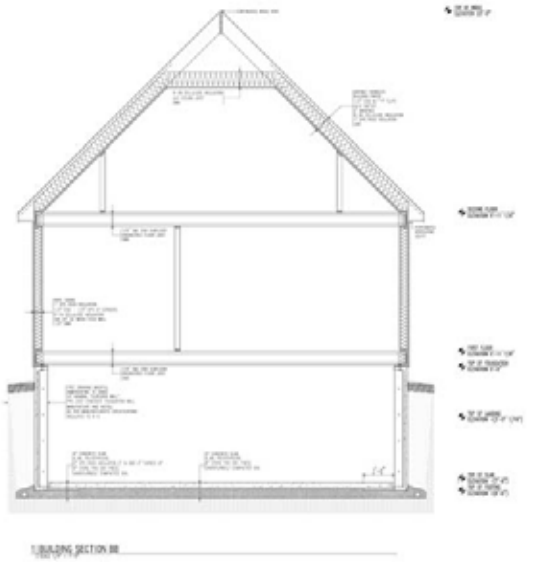
©2007
Building Science
Consulting

27



©2007
Building Science
Consulting

28

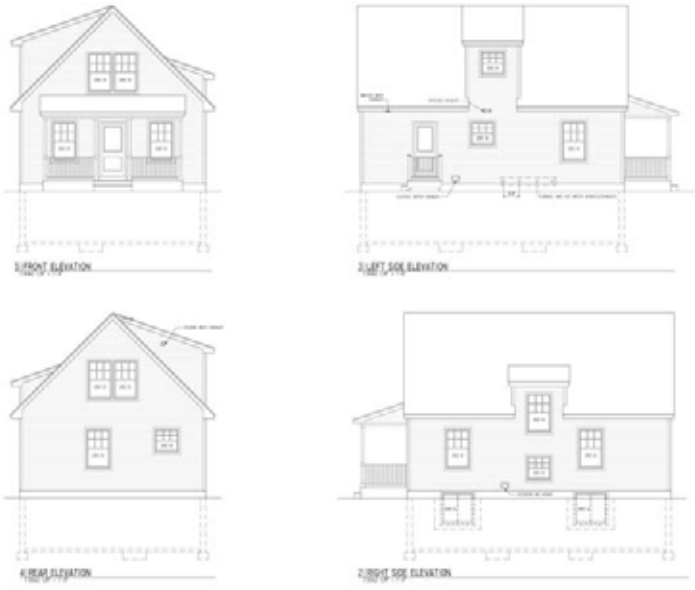


BUILDING SCIENCE CORPORATION

THREE BEDROOM HOUSE

A-5

©2007
Building Science
Consulting



BUILDING SCIENCE CORPORATION

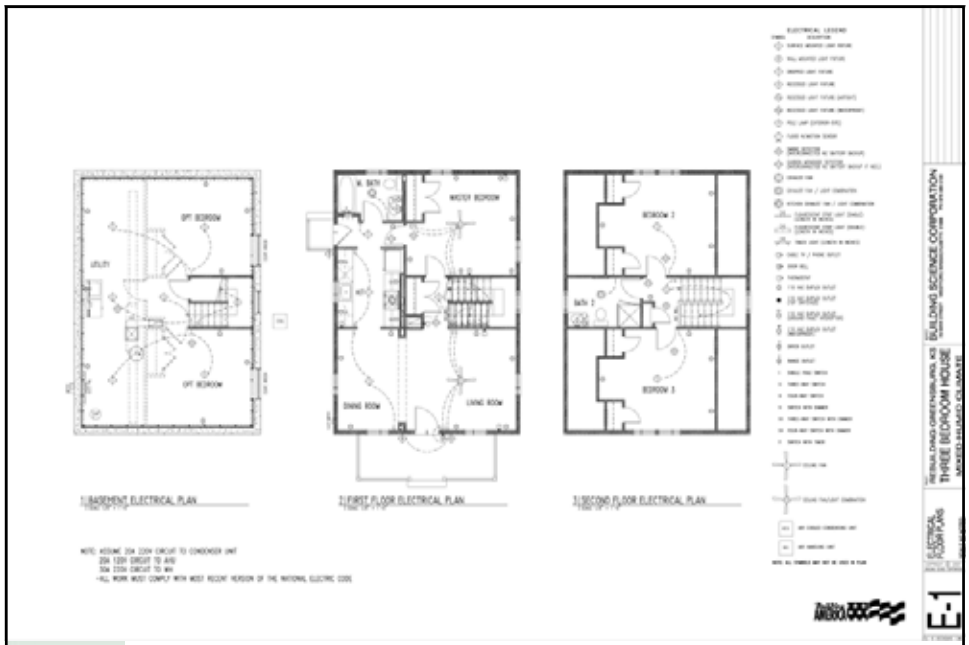
THREE BEDROOM HOUSE

A-6

©2007
Building Science
Consulting



©2007
Building Science
Consulting



©2007
Building Science
Consulting

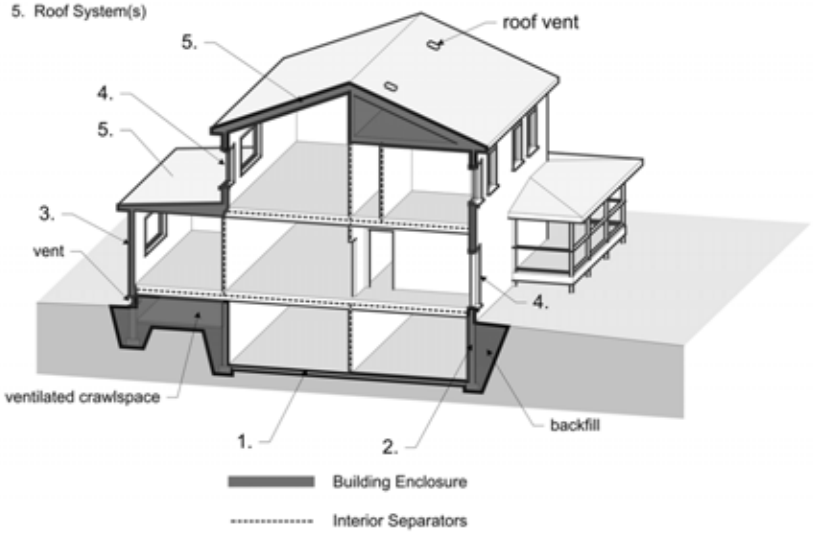
Building Science Details

- The Building Enclosure
- Rainwater Control
- Airflow Control
- Water Vapor Control
- Thermal Control

©2007
Building Science
Consulting

Building Enclosure Components:

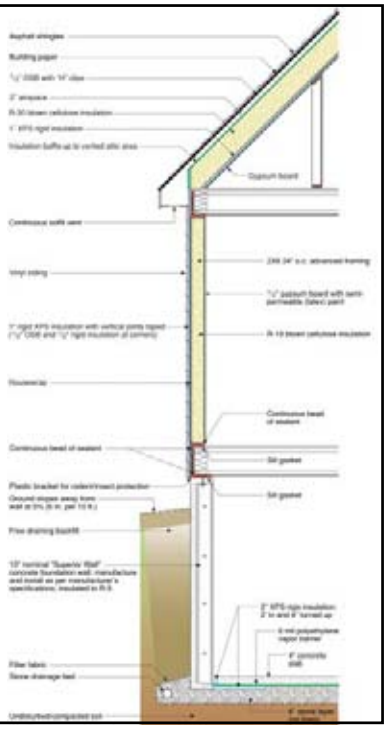
1. Basement Floor System(s)
2. Foundation Wall System(s)
3. Above Grade Wall System(s)
4. Windows and Doors
5. Roof System(s)



©2007
Building Science
Consulting

Enclosure Design

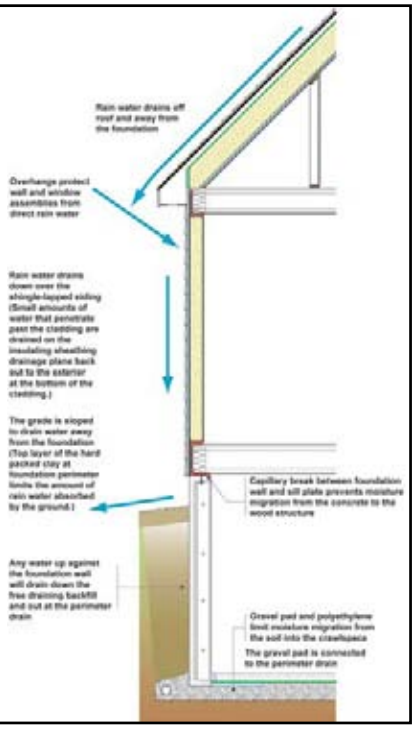
	Proposed Assembly
Above grade walls	**R-19, 2x6 frame @ 24" o.c. + R-5 Sheathed Walls**
Roofs	**R-38 Attic / R-35 Cathedral Ceiling**
Windows	**Low-e Windows (U=0.33, SHGC=0.28)**
Below grade walls	**"Superior Wall" Basement**
Airtightness	**BSC BA Airtightness (2.5 ins/100 sf)**



©2007
Building Science
Consulting

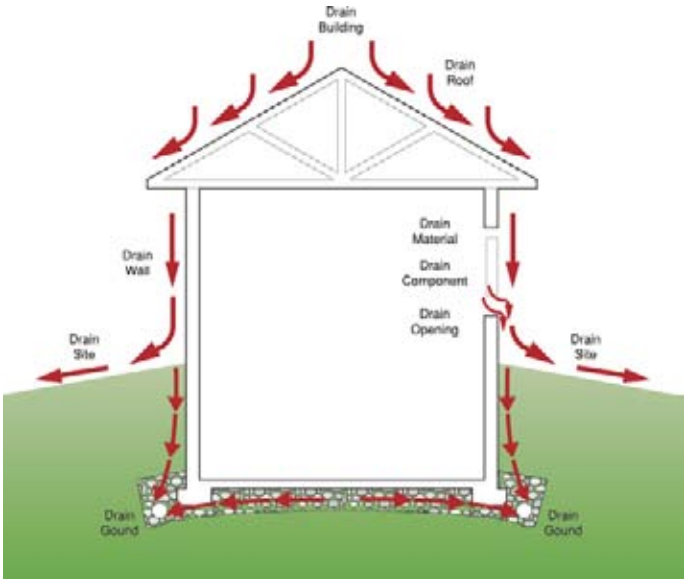
Drainage Profile

- 12-18" roof overhang
- Use draining exterior cladding
- Complete drainage plane
- Drain water away from building
- Control ground water



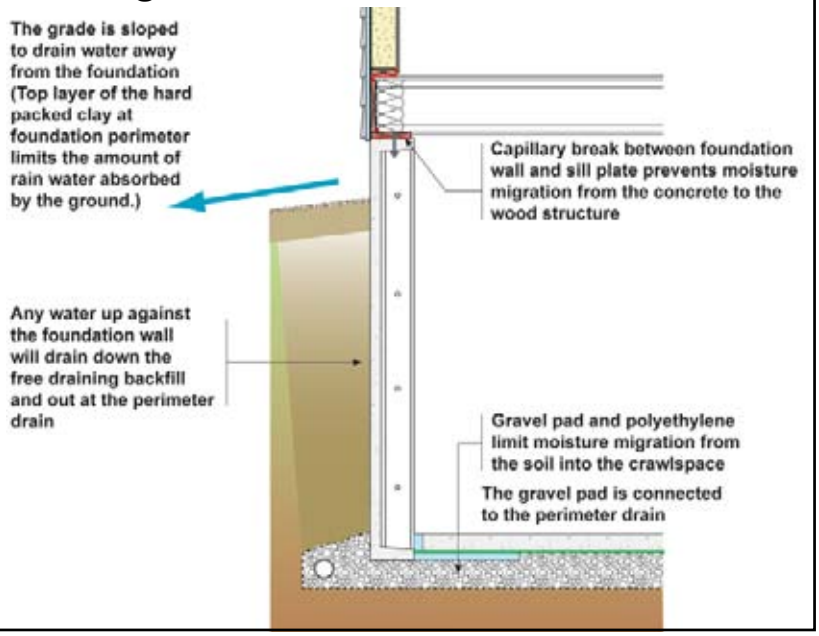
©2007
Building Science
Consulting

Drain Everything



©2007 Building Science Consulting

Drainage Profile - Foundation



©2007 Building Science Consulting

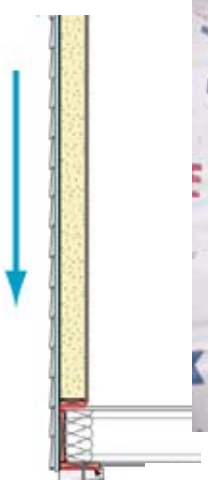




©2007
Building Science
Consulting

Drainage Profile - Walls

Rain water drains down over the shingle-lapped siding (Small amounts of water that penetrate past the cladding are drained on the insulating sheathing drainage plane back out to the exterior at the bottom of the cladding.)



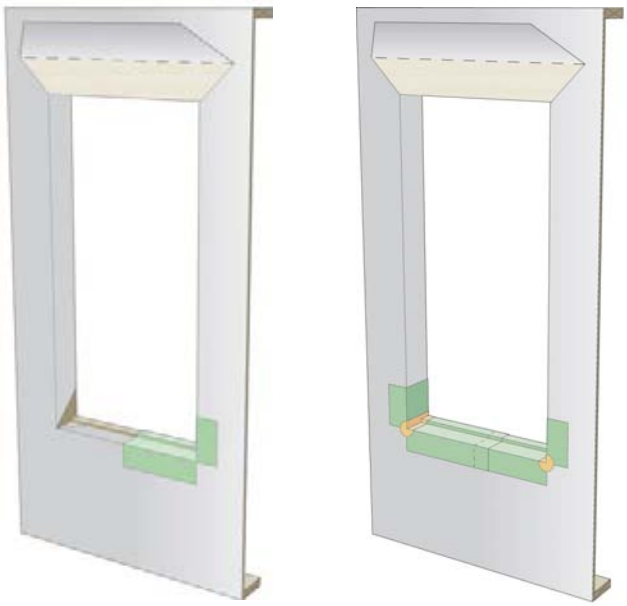


Windows and other penetrations must be integrated with drainage plane

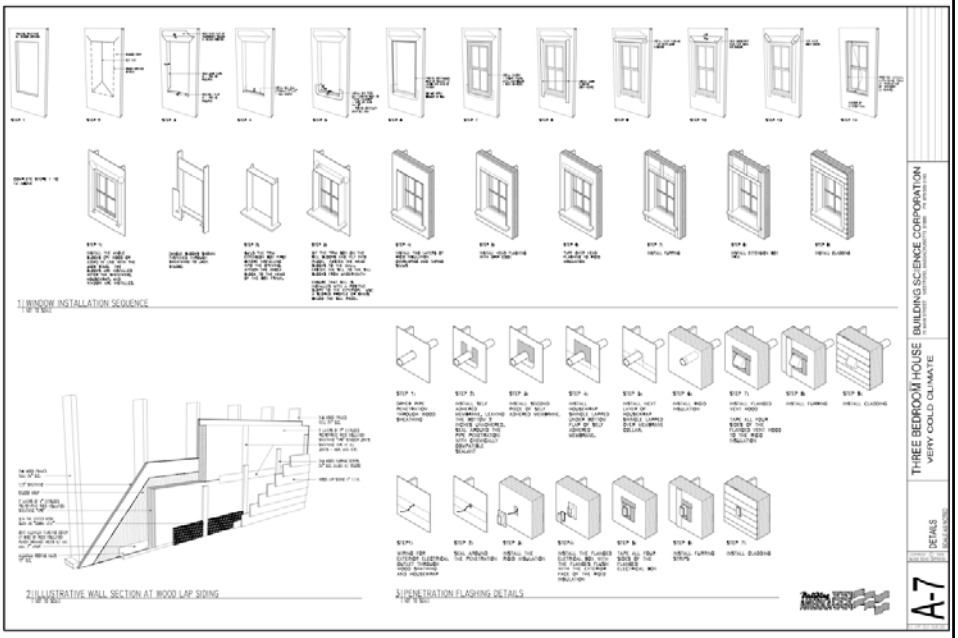
©2007
Building Science
Consulting



©2007
Building Science
Consulting



©2007
Building Science
Consulting

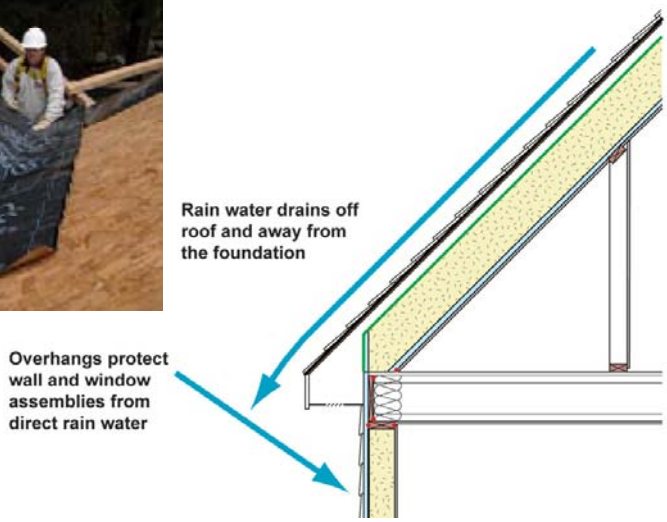


©2007
Building Science
Consulting

bsc

Drainage Profile - Roofs

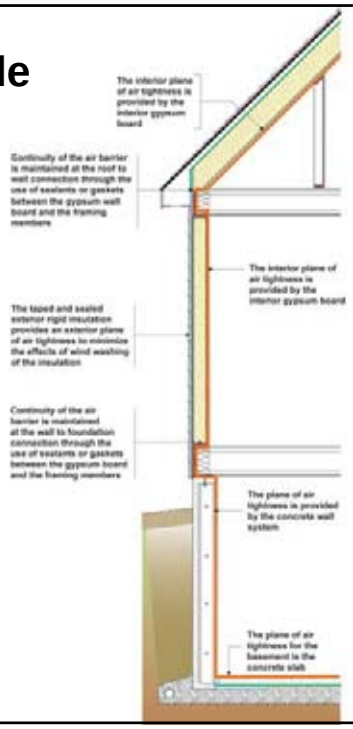




©2007
Building Science
Consulting

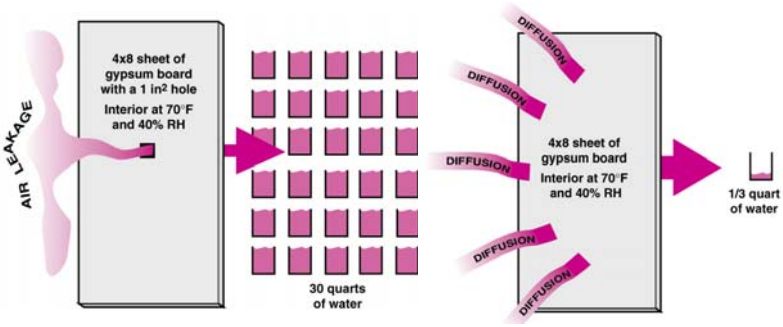
Airflow Control Profile

- Continuous interior air barrier with Airtight Drywall Approach
- Additional resistance to airflow - housewrap and exterior sheathing
- Soil gas control
- Airsealing of windows and other penetrations



©2007
Building Science
Consulting

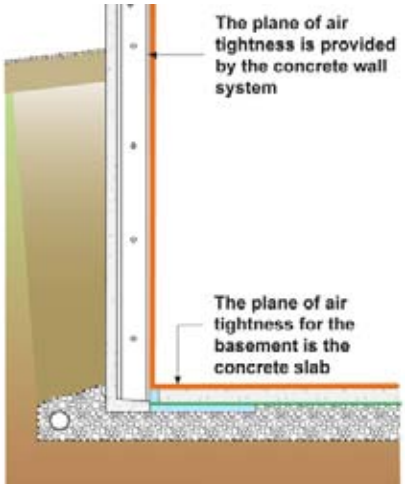
Air Leakage vs Vapor Diffusion



©2007
Building Science
Consulting

46

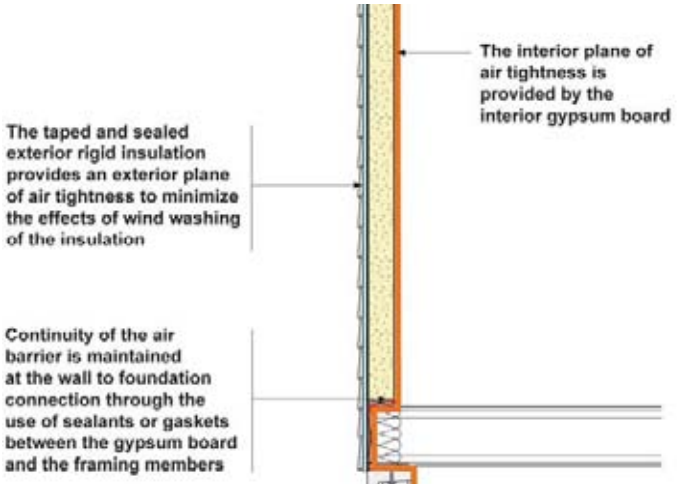
Airflow Control - Foundation



©2007 Building Science Consulting

47

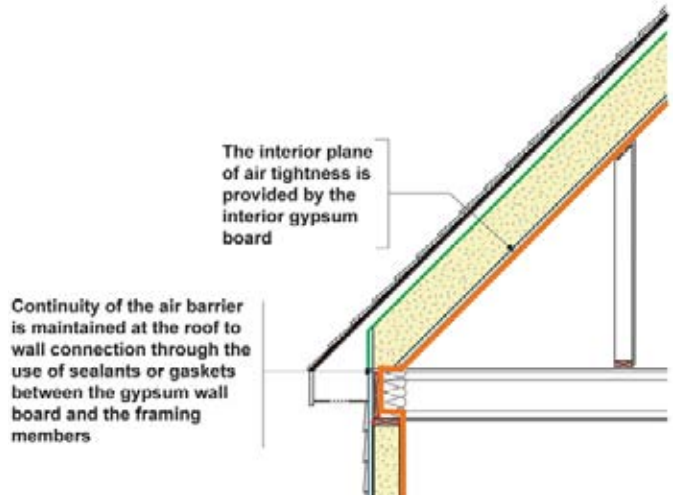
Airflow Control - Walls



©2007 Building Science Consulting

48

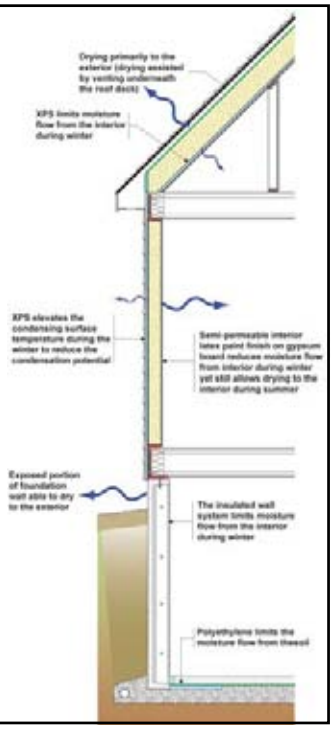
Airflow Control - Roofs



©2007 Building Science Consulting

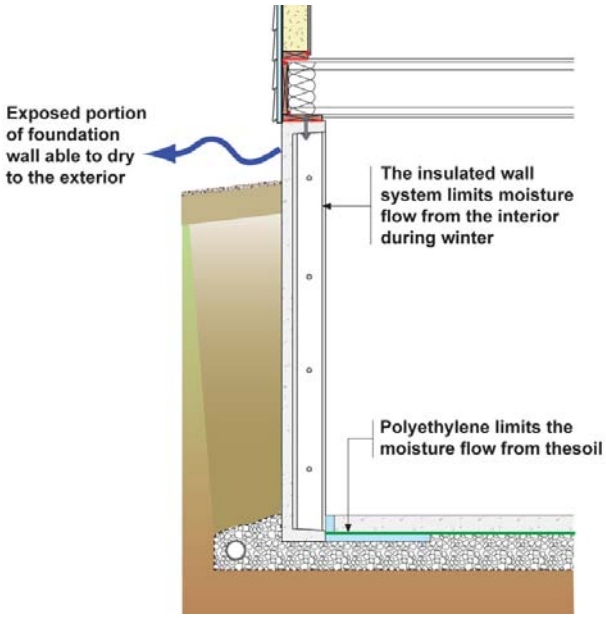
Vapor Control Profile

- Mixed-Humid Climate - assemblies need to dry to interior and exterior
- Rigid insulation (XPS) limits moisture flow
- Works with insulation to control surface temperature and reduce condensation potential



©2007 Building Science Consulting

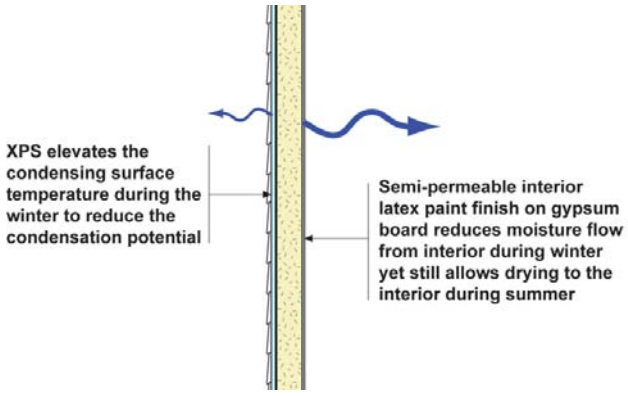
Vapor Control - Foundations



©2007 Building Science Consulting

51

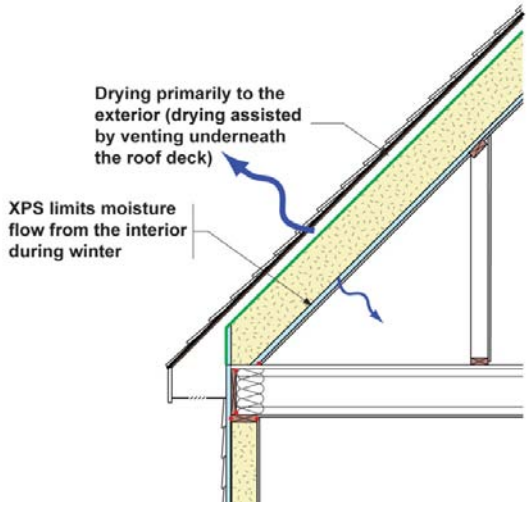
Vapor Control - Walls



©2007 Building Science Consulting

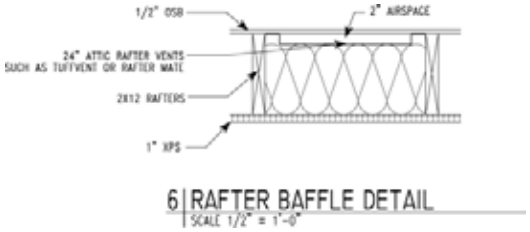
52

Vapor Control - Roofs



©2007 Building Science Consulting



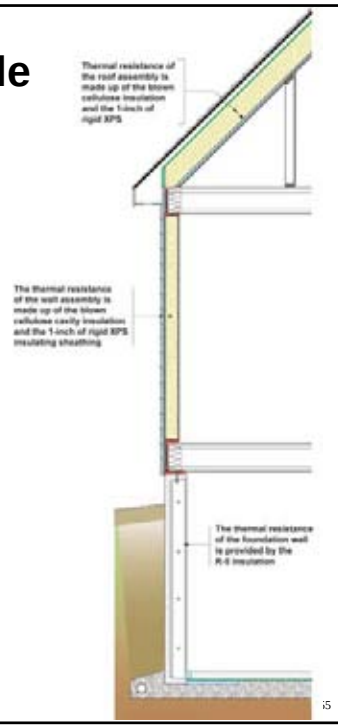


6 RAFTER BAFFLE DETAIL
SCALE 1/2" = 1'-0"

©2007 Building Science Consulting

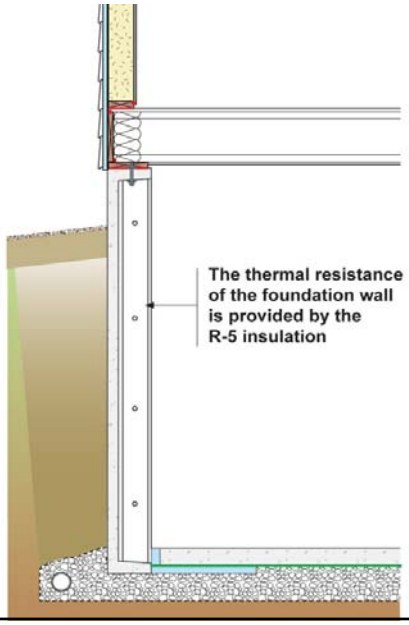
Thermal Control Profile

- Rigid insulation used to control thermal bridging
- Advanced framing techniques used to maximize overall thermal resistance
- Air barrier system and full cavity fill insulation to minimize airflow thermal bypass



©2007 Building Science Consulting

Thermal Control - Foundation



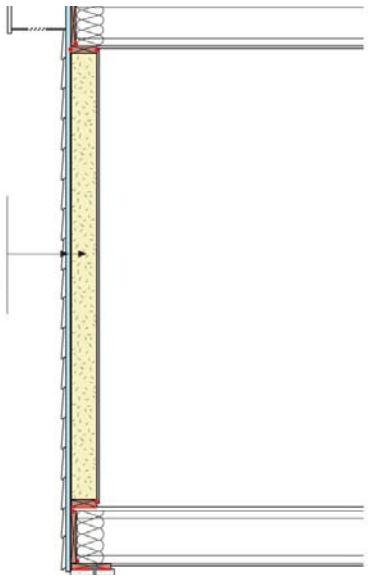
©2007 Building Science Consulting



©2007
Building Science
Consulting

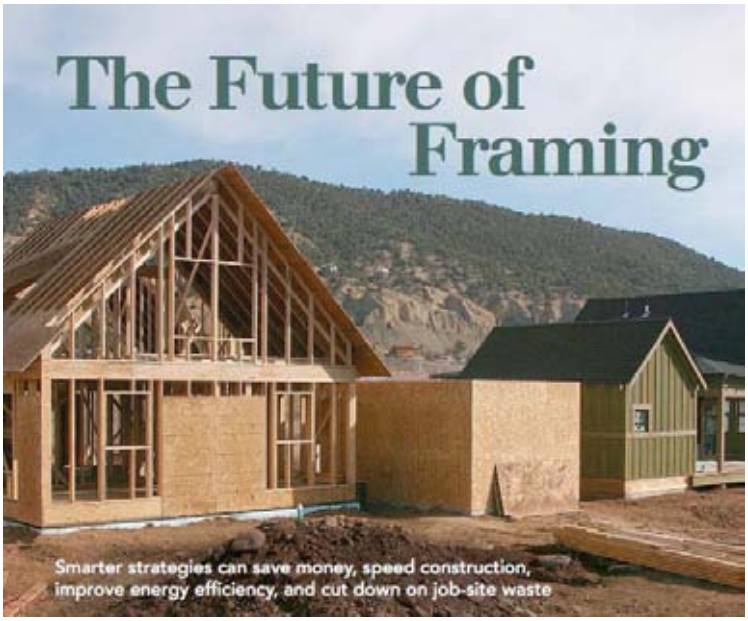
Thermal Control - Walls

The thermal resistance of the wall assembly is made up of the blown cellulose cavity insulation and the 1-inch of rigid XPS insulating sheathing



©2007
Building Science
Consulting

58



©2007 Building Science Consulting

59



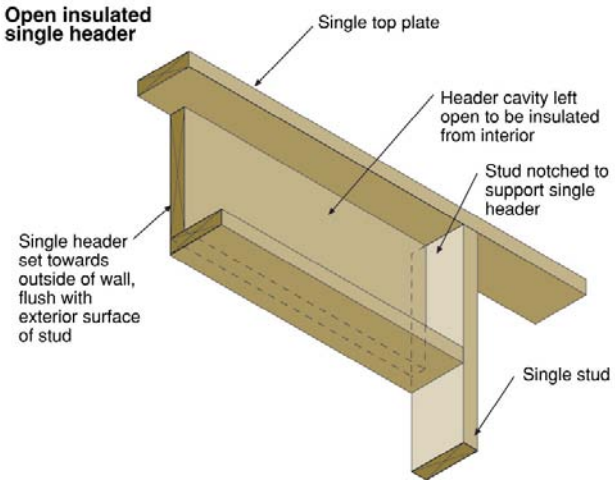
©2007 Building Science Consulting

2x6 Framing, 24” o.c.



©2007
Building Science
Consulting

Right-sized Headers



©2007
Building Science
Consulting

Reduce framing in non-bearing walls



©2007
Building Science
Consulting

Two-stud corners and Drywall clips

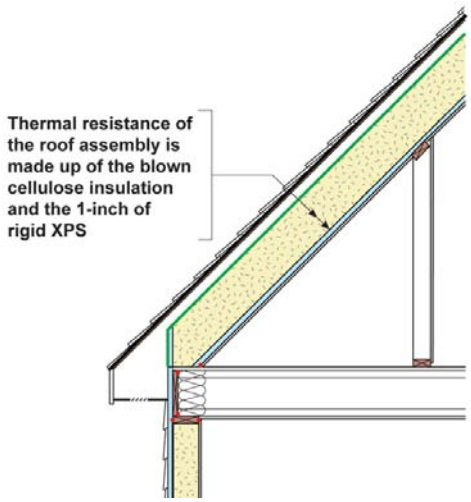




- Clips save wood, labor and call-backs
- NAHB: $100/1000 sq ft in material
- Further savings in energy . . .

©2007
Building Science
Consulting

Thermal Control - Roofs



©2007 Building Science Consulting

65

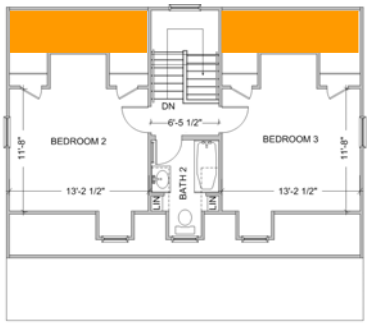


©2007 Building Science Consulting

66

Pushing the Envelope . . .





Second Floor Plan

©2007
Building Science
Consulting

Resources

©2007
Building Science
Consulting

Resources

Building Science Corporation

Designs that Work – Mixed-Humid Climate Case Study

find this at:

www.buildingscience.com/dtw



©2007 Building Science Consulting

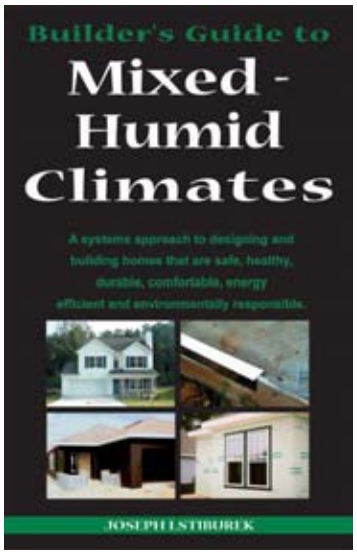
Resources

Building Science Corporation

Builder's Guide to Mixed-Humid Climates

find this at:

www.buildingsciencepress.com



©2007 Building Science Consulting

Resources

Building America

Mixed-Humid Climate Best Practices Guide

find this at:

www.buildingamerica.gov

(look for “publications”)



©2007 Building Science Consulting

Rebuilding Greensburg

A Seminar Series on Affordable, Energy Efficient Construction Techniques

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

Part 1: House Design and Foundation Systems

Date: September 8, 2007

- An overview of energy efficient and affordable house design
- Foundations and rainwater management

Part 2: Framing

- Advanced framing techniques
- Choosing the right windows and doors

Part 3: Mechanical Systems and Airtightness

- Build tight, ventilate right
- Mechanical system design and selection

Part 4: Enclosure

- Insulation – theory and installation practices
- Exterior cladding systems

Part 5: Finishes, Testing and Commissioning

- Measuring building performance
- Whole house commissioning and homeowner training

©2007 Building Science Consulting

Questions?

Before you go . . .

- **Sign up sheet for builders**

©2007
Building Science
Consulting

B.8 Building for Energy Efficiency – Part 4

Steve Bolibruck
IBACOS

IBACOS

Building for Energy Efficiency 4:

Alternative design approaches for energy efficient homes

Steve Bolibruck

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Session Objectives

- Learn about different metrics and programs available to better quantify the savings message
- Discuss different specification packages that achieve different levels of energy efficiency
- Next steps

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Program Introductions

- There are several different energy savings programs and incentives out there but this session will focus on three:
  - Building America Program
  - HERS Index
  - Federal Tax Credit for Home Builders

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Building America

- Building America is sponsored by the U.S. Department of Energy and conducts research to find energy efficient solutions for new and existing housing
- Throughout the design and construction process, research participants in Building America projects evaluate the interaction between the building site, envelope, mechanical systems, and energy-use factors
- The research conducted by Building America teams increases the quality and performance of today's homes and provides valuable information for homes of the future

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Building America

- The long-term goal of the Building America program is to develop cost-effective systems for homes that can produce as much energy as they use – a zero energy home
- Whole house energy savings goals were established and mapped out – 30%, 40%, 50%...
- The reference used to determine the whole house energy savings of a project is the Building America Benchmark

IBACOS

Building America Benchmark

- Building America Benchmark defined:
  - Benchmark is generally consistent with mid-1990s standard practice
  - In addition to the tradition programs that focus on space conditioning and hot water, the Benchmark has additional definitions that allow the evaluation of all residential end-uses
  - All building envelope component references to U-values for the Benchmark have been updated to 2003 International Energy Conservation Code (2003 IECC)
  - Benchmark represents typical construction at a fixed point in time so it can be used as the basis for Building America's multi-year energy savings goals

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town
NREL
Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

HERS Index

- The HERS Index is a scoring system established by the Residential Energy Services Network (RESNET)
- The HERS Reference Home is based on the 2006 International Energy Conservation Code
- The lower a home's HERS Index, the more energy efficient it is in comparison to the HERS Reference Home
- A house built with the same specifications as the Reference House would have a HERS Index of 100, while a net zero energy home has a HERS Index of 0
- Each 1-point decrease in the HERS Index corresponds to a 1% reduction in energy consumption

IBACOS

Federal Tax Credit

- Tax Credit for Home Builders:
  - Home builders are eligible for a $2,000 tax credit for a new energy efficient home
  - The house must achieve 50 percent energy savings for heating and cooling over the 2004 International Energy Conservation Code (IECC) and supplements. At least 1/5 (10%) of the energy savings must come from building envelope improvements
  - This credit also applies to contractors of manufactured homes conforming to Federal Manufactured Home Construction and Safety Standards

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town
NREL
Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Federal Tax Credit

- Additional Tax Credit for Manufactured Home Builders:
  - Producers of a new manufactured are eligible for a $1,000 tax credit
  - The house must achieve 30 percent energy savings for heating and cooling over the 2004 International Energy Conservation Code (IECC) and supplements. At least 1/3 (10%) of the energy savings must come from building envelope improvements
  - Manufactured homes meeting the requirements established by EPA under the ENERGY STAR program also qualify

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

30% Specification Package

Greensburg - Preliminary Specification Analysis	
Two-Story w/ Unfinished Basement 2182 ft² conditioned floor area, 287 ft² window area	
System Specifications	
Component	**30% Specification Package**
Foundation System	R-10 Basement walls, conditioned basement
Above Grade Exterior Walls	2x6 framed walls with R-19 batt insulation
Overhanging Floors	R-30
Roof	R-40 vented attic
Exterior Doors	R-5
Windows	Low-E/Low SHGC (U=0.30;SHGC=0.37)
Building Air Tightness	ACH50 = 4
Mechanical Ventilation	Supply air to return duct with runtime and damper control, adjustable to meet ASHRAE 62.2 ventilation requirements
Heating	90% AFUE Natural Gas Furnace
Cooling	SEER 14 A/C Unit
Ductwork	Supply ducts located within conditioned space, return ducts and air handler located in conditioned basement, 5% leakage to exterior, R-8 duct insulation
Water Heater	Nat. gas, EF=0.61
Appliances	Electric range & dryer
Fluorescent Lighting	50% Fluorescent lighting
% Better than Building America Benchmark	**34.0%**
HERS Index 2006	**65**
Tax Credit Compliant	**Compliant (53% htg/clg - 40% envl)**

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

30% Cost Savings

Estimated Annual Cost Savings: 30% Savings Target

	Greensburg
Estimated Incremental First Cost Relative to Standard Practice[1]	$4,000
Annual Amortized Cost 7%, 30Year mortgage[2]	$211
Estimated Annual Utility Bill Savings	$723
Net Annual Savings	**$512**

(2000 ft2, 2-story, 16% window to floor area ratio, unconditioned basement)

[1] Evaluated relative to minimum IECC 2003.
[2] Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage.

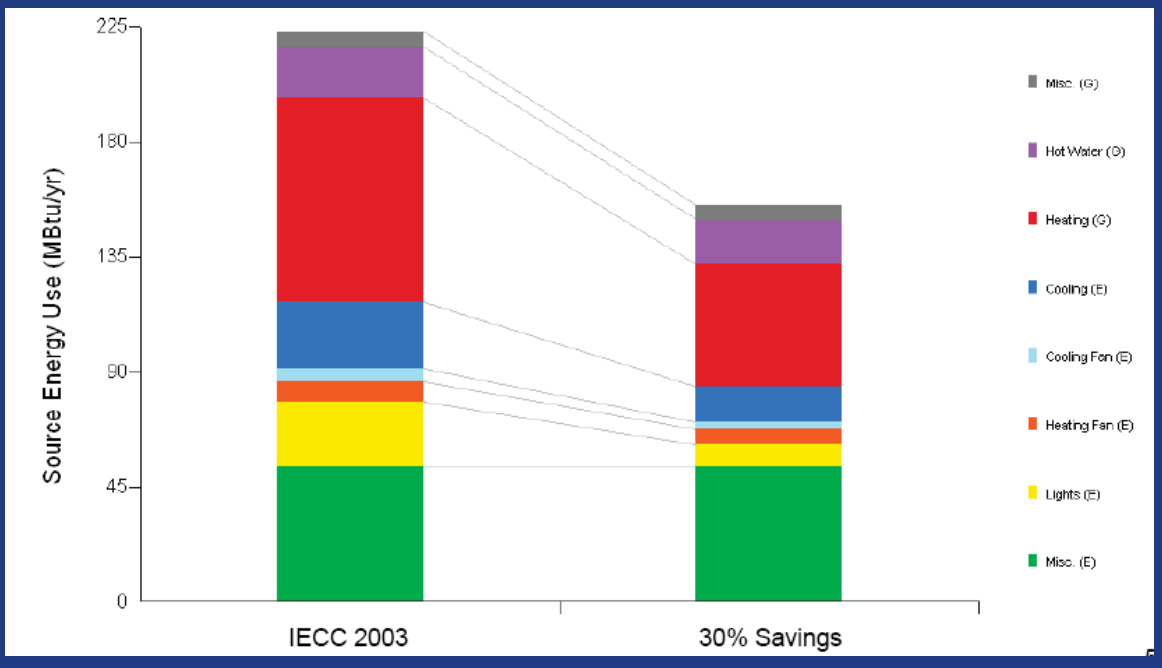
REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Estimated Annual Energy Savings by End Use – 30% Target



REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building AMERICA U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

40% Specification Packages

Greensburg - Preliminary Specification Analysis

Two-Story w/ Unfinished Basement
2182 ft² conditioned floor area, 287 ft² window area

System Specifications	
Component	**40% Specification Package**
Foundation System	R-10 Basement walls, conditioned basement
Above Grade Exterior Walls	2x6 framed walls with R-21 batt insulation
Overhanging Floors	R-30
Roof	R-50 vented attic
Exterior Doors	R-5
Windows	Low-E/Low SHGC (U=0.28;SHGC=0.37)
Building Air Tightness	ACH50 = 3
Mechanical Ventilation	Supply air to return duct with runtime and damper control, adjustable to meet ASHRAE 62.2 ventilation requirements
Heating	90% AFUE Natural Gas Furnace
Cooling	SEER 18 A/C Unit
Ductwork	Supply ducts located within conditioned space, return ducts and air handler located in conditioned basement, 2.5% leakage to exterior, R-8 duct insulation
Water Heater	Nat. gas, EF=0.61
Appliances	Electric range & dryer
Fluorescent Lighting	80% Fluorescent lighting
% Better than Building America Benchmark	**40.2%**
HERS Index 2006	**61**
Tax Credit Compliant	**Compliant (60% htg/clg - 45% envl)**

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

40% Cost Savings

Estimated Annual Costs: 40% Efficiency Target

	Greensburg
Estimated Incremental First Cost Relative to Standard Practice[1,2]	$7,000
Annual Amortized Cost 7%, 30 Year mortgage[3]	$411
Annual Utility Bill Savings	$919
Net Annual Savings	**$508**

(2000 ft2, 2-story, 16% window to floor area ratio), unconditioned basement

[1] Evaluated relative to minimum IECC 2003.
[2] Qualifies for federal new home tax credit.
[3] Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage.

8

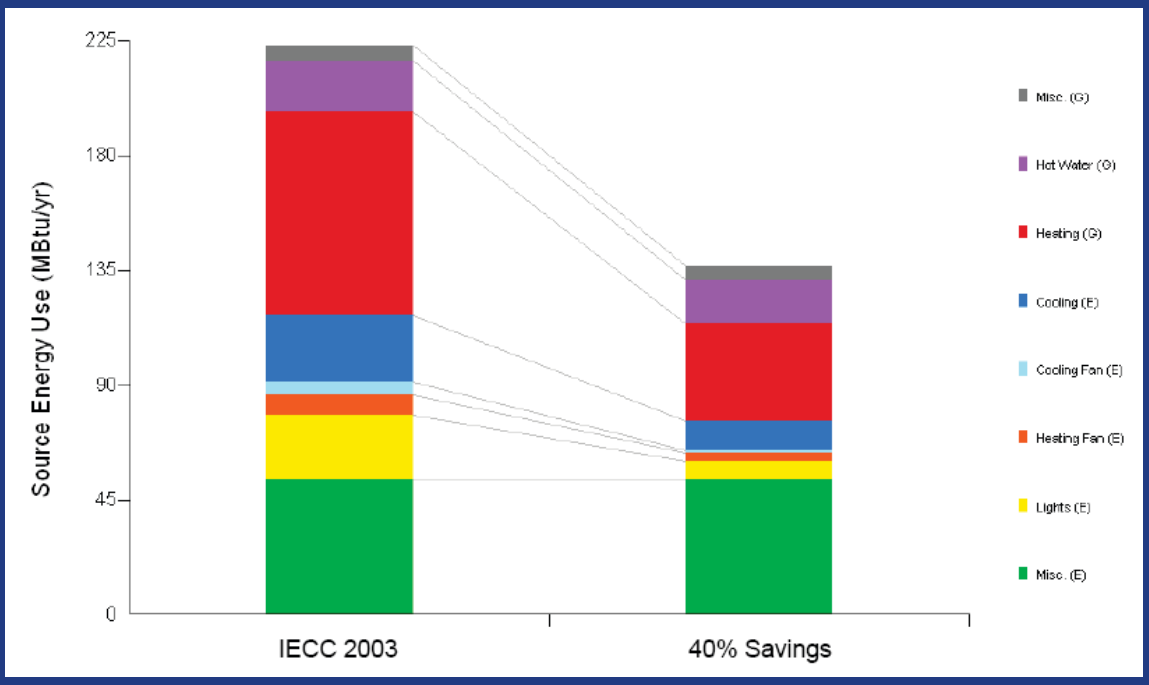
REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Estimated Annual Energy Savings by End Use – 40% Target



REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

50% Specification Packages

Greensburg - Preliminary Specification Analysis	
Two-Story w/ Unfinished Basement	
2182 ft² conditioned floor area, 287 ft² window area	
System Specifications	
Component	**50% Specification Package**
Foundation System	R-10 Basement walls, conditioned basement
Above Grade Exterior Walls	2x6 framed walls with R-22 batt insulation and foam sheathing
Overhanging Floors	R-30
Roof	R-50 vented attic
Exterior Doors	R-5
Windows	Low-E/Low SHGC (U=0.28;SHGC=0.37)
Building Air Tightness	ACH50 = 2
Mechanical Ventilation	Supply air to return duct with runtime and damper control, adjustable to meet ASHRAE 62.2 ventilation requirements
Heating	94% AFUE Natural Gas Furnace
Cooling	SEER 18 A/C Unit
Ductwork	Supply and return ducts and air handler located within conditioned space, 0% leakage to exterior
Water Heater	Nat. gas, Tankless EF=0.82
Appliances	Electric range & dryer, Energy Star appliances
Fluorescent Lighting	80% Fluorescent lighting
% Better than Building America Benchmark	49.3%
HERS Index 2006	51
Tax Credit Compliant	Compliant (68% htg/clg - 50% envl)

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

50% Cost Savings

Estimated Annual Costs: 50% Efficiency Target

	Greensburg
Estimated Incremental First Cost Relative to Standard Practice[1,2]	$13,000
Annual Amortized Cost 7%, 30Year mortgage[3]	$706
Annual Utility Bill Savings	$1162
Net Annual Savings	**$456**

(2000 ft2, 2-story, 16% window to floor area ratio), unconditioned basement

1 Evaluated relative to minimum IECC 2003.
2 Qualifies for federal new home tax credit.
3 Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage.

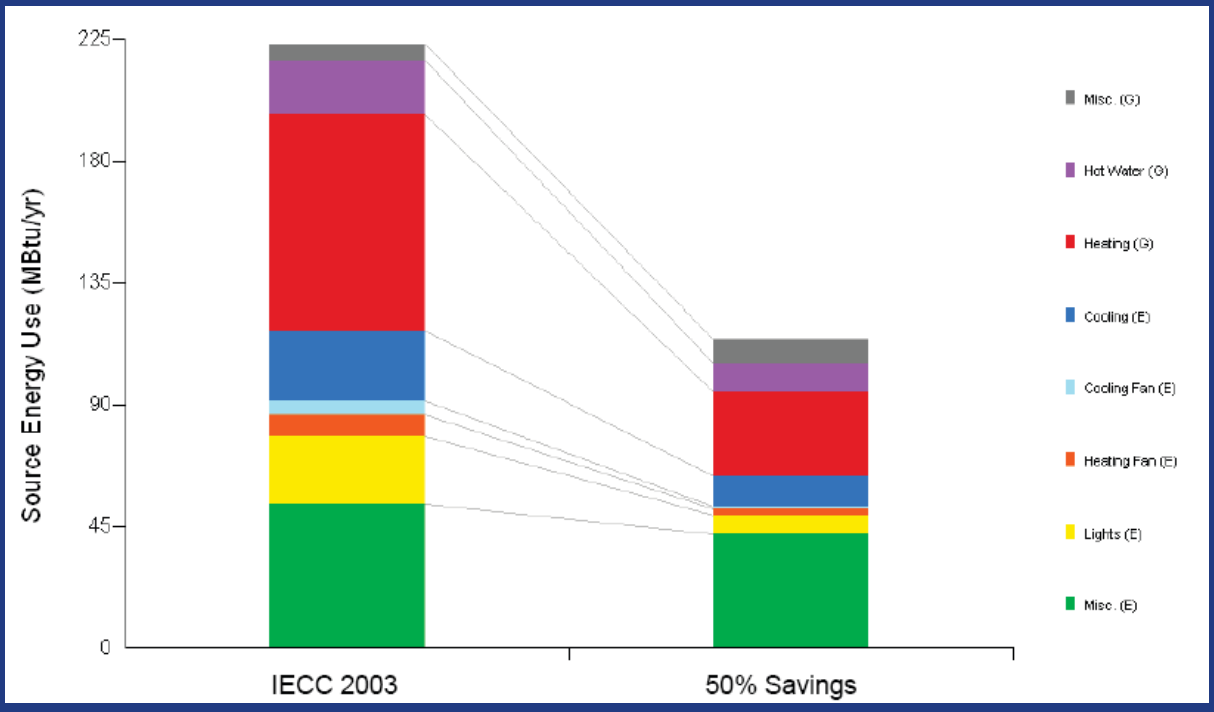
REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

IBACOS

Estimated Annual Energy Savings by End Use – 50% Target



REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

NREL

Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

Plan 1 Specification Packages

Greensburg - Plan 1 - Preliminary Specification Analysis	
Two-Story w/ Unfinished Basement	
System Specifications	
Component	**Optional Spec Package - Plan 1**
Foundation System	R-5 1" XPS foam insulation on interior of basement walls
Above Grade Exterior Walls	2x6 wood framed 24" o/c (advanced framing) with R-19 damp-spray cellulose cavity insulation and R-5 XPS insulating foam sheathing
Overhanging Floors	N/A
Roof	R-38 cellulose insulation on flat ceilings; R-30 cellulose insulation & R-5 XPS foam sheathing on cathedral ceilings
Exterior Doors	R-7
Windows	High performance, Low-E, double paned, vinyl windows (U=0.32;SHGC=0.32)
Building Air Tightness	ACH50 = 3.4
Mechanical Ventilation	Supply-only system with fan cycling controller and motorized damper, integrated with air handling unit, supply rate @ 55 CFM for 33% run-time
Heating	Natural Gas Furnace, 92.1% AFUE
Cooling	None
Ductwork	Supply and return ducts and air handler located within conditioned space, 0% leakage to exterior
Water Heater	Natural Gas, EF = 0.62
Appliances	Electric dryer & range, Energy Star Appliances
Fluorescent Lighting	100% Fluorescent Lighting
% Better than Building America Benchmark	**33.4%**
HERS Index 2006	**73**
Tax Credit Compliant	**Non-compliant (46% htg/clg - 37% envl)**

REBUILDING GREENSBURG...
as a healthy, energy efficient, affordable town

Upcoming this fall . . .

Rebuilding Greensburg:
A Seminar Series on Affordable, Energy Efficient Construction Techniques

The U S Department of Energy's Building America program will be offering a special, five-part training series for builders and homeowners involved in rebuilding Greensburg as a healthy, energy efficient and affordable town.

Each seminar will include a 1/2-day tour of current re-construction projects in Greensburg where participants will learn about and examine best practice construction methods. The field visit will be followed by a 1/2-day in-class training session lead by residential construction experts from Building America project teams.

Part 1: House Design and Foundation Systems
- Date: September 8, 2007
- Location: TBD
- Topics will include:
  - An overview of energy efficient and affordable house design
  - Foundations and rainwater management

Part 2: Framing
- Date: to be announced
- Topics will include:
  - Advanced framing techniques
  - Choosing the right windows and doors

Part 3: Mechanical Systems and Airtightness
- Topics will include:
- Date: to be announced
  - Build tight, Ventilate right
  - Mechanical system design and selection

Part 4: Enclosure
- Topics will include:
- Date: to be announced
  - Insulation - theory and installation practices
  - Exterior cladding systems

Part 5: Finishes, Testing and Commissioning
- Topics will include:
- Date: to be announced
  - Measuring building performance
  - Whole house commissioning and homeowner training

For more information about the seminar series and early registration, please contact betsy@buildingscience.com

The U.S. Department of Energy's Building America Program is reengineering the American home for energy efficiency and affordability. Building America works with the residential building industry to develop and implement innovative building processes and technologies – innovations that save builders and homeowners millions of dollars in construction and energy costs. This industry-led, cost-shared partnership program uses a systems engineering approach to reduce energy use, utility bills, construction time, and construction waste.

For more information, visit our website at: www.buildingamerica.gov

B.9 Plan 1 - Three Bedroom, Basement, Greensburg, Kansas

Building Science Corporation

Greensburg, KS

PLAN 1 - THREE BEDROOM - BASEMENT

PROJECT DESCRIPTION

These plans describe an affordable, energy-efficient, and durable 1350 sq ft single-family home. The drawing set and specifications were developed by Building Science Corporation through the Department of Energy's Building America Program for the Building Greensburg Builder Workshop Series. The plans provide an example of how homes in Greensburg could be rebuilt as part of a healthy, energy efficient and affordable town. During project planning and construction, all efforts should be made to meet the goals of this project.

SQUARE FOOTAGES

BASEMENT	816 SQ FT
FIRST FLOOR	840 SQ FT
SECOND FLOOR	528 SQ FT

Notes: 1. Area calculations according to ANSI Z765-2003.
2. Finished square footage calculations for this house were made based on plan dimensions only and may vary from the finished square footage of the house as built.

DRAWING LIST

A-N NOTES, ASSEMBLIES & SPECIFICATIONS
A-1 FOUNDATION PLAN, BASEMENT PLAN, FIRST FLOOR FRAMING PLAN & DETAILS
A-2 FIRST & SECOND FLOOR PLANS, WALL FRAMING ELEVATIONS & CABINET ELEVATIONS
A-3 SECOND FLOOR FRAMING PLAN, ROOF FRAMING PLAN, ROOF PLAN & LANDING FRAMING PLAN
A-4 BUILDING ELEVATIONS
A-5 BUILDING SECTION
A-6 BUILDING SECTION & WALL SECTION
A-11 ADVANCED FRAMING DETAILS
A-12 ENCLOSURE DETAILS
A-13 WINDOW, DOOR & MECHANICAL PENETRATION DETAILS

M-1 MECHANICAL DUCT LAYOUT, NOTES & DETAILS

E-1 ELECTRICAL PLANS



DATE: 19 OCTOBER 2007

BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886
P: 978-589-5100 F: 978-589-5103

GENERAL REQUIREMENTS

1. ALL WORK SHALL COMPLY WITH FEDERAL, STATE AND LOCAL BUILDING CODES AND REGULATIONS.

2. MECHANICAL, ELECTRICAL AND PLUMBING WORK REQUIRED OF THIS PERMIT APPLICATION TO BE PERFORMED BY SUBCONTRACTOR LICENSED IN THE STATE IN WHICH WORK IS BEING PERFORMED.

3. SUBCONTRACTOR SHALL PROVIDE CERTIFICATION OF GENERAL LIABILITY INSURANCE AND WORKMAN'S COMPENSATION COVERAGE, AS REQUIRED BY THE GENERAL CONTRACTOR.

4. CONTRACTOR SHALL COORDINATE AND OBTAIN ALL BUILDING PERMITS REQUIRED FOR CONSTRUCTION AND CERTIFICATES OF OCCUPANCY.

5. CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR ALL CONSTRUCTION MEANS, METHODS, TECHNIQUES, AND PROCEDURES.

6. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL ASPECTS OF SAFETY DURING BUILDING CONSTRUCTION AND SHALL PROVIDE ADEQUATE SHORING AND BRACING TO ENSURE SUCH SAFETY.

7. ALL DIMENSIONS AND SITE CONDITIONS TO BE FIELD VERIFIED AND SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR. NOTIFY BUILDING SCIENCE CORPORATION OF AN DISCREPANCY PRIOR TO COMMENCEMENT OF WORK.

8. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO LOCATE ALL EXISTING UTILITIES WHETHER INDICATED ON PLANS OR NOT, AND TO PROTECT THEM FROM DAMAGE.

9. ALL DETAILS, SECTIONS, NOTES, OR REFERENCE TO OTHER DRAWINGS ARE INTENDED TO BE TYPICAL.

10. DURING CONSTRUCTION, AND PRIOR TO THE INCORPORATION OF ANY CHANGES, REVISIONS, MODIFICATIONS AND/OR DEVIATIONS FROM THE CONSTRUCTION DOCUMENTS, CONTRACTOR SHALL BRING TO THE ATTENTION OF BUILDING SCIENCE CORPORATION AND OBTAIN APPROVAL FROM THE GOVERNING BUILDING OFFICIAL BEFORE PROCEEDING WITH THE WORK.

11. THE MANUFACTURERS, PRODUCTS AND EQUIPMENT LISTED ESTABLISH PERFORMANCE REQUIREMENTS. SUBSTITUTIONS OF EQUAL PERFORMANCE MAY BE SUBMITTED FOR BUILDING SCIENCE CORPORATION'S APPROVAL.

12. ALL MATERIALS SHALL BE INSTALLED PER MANUFACTURER'S INSTRUCTIONS/SPECIFICATIONS UNLESS OTHERWISE SPECIFIED BY BUILDING SCIENCE CORPORATION.

13. SPECIFIC NOTES AND DETAILS ON DRAWINGS SHALL TAKE PRECEDENCE OVER GENERAL NOTES AND TYPICAL DETAILS. WHERE NO DETAILS ARE SHOWN, CONSTRUCTION SHALL CONFORM TO SIMILAR WORK ON THE PROJECT.

BUILDING AMERICA PERFORMANCE CRITERIA

REQUIREMENTS: DESIGN

RESIDENCES MUST REDUCE WHOLE HOUSE ENERGY USE (HVAC, HOT WATER, LIGHTING, AND ALL APPLIANCES/PLUG LOADS) AS STIPULATED IN THE TABLE BELOW:

PROJECT TYPE	PERCENT REDUCTION	ENERGY STAR INDEX
SINGLE HOMES	40%	60-65
COMMUNITIES	30%	70-75

WHOLE-HOUSE DILUTION VENTILATION: A MECHANICAL VENTILATION SYSTEM MUST BE INSTALLED TO BE CAPABLE OF MEETING ASHRAE STANDARD 62.2 WHICH STIPULATES A VENTILATION RATE OF 7.5 CFM PER PERSON (COUNTED AS THE NUMBER OF BEDROOMS PLUS ONE) PLUS 0.01 CFM PER SQUARE FOOT OF FLOOR AREA. WHILE 62.2 STIPULATES THAT OPERATION OF THE VENTILATION SYSTEM IS AT THE OCCUPANT'S DISCRETION AND THE STANDARD IS SILENT REGARDING WHOLE HOUSE DISTRIBUTION OF VENTILATION AIR, THIS PERFORMANCE CRITERIA STIPULATES THAT THE 62.2 VENTILATION FLOW RATE BE DELIVERED AT LEAST ONE-THIRD OF THE TIME AND THAT WHOLE HOUSE DISTRIBUTION IS REQUIRED.

LOCAL EXHAUST VENTILATION: INTERMITTENT SPOT EXHAUST OF 100 CFM MUST BE PROVIDED FOR EACH KITCHEN (RECIRCULATING COOKTOP HOODS ARE NOT PERMITTED). INTERMITTENT SPOT EXHAUST OF 50 CFM OR CONTINUOUS EXHAUST OF 20 CFM WHEN THE BUILDING IS OCCUPIED MUST BE PROVIDED FOR EACH ROOM HAVING A TOILET, BATH, OR SHOWER.

VENTILATION INTAKE LOCATIONS: WHEN A SUPPLY-ONLY OR BALANCED VENTILATION SYSTEM IS USED, THE INTAKE MUST GO THROUGH AN OUTSIDE WALL AND NOT THE ROOF (DUE TO PROXIMITY TO EXHAUST/VENT POLLUTANTS, AND HEATED AIR/MOC'S/ODORS FROM THE ROOF). WALL INTAKES SHOULD BE LOCATED AT LEAST 10 FEET FROM, AND NOT DIRECTLY ABOVE, ANY WALL EXHAUST OR VENT.

ALL COMBUSTION APPLIANCES (EXCEPT A GAS STOVE, COOKTOP OR OVEN) IN THE CONDITIONED SPACE MUST BE SEALED COMBUSTION. SPECIFICALLY, ANY FURNACE INSIDE CONDITIONED SPACE MUST BE A SEALED-COMBUSTION 90%+ AFUE UNIT. ANY WATER HEATER INSIDE CONDITIONED SPACE MUST BE DIRECT-POWER-VENTED. ANY BOILER INSIDE A CONDITIONED SPACE MUST BE SEALED COMBUSTION.

WINDOWS WITH THE FOLLOWING CLIMATE-SPECIFIC PERFORMANCE VALUES MUST BE USED:

CLIMATE ZONE	MAXIMUM U-VALUE	MAXIMUM SHGC
ZONES 1-3	0.40	0.35
ZONES 4-8	0.35	0.40

ALL DUCTS AND AIR HANDLING EQUIPMENT MUST BE IN THE CONDITIONED SPACE.

MAJOR APPLIANCES (REFRIGERATOR, CLOTHES WASHER, AND DISHWASHER) MUST ACHIEVE ENERGY STAR PERFORMANCE IN THE TOP ONE-THIRD OF THE DOE ENERGY GUIDE RATING SCALE.

ALL LIGHTING MUST BE ENERGY STAR QUALIFIED WITH THE FOLLOWING EXCEPTIONS: MOTION-SENSITIVE OUTDOOR SPOTLIGHTS AND SOLAR-POWERED ACCENT AND PATHWAY LIGHTING. LED TECHNOLOGY IS CURRENTLY NOT CERTIFIED BY ENERGY STAR. HOWEVER, LEDS ARE ACCEPTABLE.

CARBON MONOXIDE DETECTORS (HARD WIRED UNITS) MUST BE INSTALLED (AT ONE PER EVERY APPROXIMATE 1000 SQUARE FEET) IN ANY HOUSE CONTAINING COMBUSTION APPLIANCES OR AN ATTACHED GARAGE.

REQUIREMENTS: TESTING

BUILDING AMERICA TESTING OF THE HOUSE MUST BE COMPLETED AS PART OF THE COMMISSIONING PROCESS.

IN A PRODUCTION SETTING, EACH MODEL TYPE (i.e., FLOOR PLAN) MUST BE TESTED UNTIL TWO CONSECUTIVE HOUSES OF THIS MODEL TYPE MEET TESTING REQUIREMENTS. ADDITIONALLY, TESTING OF THIS MODEL TYPE CAN BE REDUCED TO A SAMPLING RATE OF 1 IN 7 (i.e., 1 TEST, WITH 6 "PREFERENCED" HOUSES). SMALL ADDITIONS TO A FLOOR PLAN (e.g., BAY WINDOW, CONVERSION OF DEN TO BEDROOM) ARE CONSIDERED TO BE THE SAME MODEL TYPE; MAJOR CHANGES (e.g., BONUS ROOM OVER THE GARAGE, CONVERSION OF GARAGE INTO A HOBBY ROOM, ETC.) MUST BE CONSIDERED A SEPARATE MODEL TYPE. UNIQUE OR CUSTOM HOUSE PLANS MUST BE INDIVIDUALLY TESTED.

AIR LEAKAGE (DETERMINED BY PRESSURIZATION TESTING) MUST BE LESS THAN 2.5 SQUARE INCHES/100 SQUARE FEET SURFACE AREA LEAKAGE RATIO (CGSB, CALCULATED AT A 10 PA PRESSURE DIFFERENTIAL); OR 1.25 SQUARE INCHES/100 SQUARE FEET LEAKAGE RATIO (ASTM, CALCULATED AT A 4 PA PRESSURE DIFFERENTIAL); OR 0.25 CFM/SQUARE FOOT OF BUILDING ENCLOSURE SURFACE AREA AT A 50 PASCAL AIR PRESSURE DIFFERENTIAL. THE CALCULATION OF THE BUILDING ENCLOSURE AREA INCLUDES THE FOUNDATION OR BELOW GRADE SURFACE AREAS. IF THE HOUSE IS DIVIDED INTO MULTIPLE CONDITIONED ZONES, SUCH AS CONDITIONED ATTICS OR CONDITIONED CRAWL SPACE, THE BLOWER DOOR REQUIREMENT MUST BE MET WITH THE ACCESS TO THE SPACE OPEN, CONNECTING THE ZONES.

TOTAL SPACE CONDITIONING SYSTEM DUCT LEAKAGE MUST BE LESS THAN FIVE PERCENT OF THE TOTAL AIR HANDLING SYSTEM RATED AIR FLOW AT HIGH SPEED (NOMINAL 400 CFM PER TON) DETERMINED BY PRESSURIZATION TESTING AT 25 PA. TWO COMPLIANCE MECHANISMS ARE ACCEPTABLE: (1) TEST TOTAL DUCT LEAKAGE AT FINISH STAGE, OR (2) TEST TOTAL DUCT LEAKAGE AT DUCT ROUGH-IN STAGE. WHEN MORE THAN ONE AIR HANDLER EXISTS, EACH AIR HANDLING SYSTEM MUST INDIVIDUALLY MEET THE REQUIREMENT. IF ZONING IS USED, ALL ZONE DAMPERS MUST BE OPEN. MANUAL OR MOTORIZED OUTSIDE AIR VENTILATION DAMPERS MUST BE CLOSED.

LOCAL AND WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOWS MUST BE TESTED DURING COMMISSIONING OF THE BUILDING.

FORCED AIR SYSTEMS THAT DISTRIBUTE AIR FOR HEATING MUST BE DESIGNED TO PROVIDE BALANCED AIRFLOW TO ALL CONDITIONED SPACES AND ZONES (BEDROOMS, HALLWAYS, BASEMENTS). BALANCED AIRFLOW IS DEFINED AS A SYSTEM THAT CONTROLS INTER-ZONAL AIR PRESSURE DIFFERENCES WHEN DOORS ARE CLOSED TO LESS THAN 3 PA USING PASSIVE TRANSFER GRILLES, JUMP DUCTS, DOOR UNDERCUTS OR ACTIVE RETURN DUCTS OR ANY COMBINATION THEREOF.

SYSTEM EXTERNAL STATIC PRESSURE MUST BE WITHIN MANUFACTURERS SPECIFICATIONS (0.5 WC/125 PA MAXIMUM TYPICAL).

GENERAL CONSTRUCTION NOTES

CIVIL NOTES:

DEBRIS - REMOVE DEBRIS WITHIN 2'-0" OF BUILDING.

EXTERIOR GRADE - SLOPE GRADE 5% TO DRAIN AWAY FROM BUILDING.

SOIL GAS CONTROL - ALL WALLS, ROOF AND FLOORS IN CONTACT WITH THE GROUND SHALL BE CONSTRUCTED TO RESIST THE LEAKAGE OF SOIL GAS FROM THE GROUND TO THE BUILDING. A PASSIVE SUB-SLAB DEPRESSURIZATION SYSTEM IN ACCORDANCE WITH THE SUPPLEMENTARY GUIDELINES SHALL BE PROVIDED, 1 VENT PIPE, MIN. 3" DIAMETER, PER 1500 SF OF SLAB AREA. VENT STRAIGHT UP THRU ROOF.

STRUCTURAL NOTES:

CONCRETE - ALL CONCRETE TO HAVE A WATER/CEMENT RATIO OF LESS THAN 0.5 AND 10% FLY ASH PORTLAND CEMENT REPLACEMENT.

FOOTINGS - ALL FOOTINGS SHALL REST ON NATIVE, UNDISTURBED SOIL AND WILL BE A MIN. OF 48" BELOW FINISHED GRADE OR IN ACCORDANCE WITH LOCAL BUILDING CODE. APPLY LIQUID APPLIED CAPILLARY BREAK (MUST DRY TACK FREE) ON TOP OF FOOTING PRIOR TO PLACING/CASTING CONCRETE FOUNDATION WALL.

STEP FOOTINGS - HORIZONTAL STEP = 24" MAX.
- VERTICAL STEP = 24" MAX.

FOUNDATION WALLS - 8" WIDE CONCRETE WALL WITH 2 1/2" DEEP VERTICAL SAW-CUT CONTROL JOINTS ON INTERIOR FACE OF WALL. LOCATE JOINTS 18" FROM EVERY CORNER AND 20' MAX. ALONG LENGTH OF WALL SEGMENT.

DRAIN TILE - 4" DIA. PIPE, 3/4" CRUSHED STONE (NO FINES), 6" MIN. PIPE COVER. LOCATE 4" DIA. DRAIN TILE CONNECTION PIPE THROUGH BASE OF FOOTING WITHIN 5' OF EVERY CORNER AND EVERY 15' MAX. ALONG LENGTH OF WALL SEGMENT WITH MIN. 1 PER WALL SEGMENT.

~~CRAWLSPACE FLOOR - 6 mil POLYETHYLENE SHEET ON 6" CLEAN CRUSHED STONE PAD.~~

~~CRAWLSPACE WALL - 8", 2200 P.S.I. POURED CONCRETE W/ BITUMINOUS DAMPPROOFING.~~
~~- FILL AND SEAL ALL TIE HOLES.~~
~~- TOP OF FOUNDATION WALL TO BE 8" MIN. ABOVE FINISHED GRADE.~~

SILL PLATE - 2x6 TREATED SILL PLATE WITH 1/2" DIA. ANCHOR BOLTS 12" LONG, SET MIN. 4" INTO CONCRETE AND SPACED AT 6' O.C MAX. PROVIDE CAPILLARY BREAK BETWEEN SILL PLATE AND CONCRETE, 6 mil POLY OR EQUAL.

ANCHOR BOLTS - PROVIDE 1/2" DIA. ANCHOR BOLTS 12" LONG, SET MIN. 4" INTO CONCRETE SPACED AT 6' O.C. MAX. TWO BOLTS MIN. PER PLATE SECTION WITH ONE BOLT LOCATED NOT MORE THAN 12" OR LESS THAN SEVEN BOLT DIAMETERS FROM EACH END OF THE PLATE SECTION.

BEARING STUD PARTITION - 2x6 STUDS AT 24" O.C.

STEEL COLUMN - 3" DIA. HSS ON 3'-0" x 3'-0" x 12" CONCRETE PAD W/ (4) #5 REBAR EACH WAY.

CONCRETE SLAB - 4" CONCRETE SLAB WITH SAW-CUT CONTROL JOINTS SPACED AT 20' MAX. AND SAW-CUT COLUMN ISOLATION JOINTS.

~~PORCH SLAB - 4" CONC. SLAB - 4650 P.S.I. @ 28 DAYS, 5-8% AIR ENTRAINMENT ON COMPACTED CRUSHED STONE. SLOPE SLAB 1" MIN. AWAY FROM HOUSE.~~

~~GARAGE SLAB - 4" CONC. SLAB ON COMPACTED CRUSHED STONE WITH FIBERMESH REINFORCING - 4650 P.S.I. @ 28 DAYS, 5-8% AIR ENTRAINMENT, SLOPE SLAB 3" MIN TO FRONT.~~

BEAMS AND LINTELS - SUPPORT FULL WIDTH TO FOUNDATION.

ARCHITECTURAL NOTES:

~~GAVESTROUGH - ALUMINUM GAVESTROUGH ON 2x6 WOOD FASCIA BOARD.~~

DRIP EDGE - PROVIDE 1" DRIP EDGE ON FLASHING OVER OPENINGS IN EXTERIOR WALLS.

~~ATTIC ACCESS - OPENING 20" x 28" MIN. WITH WEATHERSTRIPPING AND INSULATION.~~

WOOD PROTECTION - WOOD FRAMING MEMBERS THAT ARE NOT PRESSURE TREATED WITH A WOOD PRESERVATIVE AND WHICH ARE SUPPORTED ON CONCRETE IN CONTACT WITH THE GROUND SHALL BE SEPARATED FROM THE CONCRETE BY AT LEAST 6 mil POLY FILM OR EQUAL.

STAIR DIMENSIONS (ALL INTERIOR AND EXTERIOR STAIRS)
MIN. RISE - 5"
MAX. RISE - 7 3/4"
MIN. RUN - 8 1/4"
MAX. RUN - 1'-1 7/8"
MIN. TREAD - 10"
MAX. TREAD - 1'-1 7/8"
MAX. NOSING - 1"
MIN. HEADROOM - 6'-5"
MIN. WIDTH - 2'-10"

HANDRAILS AND GUARDS
- MIN. HEIGHT - 2'-11"
- A CLEARANCE OF NOT LESS THAN 2" SHALL BE PROVIDED BETWEEN HANDRAIL AND ANY SURFACE BEHIND IT.

BEDROOM EGRESS - MIN. ONE WINDOW PER BEDROOM LEVEL SHALL PROVIDE AN INDIVIDUAL UNOBSTRUCTED OPEN PORTION HAVING A MIN. AREA OF 5.8 sq. ft. AND HAVING NO DIMENSION LESS THAN 1'-3" (NOT APPLICABLE IF THERE IS A DOOR W/ DIRECT ACCESS TO THE EXTERIOR ON THAT LEVEL).

INTERIOR DOORS - UNDERCUT ALL DOORS 3/4" MIN.

COAT CLOSETS - (1) ROD AND (1) SHELF MIN.

LINEN CLOSETS - (4) SHELVES MIN. AND 1'-2" DEEP MIN.

MINIMUM HEADROOM - 6'-5" BELOW ALL BEAMS AND DUCTS.

MECHANICAL, ELECTRICAL, AND PLUMBING NOTES:

EXHAUST FANS - VENT TO EXTERIOR.

RANGE HOODS - VENT TO EXTERIOR W/ NON-COMBUSTABLE DUCT.

DRYER VENT - CAPPED AND SCREENED DRYER VENT, DUCTING INSTALLED TO SLOPE TO EXTERIOR.

SMOKE DETECTORS - LOCATE ON EACH FLOOR LEVEL AND INTERCONNECT.

CONSTRUCTION ASSEMBLIES

CONSTRUCTION SHALL CONFORM TO BUILDING AMERICA SPECIFICATIONS (UNITED STATES DEPARTMENT OF ENERGY) AND ASSEMBLIES AS LISTED BELOW:

FOUNDATION WALLS - FOUNDATION WILL BE A CONDITIONED BASEMENT. BASEMENT WALLS WILL BE CAST-IN-PLACE CONCRETE W/ 2" RIGID FOIL-FACED POLYISOCYANURATE INSULATION (R-13) RATED TO BE EXPOSED FOR FLAME SPREAD AND SMOKE DEVELOPED.

BASEMENT FLOOR SLAB - 4" CONCRETE SLAB OVER 6 MIL POLYETHYLENE VAPOR BARRIER OVER 6" CLEAN CRUSHED STONE PAD ON UNDISTURBED / NATIVE SOIL.

FRAME WALL CONSTRUCTION - EXTERIOR WALLS SHALL BE FRAMED WITH 2X6 STUDS AT 24" O.C.. CAVITY SHALL BE INSULATED WITH CELLULOSE TO R-19 (R-19 UNFACED FIBERGLASS BATT IS A SUITABLE SUBSTITUTION). EXTERIOR WALLS SHALL BE SHEATHED WITH ONE (1) 1 1/2" LAYER XPS RIGID INSULATION (R-7.5). 1/2" OSB OR PLYWOOD AND 1" XPS RIGID INSULATION SHALL BE INSTALLED AT THE CORNERS. USE DOW WEATHERMATE FLASHING TAPE AT HORIZONTAL JOINTS AND CORNERS (EXTERIOR AND INTERIOR), AT EXTERIOR FACE OF INSULATING SHEATHING AND DOW WEATHERMATE CONSTRUCTION TAPE AT VERTICAL JOINTS AT EXTERIOR FACE OF INSULATING SHEATHING.

ROOF CONSTRUCTION - ROOF SHALL BE FRAMED WITH 2X12 ROOF RAFTERS. RAFTERS SHALL BE INSULATED WITH CELLULOSE TO R-30 (R-30 FIBERGLASS BATT IS A SUITABLE SUBSTITUTION). ONE (1) 1" LAYER XPS (R-5) TO BE INSTALLED CONTINUOUSLY WITH ALL JOINTS TAPED WITH DOW WEATHERMATE CONSTRUCTION TAPE BELOW THE ROOF RAFTERS. GWB TO BE INSTALLED CONTINUOUSLY BELOW INSULATION.

INTERIOR NON-LOAD BEARING PARTITION CONSTRUCTION - 2X4 STUDS AT 24" O.C. WITH ONE (1) LAYER 1/2" GWB EACH SIDE.

TYP. FLOOR CONSTRUCTION - 7/8" T&G OSB SUBFLOOR ON TOP OF 9 1/2" DEEP ENGINEERED FLOOR JOIST WITH ONE (1) LAYER 1/2" GWB BELOW JOIST.

DOOR SPECIFICATION

A. EXTERIOR ENTRY DOORS:
1. INSULATED STEEL AND WEATHERSTRIPPED
2. OPEN FROM INSIDE WITHOUT KEY
3. PROVIDE VIEWER UNLESS TRANSPARENT GLASS IS PROVIDED IN DOOR OR SIDELITE

B. INTERIOR DOORS:
1. HOLLOW CORE

DOOR SCHEDULE

SIZE	TYPE	QUANTITY
3068	EXTERIOR	2
2868	EXTERIOR	1
2668	INTERIOR	8
2068	INTERIOR LOUVERED	9

WINDOW SPECIFICATION

ALL WINDOWS SHALL BE SPECTRALLY SELECTIVE LOW-E DOUBLE GLAZED VINYL FRAMED WITH THE FOLLOWING PERFORMANCE VALUES FROM THE NATIONAL FENESTRATION RATING COUNCIL (NFRC):

CLIMATE ZONE 4:
U-VALUE = 0.35 OR LESS
SOLAR HEAT GAIN COEFFICIENT (SHGC) = 0.40 OR LESS

1. CONFIRM R.O. SIZES WITH WINDOW MANUFACTURER AND ADJUST WALL FRAMING ACCORDINGLY.

2. SEE 4/A-13 FOR WINDOW INSTALLATION DETAILS.

3. 3050 SINGLE HUNG WINDOW MUST MEET IRC R310 REQUIREMENTS FOR EMERGENCY ESCAPE AND RESCUE OPENINGS.

WINDOW SCHEDULE

SIZE	TYPE	QUANTITY
3030	SINGLE HUNG	4
3050	SINGLE HUNG	11
4040	SLIDING	2

PRODUCT SPECIFICATION

	Product Type	Specified Product
A	Adhesive	
	Construction Adhesive	Polyseamseal All Purpose Adhesive Caulk, PL 200® Construction Adhesive or Equal
	Foam-Compatible Construction Adhesive	Liquid Nails Foamboard & Projects Adhesive (LN-604), PL 300® Foam Board Adhesive or Equal
	Attic Rafter Vent	TuffVENT, Owens Corning Raft-R-Mate or Equal
B	Backer Board	
	Cement Backer Board	USG Durock, WonderBoard Cement Backerboard or Equal
	Fiber Cement Backer Board	James Hardie HardieBacker Cement Board or Equal
C	Capillary Break (Footing-Liquid Applied)	W.R. Meadows SEALMASTIC Emulsion-Type or Solvent-Type Dampproofing or Equal
	Capillary Break (Slil)	
	Polyethylene	6 mil Polyethylene or Equal
	Foam	Dow Styrofoam Sill Seal, Owens Corning FoamSealR or Equal
	Cellulose Insulation (Borate-Treated Product Only)	
	Damp Sprayed	US GreenFiber BNS735 Cocoon2 Stabilized Borate Formula-30 lbs. or Equal
	Loose Blown	US GreenFiber BNS735 Cocoon2 Stabilized Borate Formula-30 lbs. or Equal
	Cladding Vent	Cor-A-Vent Siding Vent 5V-3/5 or Equal
D	Dampproofing (Liquid Applied Bituminous)	W.R. Meadows SEALMASTIC Emulsion-Type or Solvent-Type Dampproofing or Equal
E	Expanding Polyurethane Foam Sealant	
	High Expansion	Dow Great Stuff Big Gap Filler or Equal
	Low Expansion	Dow Great Stuff Window & Door or Equal
	Extruded Polystyrene Foam (XPS)	Dow Styrofoam or Owens Corning Foamular
F	Filter Fabric	DuPont Landscape PRO Professional Grade Landscape Fabric or Equal
	Flashing	
	Metal Flashing	York Manufacturing Sole!® Copper-Aluminum Flashing or Equal
	Pre-Manufactured Sill Pan Flashing	Dow Weathermate Sill Pan or Equal
	Self Adhered Flashing	
	Formable Flashing	DuPont FlexWrap, Dow Weathermate Flexible Flashing or Equal
	Straight Flashing	W.R. Grace Vycor Plus, DuPont StraightFlash, Dow Weathermate Straight Flashing or Equal
	Fiberglass Insulation	
	Batts	Owens Corning PINK FIBERGLAS® Unfaced, Johns Manville Formaldehyde-free™Isella Unfaced, Certainteed High-Performance Batts Unfaced
	Loose Fill	Owens Corning PINK FIBERGLAS®, Johns Manville Formaldehyde-free™ Climate Pro®/Attic Protector®, Certainteed InsulSafe® or Equal
	Foundation Drainage Mat	Cosella-Dorken Delta-MS, System Platon or Equal
	Fully-Adhered Waterproofing Membrane	W.R. Grace Ice and Water Shield or Equal
G	Gypsum Wall Board (GWB)	
	Paper Faced Gypsum Wall Board (GWB)	Sheetrock Brand Gypsum Panels or Equal
	Paperless Gypsum Wall Board (PGWB)	Georgia Pacific DensArmor Plus
H	Housewrap (Non-Micro Perforated Plastic)	
	Draining Housewrap	DuPont Tyvek Drainwrap
	Housewrap	DuPont Tyvek Homewrap, Fiberweb Typar HouseWrap, Dow Weathermate Plus, Johns Manville Gorilla Wrap, FortiFiber WeatherSmart
K	Kick-Out Diverter	Berger Kick-Out Diverter or Equal
R	Ridge Vent	Cor-A-Vent X-5 Extreme Ridge Vent, Trim Line Ridge Vents or Equal
	Rigid Polyisocyanurate	
	Foil Faced	Dow Tuff-R or Thermax
	Glass Fiber Faced	Dow Quik-R or Equal
S	Sealant	
	Air-Barrier Sealant	Tremco Acoustical Sealant or Equal
	Paintable Sealant	Polyseamseal All Purpose Adhesive Caulk, Sashco Sealants Big Stretch, Geosel ProCOLOR™ Tripolymer Sealant or Equal
	Urethane Sealant	Bostik Chem-Calk 955-SL Polyurethane Sealant or Equal
	Spray Polyurethane Foam	
	Closed Cell Spray Foam	Demilec Heatlok 2lbs/cubic foot or Equal
	Open Cell Spray Foam	Icynene 0.5 lbs/cubic foot or Equal
T	Tape	
	Builder's Sheathing Tape	Tyvek Tape, Dow Weathermate Construction Tape, 3M Contractor's Tape or Equal
	Foil Tape	3M Aluminum Foil Tape 1449 or Equal
	Thin Profile Sheathing	Thermoply or Equal

Building America

WORKS:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

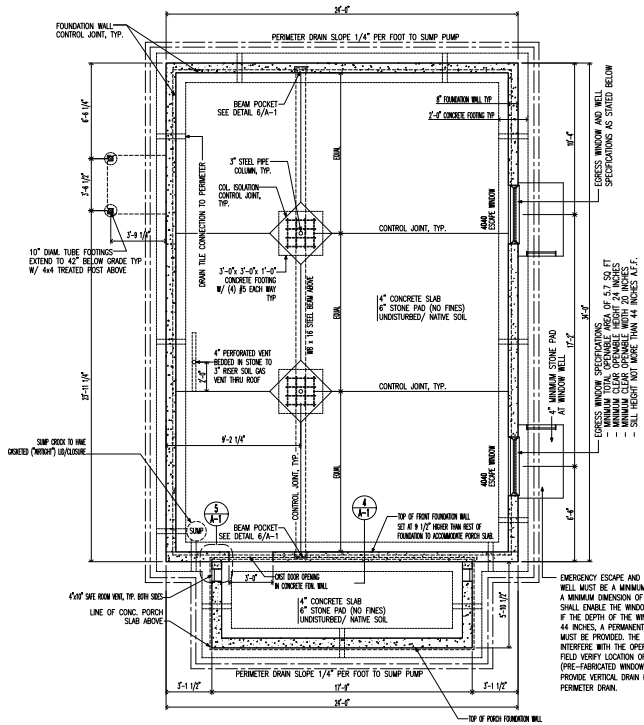
Notes, Assemblies & Specifications

SCALE AS NOTED

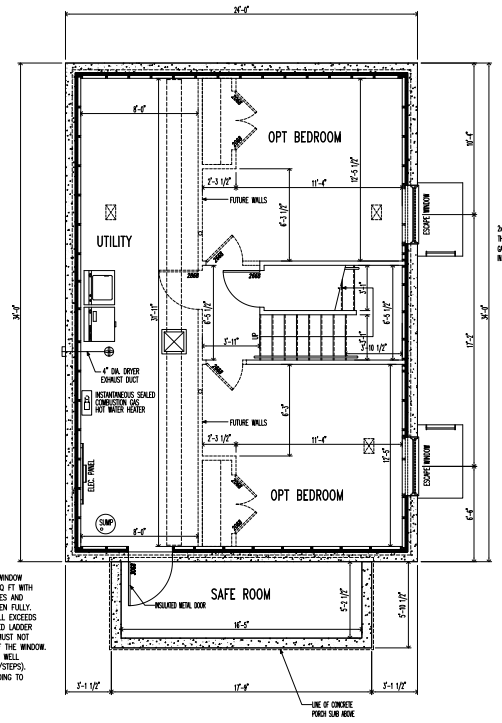
COPYRIGHT © 2007
BUILDING SCIENCE CORPORATION

A-N

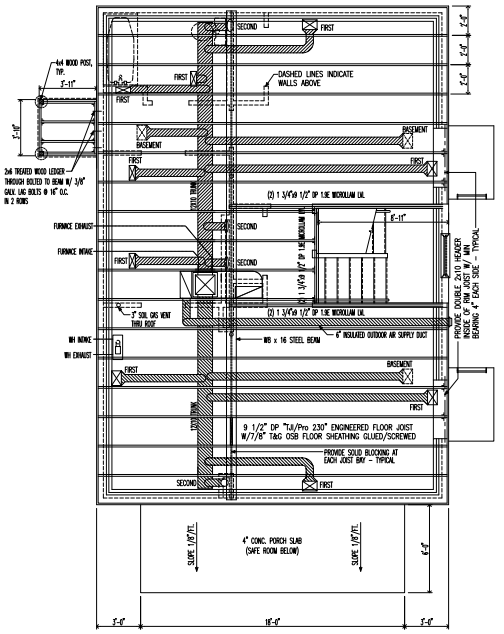
FILE: KS GREENSBURG 1.DWG



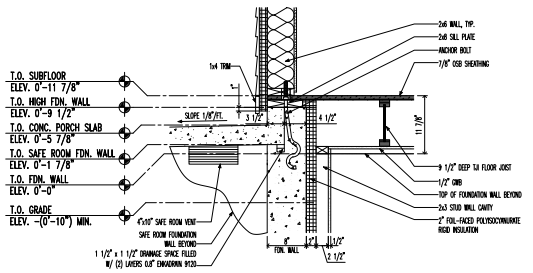
1 | FOUNDATION PLAN
SCALE 1/4" = 1'-0"



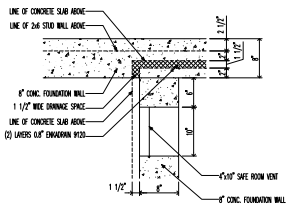
2 | BASEMENT PLAN
SCALE 1/4" = 1'-0"



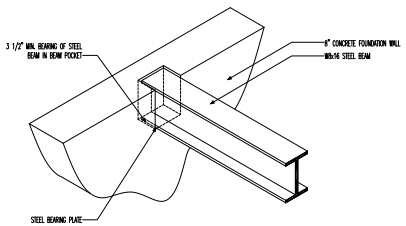
3 | FIRST FLOOR FRAMING PLAN
SCALE 1/4" = 1'-0"



4 | CONCRETE PORCH SLAB / FOUNDATION WALL SECTION DETAIL
SCALE 1" = 1'-0"



5 | FOUNDATION WALL DRAINAGE DETAIL
SCALE 1" = 1'-0"



6 | BEAM POCKET DETAIL
SCALE 1" = 1'-0"

Built in America

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

ARCHITECT:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

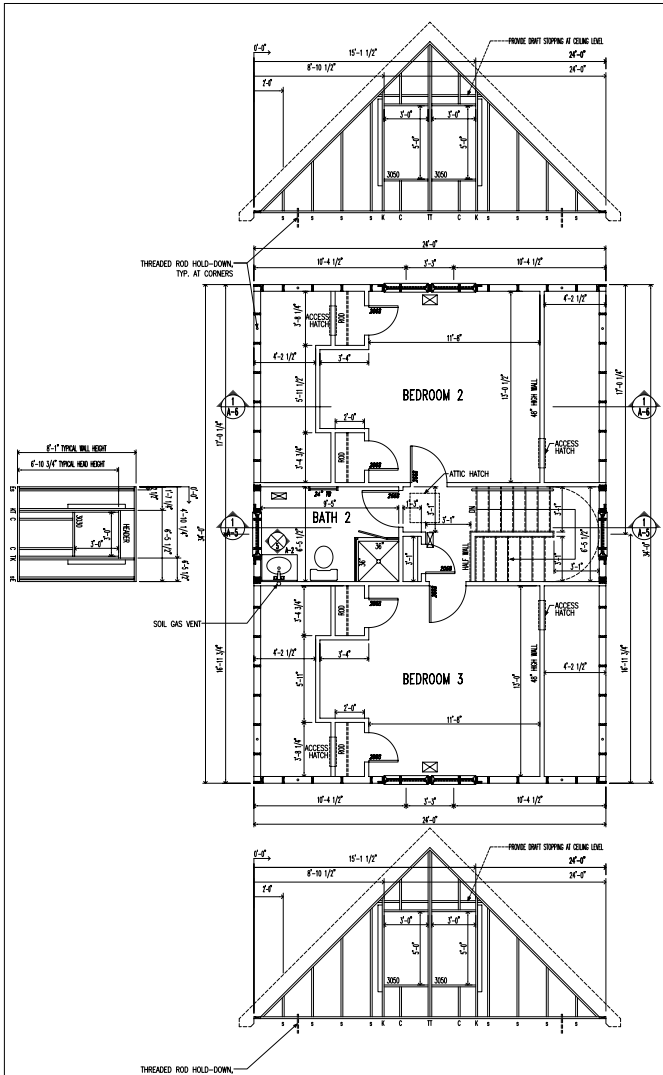
Foundation Plan, Basement Plan & First Floor Framing Plan & Details

SCALE AS NOTED

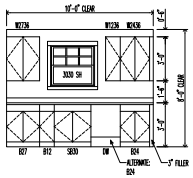
COPYRIGHT © 2007 BUILDING SCIENCE CORPORATION

A-1

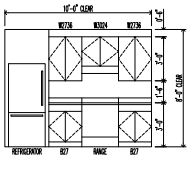
FILE: KS GREENSBURG 1.DWG



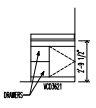
2 | SECOND FLOOR PLAN & WALL FRAMING ELEVATIONS
SCALE 1/4" = 1'-0"



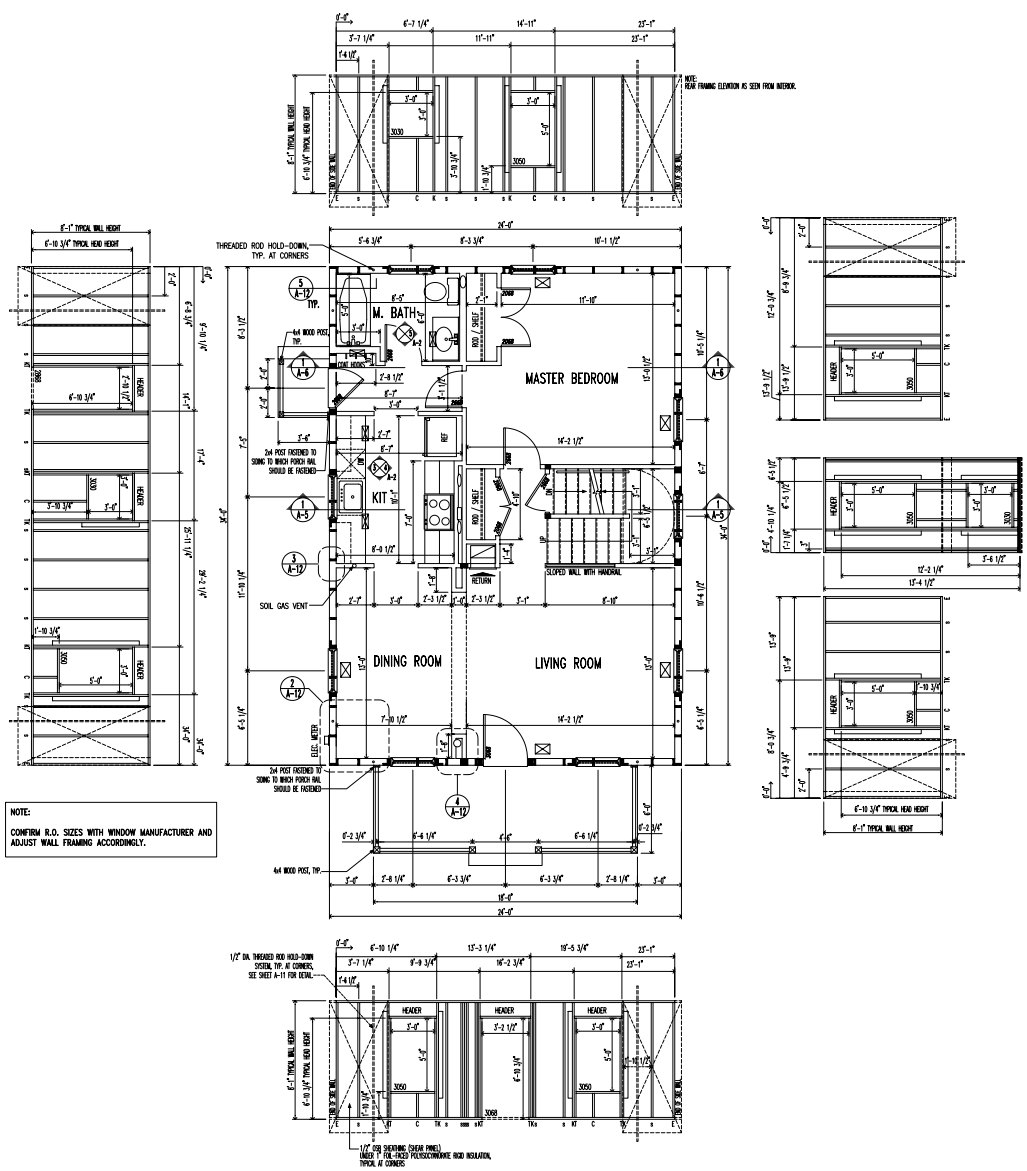
3 | KITCHEN ELEVATION
SCALE 1/4" = 1'-0"



4 | KITCHEN ELEVATION
SCALE 1/4" = 1'-0"



5 | VANITY ELEVATION
SCALE 1/4" = 1'-0"



1 | FIRST FLOOR PLAN & WALL FRAMING ELEVATIONS
SCALE 1/4" = 1'-0"

Built in America

PROJECT: REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

PROJECT: BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

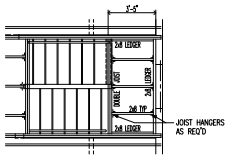
First & Second Floor Plans, Wall Framing Elevations & Cabinet Elevations

SCALE AS NOTED

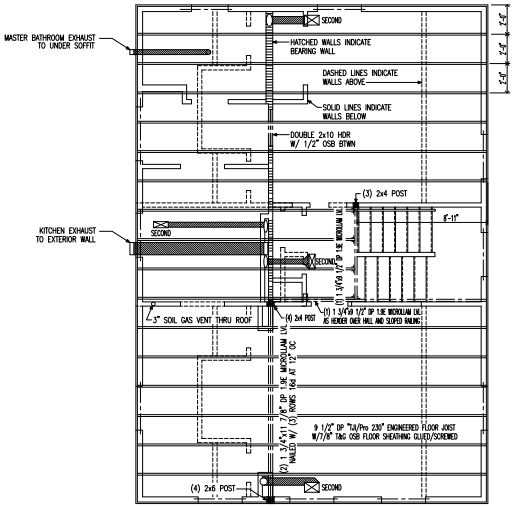
COPYRIGHT © 2007 BUILDING SCIENCE CORPORATION

A-2

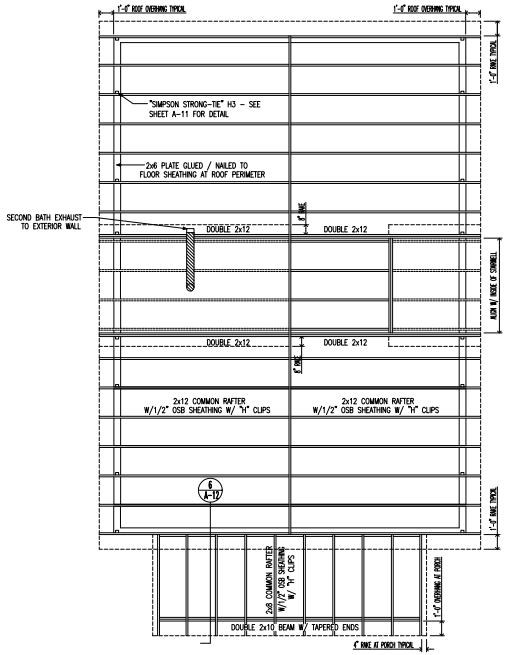
FILE: KS GREENSBURG 1.DWG



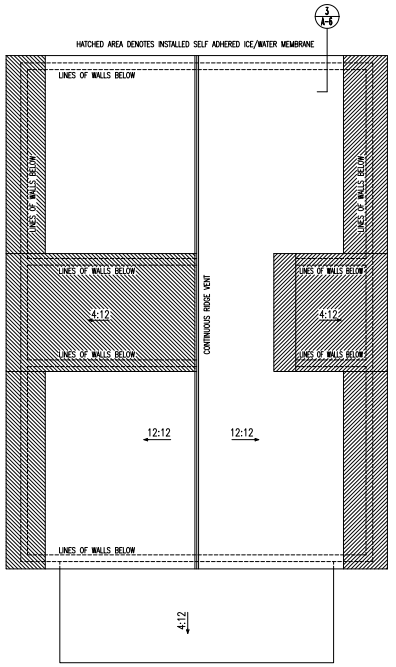
4 | LANDING FRAMING PLAN
SCALE 1/4" = 1'-0"



1 | SECOND FLOOR FRAMING PLAN
SCALE 1/4" = 1'-0"



2 | ROOF FRAMING PLAN
SCALE 1/4" = 1'-0"



3 | ROOF PLAN
SCALE 1/4" = 1'-0"

BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

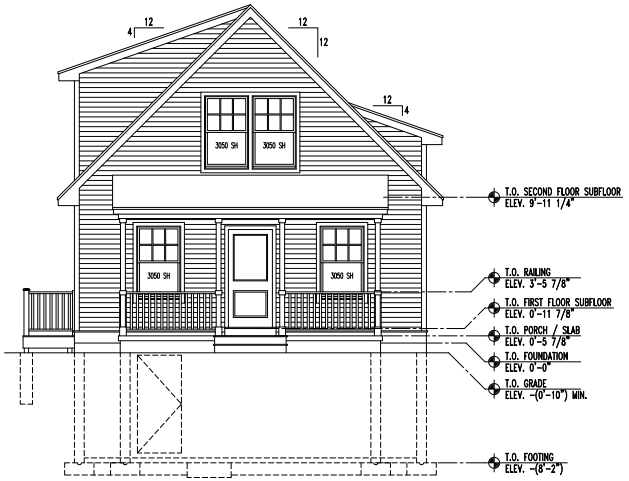
Second Floor Framing Plan, Roof Framing Plan, Roof Plan & Landing Framing Plan

SCALE AS NOTED

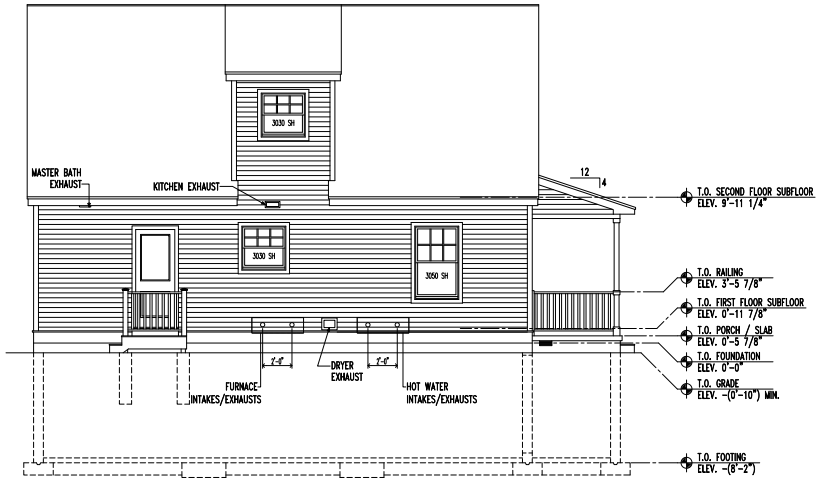
COPYRIGHT © 2007 BUILDING SCIENCE CORPORATION

A-3

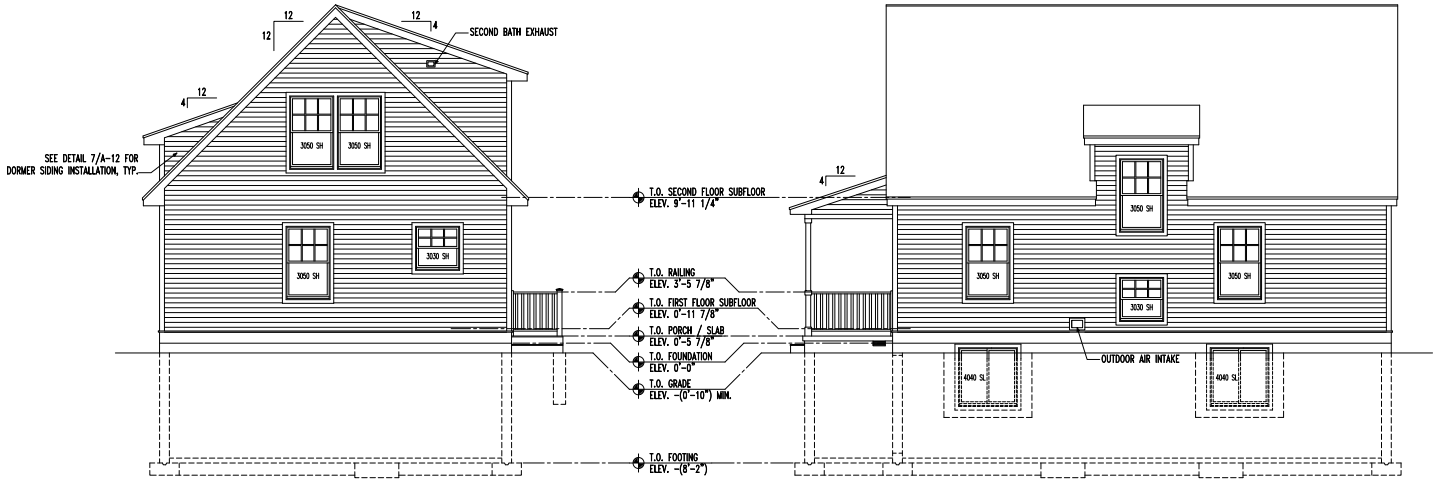
FILE: KS GREENSBURG 1.DWG



1 | FRONT ELEVATION
SCALE 1/4" = 1'-0"



2 | LEFT SIDE ELEVATION
SCALE 1/4" = 1'-0"



3 | REAR ELEVATION
SCALE 1/4" = 1'-0"

4 | RIGHT SIDE ELEVATION
SCALE 1/4" = 1'-0"

Built in the USA

ARCHITECT:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

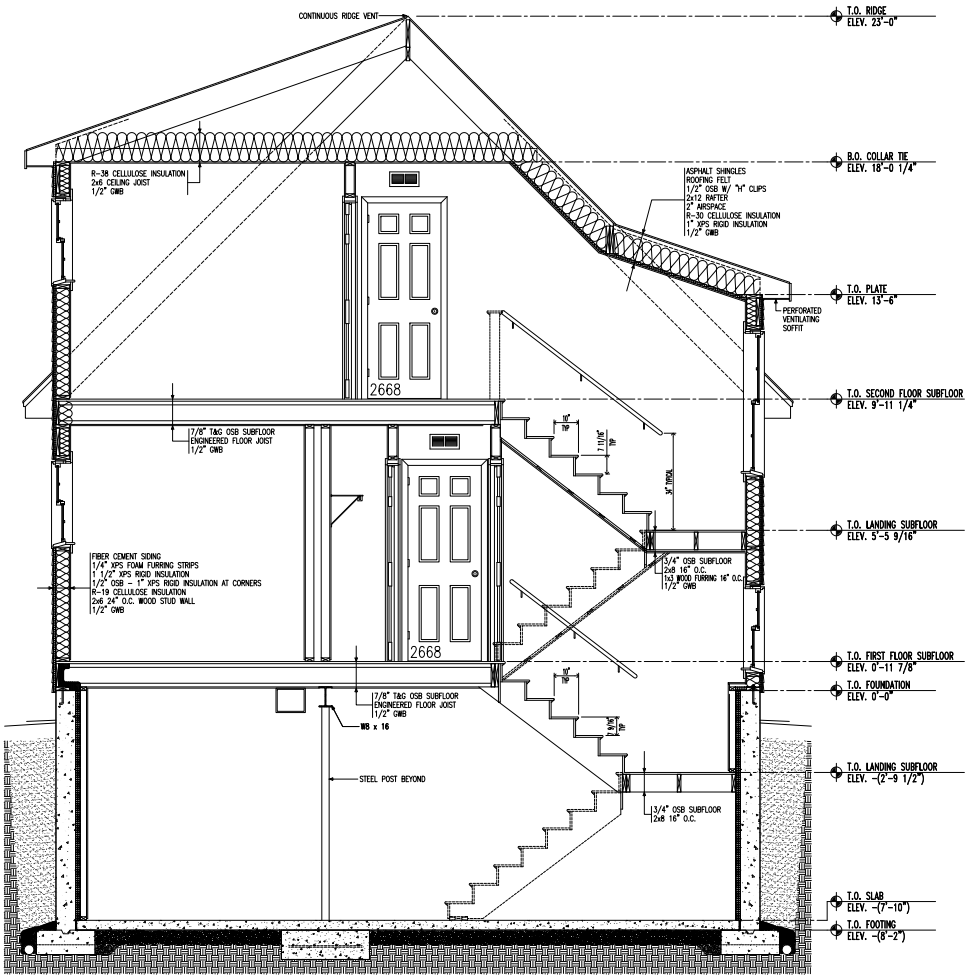
Building Elevations

SCALE AS NOTED

COPYRIGHT © 2007
BUILDING SCIENCE CORPORATION

A-4

FILE: KS GREENSBURG 1.DWG



1 BUILDING SECTION
SCALE 1/2" = 1'-0"

ARCHITECT:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

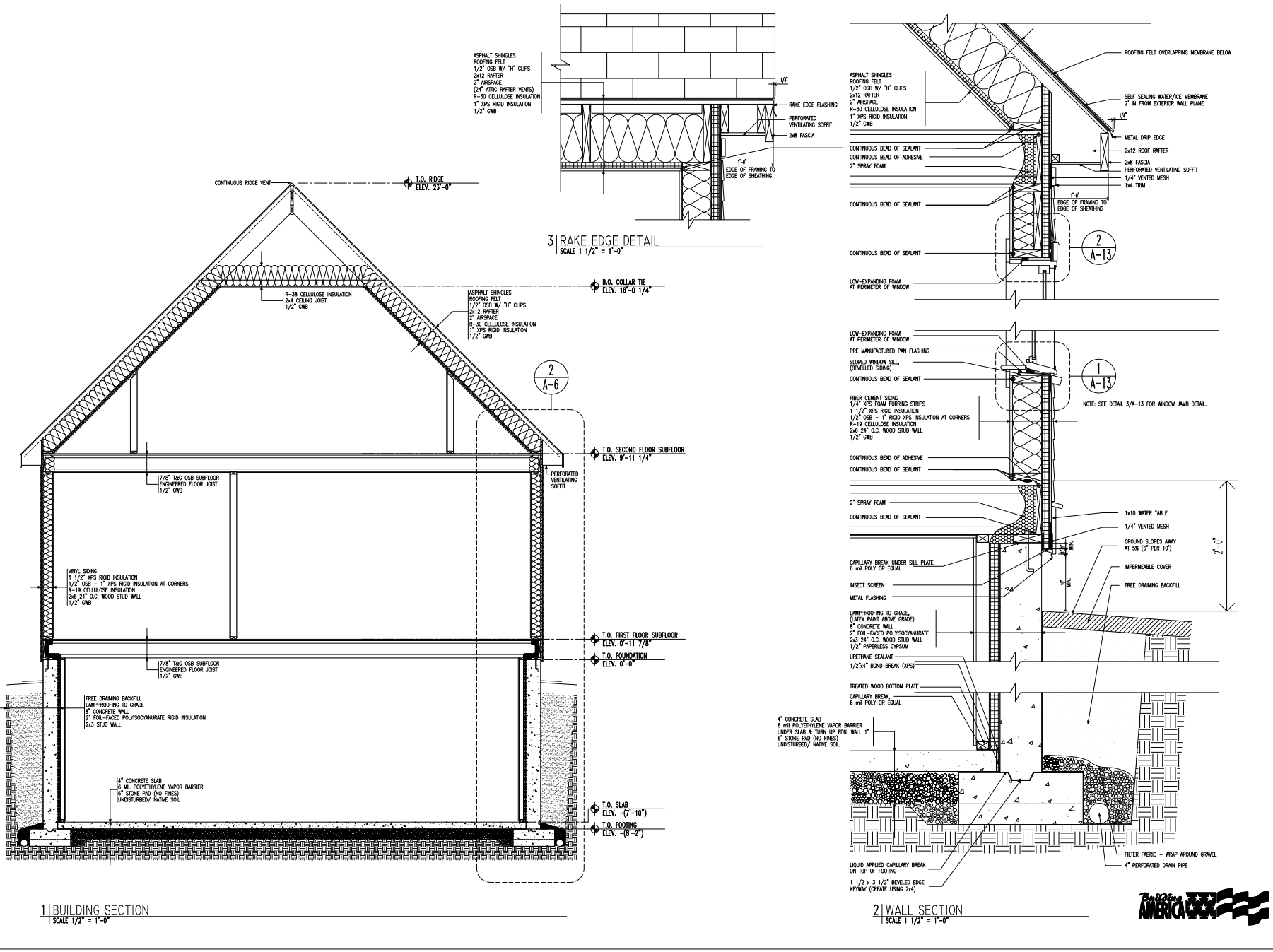
Building Section

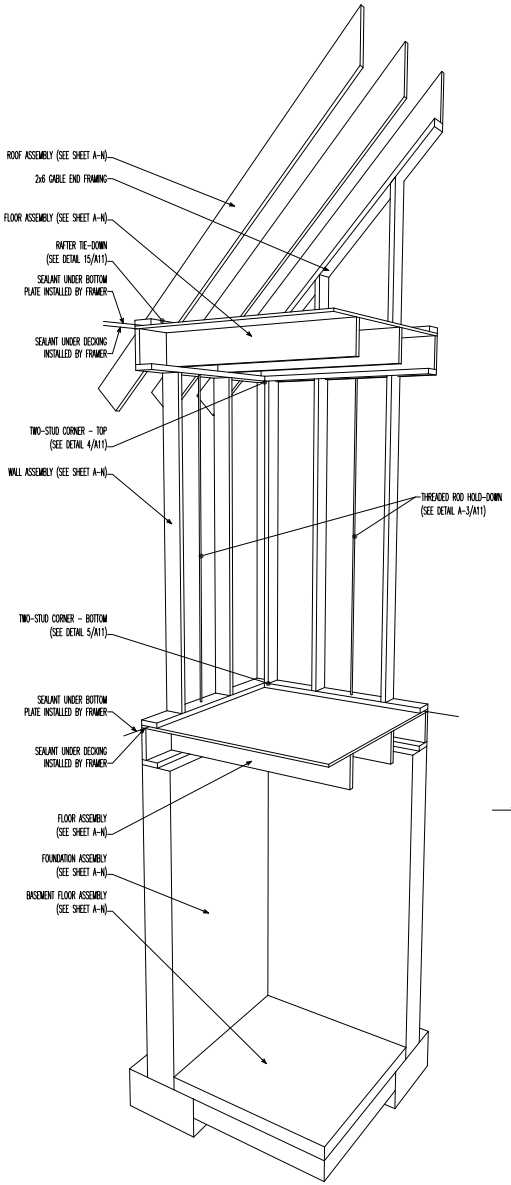
SCALE AS NOTED

COPYRIGHT © 2007
BUILDING SCIENCE CORPORATION

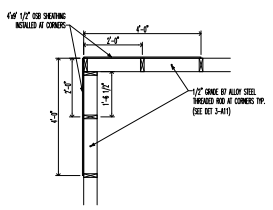
A-5

FILE: KS GREENSBURG 1.DWG

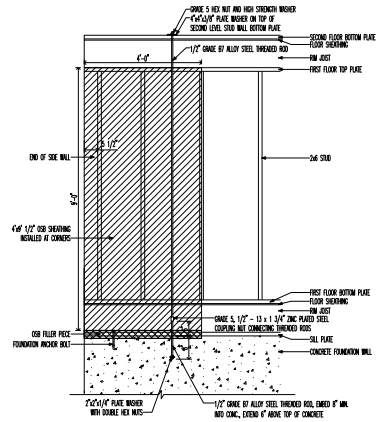

ASPHALT SHINGLES
ROOFING FELT
1/2" OSB W/ "H" CLIPS
2x12 RAFTER
2" AIRSPACE
(24" ATTIC RAFTER VENTS)
R-30 CELLULOSE INSULATION
1" XPS RIGID INSULATION
1/2" GWB
1/4"
RAKE EDGE FLASHING
PERFORATED VENTILATING SOFFIT
2x8 FASCIA
1'-0"
EDGE OF FRAMING TO EDGE OF SHEATHING
3 RAKE EDGE DETAIL
SCALE 1 1/2" = 1'-0"
CONTINUOUS RIDGE VENT
T.O. RIDGE
ELEV. 23'-0"
B.O. COLLAR TIE
ELEV. 18'-0 1/4"
R-38 CELLULOSE INSULATION
2x4 CEILING JOIST
1/2" GWB
ASPHALT SHINGLES
ROOFING FELT
1/2" OSB W/ "H" CLIPS
2x12 RAFTER
2" AIRSPACE
R-30 CELLULOSE INSULATION
1" XPS RIGID INSULATION
1/2" GWB
2
A-6
T.O. SECOND FLOOR SUBFLOOR
ELEV. 9'-11 1/4"
7/8" T&G OSB SUBFLOOR
ENGINEERED FLOOR JOIST
1/2" GWB
PERFORATED VENTILATING SOFFIT
VINYL SIDING
1 1/2" XPS RIGID INSULATION
1/2" OSB – 1" XPS RIGID INSULATION AT CORNERS
R-19 CELLULOSE INSULATION
2x6 24" O.C. WOOD STUD WALL
1/2" GWB
T.O. FIRST FLOOR SUBFLOOR
ELEV. 0'-11 7/8"
T.O. FOUNDATION
ELEV. 0'-0"
7/8" T&G OSB SUBFLOOR
ENGINEERED FLOOR JOIST
1/2" GWB
FREE DRAINING BACKFILL
DAMPPROOFING TO GRADE
8" CONCRETE WALL
2" FOIL-FACED POLYISOCYANURATE RIGID INSULATION
2x3 STUD WALL
4" CONCRETE SLAB
6 MIL POLYETHYLENE VAPOR BARRIER
6" STONE PAD (NO FINES)
UNDISTURBED/ NATIVE SOIL
T.O. SLAB
ELEV. -(7'-10")
T.O. FOOTING
ELEV. -(8'-2")
1 BUILDING SECTION
SCALE 1/2" = 1'-0"
ROOFING FELT OVERLAPPING MEMBRANE BELOW
ASPHALT SHINGLES
ROOFING FELT
1/2" OSB W/ "H" CLIPS
2x12 RAFTER
2" AIRSPACE
R-30 CELLULOSE INSULATION
1" XPS RIGID INSULATION
1/2" GWB
SELF SEALING WATER/ICE MEMBRANE
2" IN FROM EXTERIOR WALL PLANE
1/4"
METAL DRIP EDGE
2x12 ROOF RAFTER
2x8 FASCIA
PERFORATED VENTILATING SOFFIT
1/4" VENTED MESH
1x4 TRIM
CONTINUOUS BEAD OF SEALANT
CONTINUOUS BEAD OF ADHESIVE
2" SPRAY FOAM
CONTINUOUS BEAD OF SEALANT
1'-0"
EDGE OF FRAMING TO EDGE OF SHEATHING
2
A-13
CONTINUOUS BEAD OF SEALANT
LOW-EXPANDING FOAM AT PERIMETER OF WINDOW
LOW-EXPANDING FOAM AT PERIMETER OF WINDOW
PRE MANUFACTURED PAN FLASHING
SLOPED WINDOW SILL, (BEVELLED SIDING)
CONTINUOUS BEAD OF SEALANT
1
A-13
NOTE: SEE DETAIL 3/A-13 FOR WINDOW JAMB DETAIL.
FIBER CEMENT SIDING
1/4" XPS FOAM FURRING STRIPS
1 1/2" XPS RIGID INSULATION
1/2" OSB – 1" RIGID XPS INSULATION AT CORNERS
R-19 CELLULOSE INSULATION
2x6 24" O.C. WOOD STUD WALL
1/2" GWB
CONTINUOUS BEAD OF ADHESIVE
CONTINUOUS BEAD OF SEALANT
2" SPRAY FOAM
CONTINUOUS BEAD OF SEALANT
1x10 WATER TABLE
1/4" VENTED MESH
GROUND SLOPES AWAY AT 5% (6" PER 10')
2'-0"
6" MIN.
12" MIN.
CAPILLARY BREAK UNDER SILL PLATE, 6 mil POLY OR EQUAL
IMPERMEABLE COVER
INSECT SCREEN
FREE DRAINING BACKFILL
METAL FLASHING
DAMPPROOFING TO GRADE, (LATEX PAINT ABOVE GRADE)
8" CONCRETE WALL
2" FOIL-FACED POLYISOCYANURATE
2x3 24" O.C. WOOD STUD WALL
1/2" PAPERLESS GYPSUM
URETHANE SEALANT
1/2"x4" BOND BREAK (XPS)
TREATED WOOD BOTTOM PLATE
CAPILLARY BREAK, 6 mil POLY OR EQUAL
4" CONCRETE SLAB
6 mil POLYETHYLENE VAPOR BARRIER
UNDER SLAB & TURN UP FDN. WALL 1"
6" STONE PAD (NO FINES)
UNDISTURBED/ NATIVE SOIL
FILTER FABRIC – WRAP AROUND GRAVEL
4" PERFORATED DRAIN PIPE
LIQUID APPLIED CAPILLARY BREAK ON TOP OF FOOTING
1 1/2 x 3 1/2" BEVELED EDGE KEYWAY (CREATE USING 2x4)
2 WALL SECTION
SCALE 1 1/2" = 1'-0"
Built in the USA
ARCHITECT:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100
PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE
Building Section & Wall Section
SCALE AS NOTED
COPYRIGHT © 2007 BUILDING SCIENCE CORPORATION
A-6
FILE: KS GREENSBURG 1.DWG



1 | FRAMING OVERVIEW
N.T.S.



2 | TYPICAL CORNER FRAMING
N.T.S.



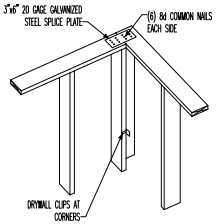
3 | TYPICAL THREADED ROD TIE-DOWN
N.T.S.

ADVANCED FRAMING IRC 2003 REFERENCES

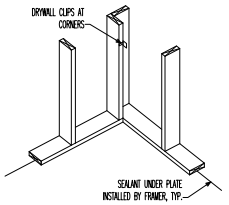
SINGLE TOP PLATE
– IRC 2000 and 2003, in Section R602.3.2 Top Plate: Exception: A single top plate may be installed in stud walls, provided that the plate is adequately tied at joints, corners, and intersecting walls by a minimum 3-inch-by-6-inch by 0.036 inch-thick (76 mm by 152 mm by 0.914 mm) galvanized steel plate that is nailed to each wall or segment of wall by six 8d nails on each side, provided that the rafters or joists are centered over the studs with a tolerance of no more than 1 inch (25.4 mm). The top plate may be omitted over lintels that are adequately tied to adjacent wall sections with steel plates or equivalent as previously described.
– IRC 2000 and 2003, in Figure 602.3(2): The figure label states "single or double top plate."
– IRC 2000 and 2003, in Section R602.5: Interior, nonbearing walls shall be permitted to be constructed with 2-inch-by-3-inch (51 mm by 76 mm) studs spaced 24 inches (610 mm) on center or, when not part of a braced wall line, 2-inch-by-4-inch (51 mm by 102 mm) flat studs spaced at 16 inches (406 mm) on center. Interior, nonbearing walls shall be capped with at least a single top plate. Interior, nonbearing walls shall be fireblocked in accordance with Section R602.8.
– IRC Table R602.3(1): For top or sole plate to stud (end nail), two 16d fasteners are required.

NO HEADERS IN NON-LOAD-BEARING WALLS
– IRC 2000 and 2003, Section R602.7.2: Nonbearing walls. Load-bearing headers are not required in interior or exterior nonbearing walls. A single, flat 2-inch-by-4-inch (51 mm by 102 mm) member may be used as a header in interior or exterior nonbearing walls for openings up to 8 feet (2438 mm) in width if the vertical distance to the parallel nailing surface above is not more than 24 inches (610 mm). For such nonbearing headers, no cripples or blocking is required above the header.
– IRC 2000 and 2003 Table R702.3.5 Minimum Thickness and Application of Gypsum Board: Allows the use of 24-inch-on-center framing for fastening gypsum board with either fasteners or adhesive 1/2 inch thickness or greater.
– IRC 2000 and 2003 Section R703 Exterior Covering: Structural sheathing and siding requirements are based on Table R703.4. Note that footnote "a" specifies that the table is based on 16 inches on center and that studs-spaced-24-inches-on-center siding shall be applied to sheathing approved for that spacing.
– IRC 2003 Section R602.10.2 Seismic Design Category D2: In Seismic Design Category D2, cripple walls shall be braced in accordance with Table R602.10.1.

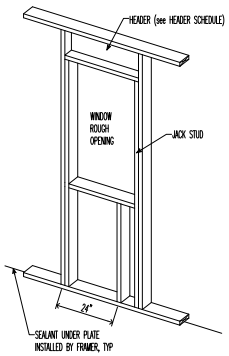
DRYWALL CLIPS
– IRC 2000 and 2003, Section R602.3 Design and Construction: Exterior walls of wood-frame construction shall be designed and constructed in accordance with the provisions of this chapter and Figures R602.3(1) and R602.3(2) or in accordance with AF and PA's NDS. Components of exterior walls shall be fastened in accordance with Table R602.3(1) through R602.3(4). [Excerpt]
– IRC 2000 and 2003, Figure R602.3(2): Note: A third stud and/or partition intersection backing studs shall be permitted to be omitted through the use of wood back-up cleats, metal drywall clips, or other approved devices that will serve as adequate backing for the facing materials.



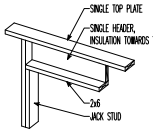
4 | TWO-STUD CORNER - TOP
N.T.S.



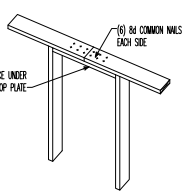
5 | TWO-STUD CORNER - BOTTOM
N.T.S.



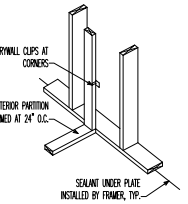
6 | LOAD-BEARING WALL OPENING
N.T.S.



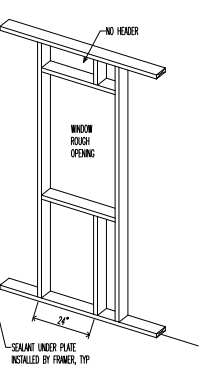
7 | SINGLE HEADER
N.T.S.



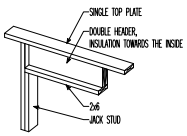
8 | SINGLE TOP PLATE SPLICE
N.T.S.



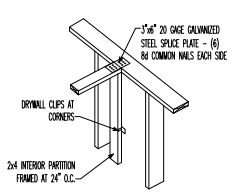
9 | BOTTOM PLATE AT PARTITION
N.T.S.



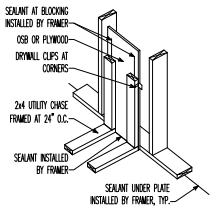
10 | NON-LOAD-BEARING WALL OPENING
N.T.S.



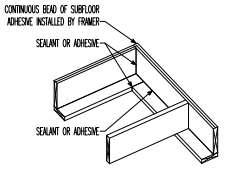
11 | DOUBLE HEADER
N.T.S.



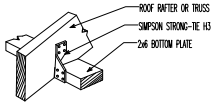
12 | SINGLE TOP PLATE AT PARTITION
N.T.S.



13 | AIR SEALING AT MECH CHASE
N.T.S.



14 | RIM JOIST AIR SEALING
N.T.S.



15 | ROOF-WALL FRAMING CONNECTION
N.T.S.

Built in America

ARCHITECT:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

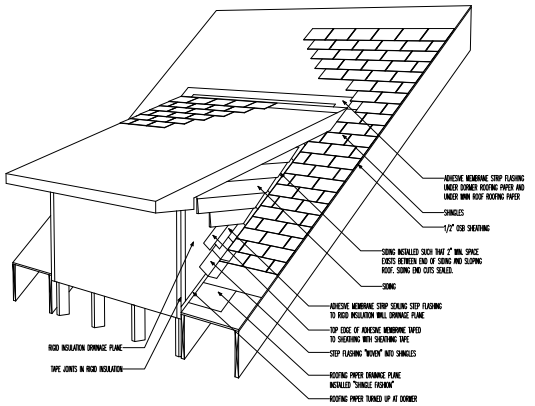
Advanced Framing Details

SCALE AS NOTED

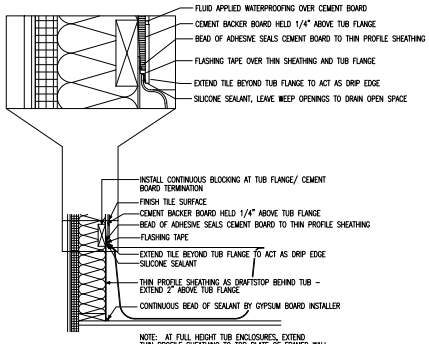
COPYRIGHT © 2007
BUILDING SCIENCE CORPORATION

A-11

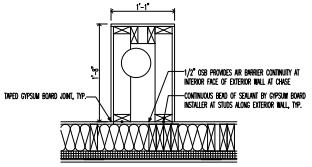
FILE: KS GREENSBURG 1.DWG



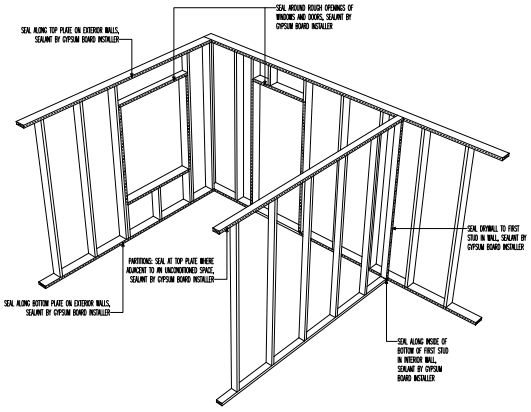
7 | DORMER SIDING INSTALLATION
SCALE N.T.S.



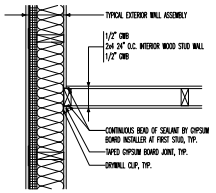
5 | EXTERIOR WALL AT BATHTUB / SHOWER
SCALE 1" = 1'-0"



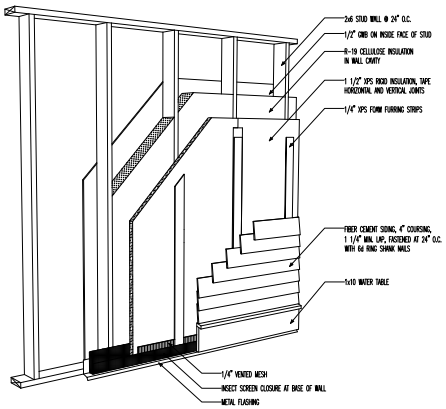
4 | MECHANICAL CHASE AT EXTERIOR WALL
SCALE 1" = 1'-0"



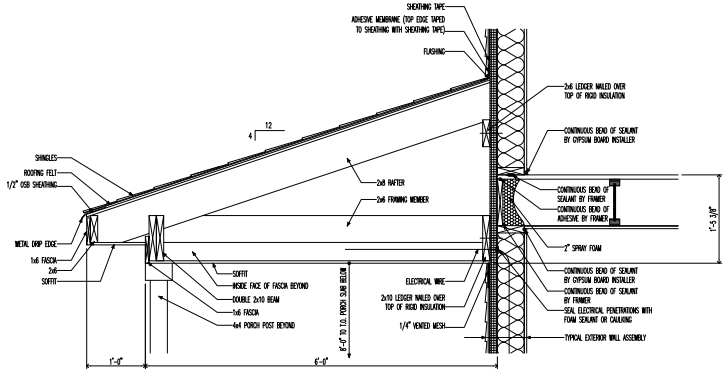
1b | AIR BARRIER AT WALLS AND CEILINGS PERSPECTIVE
SCALE N.T.S.



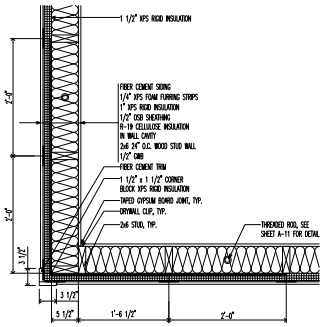
3 | INTERIOR WALL AT EXTERIOR WALL
SCALE 1" = 1'-0"



1a | ENCLOSURE ASSEMBLY
SCALE N.T.S.



6 | SHED ROOF AT EXTERIOR WALL
SCALE 1" = 1'-0"



2 | 2 STUD CORNER AT EXTERIOR WALL
SCALE 1" = 1'-0"

Built in America

ARCHITECT:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

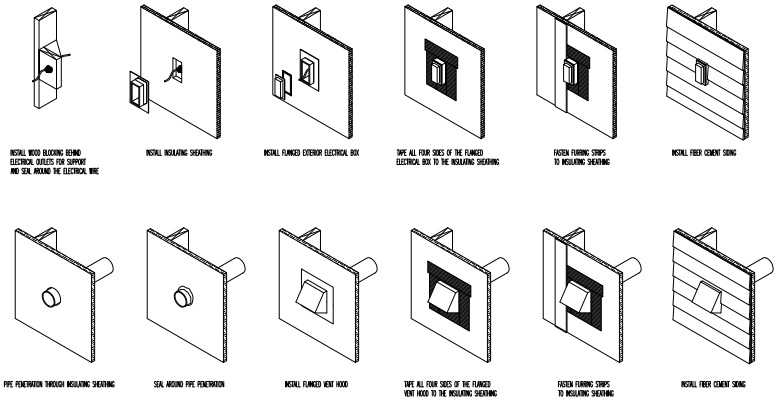
Enclosure Details

SCALE AS NOTED

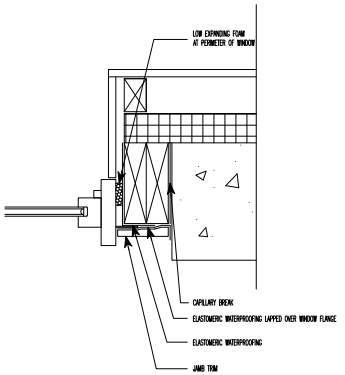
COPYRIGHT © 2007
BUILDING SCIENCE CORPORATION

A-12

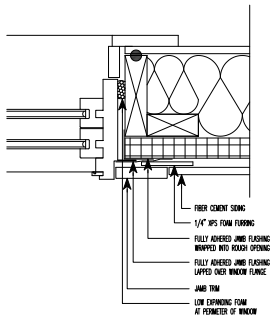
FILE: KS GREENSBURG 1.DWG



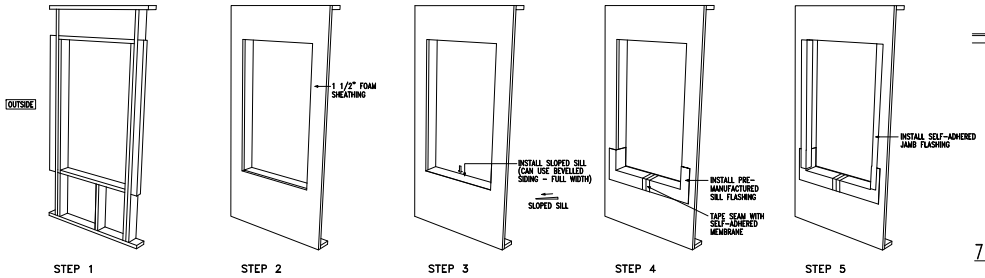
5 | MECHANICAL PENETRATION DETAILS
SCALE NTS

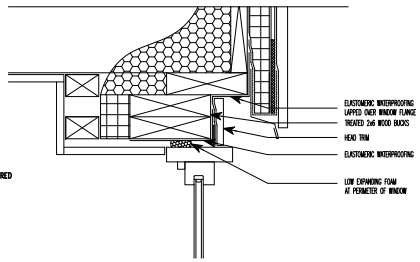


8 | BASEMENT WINDOW JAMB DETAIL
SCALE 3" = 1'-0"

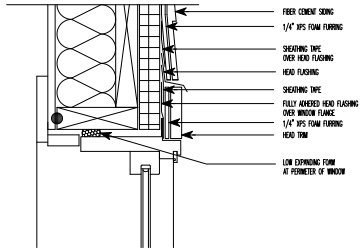


3 | WINDOW JAMB DETAIL
SCALE 3" = 1'-0"

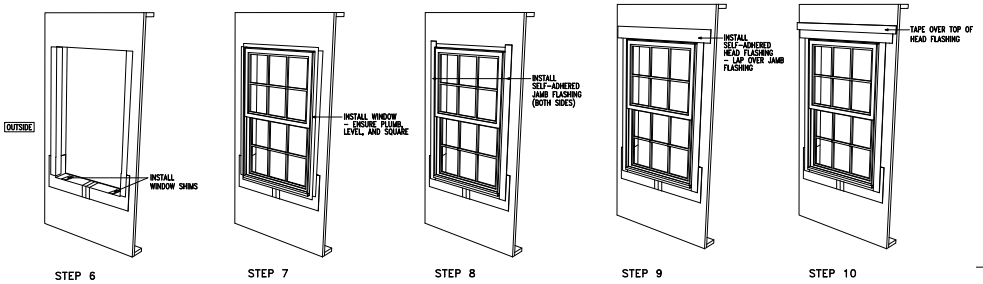




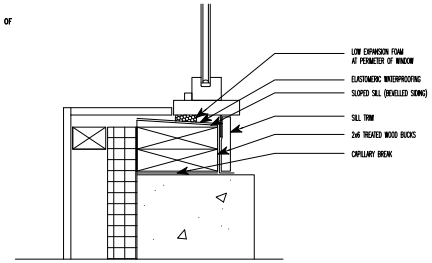
7 | BASEMENT WINDOW HEAD DETAIL
SCALE 3" = 1'-0"



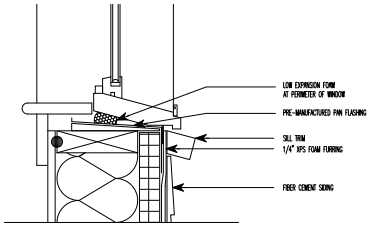
2 | WINDOW HEAD DETAIL
SCALE 3" = 1'-0"



4 | WINDOW INSTALLATION DETAILS
SCALE NTS



6 | BASEMENT WINDOW SILL DETAIL
SCALE 3" = 1'-0"



1 | WINDOW SILL DETAIL
SCALE 3" = 1'-0"

Built Right AMERICA

ARCHITECT:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

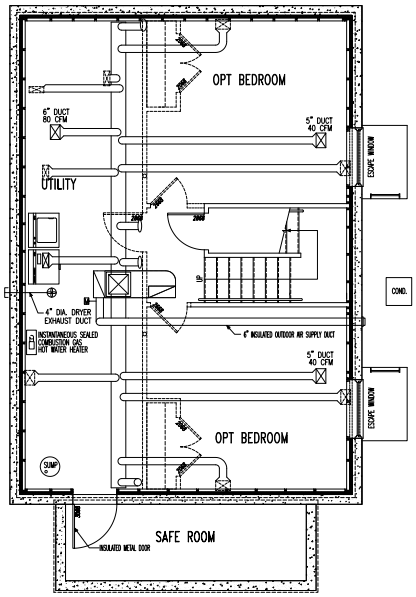
Window, Door & Mechanical Penetration Details

SCALE AS NOTED

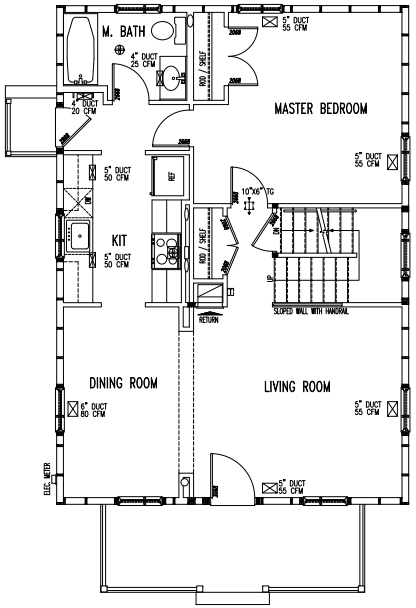
COPYRIGHT © 2007 BUILDING SCIENCE CORPORATION

A-13

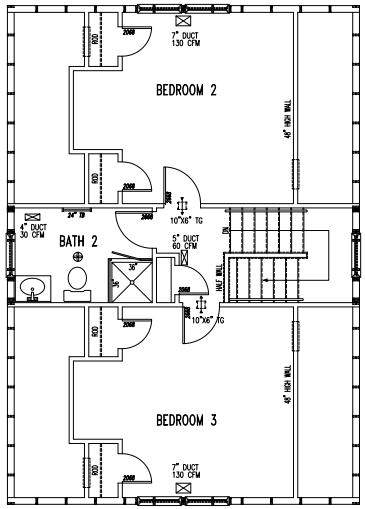
FILE: KS GREENSBURG 1.DWG



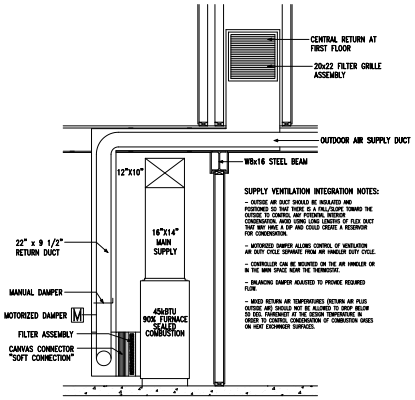
1 | BASEMENT REGISTER FLOWS
SCALE 1/4" = 1'-0"



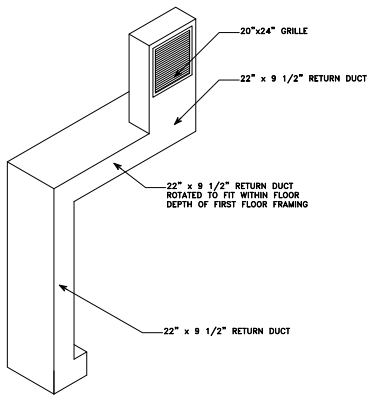
2 | FIRST FLOOR REGISTER FLOWS
SCALE 1/4" = 1'-0"



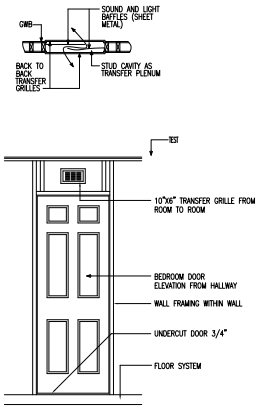
3 | SECOND FLOOR REGISTER FLOWS
SCALE 1/4" = 1'-0"



4 | AIR HANDLER DETAIL
SCALE 1/2" = 1'-0"



5 | RETURN DUCT ISOMETRIC
SCALE 1/2" = 1'-0"



6 | TRANSFER GRILLE OVER DOOR DETAIL
SCALE 1/2" = 1'-0"

NOTES:

1. ALL DUCTS TO BE SEALED WITH MASTIC AND LOCATED IN CONDITIONED SPACE.
2. ALL REGISTERS TO BE ADJUSTABLE DIRECTIONAL MOUNTED WITH DAMPER.
3. TRANSFER GRILLES PROVIDE PRESSURE RELIEF / PRESSURE EQUALIZATION BETWEEN CLOSED ROOMS AND COMMON AREAS (SEE 6/M-1).
4. DOORS TO BE UNDERCUT 3/4" BETWEEN TOP OF FINISH FLOOR AND UNDERSIDE OF DOOR.
5. AIR HANDLER LOCATED AND ACCESSED WITHIN INTERIOR CONDITIONED SPACE.
6. RETURN DUCTED WITH TWO OFFSETS TO REDUCE SOUND AND VIBRATION.
7. A FILTER WITH A MERV 12 RATING SHALL BE INSTALLED AT THE AIR HANDLER.
8. OUTSIDE AIR PROVIDED TO RETURN SIDE OF SYSTEM WITH DAMPER CONTROL.
9. 6" DIAMETER INSULATED OUTSIDE AIR DUCT FROM EXTERIOR SHALL BE INSTALLED WITH A MANUAL DAMPER TO SET FLOW.

LEGEND	
	SUPPLY REGISTER
	OVER DOOR TRANSFER GRILLES
	TOILET EXHAUST FAN, PANSONIC FV-05VFL1
	KITCHEN EXHAUST FAN W/ LIGHT
	THERMOSTAT
M	MOTORIZED DAMPER FOR O.A. CONTROL
	MANUAL DAMPER
	RETURN AIR FLOW

Built Right AMERICA

ARCHITECT:
BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

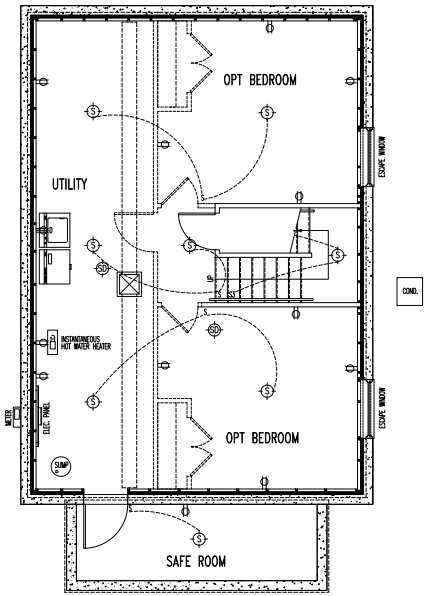
Mechanical Duct Layout, Notes & Details

SCALE AS NOTED

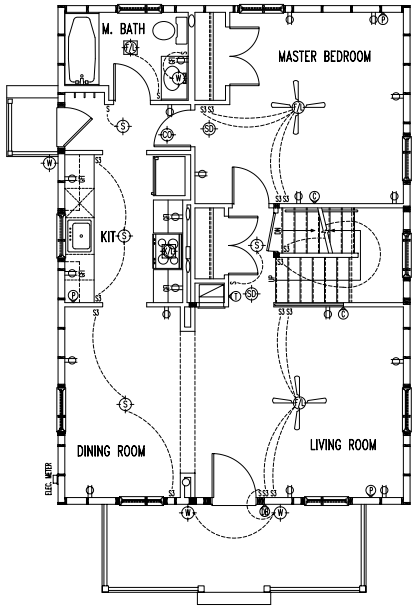
COPYRIGHT © 2007 BUILDING SCIENCE CORPORATION

M-1

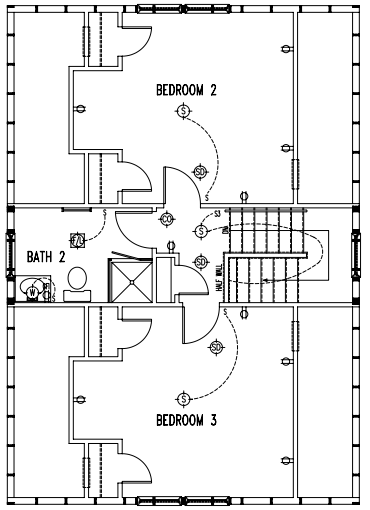
FILE: KS GREENSBURG 1.DWG



1 | BASEMENT ELECTRICAL PLAN
SCALE 1/4" = 1'-0"



2 | FIRST FLOOR ELECTRICAL PLAN
SCALE 1/4" = 1'-0"



3 | SECOND FLOOR ELECTRICAL PLAN
SCALE 1/4" = 1'-0"

NOTES:

1. 20A 220V CIRCUIT TO CONDENSER UNIT.
2. 20A 120V CIRCUIT TO AHU.
3. ALL WORK MUST COMPLY WITH MOST RECENT VERSION OF THE NATIONAL ELECTRIC CODE.

ELECTRICAL LEGEND

SYMBOL	DESCRIPTION
S	SURFACE MOUNTED LIGHT FIXTURE
W	WALL MOUNTED LIGHT FIXTURE
D	DROPPED LIGHT FIXTURE
R	RECESSED LIGHT FIXTURE
RA	RECESSED LIGHT FIXTURE (AIRTIGHT)
RW	RECESSED LIGHT FIXTURE (WATERPROOF)
P	POLE LAMP (EXTERIOR-SITE)
F	FLOOD W/MOTION SENSOR
SD	SMOKE DETECTOR (INTERCONNECTED W/ BATTERY BACKUP)
CO	CARBON MONOXIDE DETECTOR (INTERCONNECTED W/ BATTERY BACKUP IF REQ.)
E	EXHAUST FAN
EL	EXHAUST FAN / LIGHT COMBINATION
KL	KITCHEN EXHAUST FAN / LIGHT COMBINATION
(24)	FLOURESCENT STRIP LIGHT (SINGLE) (LENGTH IN INCHES)
(24)	FLOURESCENT STRIP LIGHT (DOUBLE) (LENGTH IN INCHES)
(24)	TRACK LIGHT (LENGTH IN INCHES)
C	CABLE TV / PHONE OUTLET
DB	DOOR BELL
T	THERMOSTAT
	110 VAC DUPLEX OUTLET
	110 VAC DUPLEX OUTLET (TOP SWITCHED)
GFI	110 VAC DUPLEX OUTLET (GROUND FAULT INTERUPTOR)
WP	110 VAC DUPLEX OUTLET (WATERPROOF)
	DRYER OUTLET
	RANGE OUTLET
S	SINGLE POLE SWITCH
S3	THREE-WAY SWITCH
S4	FOUR-WAY SWITCH
SD	SWITCH WITH DIMMER
S3D	THREE-WAY SWITCH WITH DIMMER
S4D	FOUR-WAY SWITCH WITH DIMMER
ST	SWITCH WITH TIMER
F	CEILING FAN
FL	CEILING FAN/LIGHT COMBINATION
ACCU	AIR COOLED CONDENSING UNIT
AHU	AIR HANDLING UNIT

NOTE: ALL SYMBOLS MAY NOT BE USED IN PLAN

Building America

WORKED: BUILDING SCIENCE CORPORATION
70 MAIN STREET WESTFORD, MASSACHUSETTS 01886 PH: 978-589-5100

PROJECT:
REBUILDING GREENSBURG, KS
PLAN 1 - THREE BEDROOM HOUSE
MIXED-HUMID CLIMATE

Electrical Plans

SCALE AS NOTED

COPYRIGHT © 2007
BUILDING SCIENCE CORPORATION

E1

FILE: KS GREENSBURG 1.DWG

B.10 Fact Sheet: Energy Efficient Homes are More Affordable than Conventional Homes

National Renewable Energy Laboratory

Energy Efficient Homes are More Affordable than Conventional Homes

As part of its technical support of the rebuilding effort in Greensburg, NREL has evaluated the cost and performance tradeoffs associated with adding energy performance upgrades to new homes. The results of this evaluation indicate that Greensburg residents can use savings in utility bills to pay for improvements in energy efficiency of new homes. Because of the relatively high cost of energy in Greensburg, the increase in annual mortgage payments for energy upgrades, when financed as part of a 30 year mortgage, can be offset by the corresponding savings in annual utility bills.

Table 1 - Estimated Annual Cost Savings: Greensburg 30% Energy Savings Target

	Greensburg: 30% Savings
Estimated Incremental First Cost for Energy Upgrades that Provide 30% Savings Relative to Standard Practice[1]	$4,000
Annual Amortized Cost for Energy Upgrades (7%, 30Year mortgage)[2]	$211
Estimated Annual Utility Bill Savings	$723
Net Annual Savings	*$512*

A detailed summary of specific recommendations for improvements in energy efficiency that are cost effective in Greensburg is included in Appendix XX. The recommendations include packages that will produce energy savings of 30%, 40% and 50% beyond the current minimum Greensburg code. Because of the large annual savings in utility bills from energy efficiency upgrades, other approaches for financing energy efficiency upgrades can also be considered.

[1] Evaluated relative to minimum IECC 2003. 2000 ft2, 2-story, 16% window to floor area ratio, unconditioned basement.
[2] Assumes 28% marginal tax bracket and includes present value of future replacements of equipment over 30 year life of mortgage. Federal tax credits not included.

Energy Efficient Homes are more Durable than Conventional Homes

Energy efficient homes not only reduce homeowner utility bills, they are also designed to be more durable than conventional homes. Current designs for high performance walls, roofs, windows, and foundation systems include increased protection from moisture damage. "Peel and stick" materials are used to seal roofs and windows, and attention to flashing, drainage, and drying details from roof to foundation ensure that water drains quickly away from the building so that the building can dry out quickly.

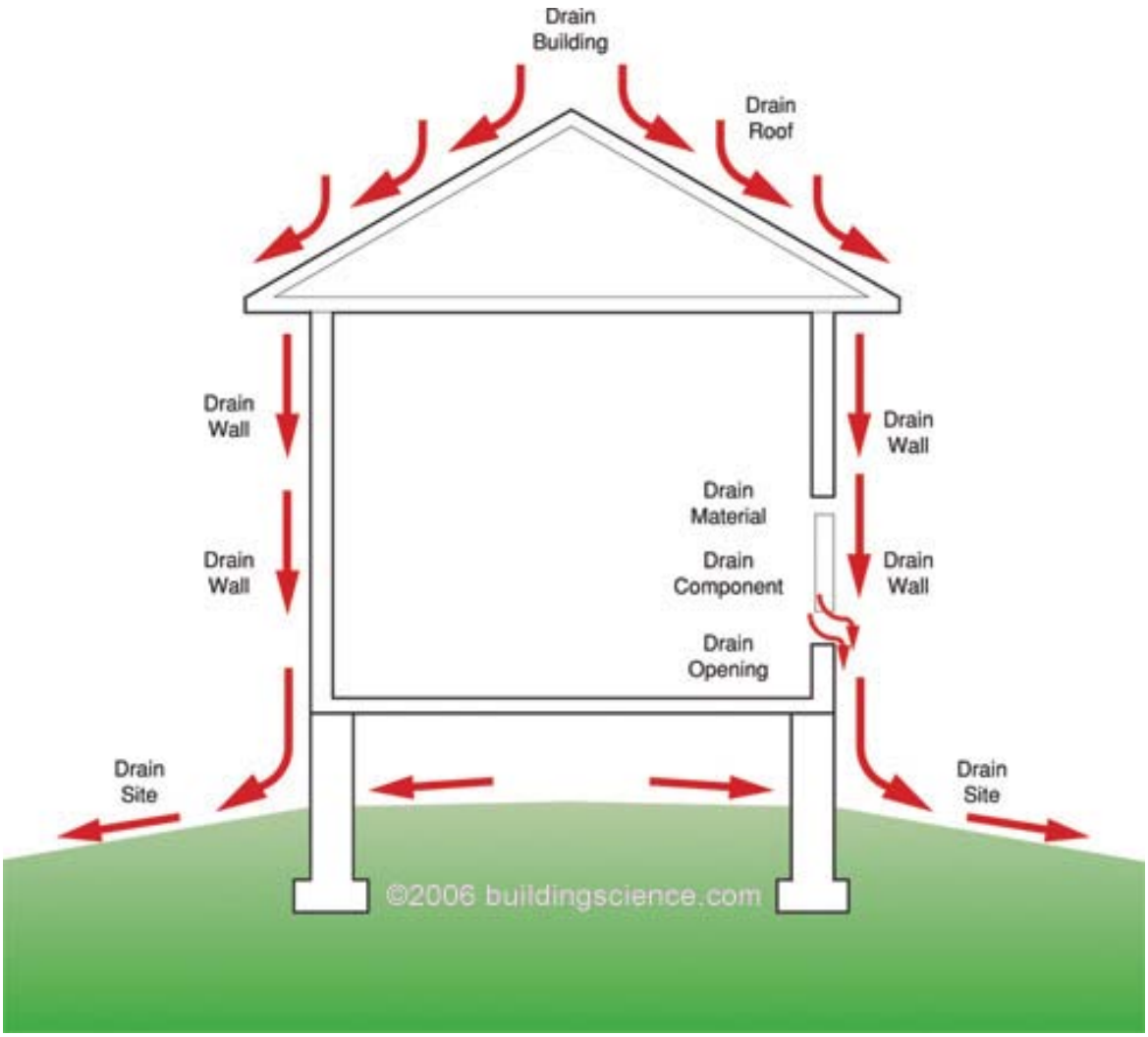


Figure 1 - Moisture Control in High Performance Homes. More information on specific design details and example building plans can be found on, **http://www.buildingamerica-greensburg.com/**

Additional Savings from Peak Cooling Demand Reductions in Energy Efficient Homes

In addition to providing overall benefits in terms of annual energy savings, energy efficient homes also reduce the amount of electric power required to meet peak cooling loads compared to conventional homes, allowing reduced investments in backup power systems required to meet peak electric demand. Assuming an average installed cost for a diesel generator of about $1000/kW, each kW of reduced electric demand produced by energy efficiency upgrades in new homes potentially translates into $1000 in savings for the Greensburg municipal utility.

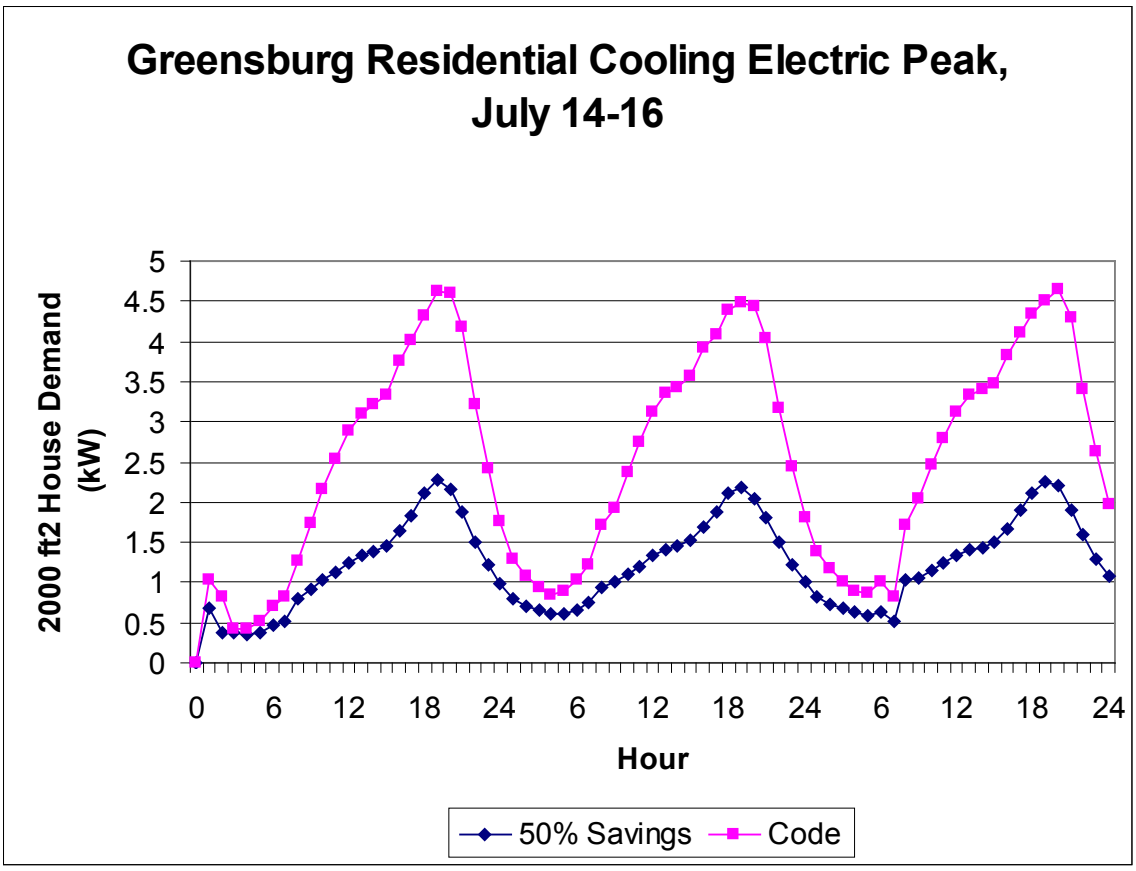


Figure 2 – Peak Demand Savings From Energy Efficient Homes. A home designed to reduce energy use by 50% compared to a conventional home also reduces peak electric demand by about 2kW.

Additional Resources and Case Studies for Designing and Building Energy Efficient Homes in Greensburg

CASE STUDIES

Building Greensburg:

http://buildingamerica-greensburg.com

Mixed-Humid Climate Construction Details:

www.buildingscience.com/housesthatwork/mixedhumid/atlanta.htm

www.buildingscience.com/housesthatwork/mixedhumid/charlotte.htm

www.buildingscience.com/housesthatwork/mixedhumid/louisville.htm

http://www.buildingscience.com/buildingamerica/casestudies/fairburn/default.htm

RESIDENTIAL RENEWABLE ENERGY RESOURCES

Primer on Photovoltaics:

www.buildingscience.com/resources/misc/BSC_PV_Primer.pdf

Best Practices: Volume 6, High Performance Home Technologies: Solar Thermal and Photovoltaic Systems:

www.eere.energy.gov/buildings/building_america/pdfs/41085.pdf

GENERAL RESOURCES

Builder's Guide to Mixed-Humid Climates:

www.buildingsciencepress.com

EEBA Water Management Guide:

www.eebga.org/bookstore

Building America Performance Targets:

www.buildingscience.com/buildingamerica/targets.htm

International Energy Conservation Code (IECC) Climate Zones:

www.energycodes.gov/implement/pdfs/color_map_climate_zones_Mar03.pdf

DOE Climate Zones by County:

www.eere.energy.gov/buildings/building_america

Houses That Work II:

www.buildingscience.com/housesthatwork

Building Materials Property Table:

www.buildingscience.com/housesthatwork/buildingmaterials.htm

Building Science Glossary:

www.buildingscience.com/resources/glossary.htm

SITE: DRAINAGE, PEST CONTROL, AND LANDSCAPING

Pest Control:

www.uky.edu/Ag/Entomology/entfacts/efstruc.htm

FOUNDATION: MOISTURE CONTROL AND ENERGY PERFORMANCE

Radon Resistant Construction Practices (EPA Radon Control Web Site):

www.epa.gov/iaq/radon/construc.html

Borate-Treated Rigid Insulation:

www.buildingscience.com/buildingamerica/casestudies/fairburn/default.htm

MECHANICALS/ELECTRICAL/PLUMBING

HVAC System Sizing (ACCA Manual J and Manual D):

www.buildingscience.com/resources/mechanical/hvac/509a3_cooling_system_sizing_pro.pdf

Mechanical Ventilation Integrated with HVAC System Design:

www.buildingscience.com/resources/mechanical/hvac/advanced_space_conditioning.pdf

Transfer Grilles:

www.buildingscience.com/resources/mechanical/hvac/transfer_grille_detail.pdf

www.buildingscience.com/resources/mechanical/hvac/transfer_grills.htm

Indoor Humidity:

www.buildingscience.com/resources/moisture/relative_humidity_0202.pdf

Whole House Dehumidification System:

www.buildingscience.com/resources/mechanical/hvac/residential_dehumidification.pdf

Air Conditioning Best Practices:

www.buildingscience.com/resources/mechanical/air_conditioning_equipment_efficiency.pdf

High-Energy Efficiency Major Appliances:

www.eere.energy.gov/EE/buildings_appliances.html

BUILDING ENCLOSURE: MOISTURE CONTROL AND ENERGY PERFORMANCE

Design Using Advanced Framing Methods:

www.buildingscience.com/housesthatwork/advancedframing/default.htm

Air Sealing Details:

www.buildingscience.com/housesthatwork/airsealing/default.htm

"Insulations, Sheathings, and Vapor Diffusion Retarders"

www.buildingscience.com/resources

Solar Driven Moisture in Wall Assemblies:

www.buildingscience.com/resources/walls/solar_driven_moisture_brick.htm

Solar Driven Moisture in Roof Assemblies:

www.buildingscience.com/resources/roofs/unvented_roof.pdf

Window Flashing:

EEBA Water Management Guide (www.eeba.org/bookstore)

COMMISSIONING

SNAPSHOT (Short Non-Destructive Approach to Provide Significant House Operation Thresholds) Form:

www.buildingscience.com/buildingamerica/snapshot_form.pdf

www.buildingscience.com/buildingamerica/snapshot_instructions.pdf

Appendix C: Commercial, Nonprofit, and Public Buildings

Page

C.1 Setting Goals and Implementing Energy Efficiency Strategies 207

C.2 Setting Goals and Implementing Energy Efficiency Strategies for the Kiowa County Memorial Hospital 220

C.3 Applying a Whole-Building Design Process for New Commercial Buildings in Greensburg 230

C.4 Greensburg, Kansas, Should Adopt the Best Green Municipal Building Requirement in the United States 235

C.5 The City of Greensburg, Kansas, Should Encourage Green Commercial, Nonprofit and Public Building Design to Align with the Community Master Plan 236

C.6 Metal Building Recommendations for Greensburg, Kansas 237

C.1 Setting Goals and Implementing Energy Efficiency Strategies

Shanti Pless, Lynn Billman
National Renewable Energy Laboratory

Setting Goals and Implementing Energy Efficiency Strategies

Greensburg, Kansas

US Department of Energy
Through the
National Renewable Energy Laboratory

November 13, 2007

Shanti Pless
Lynn Billman

www.highperformancebuildings.gov

NREL is operated by Midwest Research Institute • Battelle

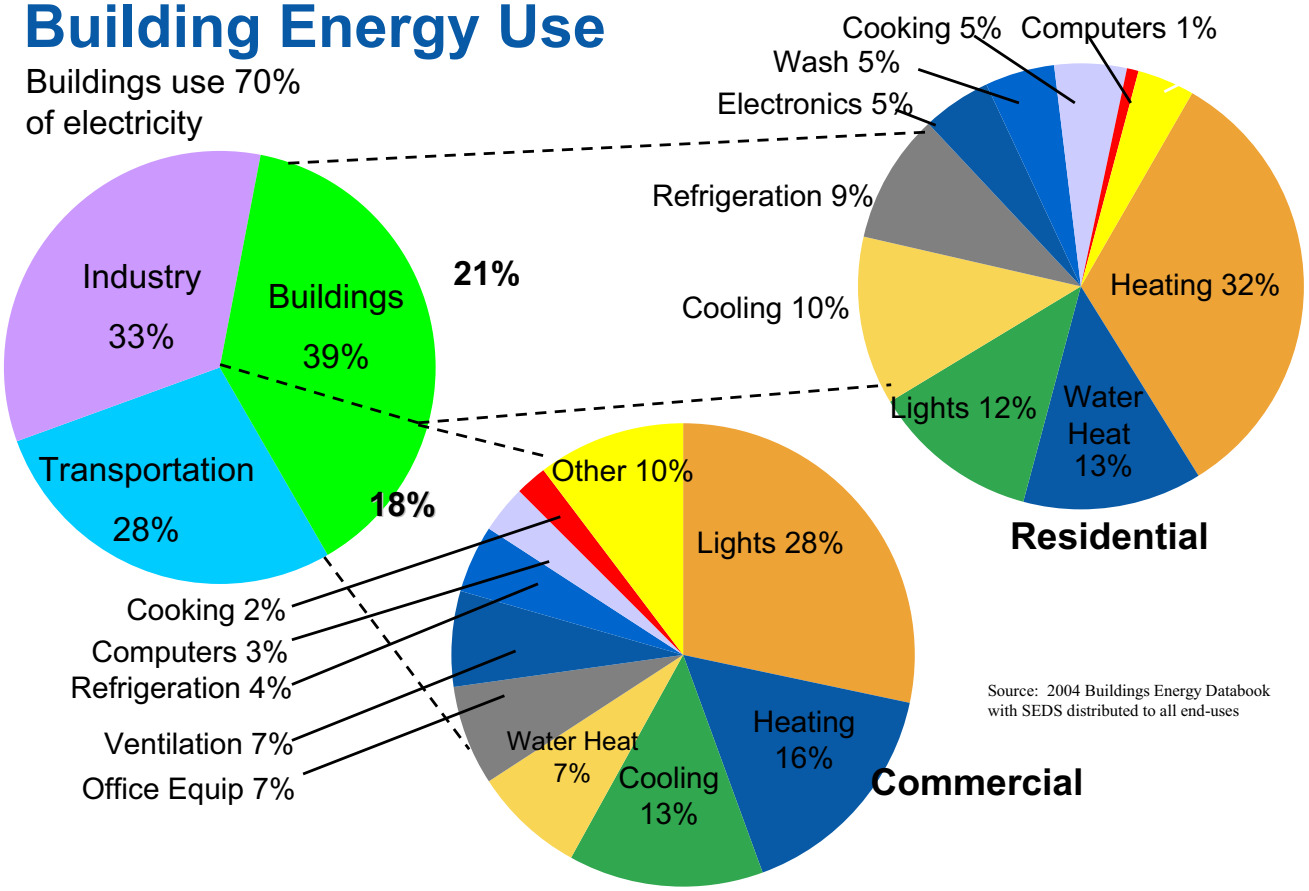
NREL Building Technologies Program

- Commercial Building Energy Efficiency
- Design Analysis
- Computer Simulation Tool Development
- Solar Strategies
  - Daylighting, Passive, PV, Thermal
- Whole-Building/Integrated Design
- Field Evaluation



Building Energy Use

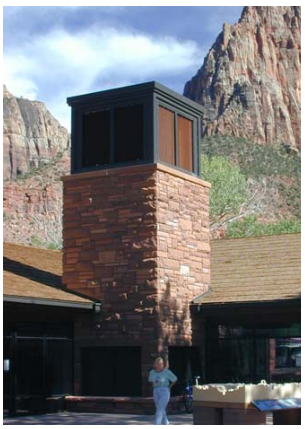
Buildings use 70%
of electricity

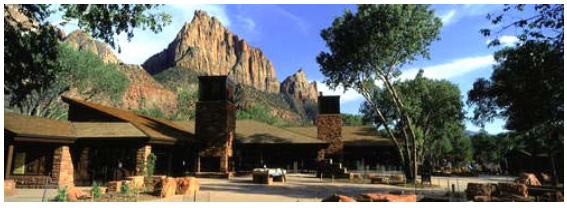


Source: 2004 Buildings Energy Databook with SEDS distributed to all end-uses

What is a "Green" Building?

- Energy Efficiency
- Water Efficiency
- Material Efficiency
- Site Efficiency
- Enhanced Comfort and Control
- Indoor Air Quality







Green Building Rating

Leadership In Energy and Environmental Design (LEED)

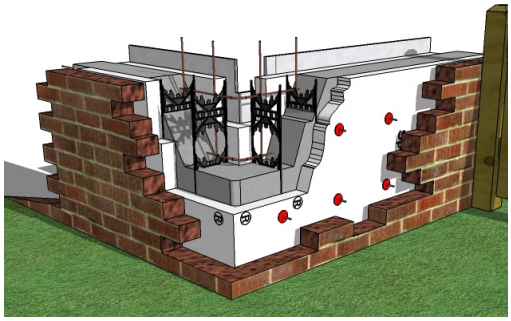


- System to design and measure “green” buildings
- LEED Certified, Silver, Gold, Platinum
- Points in 6 categories:
  - Sustainable Sites
  - Water Efficiency
  - Energy
  - Materials
  - Indoor Environmental Quality
  - Innovative Design
- Industry Average Costs:
  - 0%-5%, 10% max



Energy Efficiency and Green

- Doing more with less
- Primary driver is owner demand
- Owner demand for reduced operating costs
- Disaster resistance
- Marketing and image value added





Bighorn Home Improvement Center

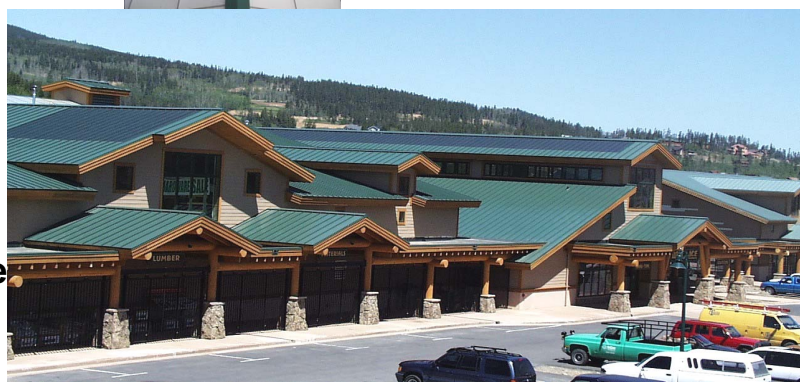
Silverthorne, Colorado

Energy Efficiency Features:

- Additional wall, roof, and floor insulation
- Full daylighting with clerestories
- Efficient electrical lighting system
- 9kW PV System
- Radiant floors with efficient boilers
- Natural ventilation
- 400W Wind Turbine
- **53% Energy Cost Savings**
- **Widespread Media Exposure**







Starting Point… Goal Setting

Measurable energy goals are better

From bad to good…

- I want a green building
- Design a LEED <rating> building
- Design a building to use 30% less energy than Code
  - Energy efficient buildings that are Code compliant are the legal minimum
- Design a building to use less than $0.50/ft^2

Set measurable energy goals and have the architects and engineers strive to meet these goals

How to Achieve Energy Savings…

1. Daylighting (includes site selection)
2. Lighting design to match daylighting
3. Good envelope (including overhangs)
4. Plug loads
   - Design vs. owner loads
5. HVAC designed for the remaining loads
6. Commissioning (making sure the building works)
7. Metering and evaluation
8. Make it Simple
9. Renewable Generation





Design Process

Cost effective integrated design is about making decisions and trade-offs:

- Increase insulation
- Daylighting
- Optimize window size and placement
- Then, right size HVAC and lighting equipment



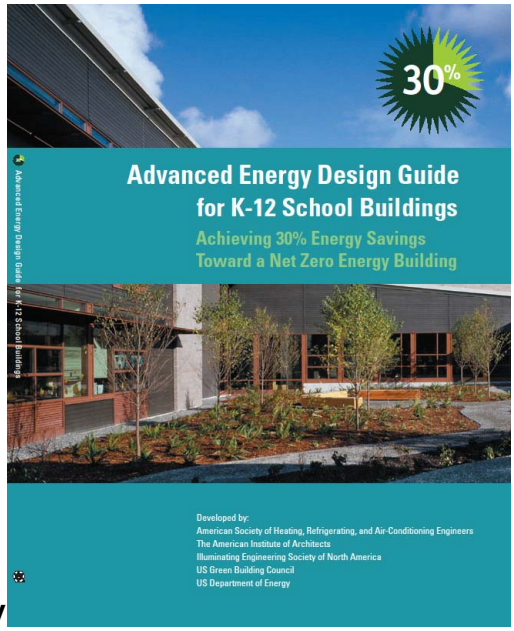
- Capital cost whole building trade-offs

Requires architects and engineers to work together from the start



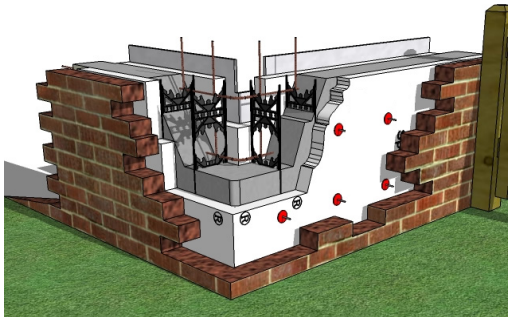
Advanced Energy Design Guides

- Developed by ASHRAE, AIA, USGBC, IESNA, and DOE
- Easy to use guidance to achieve 30% in Small Offices, Small Retail, Warehouses, and K-12 Schools
- Low- to no-cost solutions by climate zone
- 4 LEED energy points
- Pre-engineered solutions—hourly simulations done by NREL



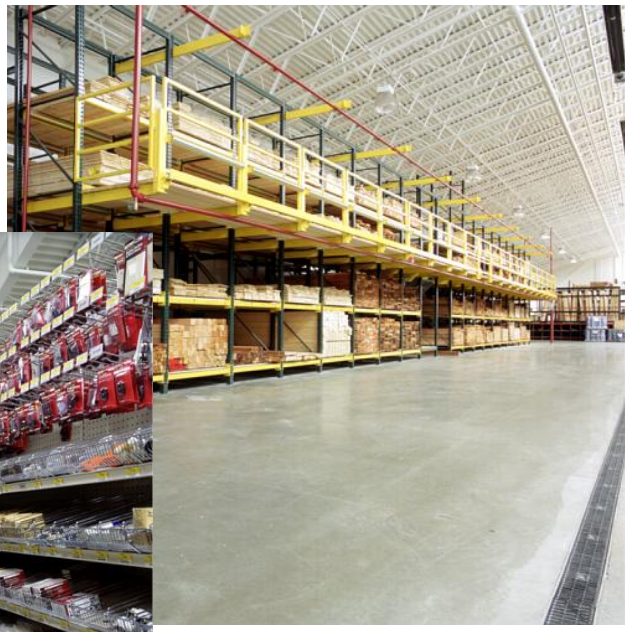
Envelope Recommendations

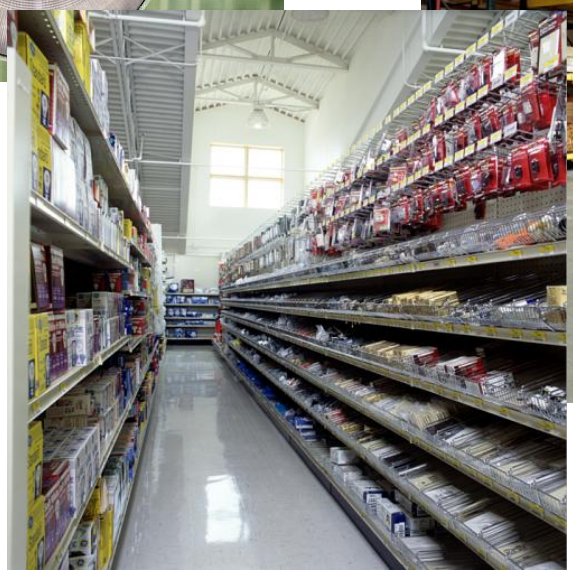
- **Roofs**
  - R-25 continuous insulation above deck
  - R-38 attic insulation
- **Walls**
  - R-11.4 continuous insulation mass wall
  - R-13 + R-7.5 c.i. steel or wood framed
- **Windows**
  - Overhangs on South, East, and West
  - U-0.42 (double pane, low-e)
  - SHGC-0.46 (0.75 with overhangs)
- **Interior Finishes**
  - 80% reflectance or higher on ceilings, walls above 7’
  - 70%+ reflectance on wall below 7’



Electric Lighting and Daylighting







Tubular Daylighting Devices





More Daylighting…







HVAC Recommendations

- Higher efficiency air conditioners and furnaces
- Better control of outside air
- Energy recovery from exhaust air
- Economizers
- Radiant heating





Education and Marketing





Image…





Smith Middle School

Zone 4 – Chapel Hill, North Carolina

Energy Efficiency Features:

- 30 kBtu/sq.ft/year
- Daylighting with Roof Monitors in the Classrooms and Gym, Light Shelves on South Windows
- R-19 Wall Insulation R-30 Roof Insulation
- 85% Efficiency Boilers
- 2 kW PV System, Solar Domestic Hot Water System









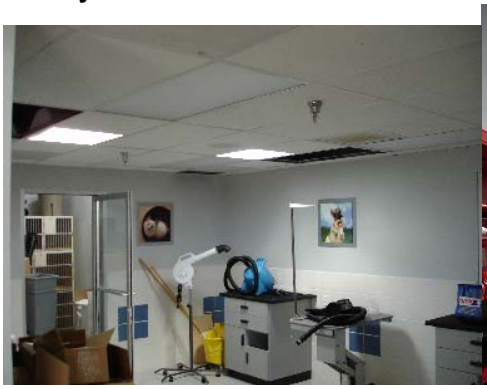
Petco Energy Showcase Store

Zone 3 – Elsinore, California

Energy Efficiency Features:

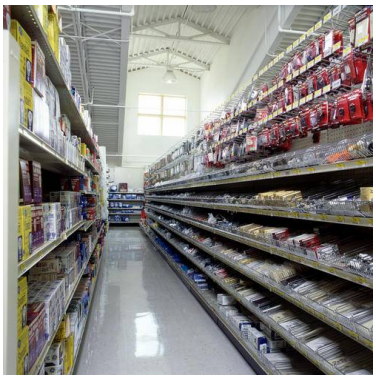
- Tubular Daylighting
- Lighting Controls
- Tankless Gas Hot Water Heater
- T-8 Electrical Lighting
- 1.2 W/sqft Lighting Power Density
- OA Ventilation Control







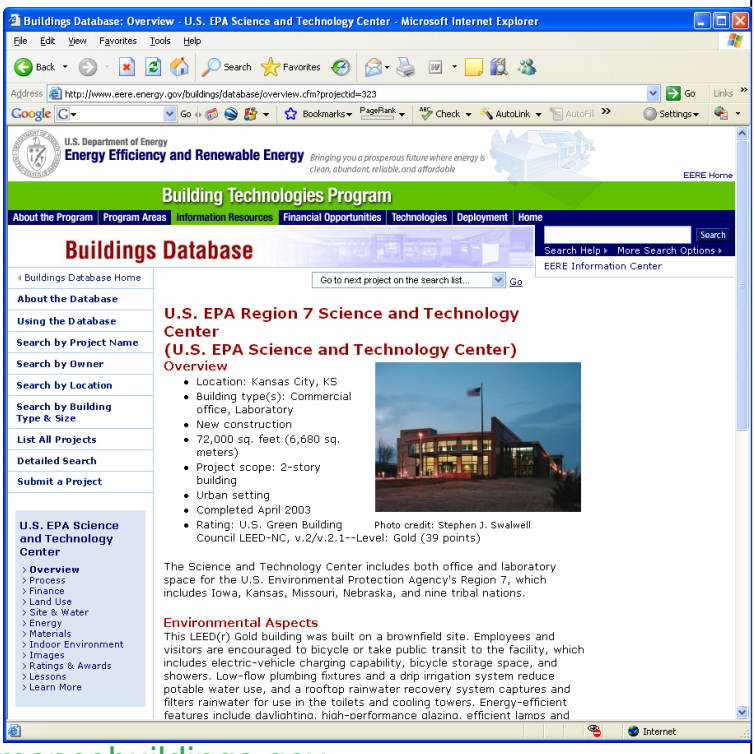
DOE Can Provide:



- Facilitating integrated design
  - Help with goal setting
  - Identifying trade offs
  - Energy modeling expertise
  - Application of Advance Energy Design Guides
- If you have designs that are very low energy
  - Data analysis from monitoring and evaluation
    - Need meters for HVAC, Lighting, and all other loads
  - Case studies (4-pagers, DOE database, and technical reports)
- Other needs?

DOE High Performance Buildings Database

- Share successes and lessons learned about projects
- Public database
- EnergyStar
- LEED



www.highperformancebuildings.gov

Final Thoughts…

•Set energy goals

•Use the architecture to reduce heating and cooling loads

•Harvest the daylighting potential

•Right-size heating and cooling systems

•Turn systems off when not in use

•Keep it Simple

•We can help with the details

Questions?

www.highperformancebuildings.gov

Creative Financing

•EPACT 2005

- 30% tax credit of total costs of solar (PV and hot water) for commercial installations
- $1.80/ft^2 tax deduction for 50% energy savings over code for new commercial buildings

USDA Rural Development

- 25% grant for total costs of renewable in new, for-profit commercial installations
  - Wind, PV, Geothermal, Biomass
  - Also for efficiency reterofits
- 50% load for total costs of renewables in new for –profit commercial installations

C.2 Setting Goals and Implementing Energy Efficiency Strategies for the Kiowa County Memorial Hospital

Paul Torcellini, Shanti Pless, Lynn Billman
National Renewable Energy Laboratory

NREL National Renewable Energy Laboratory

A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

Innovation for Our Energy Future

Setting Goals and Implementing Energy Efficiency Strategies for the Kiowa County Memorial Hospital

US Department of Energy
Through the
National Renewable Energy Laboratory
October 31, 2007

Paul Torcellini, Ph.D., PE
Shanti Pless
Lynn Billman

NREL is operated by Midwest Research Institute • Battelle

NREL is a national lab for the US Department of Energy with a single mission to develop renewable and energy efficiency technologies.

Commercial Buildings Team

- Develop energy simulations
- Optimize building designs through simulation application
- Develop standardized metrics and implementation of these metrics
- Evaluate energy performance of buildings



NREL National Renewable Energy Laboratory

Starting Point… Goal Setting

Measurable goals are better

From bad to good…

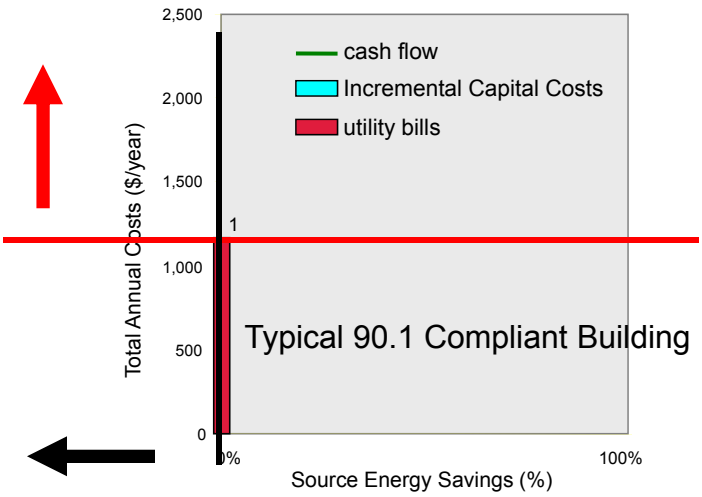
- I want a green building
- Design a LEED <rating> building
- Design a building to use 30% less energy than ASHRAE 90.1-2004
- Design a building to use less than 30,000 BTU/sqft

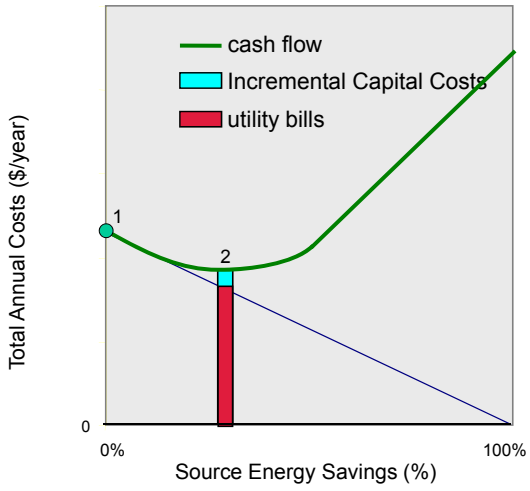
Design Process

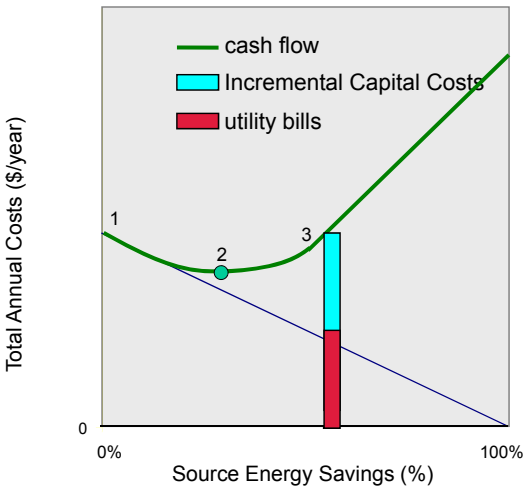
Design is about making decisions and trade-offs

- More insulation, daylighting, or ERVs – smaller HVAC?
- Capital cost whole building trade-offs

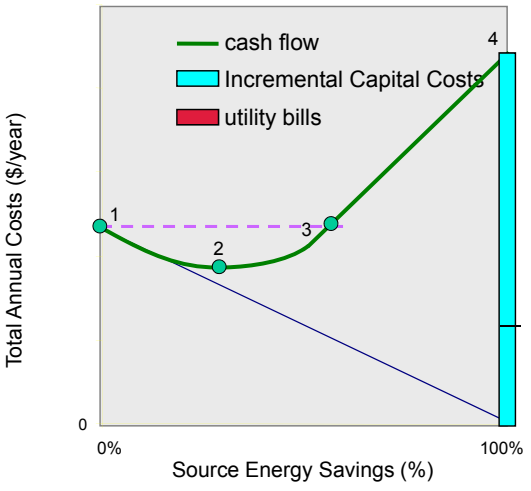
Integrated Design should not cost more


2,500
2,000
1,500
1,000
500
0
Total Annual Costs ($/year)
cash flow
Incremental Capital Costs
utility bills
1
Typical 90.1 Compliant Building
0%
100%
Source Energy Savings (%)


cash flow
Incremental Capital Costs
utility bills
Total Annual Costs ($/year)
1
2
0
0%
100%
Source Energy Savings (%)

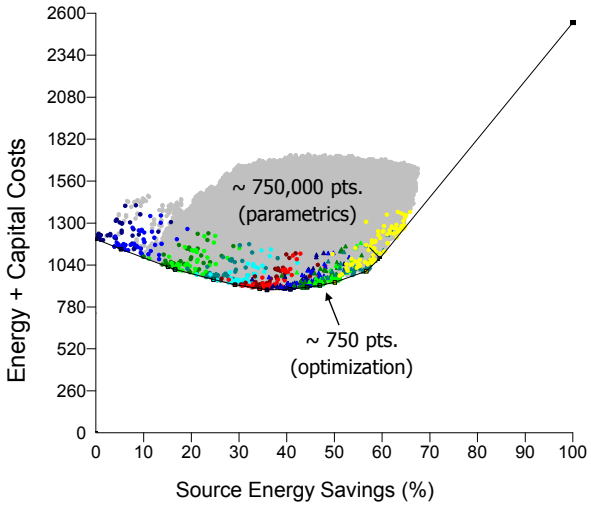


NREL National Renewable Energy Laboratory



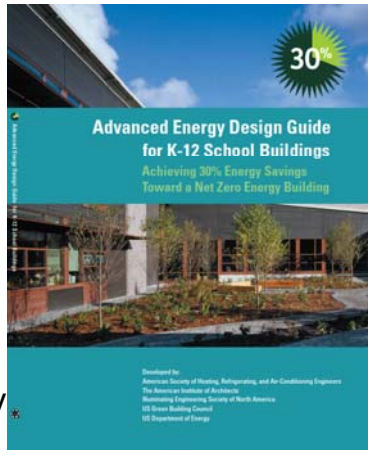
NREL National Renewable Energy Laboratory

Parametrics / Optimization



Advanced Energy Design Guides

- Developed by ASHRAE, AIA, USGBC, IESNA, and DOE
- Easy to use guidance to achieve 30% in Small Offices, Small Retail, and K-12 Schools
- Solutions by climate zone
- 4 LEED energy points
- Pre-engineered solutions—hourly simulations done by NREL



How to Achieve Energy Savings…

1. Daylighting (includes site selection)
2. Lighting design to match daylighting
   - Occupancy sensors
3. Good envelope (including overhangs)
4. Plug loads
   - Design vs. owner loads
5. HVAC designed for the remaining loads
   - Energy recovery
6. Commissioning (making sure the building works)
7. Metering and evaluation
8. Make it Simple
9. Renewable Generation

Envelope Recommendations for Small Office

- Roofs
  - R-20 continuous insulation above deck
  - R-38 attic insulation
- Walls
  - R-11.4 continuous insulation mass wall
  - R-13 + R-7.5 c.i. steel or wood framed
- Windows
  - Overhangs on South, East, and West
  - U-0.42 (double pane, low-e)
  - SHGC-0.46 (0.75 with overhangs)
- Interior Finishes
  - 80% reflectance or higher on ceilings, walls above 7’
  - 70%+ reflectance on wall below 7’

Way Station Headquarters

Frederick, MD

- 30,000 ft^2 Mental Health Facility
- R-25 roof insulation, R-15 wall insulation
- Daylighting with roof monitors and light shelves on south facing windows
- Greenhouse for passive solar heating
- Double pane, low-e windows
- High efficiency boilers
- Ice storage
- Details in the DOE High Performance Buildings Database







SMDC Health System

Duluth, Minnesota

- LEED Gold Certified
- 22% energy savings
- 236,000 ft^2
- Daylighting in central atrium and outlying clinics
- Dimming controls and occupancy sensors
- R-30 roof, R-26 walls
- Water cooled chiller with VFDs
- 83% efficient steam boilers
- Heat recovery from exhaust air
- Permanent commissioning program
- More info in July '07 Eco-Structure



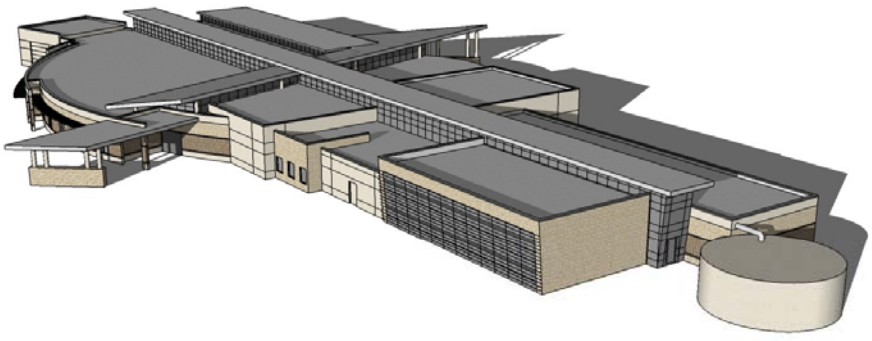


Greensburg Concept



NREL National Renewable Energy Laboratory

Greensburg Concept



NREL National Renewable Energy Laboratory

NREL Can Provide:

- Help with goal setting
- Energy modeling expertise
- Application of Advance Energy Design Guides
  - Development of Hospital AEDG
- If you have designs that are very low energy
  - Data analysis from monitoring and evaluation
    - Need meters for HVAC, Lighting, and all other loads
  - Case studies (4-pagers, DOE database, and technical reports)
- Other needs?

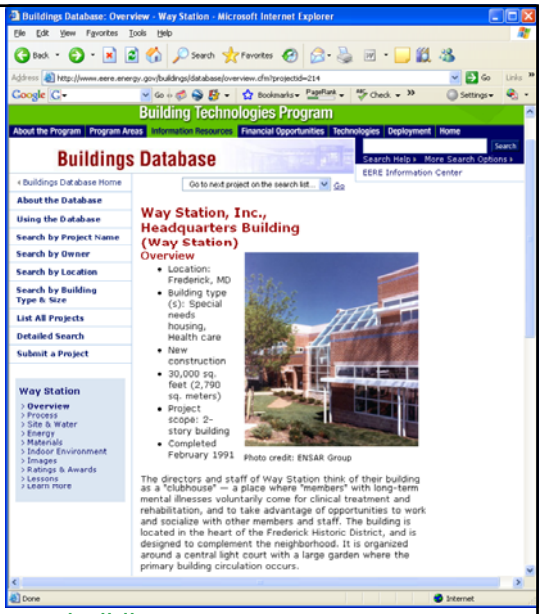
Additional Resources

•Share successes and lessons learned about projects

•Public database

•Green Guide for Health Care

- http://www.gghc.org/



www.highperformancebuildings.gov

C.3 Applying a Whole-Building Design Process for New Commercial Buildings in Greensburg

Shanti Pless
National Renewable Energy Laboratory

The following best practices should be applied to future low-energy Greensburg commercial buildings:

- Use a whole-building design process to design, construct, and operate future low-energy buildings. This includes:
    - Set a specific, quantifiable energy design goal that is used to guide the design process and can be verified during operation.
    - Include everyone involved in the project at the earliest stages of the design process.
    - Use whole building simulation tools to determine the energy performance of the building at all stages of design, construction, and occupancy. The whole-building design process is a simulation-based, quantitative, and qualitative method to help architects and engineers create low-energy buildings. Low-energy design is not intuitive. The energy use and energy cost of a building depend on the complex interaction of many parameters and variables. The problem is far too complex for "rules of thumb" or hand calculations. The interactions are best studied with computerized energy simulation software to thoroughly evaluate all interactions between the building envelope, HVAC system, and design features.
    - Design the building envelope such that it can be used to meet as many of the loads as possible. The envelope should be the first method of creating low-energy buildings; the mechanical and lighting systems should then be sized to meet any remaining loads. Low-energy architecture is not effective if mechanical systems have to solve problems from the architectural design.
    - Update the design simulations from predesign through occupancy to ensure the design simulations will measure up to actual performance.

In the traditional building design process, the architectural team works with the owner to create a building program that specifies the needs for the building and parameters that should be considered in the design. The architect designs the building to satisfy the program requirements, and then the project engineers design the electrical and mechanical systems and evaluate compliance with energy codes and acceptable levels of environmental comfort. However, because many important architectural decisions are set at this point, few changes can be made that would improve energy performance. Typically, no energy performance goals are established. The architect and engineers may try to design efficient systems, but they have little interaction or goals to direct the design, so the results are usually mediocre.

In contrast to the traditional building process, the whole-building design process requires the team—the architect, engineers (lighting, electrical, and mechanical), energy and other

consultants, and the building's owner and occupants—to work together to set and understand the energy performance goals. The purpose of whole-building design approach is to enable the full design team to interact throughout the design process to fully understand the building systems interdependences. The full design team focuses from the outset on energy and energy cost savings. The process relies heavily on energy simulation, includes design charrettes involving all members of the design team, and establishes energy goals early in the process. The whole-building design process begins with predesign, where often little more than the building size, type, location, and use are known. To be effective, the process must continue through design, construction, and commissioning (Deru 2004).

The best time to develop performance targets is at the beginning, before any design concepts have been developed. Once everyone has committed to an energy-saving goal, the process can be used to guide the team toward good decision-making and trade-off analysis without sacrificing programmatic requirements. Team members must commit to an energy goal early in the process so that they thoroughly understand the interdependencies of the architecture and systems and can create more efficient and cost-effective buildings. To realize low-energy buildings, the project team must not only set a low-energy performance goal, but must *commit* to it. Each member is encouraged to find solutions and offer suggestions that benefit other disciplines, the process, and ultimately the building design.

Whole-building energy simulations guided the designs of some of the buildings in Greensburg. Some used ASHRAE's Advanced Energy Design Guides (http://www.ashrae.org/technology/page/938), which provides prescriptive recommendations for a given level of energy savings. Energy simulation in pre-design helped to set quantified goals, and identified areas with high potential for energy savings and peak reductions. In addition, energy simulations are a crucial tool for understanding the impact of design decisions on energy performance. Experience has shown that the chances of energy analysis affecting the design of a building decrease rapidly as the design proceeds.

- Some of the most important concepts to remember when using energy modeling as part of an integrated building design are as follows:
    - A whole-building design approach is a good way to lower energy use and cost. An integrated whole-building approach begins with a design team that is committed to the energy goals. The building must be engineered as a system if the technologies are to be integrated in design and operation. The integrated design process starts with predesign and is applied through construction and operation, ensuring that the building is built to plan. Whole-building energy simulation, or energy modeling, is a great help in setting goals, informing the design process, and evaluating the energy impacts of design and construction decisions.
    - Owners provide the main motivation for low-energy buildings. The owner is the driving force in many cases. The owner, along with the design teams, sets the goals and makes decisions to keep the project on track. The architects and engineers strive to meet the goals of the building owners, which result in a whole-building design process.
    - Setting measurable energy saving goals at the onset of the project is crucial to realizing low-energy buildings. In many cases, the owners and design teams set

aggressive energy saving goals at the outset. The goals ranged from 30% better than code to obtaining a high LEED score. Design teams are motivated to achieve when they set the goals. Setting such goals enables owners to make decisions that align with the goals. In general, the teams that set the strongest energy performance goals and used energy simulation to understand the energy impacts of design decisions had the best energy performance. Past projects have shown that defining specific, measurable energy saving goals early in the design process helps the design team achieve better results.

- Use the envelope as the first method of creating low-energy buildings. Engineer the envelope to reduce loads with features such as increased insulation, window tuning, and self-shading, and at the same time integrate passive solar heating, cooling, daylighting, and natural ventilation technologies. A better envelope and favorable building orientation are typically the most cost effective energy efficiency measures. Energy modeling is necessary to understand how to best do this. Then size HVAC equipment to meet the remaining loads. Use the mechanical system to make up for what cannot be accomplished by architectural form and envelope, not to correct for an architectural design that is climatically ill conceived.

  In general, the envelope should be designed to both reduce the loads, and meet as many needs as possible. Building siting and envelope should be the first method of creating a low-energy building. Low-energy architecture is not achievable if mechanical systems have to solve problems from inadequate envelopes or ill conceived siting.

  The best way to reduce the cost of low-energy features and ensure successful integration is to incorporate them into the architecture early. If low-energy features such as good orientation, daylighting, clerestories, or cooltowers can be integrated into the architectural design and statement, they can be included as part of the architecture costs.

The "green" building industry has generally recognized the value of whole-building design. The *Whole Building Design Guide* (NIBS 2008) offers up-to-date tools, design guidance, and technologies related to applying the whole-building design process. Further details of the whole building design process are outlined in Table 1 (Torcellini, et al. 2006).

Table 1. Ten-Step Process for Designing and Constructing Low-Energy Buildings

Predesign	1. Set specific and measurable energy performance goals, which may include percent energy savings, percent energy cost savings, and emission reductions. The entire team must understand these goals and how they are affected by design features. Also at this stage, the design team should develop a thorough understanding of the building site, local weather patterns, and building functional requirements. At this point, the design team should brainstorm energy solutions, especially those that affect the architecture. Each building is unique and will have a different minimization strategy. Energy simulation at this stage helps to set quantified goals, and identifies areas with high potential for energy savings and peak reductions. 2. Create a base-case building model to quantify base-case energy use and costs. The base-case building is solar neutral (equal glazing areas on all wall orientations) with equivalent floor area and meets the requirements of applicable energy efficiency codes such as ASHRAE Standard 90.1 (ASHRAE 2004). When building designs and operations change, the baseline has to evolve along with the building under consideration. 3. Complete a parametric analysis of the base-case model to determine sensitivities to specific load components. Sequentially eliminate loads such as conductive losses, lighting loads, solar gains, and plug loads from the base-case building. 4. Develop preliminary design solutions. The design team brainstorms possible solutions, which may include strategies to reduce lighting and cooling loads by incorporating daylighting or to meet heating loads with passive solar heating.
Schematic Design	5. Incorporate preliminary design solutions into a computer model of the proposed building design. The energy impact and cost effectiveness of each variant are determined by comparing the calculated energy performance with the original base-case building and to the other variants. Variants with the most favorable results should be incorporated into the building design. 6. Prepare a preliminary set of construction drawings. These drawings are based on the decisions made in Step 4. Architectural decisions made during the schematic design phase can have the greatest impact on the long-term building energy performance.
Design Development	7. Identify the HVAC system that will meet the predicted loads. The HVAC system should complement the building architecture and exploit the specific climatic characteristics of the site for maximum efficiency. Often, the HVAC system capacity is much less than in a typical building. Verify that baseline and design simulations are updated with design changes.
Construction Documents and Bid	8. Finalize plans and specifications. Ensure that the building plans are properly detailed and that the specifications are accurate. The final design simulation should incorporate all cost-effective features. Savings that exceed 50% from a base-case building are frequently possible with this approach.
Construction	9. Rerun simulations before changes are made to the design during construction. Verify that changes will not adversely affect the building's energy performance.
Postoccupancy Evaluation	10. Commission all equipment and controls. Educate building operators. Only a properly operated building will meet the original energy efficiency design goals. Building operators must understand how to properly operate the building to maximize its performance. Measure and evaluate actual energy performance to verify design goals were met.

In addition, the U.S. Green Building Council has established rating systems and provided extensive information on high-performance commercial buildings on their website (http://www.usgbc.org).

Deru, M.; Torcellini, P. (2004). *Improving Sustainability of Buildings Through a Performance-Based Design Approach: Preprint*. NREL Report No. CP-550-36276. World Renewable Energy Congress VIII, Denver, CO, August 29 - September 3, 2004. Golden, CO: National Renewable Energy Laboratory, 8 pp. www.nrel.gov/docs/fy04osti/36276.pdf (PDF 381 KB)

NIBS. (2008). *Whole Building Design Guide.* National Institute of Building Sciences. http://www.wbdg.org/wbdg_approach.php Last accessed March 2008.

Torcellini, P.; Pless, S.; Deru, M.; Griffith, B.; Long, N.; Judkoff, R. (2006). *Lessons Learned from Case Studies of Six High-Performance Buildings*. NREL Report No. TP-550-37542. Golden, CO: National Renewable Energy Laboratory, June 2006. 151 pp. www.nrel.gov/docs/fy06osti/37542.pdf (PDF 3.9 MB)

C.4 Recommendation: Greensburg, Kansas, Should Adopt the Best Green Municipal Building Requirement in the United States

Shanti Pless
National Renewable Energy Laboratory

Requirement: All new, occupied city buildings, of any size, shall be designed, contracted, and built via a "green building" approach to achieve certification in the Leadership in Energy and Environmental Design (LEED®) Program at the Platinum certification level – the highest benchmark awarded by the U.S. Green Building Council.

"Green building" is a whole-systems approach utilizing design and building techniques to minimize environmental impact and reduce the energy consumption and utility costs of a building while contributing to the health of its occupants and building durability. This requirement includes:

- Fifty percent energy cost savings compared to a typical building built to code
- A healthy indoor environment
- Fifty percent reduction in water use compared to a typical building
- Use of renewable energy generation wherever appropriate
- Use of locally available and recycled materials while minimizing construction waste
- Reducing the overall environmental impact from the site

C.4.1 What are the Benefits of Green Building and LEED Certification to City Leadership?

By adopting this approach the city will:

- Reduce utility costs
- Substantially reduce negative environmental impacts
- Enhance building value and marketability
- Increase occupant comfort and worker productivity
- Set the example for other public buildings, businesses, and homeowners in Greensburg
- Receive extensive media coverage potentially leading to economic growth

C.4.2 How Will Greensburg Compare to Other Cities?

- Ninety other local governments have adopted LEED certification requirements
    - None in Kansas
    - None LEED Platinum
- Greensburg will be the first city in the nation to:
    - Have *all* of its municipal buildings LEED certified
    - Have municipal buildings certified to the LEED Platinum level

C.4.3 What are the Cost Impacts?

- The best designed larger buildings have been documented to have *no* increase in cost
- Cost increases may be 3%-10% for Greensburg's smaller buildings

C.5 Recommendation: The City of Greensburg, Kansas, Should Encourage Green Commercial, Nonprofit, and Public Building Design to Align with the Community Master Plan

Shanti Pless
National Renewable Energy Laboratory

All new commercial, non-profit, and non-city-owned public buildings of any size are encouraged to be designed, contracted, and built via a "green building" approach to achieve at least 30% energy efficiency compared to current building code. Additional green features, as outlined in the Leadership in Energy and Environmental Design (LEED®) Program, should be incorporated to achieve the Silver certification level or higher.

The City of Greensburg has set an aggressive goal of LEED Platinum and 42% energy savings for all city-owned buildings. The purpose of setting this aggressive goal was to provide leadership and to foster a future sustainable business environment. In line with the master plan, we recommend that the city encourage all commercial and non-city public buildings to build "green".

"Green building" is a whole-systems approach utilizing design and building techniques to minimize environmental impact and reduce the energy consumption and utility costs of a building while contributing to the health of its occupants and building durability. This recommendation focuses on a 30% energy cost savings compared to a typical building built to code. To meet the recommended level of energy savings, follow the simple, prescriptive energy efficiency recommendations, when life cycle cost effective, available in the Advanced Energy Design Guides, available from www.ashrae.org/aedg.

In addition to energy savings, green building features include:

- A healthy indoor environment
- Thirty percent reduction in water use compared to a typical building
- Use of renewable energy generation wherever appropriate
- Use of locally available and recycled materials while minimizing construction waste
- Reducing the overall environmental impact from the site

C.5.1 What are the Benefits of Green Building and LEED Certification to the City Leadership?

By adopting this approach, commercial and public buildings will:

- Reduce utility costs
- Substantially reduce negative environmental impacts
- Enhance business marketability and image
- Increase occupant comfort and worker productivity
- Align with the city's Sustainable Comprehensive Master Plan
- Receive extensive media coverage, potentially expanding economic growth

C.5.2 What are the Cost Impacts?

- Recommend 30% energy savings and sustainable design when life cycle cost effective

C.6 Metal Building Recommendations for Greensburg, Kansas

Shanti Pless
National Renewable Energy Laboratory

Recommendations

We expect these recommendations would result in at least 30% energy savings for metal buildings in the Greensburg climate zone. These recommendations are based on those in the Small Retail Advanced Energy Design Guide, but with additional details.

Site Orientation

During site selection, preference should be given to sites that permit elongating the building in the east-west direction and that permit orienting more windows to the north and south. North and south glass can be more easily shielded and can result in less solar heat gain and less glare than do east- and west-facing glass.

Roof Insulation

We recommend that the roof assemblies are a minimum of R-25. The general concept is shown below. Additional insulation is needed between the purlins, or as continuous insulation foam board (not draped) or insulated panels on exterior of the purlins. The insulation can be sprayed in, integral to a metal panel, or standard fiberglass, as long as the assembly is R-25 or greater. The best type of insulation will depend on local costs and availability of installers and materials. See Figures 1 and 2 for different examples of metal roof insulation. The best strategy will depend on local installation and materials, as long as the total roof assembly achieves a minimum of R-25.

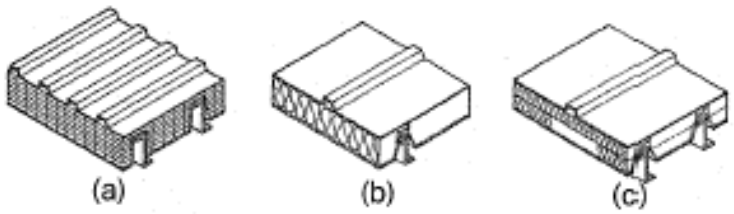


Figure 1: Pre-fabricated metal roofs showing various options for thermal blocking of purlins

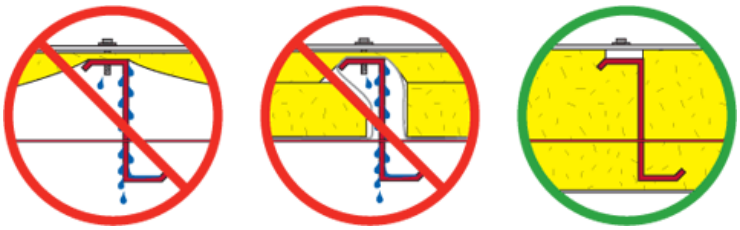


Figure 2: Recommended roof insulation mounting (from http://thermaldesign.com/systems/simplesaver/concept.html)

Various suppliers are available. Designs similar to:

- http://thermaldesign.com/systems/simplesaver/concept.html
- http://www.suspenderbar.com/index.html
- http://www.rhinobldg.com/steel-building-insulation.htm

Wall Insulation

We recommend that the wall assemblies are a minimum of R-19. Typical insulation systems in metal buildings are installed in a way that compresses the insulation, which decreases the R-Value. Below are various recommendations to achieve the recommended whole-wall R-19.

- Fill the purlin and girt cavities completely with uncompressed insulation. An additional thermal barrier of insulation over the purlins and/or the placement of thermal blocks greatly decreases the thermal bridging. See Figure 3.
- Use one layer of fiberglass batt insulation along with a layer of rigid continuous insulation (c.i.). The fiberglass layer is installed continuously perpendicular to the exterior of the girts. The rigid c.i. insulation is installed on the inside of the fiberglass layer. The fiberglass layer is compressed as the metal skin is attached to the girts.
- Spray foam insulation is another possible method for obtaining the recommended R-value.
- Use exterior metal wall panels with integral insulation to obtain the recommended R-value.

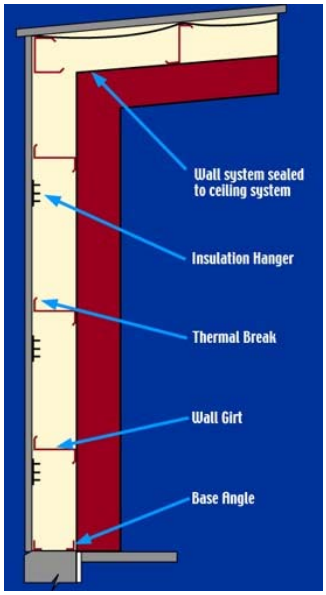


Figure 3: Cross section of typical metal wall
red layer is the structural beams, yellow layer is the insulation

Windows and Daylighting from the Walls

A good design strategy minimizes glass that does not contribute to the daylighting of the space. If possible, configure the building to maximize north and south-facing walls and glass by elongating the floor plan. Since sun control devices are less effective on the east and west façades, the solar penetration through the east- and west-facing glazing can cause a problem with glare and is usually shaded in the retail environment. This can be done by reducing the area of glazing, reducing the Solar Heat Gain Coefficient, and using diffusing panels or films.

- Avoid placing windows below 3 feet. Low windows do not contribute to daylighting.
- Place daylighting glass as high as possible on the exterior walls, with 12in. – 18in. strip of glass dedicated to daylighting.
- Minimize eastern and western exposures.
- For daylighting, wall areas should be made up of 20% to 40% windows.
- Windows should have a thermal transmittance of U-0.42 or lower.
- Windows should have a solar heat gain coefficient of approximately 0.46 for all window orientations.
- Overhangs with a projection factor of 0.5 should be used on south facing windows (see Figure 4).

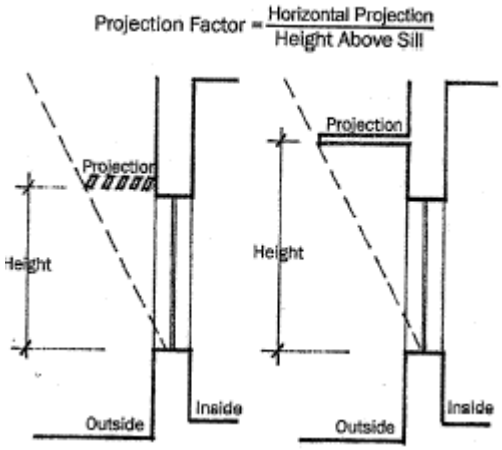


Figure 4: Overhang Projection Factor

Daylighting from the Roof

- Place top lighting with clerestories, roof monitors, diffusing panels, or tubular daylighting devices in all zones without side daylighting.
- Clerestories, diffusing panels, and roof monitors should make up not more than 10% of the roof area.
- Tubular daylighting devices should make up not more than 3% of the roof area.

Slab Insulation (Heated and Un-heated)

- Heated slabs should have full slab thickness and R-10 continuous insulation that runs underneath the heated portion of the slab. Bubble wrap is not recommended.
- Unheated slabs should have 24 in. of R-10 continuous insulation that runs along the perimeter of the slab.

Doors

- Single swinging doors should be used as much as possible.
- If double swinging doors are used, include a center post.
- Swinging doors should have a U-value of approximately 0.70.
- Non-swinging doors, such as overhead doors, should have a R-value greater than R-6. Highly insulated overhead doors are available, with an R-value of approximately R-14. An example is shown at http://www.chiohd.com/commercial/3216/. For walls that contain large overhead doors and represent a significant percentage of the gross wall area (door-to-wall area >10%), this type of insulated overhead door is recommended.

- ***Lighting Power Density***
  - Average building lighting power density: 0.9 W/ft^2
  - Office: 0.9 W/ft^2
  - Retail: 1.3 W/ft^2
  - Lobby: 0.7 W/ft^2
  - Corridor/mechanical: 0.5 W/ft^2
  - Bathroom: 0.5 W/ft^2

    - Service: 0.9 W/ft^2
    - Classroom: 0.9 W/ft^2
    - Storage: 0.5 W/ft^2
- Keep controls simple
- No incandescent lamps for general space lighting
- Compact fluorescent lights in spaces less than 25 sq ft
- No emergency ballasted egress lighting
- General space lighting should come from T-8s or T-5s linear fluorescent lighting
- Electronic ballasts should be used for all fluorescent lighting
- Electronic lighting should be dimmable or switchable to make use of the available daylighting
- Occupancy sensors should be used to turn off electronic lighting in spaces with variable occupancy (bathrooms, storage, corridors, etc.)
- Use light-colored surfaces (>70% reflectance) for interior walls and ceilings to maximize use of daylighting

Radiant Slab Heating, Boiler Efficiency, Energy Efficiency Ratio of Air Conditioners

- Radiant slab heating or direct gas burner heating in automotive service bays
- No heating or cooling in vestibules
- Boiler
    - Condensing Boiler with 95% (or greater) efficiency
- Air Conditioners
    - Air Conditioner (0-65 kBtuh): 13.0 EER
    - Air Conditioner (>65-135 kBtuh): 11.0 EER/11.4 IPLV
    - Air Conditioner (>135-240 kBtuh): 10.8 EER/11.2 IPLV
    - Air Conditioner (>240 kBtuh): 10.0 EER/10.4 IPLV
- Gas Furnace
    - Gas Furnace (0-225 kBtuh – single package): 80% AFUE
    - Gas Furnace (0-225 kBtuh - split): 90% AFUE
    - Gas Furnace (>225 kBtuh): 80% efficiency
- Economizer
    - Economizers should be used on air conditioners to save energy by providing free cooling when ambient conditions permit
- Solar and Water Heating
    - The water heating system should be sized to meet the anticipated peak hot water load
    - Gas storage: 90% efficiency
    - Gas instantaneous: 81% efficiency

Plug Loads

- Turn off plugs when not in use
    - www.greenswitch.tv

- Energy Star appliances
    - http://www.energystar.gov/
- Use LCD computer monitors.

Exterior Lights

- Control with an exterior photosensor to turn off during the day

Allow for Renewable Generation Options

- Tilt of roof for PV
- Conduit for future installation of PV or wind

Performance Metrics

- Report metrics to evaluate energy efficiency design
- Lighting power density per zone (W/ft^2)
- Cooling capacity (ft^2/ton)
- Energy savings over code
- Site energy use ($kBtu/ft^2$)
- Energy cost intensity ($\$/ft^2$)

Appendix D: Power Generation

Page

D.1 Electricity Supply for Greensburg, Kansas, as of December 2007 244

D.2 Community Wind Options 246

D.3 Examples of Community Owned Wind Projects 260

D.4 Analysis of Wind Generation Options for Greensburg, Kansas 276

D.5 Analysis of Greensburg Municipal Utility Business Strategies to Become Green 292

D.6 Refined Wind Speed Maps for Greensburg 362

D.7 Only Very Small Wind Turbines Should be Building Mounted and Primarily for Architectural Purposes, not Primarily for Energy-generation Purposes 369

D.8 Analysis of Photovoltaic Generation Options for Greensburg, Kansas .. 370

D.9 Greensburg, Kansas, Biomass Resource Assessment and Opportunities for Converting and Using Fuels from Biomass 408

D.10 Biomass Pellet Options for Greensburg and Surrounding Regions 417

D.11 Assessment of Biomass Pelletization Options for Greensburg, Kansas 447

D.12 Greensburg, Kansas, Long Term Recovery Plan, Landfill Gas Potential 466

D.13 Greensburg, Kansas, Downtown District Heating and Cooling Study 467

D.14 Greensburg Recovery Program – The Feasibility and Benefits of Fuel Cell Cogeneration 476

D.1 Summary: Electricity Supply for Greensburg, Kansas, as of December 2007

Lynn Billman
National Renewable Energy Laboratory

D.1.1 Pre-Tornado Electricity Supply

The City of Greensburg acts as a municipal utility which provides customers in Greensburg with electricity, water, sewer, and trash services. The City owned the distribution lines within the community before they were largely destroyed. The City bought electricity under a ten-year, co-generation agreement with Sunflower Electric Power Corporation, a consumer-owned, nonprofit generation and transmission service provider. Sunflower is owned and operated by six rural electric distribution cooperatives; the cooperative serving Greensburg is Southern Pioneer. These six rural electric coops recently formed a coalition, Mid-Kansas Electric Company, LLC, to buy the assets of Aquila's Kansas Electric Network.

The City also owned and operated a power plant and substation with five Fairbanks dual-fuel (natural gas and diesel) generators. At Sunflower's notification, city operators would fire up the generators to meet peak loads, generally summer air conditioning.

The City had approximately 1,000 customers at the time of the tornado. In total, city customers used 15.6 million kWh of electricity in 2005 and 14.0 million kWh in 2006. The average load was 2.7 MW; peak load (generally summer) was 4.3 MW. The City charged the customers 12 ¢/kWh. This covered expenses approximately as follows: 4 ¢/kWh for wholesale electricity from Sunflower; 2 ¢/kWh fuel charges; 4 ¢/kWh for city-owned power plant; and 2 ¢/kWh for other city expenses.

D.1.2 Post-Tornado Electricity Supply

Immediately following the tornado of May 4, 2007, FEMA provided emergency generators and other support. Sunflower assisted in providing limited power very quickly as well.

The first action of the City was to replace the distribution lines, a $10M project. FEMA provided 75% ($7.5M), the state 10%, and the City 15%. The electricity distribution system was completed about December 1, 2007.

In July 2007, the city entered into a Memorandum of Understanding (MOU) with Sunflower. The key provisions of this MOU are as follows:

- When the distribution lines are complete, Southern Pioneer will purchase the City's electrical system.
- The City will enter into a long-term franchise agreement for Southern to provide electricity to the citizens at retail rates, proposed verbally to the City as 9 ¢/kWh.

The rates are regulated by the Kansas Corporation Commission. The higher the franchise percentage the City wants, the higher the rates.

This arrangement is attractive to the City because it would relieve the City of the responsibility of managing an electrical utility, and the cash received for the distribution assets would help the City pay off

some outstanding debts. However, the City would no longer act as a municipal electric utility, and would lose the ability to add or change generating sources such as wind or solar.

Greensburg's contract with Sunflower expired Oct 31, 2007. On November 1, 2007, the City entered into a 180-day contract for electricity, which expires April 2008. Under this contract, Mid-Kansas provides electricity from its generating sources or from market sources (at Mid-Kansas sole discretion) to the Kansas Municipal Electric Association (a cooperative of 15 cities with a load of about 30 MW) for resale to the City. The price to Greensburg is Mid-Kansas' cost plus 10%, plus a monthly demand charge of $3.00 per kW, based on the peak requirement integrated on a 15-minute basis.

D.2 Community Wind Options

Trudy Forsyth
National Renewable Energy Laboratory

Tom Wind
Wind Utility Consulting



Community Wind Options





Trudy Forsyth (NREL) & Tom Wind (Wind Utility Consulting)

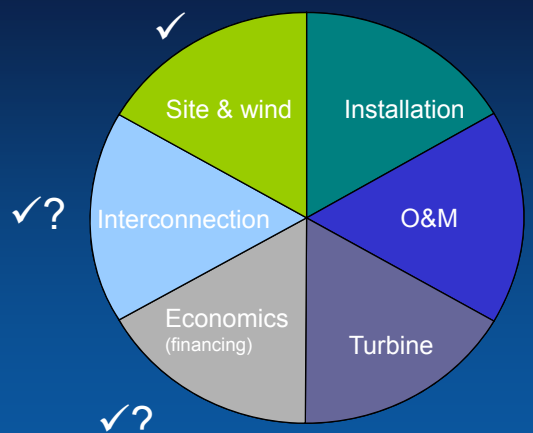
NREL National Renewable Energy Laboratory

Overview

- Definition of community wind
- Where have community wind installations occurred
- Where is policy driving this market
- What specific policies are moving the market
- What are the successful economic models turbine
- Turbine costs/availability (?)
- Options for Greensburg
- Lists of more sources of information
- Contact information

NREL National Renewable Energy Laboratory

Key Issues of Community Wind project



NREL National Renewable Energy Laboratory

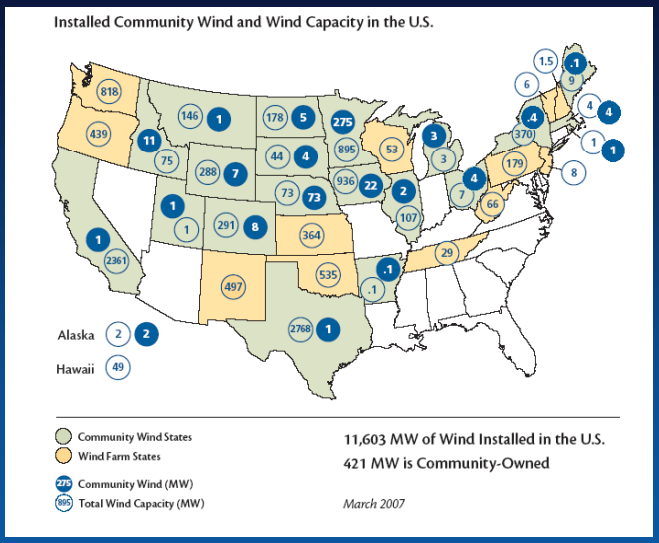
Defining "Community Wind"

- **Locally Owned:** One or more members of local community have a direct financial stake in the project, other than through land lease or tax revenue
- **Utility-Scale Turbines:** 50 kW threshold for new turbine projects and refurbished turbine projects
- **On Either Side of Meter:** Power consumed on site or sold to unrelated party (or both)

BERKELEY LAB

NREL National Renewable Energy Laboratory

Community Wind in the United States

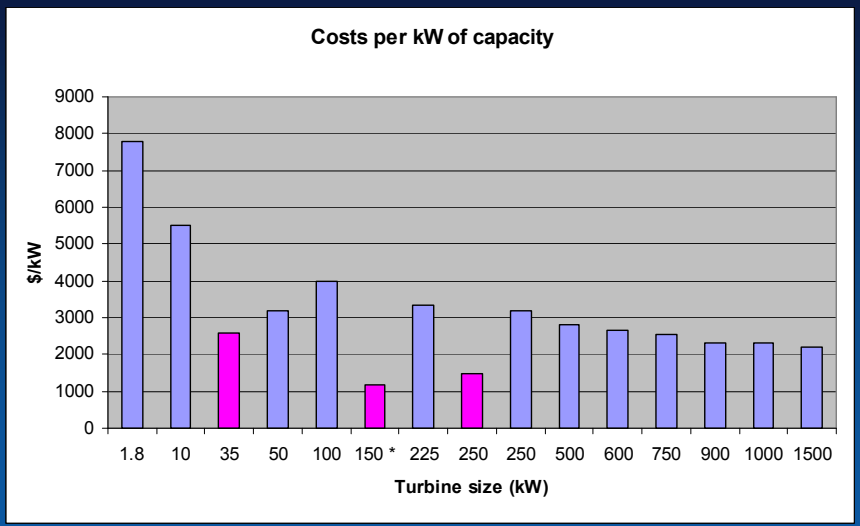


In 2000, 80% of installed turbines in EU are community wind

WINDUSTRY

NREL National Renewable Energy Laboratory

Turbine costs per kW



NREL National Renewable Energy Laboratory

The Major Challenge for This Project: --- Wind turbine procurement ---

- It is a Seller's Market!
- Most major manufacturers have no wind turbines available for 2008 or 2009
  - Large wind farm developers have purchased most wind turbines
  - Earliest delivery for major new projects may be in 2008
  - A few turbines become available as construction schedules slip
  - Three years ago, delivery time was 20-25 weeks
- Manufacturers favor larger orders rather than smaller orders since they make more money
  - In many cases, no manufacturers may even bid on supplying a single wind turbine
- To get a turbine in the near future you may have to work through a larger developer

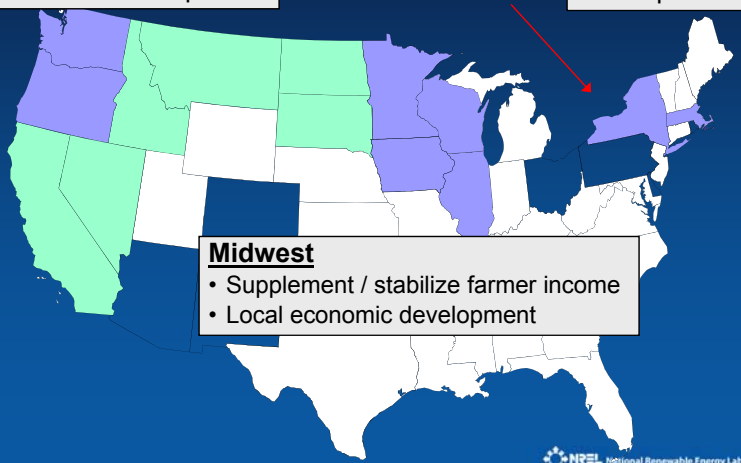
NREL National Renewable Energy Laboratory

2004 – Spanning the Country

Northwest
- "Fill the valleys" between "lumpy" big projects
- Local economic development

Northeast
- Increase public acceptance of wind power

Toronto



Midwest
- Supplement / stabilize farmer income
- Local economic development

BERKELEY LAB

NREL National Renewable Energy Laboratory

How did Minnesota become a Community Wind leader?

- Xcel Energy's wind mandate (1994)
- Minnesota's 10-year production incentive of 1.5¢/kWh (1997)
- Minnesota's renewable energy objective (2001)
- Xcel Energy's small wind tariff and standardized power purchase agreement (2001)
- Xcel Energy's Renewable Development Fund (implemented in 2001)
- USDA Farm Bill, Energy Title Grants (2002)
- C-BED Tariff (2005 and 2007)

Successful incentives address financing issues, provide access to capital, equipment, and/or strengthen the market for community wind.

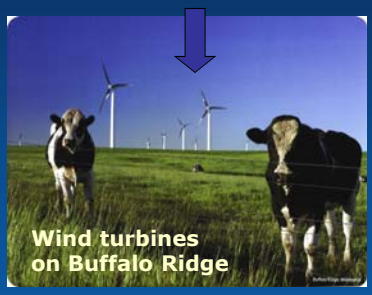
WINDUSTRY

NREL National Renewable Energy Laboratory

Xcel Energy Wind Requirement

- 1994
  - Legislature requires that Minnesota's largest utility acquire 425 MW
- 1999
  - expanded to 825 MW
- 2003
  - expanded to 1,125 MW
- 2007
  - Expanded to 30% by 2020

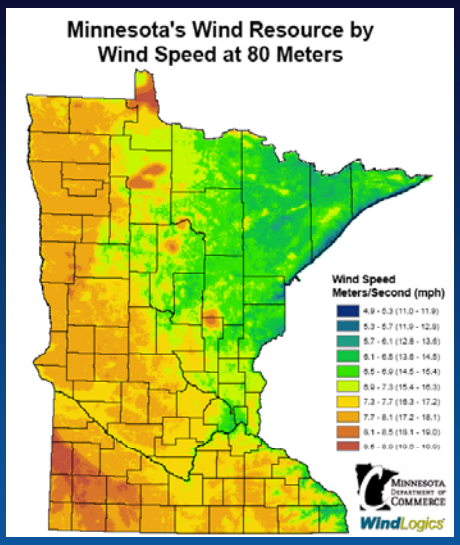


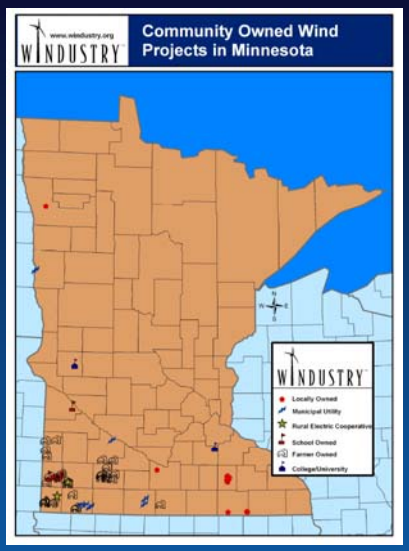


This created a market for wind development in Minnesota!!!

WINDUSTRY

NREL National Renewable Energy Laboratory





Minnesota has made local ownership a priority!

WINDUSTRY

NREL National Renewable Energy Laboratory

Illinois

Bureau Valley School District (660 kW, on-site)
- $20,000 grant for feasibility study (ILCECF)
- $375,000 construction grant (ILCECF)
- In final permitting stages

Illinois Rural Electric Cooperative (1.65 MW, supply mix)
- $175,000 up-front 10-year REC purchase (ILCECF)
- $250,000 grant (RERP)
- $438,544 grant (USDA)
- Broke ground in May 2004

Illinois State University (1.5 MW, seeking power purchaser)
- $500,000 grant (ILCECF), dependent on other grants

3-Year Statewide Wind Monitoring Program (ILCECF)
- Targets sites suitable for community-scale turbines

BERKELEY LAB

NREL National Renewable Energy Laboratory

Illinois Rural Electric Cooperative

Pike County, Illinois

- *Size:* 1.65 MW turbine
- *Date:* Spring 2005 ribbon cutting for one.
- *Inspiration:* IL wind maps showed some of the best wind in the state to be in IREC territory.
- *Output:* Turbine generates about 4% of IREC's power needs, close to the 5% limit in wholesale power contract.
- *Financing:* Project supported by 3 grants
  - USDA
    IL State grant
    IL Clean Energy Foundation



IREC Engineering Manager and project leader Sean Middleton.

WINDUSTRY

NREL National Renewable Energy Laboratory

How do state policies stack up?

Feed-In Tariffs (MN): Ideal for community wind

RPS (various states): Philosophically at odds with feed-in tariffs, community wind may require "carve out" (like in Minnesota)

Cash Production Incentives (MN): Accessible (tax liability not required, low transaction costs), and work well with the PTC (no haircut)

Infrastructure Development (WI, MA, OR): Reduces transaction costs of development, which can otherwise kill a community wind project

Grants (IL): Structure so that do not reduce value of PTC

BERKELEY LAB

NREL National Renewable Energy Laboratory

CREB Overview

- Clean Renewable Energy Bonds (CREBs) were created by Energy Policy Act of 2005 (Baucus & Grassley)
- Provide gov't entities with ability to obtain interest-free financing for renewable energy projects by providing investors with federal tax credit in lieu of interest payments
- 2006 CREBs were authorized for $800M through FY07:
  - $500M: Cities, Counties, Tribes
  - $300M: Rural Electric Co-ops
- House proposal for 2007 $2B
  - 60% municipalities
  - 40% Rural Electric Co-ops
- Allocations made from smallest to largest (pyramid)
- CREBs are an excellent funding vehicle for county/city/tribally-owned renewable energy projects



NREL National Renewable Energy Laboratory

On-Site *(Customer Side of Meter)*

A large electricity customer installs a utility-scale wind turbine to supply on-site power and thereby displace power purchased from the utility.

Examples: Iowa schools (e.g., Spirit Lake)

Strengths:

- Potential to offset retail (rather than earn wholesale) rates

Weaknesses:

- Sites with both large enough load *and* good wind are rare
- Net metering capacity limits usually well below nameplate capacity of modern utility-scale wind turbines
- Large loads typically face *demand* (and *standby*) charges
- PTC (or REPI) not available for power consumed on site
- Electric bill savings are taxable income (to a taxable owner)

NREL National Renewable Energy Laboratory

Multiple Local Owner

Local investors jointly own off-site, utility-scale wind turbine(s), and sell power to a utility.

Examples: Minwind I & II

Strengths:

- Straightforward, no corporate equity involved, purely local
- Don't have to wait 10 years for serious cash

Weaknesses:

- To maximize return, need investors with passive income
- Project shares may need to be registered as "securities"
- Relatively high organizational burden
- Must secure a power purchase agreement

NREL National Renewable Energy Laboratory

Minnesota-Style Flip

Landowner with insufficient tax liability partners with tax-motivated corporate investor to own utility-scale wind turbine(s) and sell power to the utility. Initial interests in project LLC (99% corporate/1% local) "flip" after 10 years.

Examples: Dan Juhl projects

Strengths:

- Innovative way to ensure capture of PTC and improve project economics

Weaknesses:

- Local makes above-normal returns (sub-optimal)
- Local return may be heavily back-loaded (after year 10)
- Need to engage corporate equity partner
- Must secure a power purchase agreement

NREL National Renewable Energy Laboratory

Town-Owned *(Utility Side of Meter)*

A municipality (but *not* a municipal utility) owns a utility-scale wind turbine and sells power to a utility.

Examples: Northfield, MN and Massachusetts (both planned)

Strengths:

- No land lease or property tax expense, municipal debt(?)

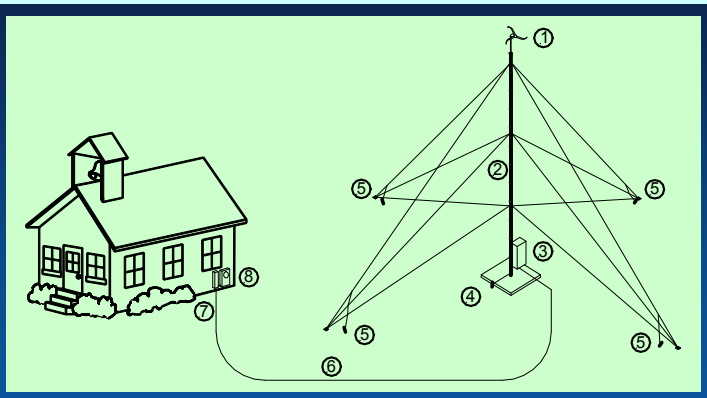
Weaknesses:

- ? May not be legal…
- "Private use" issues may restrict ability to finance project using tax-exempt municipal debt
- Economics depend heavily on availability of REPI or CBED
- Relatively weak opportunities for local citizen participation
- Must secure a power purchase agreement

NREL National Renewable Energy Laboratory

Wind for School

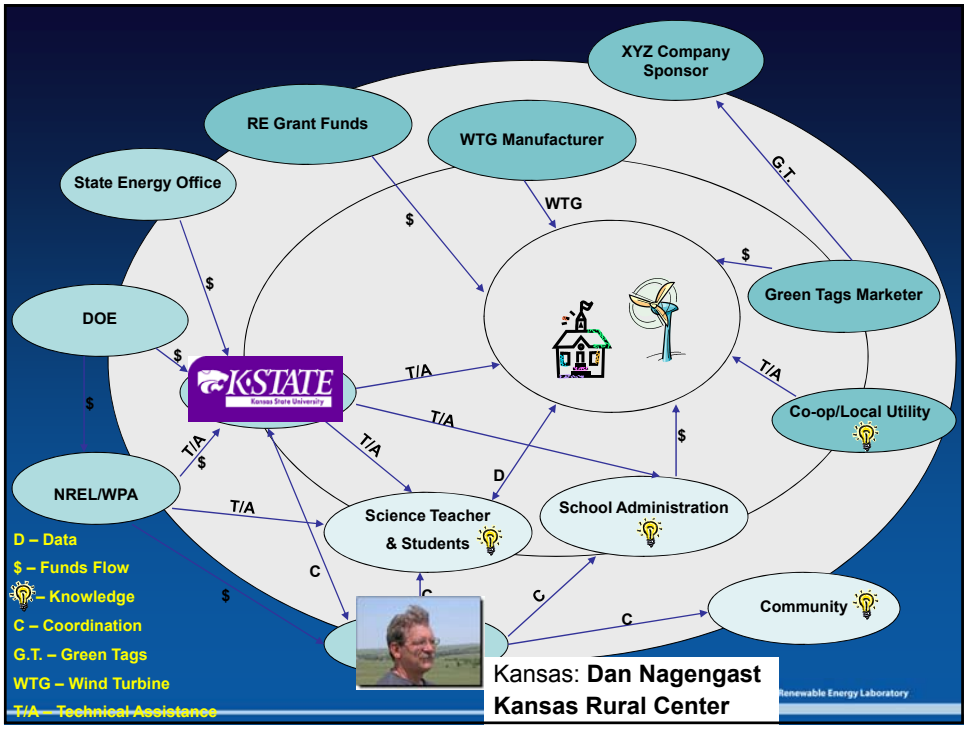
Initially envision using a standard system package, but could branch out and provides a process for the use of larger or different systems.



SKYSTREAM 3.7™
www.skystreamenergy.com

Southwest Windpower
Renewable Energy Made Simple

NREL National Renewable Energy Laboratory



Options for Greensburg

- Piggyback model – buy turbines planned for future wind farm
  - Economy of scale for turbine costs, development, installation and O&M
- Town-owned or multiple local owners
- On-site Customer side of electric meter
  - To meet cost goals must be refurbished turbines
    - Buyer beware



Need to know turbine history
Need to know refurbishment process & track record
Need to know warranty & performance bonding

NREL National Renewable Energy Laboratory

Community Wind contacts

matney-frantz engineering

Mike Costanti | Principal
105 W. Main St., Suite G | Bozeman, MT 59715
406.556.9827 | mcostanti@matneyfrantz.com
www.matneyfrantz.com

Mark Bolinger
MABolinger@lbl.gov
603 795 4937

Berkeley Lab

www.windustry.org
2105 1st Ave S
Minneapolis, MN 55404
toll free: (800) 946-3640
Lisa's phone: 612-870-3462
Lisa's email: lisadaniels@windustry.org

WINDUSTRY

NREL National Renewable Energy Laboratory

Trudy Forsyth
NREL/NWTC
1617 Cole Blvd. #3811
Golden, CO 80401
(303) 384-6932
Trudy_forsyth@nrel.gov

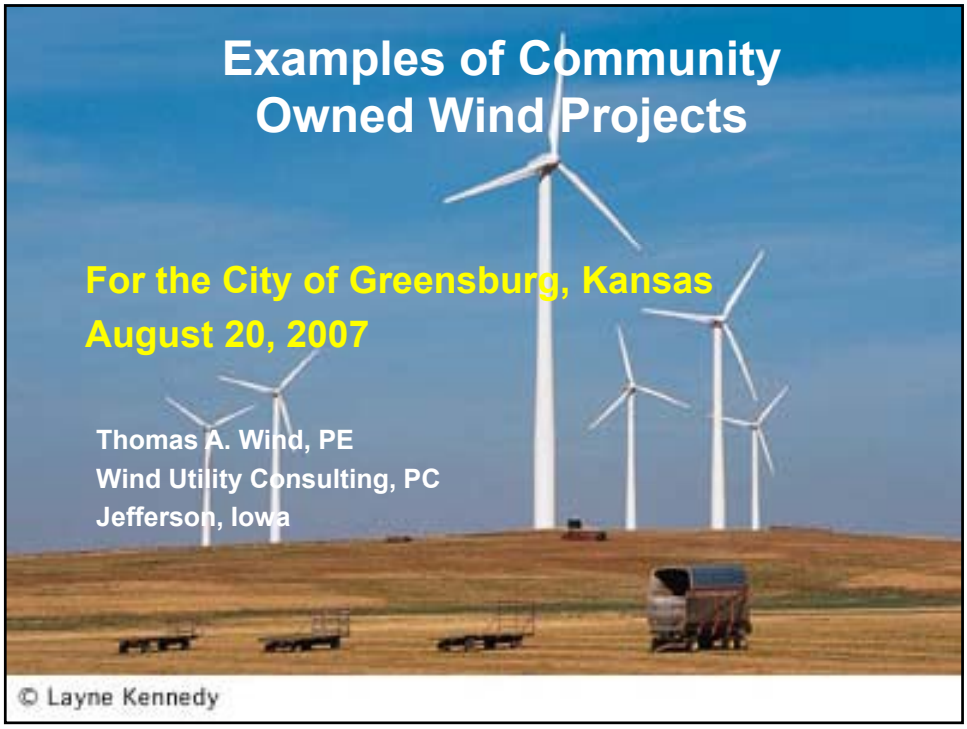
NREL National Renewable Energy Laboratory

Thomas A. Wind, PE

Wind Utility Consulting, PC
412 S. Locust St.
Jefferson, Iowa 50129
tomwind@netins.net

D.3 Examples of Community-Owned Wind Projects

Tom Wind
Wind Utility Consulting



Examples I Will Discuss

- Municipal Utility-Owned Wind Turbines
  - Stuart Municipal Utilities
  - Lenox Municipal Utilities
  - Wall Lake Municipal Utilities
  - Southern MN Municipal Utilities
- Cooperative-Owned Wind Turbines
  - Illinois Rural Electric Cooperatives
- School-Owned Wind Turbines
  - Sentral Schools
  - Spirit Lake Schools
  - Eldora Schools
- Local Farmer-Owned Wind Turbines

2

Municipal Utility-Owned Wind Turbines

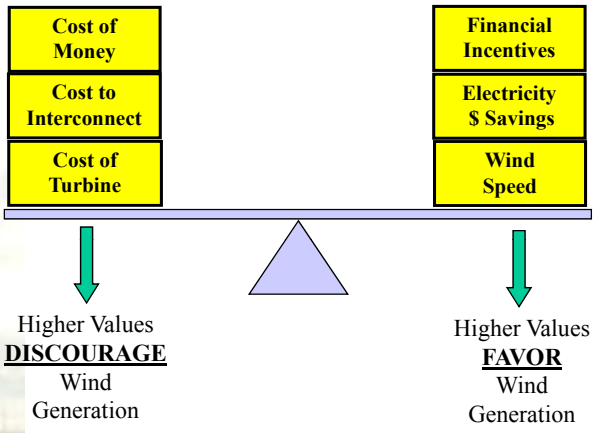
Wind Turbines for Consumer-Owned Utilities

School Children on a Field Trip to Visit Turbines Owned by Seven Iowa Municipal Utilities



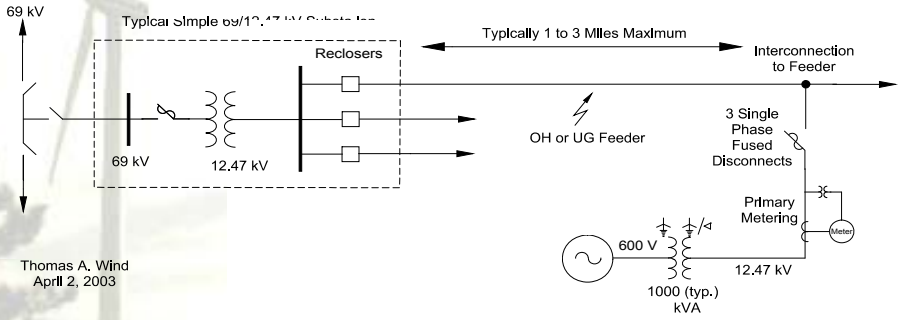
- Small utilities owned by city residents or cooperative members
- Minnesota & Iowa have about 10 utilities that own a turbine installed locally
  - Another 100 utilities own a share of a larger wind farm
- In nearly all cases, wind power costs more for the first 10 to 15 years of the turbine's life, with savings occurring after that.
- Customer pressure is primary driver, with other drivers being environmental benefits and local champions
- Grants and CREBs very important

The Overall Economics of Wind Generation is Determined by a Balance of Factors



5

Single Line Diagram of Basic Interconnection



6

City of Moorhead, Minnesota

- Nearby Anemometer was used to estimate wind speed…. not very windy
- Initial study in 1997 indicated some potential savings, but not much
- Utility decided to proceed due to interest of customers and good cooperation of power supplier
- Installed 750 kW wind turbine in 1999, $667,000 + interconnection
- Sold all green power at 0.5¢ per kWh premium
- Installed second 750 kW wind turbine in 2001, $651,000 + interconnection
- Named wind turbines “Zephyr” and “Freedom”



From left: MPS Commissioner Bob Swenson, Pat and Marilyn Hecker, Tammy and Jeremy Kroke, MPS Commissioner Dave Kerssen, and MPS Commissioner Ken Norman.

7

Wall Lake, Iowa

- Initial preliminary study in late 1998 piqued interest
- More detailed studies in 2001 and 2002 showed slightly increased costs with a wind turbine, unless a grant was received
- Wall Lake received $250,000 CDBG grant
- Installed 660 kW wind turbine in 2003, costing about $750,000
- Levelized Long-term Cost is 3.6¢ without federal REPI payment
- Turbine provides 20% of town’s energy needs
- This is a Big Deal for Wall Lake!



Lamar, Colorado

- *Owners:* Lamar Light & Power/Arkansas River Power Authority
- Lamar piggybacked on larger project to achieve economies of scale.
- *Size:* 5 turbines – 7.5 MW
  - 3 Lamar
  - 2 ARPA
- *Date:* Commissioned in 2004
- *Output:* About 15% of Lamar's annual energy needs
- *Financing:*
  - Revenue savings bonds,
  - Renewable energy credits,
  - Savings from piggybacking on top of 162MW Colorado Green Project





Photo Credit: Leon Sparks

Presentation: City of Lamar Light & Power and ARPA /Springfield Wind Project, Colorado Wind and Distributed Energy Conference, April 2004

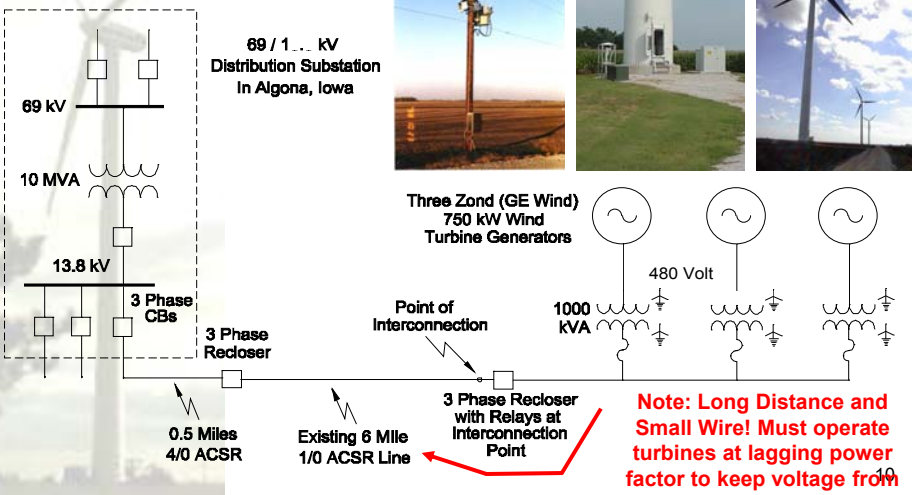
9

Iowa Distributed Wind Generation Project With Three 750 kW Wind Turbines Near Algona, Iowa









10

Two Wind Turbines for the City of Fairmont, Minnesota





2 x 950 kW

11

City of Lenox, Iowa

- Original study in 2001 concluded no big savings
- Community supported project
- Added 750 kW wind turbine in late 2003 costing $950,000
- Received $400,000 Community Development Block Grant
- Power quality was important design issue due to weak rural system
- This is a Big Deal for Lenox!

"We're involved with wind energy in Lenox because it's good for the environment, the economy, and our state's and nation's energy independence. Supporting renewable energy and making Lenox a green city is a way we can ensure that what we're leaving to our children and grandchildren is a clean environment, a healthy economy, and a secure nation." Dave Ferris, Utility Manager

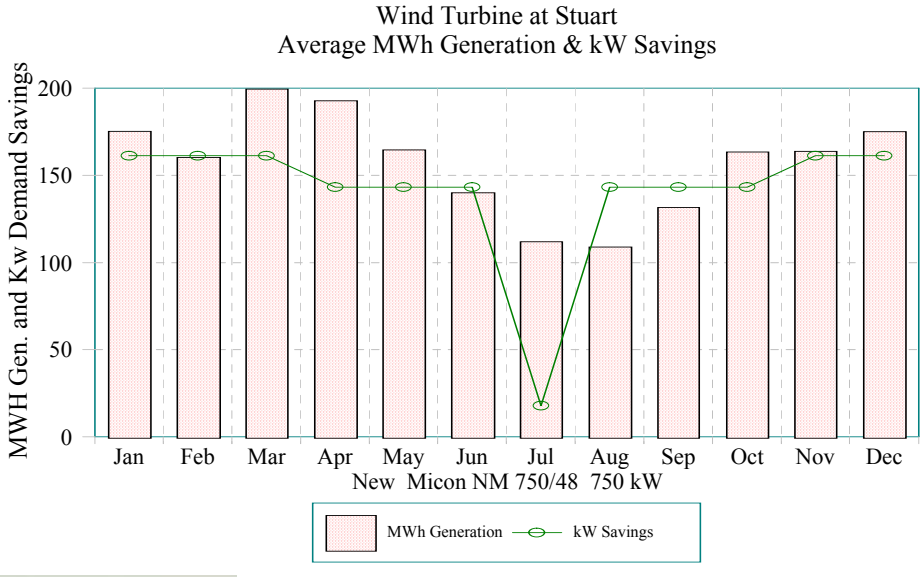


Stuart Municipal Utilities

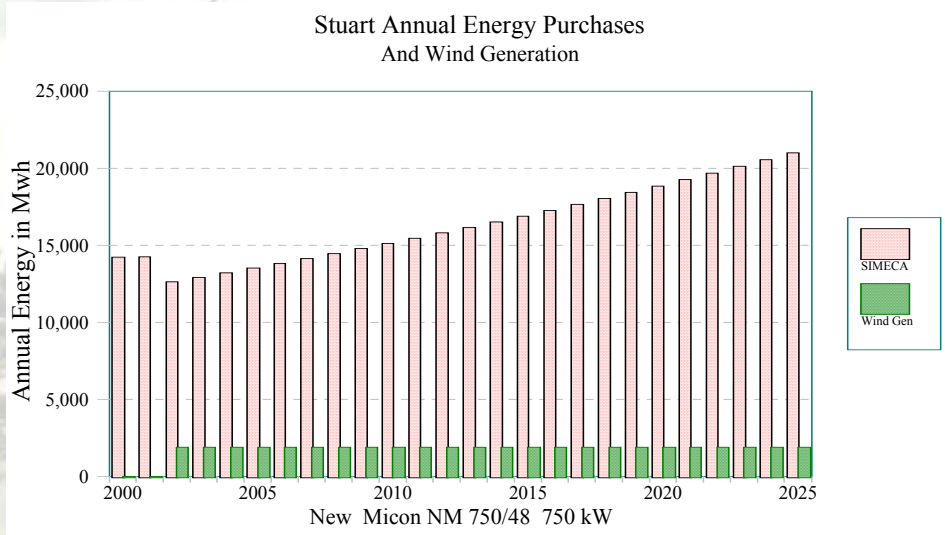
- Small Iowa town (1700 people) in central Iowa
- Buys wholesale power from Cooperative G&T
- Has diesel generators to cover peak load
- Looked at long term savings in wholesale power costs
- Received CDBG grant
- Installed a 660 kW Vestas V47 wind turbine 300' from Interstate Highway 80.

13

Monthly Energy & Capacity Value for a 750 kW Wind Turbine

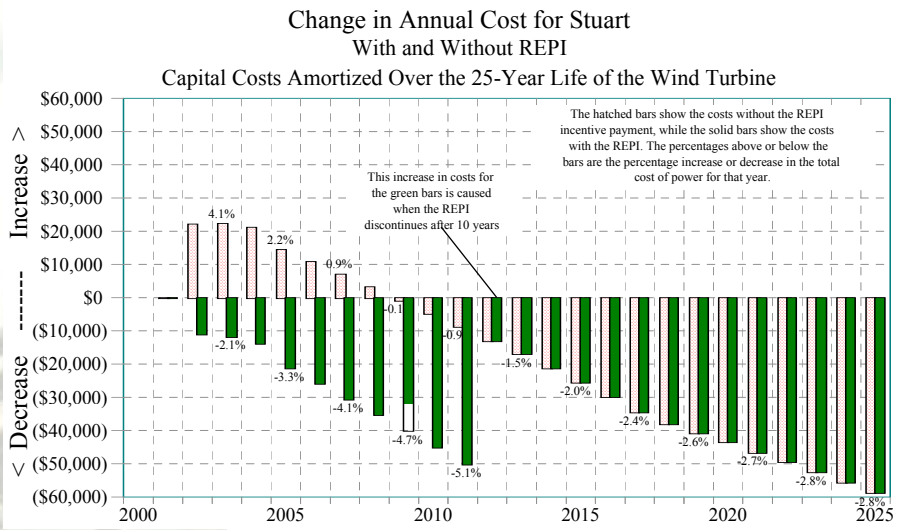


Annual Energy Purchases & Wind Generation



15

Preliminary Cash Flow Impact



Cost of wind generation was 3.7¢ with REPI, or 4.8 ¢ without REPI

16



Cooperative Utility-Owned Wind Turbines

17



Illinois & Iowa Cooperatives

- Illinois Rural Electric Cooperative installed a 1.65 MW Vestas V82 wind turbine in 2005
- Rural Electric Convenience Cooperative has ordered a 900 kW AWE direct drive wind turbine.
- Adams Electric Cooperative has also ordered a 900 kW AWE direct drive wind turbine.
- A few other Iowa rural electric distribution cooperatives are now considering installing single turbines near their distribution substation.
- Cooperative G&Ts often own or buy wind power from larger wind farms. Sunflower is an example.

18

School-Owned Wind Turbines

19

Wind Turbines at Schools and Colleges



600 kW Wind Turbine for School at Forrest City Iowa

- Twelve Iowa schools and colleges in Iowa, and five in Minnesota have wind turbines. All projects are the result of two major factors:

1) Supportive Public Policies
   - Net Metering
   - Grants
   - Low cost financing
   - Tradable state tax credits
   - Green tags or RECs
   - Administrative and technical support from state
2) Determined local champions

Iowa Schools: Spirit Lake, Nevada, Sentral, Clay-Everly, Akron-Westfield, Forest City, Clarion, Eldora, Iowa Lakes Community College, Grinnell College
Minnesota Schools: Lac Qui Parle, Pipestone, Carleton College, St. Olaf, U of M at Morris

Sentral Schools at Fenton, Iowa

- Very small school system in NW Iowa
- Refurbished 65 kW WindMatic unit installed in 1994
- Generates about 40% of school's needs
- Went through period of time when they didn't get timely maintenance





21

Wind Turbines at Spirit Lake Schools in Iowa

- 250 kW Wind Turbine installed in 1993 at a total cost of $239,000
- Loan repaid in 5 years
- Generates 350,000 kWh/year, saves school $25,000 per year



- 750 kW Wind Turbine cost $750,000 in 2001
- Loan paid off in 2007
- Generates 1,700,000 kWh/year
- After loan is repaid, savings from both turbines will be about $120,000/yr.



22

Two Wind Turbines at School in Spirit Lake, Iowa







750 & 250 kW

23

600 kW Turbine at School in Forest City, Iowa



24

Iowa Lakes Community College

- Small college in northern Iowa wanted to start wind technician training program
- Received federal budget earmark of $500,000 to help pay for a 1.65 MW Vestas V82 wind turbine and start up technician program.
- Considered connecting turbine to campus to reduce electricity purchases, but opted to sell all power to local municipal utility instead.



1650 kW Wind Turbine at Iowa Lakes Community College in 2005

25

Local Farmer-Owned Wind Turbines

26

Community Wind Economics Using Partnership Flip Model

- Many Community Wind projects use the Partnership Flip LLC structure ("Minnesota Flip")
- This structure allows the project owners to take advantage of the federal income tax benefits provided to wind power
- Consumer-owned utilities cannot use federal income tax benefits since they are non-profit
- A three way partnership could possibly be formed between private owners, the city, and outside equity owners that can readily use the tax benefits.

27

Farmer-Owned Wind Turbines

- Several 2 MW projects in SW Minnesota owned by individual landowners
- Developed by Dan Juhl on behalf of the farmers
- Typically two 900-950 kW Wind Turbines
- Enabled by Minnesota's 1.5¢ per kWh incentive payment
- LLC formed with a tax investor that can use production tax credit and accelerated depreciation
  - Tax investor contributes up front capital to project



28

MinWind 1 & 2 Wind Farms

- Two Farmer-Owned Cooperatives in LuVerne, Minnesota owning four 950 kW wind turbines
- Farmers provide equity (40%) and borrow balance from local banks
- Farmes have some difficulty using federal tax credits
- Projects received state 1.5 ¢ incentive payment





29

Summary

- There are many wind turbine projects that are owned by local communities, cooperatives, and individuals
- In most cases, there have been favorable state policies which have provided some incentives that enabled the projects.
- In most cases, the economics resulted in nominal near-term savings. The longer terms savings often were the driving factors.

30

D.4 Analysis of Wind Generation Options for Greensburg, Kansas

Tom Wind
Wind Utility Consulting

Executive Summary

The city of Greensburg faces some key decisions regarding the source of electricity for the city as it rebuilds after the May 2007 tornado. This preliminary study considers five principal wind energy options for the City, and explores some ramifications of whether or not the City continues to operate a municipal utility, and the City's green electricity goals.

The city could choose to sell its municipal electricity system and depend fully on electricity from the current local cooperative, which expects to have 10% wind-generated electricity by the end of 2007. The city could purchase more renewable energy credits annually, to raise its percentage of wind energy from 10% (local cooperative) up to as much as 100% (Option 1). However, this wind-generated or green electricity would not be obviously visible to the residents or anyone else.

With the approval of the local cooperative, larger individual customers (school, hospital, own businesses with larger energy needs) could install their own grid-connected, mid-sized wind turbines, up to 200 kw per customer (Option 2). This would increase the amount of green electricity in the city and provide good green visibility. However, the cost of energy from mid-sized turbines is much higher than from one or two large turbines.

If the city retains its municipal electricity system, it has several more options for wind-generated green electricity, depending on the city's goals and economic possibilities:

- City-owned large wind turbines at the edge of city could provide potentially 50% green electricity and be very visible (Option 3).
- City-owned large wind turbines with energy storage could potentially provide the city with up to 90% green electricity, and demonstrate a revolutionary vision (Option 3-A).
- The school and hospital (largest individual energy users) could each install a large wind turbine with energy storage systems, providing a very innovative demonstration to maximize the use of wind power for these energy users (Option 4).
- Private investors could install a small wind farm near Greensburg, connected to the local grid, and sell the power to the Greensburg municipal utility (a version of Option 3) or to the local cooperative (Option 5). This would provide some green visibility since the wind turbines would be located near the city.

After further guidance is provided, further studies should be done to refine the chosen options.

Table of Contents

Assumptions for Future Electricity Needs 1

Overview of Wind Generation Options 1

Option 1: Purchase Green Tags 2

Option 2: Mid-Sized Wind Turbines for Larger Individual Customers 3

Option 3: City-Owned Large Wind Turbines 3

Option 3-A: City-Owned Large Wind Turbines with Energy Storage 5

Option 4: Large Turbines for School and Hospital 6

Option 5: Private Wind Farm at Greensburg 7

Summary of Analysis of Greensburg Wind Power Options 8

Addendum: Preliminary Estimate of Wind Speeds in the Greensburg Area 9

Assumptions for Future Electricity Needs

There is some uncertainty about Greensburg's future electrical needs, since the amount of reconstruction of homes and businesses is unknown. Furthermore, even with more energy-efficient homes, the amount of electricity needs for each home will depend upon the amount of renewable energy used by each home. For example, solar photovoltaics and solar water heating on an individual home will reduce electricity needs.

Electricity needs might even increase if homeowners switch from natural gas heating to renewably-supplied electric heating. One possibility is to convert nearly all gas heating to electric heating. This would include using a combination of heat pumps and thermal heat storage. All of this new demand for electricity could be met by a couple of large wind turbines. This concept of using wind power for heating has been coined "Green Heat." Converting electricity into thermal energy, especially during off-peak hours, provides a means of energy storage when the wind doesn't blow or the sun doesn't shine. Thermal storage units have been used many years by thousands of customers of electric cooperatives in the Dakotas.

Natural gas usage could be nearly eliminated in city with the conversion to Green Heat. This increased need for electricity could also be supplied fairly economically by large wind turbines. Since wind power costs are relatively fixed once the wind turbines are installed, customers' heating costs would be nearly inflation proof, because they would not escalate with fossil fuel prices.

Using plug-in hybrid cars would further reduce fossil fuel usage in Greensburg, if the electricity for charging the cars' batteries primarily came from renewable electricity supplied by the city.

The city used 15.6 million kWh in 2005 with a peak load of 4.7 megawatts ("MW"). Regardless of the large uncertainty in future growth, the following assumptions were used for purposes of this wind power assessment:

- 2008 – 6.6 million kWh, 2.0 MW peak
- 2009 – 8.0 million kWh, 2.4 MW peak
- 2010 – 9.6 million kWh, 2.9 MW peak
- 2011 – 11.5 million kWh, 3.5 MW peak
- 2012 – 13.3 million kWh, 4.0 MW peak (full recovery)
- 2013 and beyond – 1.5% growth per year

Overview of Wind Generation Options

There are at least five different options for Greensburg to use wind power. An assessment was made of these options, based upon these assumptions about future electricity needs and information on the local wind resources.

Option 1. The city could purchase renewable energy credits or green tags for all electricity used in Greensburg.

Option 2. Individual customers with large energy use could install wind turbines at their locations to supply part of their power needs.

Option 3. The city's electric utility could install or purchase power from one or more large wind turbines to provide a significant percentage of the city's energy needs from wind power. Option 3-A has more wind turbines, along with an energy storage system.

Option 4. The school or hospital could install a large wind turbine with an energy storage system to supply the majority or all of the electricity and heating needs at each facility.

Option 5. The city could partner with private investors to install one or two large wind turbines at the edge of Greensburg, with all of the power sold at wholesale to outside electric utilities.

The viability of the options depends upon who owns the local electric system.

- *If the city sells its electric system, then it no longer makes any decisions about electric generation resource options or wind power. Under this scenario, there are few options available to effectively "green up" Greensburg. Southern Pioneer's electric power will be only about 10% green by the end of 2007. Individual electric customers could use additional green energy by installing their own wind turbines or solar photovoltaic ("PV") generators, within the limitations imposed by Kansas statutes.*

- *If the city continues to own its electric system, then it has several more wind power options, since it will make the decisions about its power supply resources. It could choose to install large wind turbines.*

If Greensburg retains ownership of its electric system, then all five of the options studied are available. If Greensburg sells its electric system to the current local cooperative, then only options #1 and #2 from above are available. (The cooperative does not have any green power options available at this time.)

The following pages present these options in more detail.

Option 1: Purchase Green Tags

The city could purchase renewable energy credits or green tags for all electricity used in Greensburg. With a bulk purchase of green energy, the cost premium might initially be less than 0.5 ¢ per kWh.

In 2005, the city used 15.6 million kWh before the tornado. Assuming sales in 2008 will be about 40% of that or about 6.6 million kWh, the cost premium at 0.5 ¢ per kWh would be $30,000 per year. This premium would rise as kWh sales increase with rebuilding. Furthermore, the cost of each green tag will likely escalate quickly as the U.S. adopts policies to reduce carbon

emissions. The cost might be $125,000 in 2012. The annual average over 5 years might be $80,000.

This option would have the lowest up-front cost, since there would be no capital cost for wind turbines or solar PV generation. If the city owns the electric system, the cost of the purchase is in the utility budget. If the local cooperative owns the electric system, they would not be involved and the cost of the green tags would be in the city's general budget.

Option 2: Install Mid-Sized Wind Turbines for Larger Individual Customers

Larger individual customers – the school, hospital, water and waste treatment plants, and larger businesses -- could install mid-sized wind turbines at their locations to supply part of their power needs. This option would be applicable if there is adequate clear space where a wind turbine could be installed without bothering neighbors.

The only mid-sized turbine readily available in the U.S. is the Entegrity 50 kW unit. Each turbine on a 100' lattice tower would generate over 160,000 kWh per year at Greensburg. The facilities using more energy, such as the school and hospital, could each use the power from several turbines. From one up to four units could be installed to provide part of the electricity needs at each of the following facilities using net metering, up to a limit of 200 kW per energy user. If multiple units are purchased, then installation, maintenance, and servicing could be obtained at a discount. A local person would be trained to maintain the units.

An Entegrity 50 kW wind turbine would cost about $170,000, including installation. The operating cost would initially average about 3 ¢ per kWh. The fixed financing cost would be another 8.5 ¢ per kWh, based on a 20-year amortization at 5% interest. The total cost would be about 11.5 ¢ per kWh.

If the retail cost of electricity is initially 11 ¢ per kWh, the wind turbines will likely pay for themselves over their lifetimes. Electricity costs will likely escalate over time, if fossil fuels are used and carbon emissions are regulated.

Installing wind turbines requires extra capital up front, which may be difficult to justify. A capital contribution of $50,000 per wind turbine would lower the wind power cost to about 9 ¢ per kWh. This makes the wind turbine a more attractive investment with a more assured payback.

Option 3: Install City-Owned Large Wind Turbines

If the city continued to own the electric utility, it could install from 1 to 4 MW of wind generation to supplement its other power resources. Along with the wind generation, a reasonable mix of generating resources might include 4 to 6 MW of engine generation (natural gas or biodiesel) and a flexible supplemental wholesale power purchase contract. Since the purchased power would be less expensive than the engine generation, the engines would typically operate only a few hundred hours per year during peak load periods. If more than 2 MW of wind generation is installed, some type of energy storage may be cost-justified.

1 MW of wind generation will provide about 25% of Greensburg's projected energy needs in 2012, with 2 MW providing about 50%. The cost of supplemental purchased power becomes increasingly more expensive per kWh with increasing amounts of wind generation. This is due to wind power's variable output, which must be accommodated by the purchased power schedule.

The installed cost of a large wind turbine is about $2 million per MW. It could be connected directly to the distribution system, rather than the transmission system. Each MW would generate between 3.1 and 3.6 million kWh (assuming 35 to 40% annual capacity factor), depending upon the turbine model.

There are at least two options for financing the wind turbines:

1. *The City could sell Clean Renewable Energy Bonds, which are zero-interest bonds with a term of about 15 years. The cost of wind power would be 5.5 ¢ to 6.5 ¢ per kWh during the 15-year debt repayment period, and less than 2 ¢ per kWh for the last 10 years of its expected life.*

2. *An alternative to City ownership would be to purchase wind power from a private entity that would agree to purchase and install wind turbines at Greensburg, and connect them to the distribution system. The private entity would use the federal production tax credit. The cost of the wind power might be 0.5 to 1.0 ¢ per kWh higher, depending upon the equity return required for the investment.*

If more than about 2 MW of wind generation is installed, Greensburg would either require a special supplemental power purchase agreement or an energy storage system. Either of these would be required to accommodate the great variability in the wind generation. Even though engine-driven generation may be able to accommodate such variability, the high fuel costs would likely make it more expensive than either of the other two options.

A high-level estimate was made of the total cost of generation for one scenario with 6 MW of engine generation, a 2 MW purchase of wind power, and a special supplemental power purchase agreement from the grid. This generation combination would provide Greensburg with about 50% green power, which is probably the highest percentage use of wind power for a grid-connected utility in the U.S.

A summary of some basic assumptions is shown on the following table.

Assumptions Used in Preliminary Analysis	
6.00	Engine Generation Installed, MW
$3.60	Capital Cost of Engine Generators, $ Millions
4.0	Engine O&M Cost less fuel, ¢ per kWh
$8.50	Natural Gas cost, $ per MMBTU
4.0%	Annual escalation in natural gas cost
2.0	Wind Generation Purchased, MW in 2011
6.0	Wind generation Power Purchase Agreement, ¢ per kWh Flat
38%	Annual Capacity Factor for Wind Generation at Greensburg
6.9	Special Supplemental Power Purchase Rate, ¢ per kWh in 2011
Notes:	Fixed financing charges were based on 20 year bonds at 5% interest. The supplemental power rate escalated 3.5% per year and also increased with the % of wind generation used. Engine generation was limited to 200 full load hours per year.

Based on the above assumptions, the capital cost of generation to the city would be $3.6 million, with an all-in cost of about 9 to 10 ¢ per kWh in 2012 when the city grows into the full capability of the installed generation. The cost per kWh would be a little higher at first, since the kWh needs of the city would initially be lower. To keep costs down at the beginning, the engine and wind generation could be installed in two phases to better match the city's growing needs.

The cost of using biodiesel instead of natural gas might result in the total generation cost being perhaps 1 ¢ per kWh higher.

If the cost of electric distribution is another 4 ¢ per kWh on top of the generation cost (based on using natural gas), the total retail cost would be about 13 to 14 ¢ per kWh. This is likely higher than nearly all other Kansas utilities. If a target retail rate of 11 ¢ per kWh is assumed (actual cost in 2005), the generation cost component would have to drop to 7 ¢ per kWh.

In order to reduce the generation cost from the 9-10 ¢ range down to 7 ¢ per kWh, a grant or gift would be required to help buy down the cost of the engines, the cost of the wind power, or the cost of the supplemental purchased power. Any one of the following grants or gifts would accomplish this alone:

- *The capital cost of 2 MW of wind generation (making the wind power cost 1.5 ¢ per kWh) or a wind power purchase agreement of 1.5 ¢ per kWh,* ***or***
- *Supplemental purchased power cost lowered from 6.9 ¢ to 2.0 ¢ per kWh,* ***or***
- *A $2.7 million grant toward the $3.6 million cost for the engines*

Option 3-A: Install City-Owned Large Wind Turbines with Energy Storage

There are two methods of attaining an even higher percentage of wind power.

The first method is to obtain a special supplemental power purchase and sales agreement that would allow power to either be purchased or sold depending upon the amount of wind generator output. This could best be accomplished by having a larger utility deliver or absorb the extra power into its control area. This could be accomplished by dynamically scheduling power automatically and it would not have to be done by the local cooperative, although the local cooperative would likely want to collect transmission service charges from Greensburg. No cost estimate was made for this option.

The second method of using more wind power is to add an energy storage system. A scenario using 4 MW of wind generation was developed that uses a 2 MW battery storage system and 4 MW of engine generators. The battery was assumed to cost $1.5 million. A 2 ¢ per kWh battery operating cost was assumed with a round-trip efficiency of 75%, and an operating capacity factor of 33%. Energy losses would add perhaps 1.5 million kWh annually to the city's needs.

This scenario allows wind generation to provide about 90% of Greensburg's energy needs. This scenario results in generation costs of about 10 ¢ per kWh. In order to reduce the generation cost from 10 ¢ to 7 ¢ per kWh, any one of the following grants or gifts would accomplish this alone:

- *The capital cost of 3 MW (out of 4 MW) of wind generation making the cost of wind power 3.0 ¢ per kWh, or a wind power purchase agreement of 3.0 ¢ per kWh,* ***or***

- *The capital cost of the battery storage system along with the elimination of the 2 ¢ operating cost* ***plus*** *a $1.2 million grant toward the $2.4 million cost for the 4 MW engine generators,* ***or***

- *All Green Tags are sold for 2.5 ¢ per kWh.*

Option 4: Install Large Turbines for School and Hospital

A larger wind turbine could be installed to provide the majority of the electricity and heating needs of the school or the hospital. The Kansas K.S.A. 55-422 law specifies the minimum standards for utilities interconnecting renewable generators. Since the current local cooperative has adopted these minimum standards, it has indicated that it would not allow a large wind turbine to be used for Greensburg's school or hospital, if it serves these facilities. The law also limits net metering to 200 kW of wind generation for commercial customers. However, if the city maintains its utility, it can use less restrictive requirements if it wants to encourage renewable generation. Therefore, it was assumed that the city would allow its customers to install large wind turbines. Since the law limits net billing to 200 kW, net billing was not assumed in the analysis for large turbines at the school and hospital.

The smallest new large turbine readily available in the U.S. is 900 kW. This size of turbine would cost about $1.9 million installed, and generate about 2.8 million kWh per year. This amount of electricity would probably be enough to supply both the electricity needs and heating needs of either the new school or the new hospital.

To best utilize the variable nature of wind energy and minimize the utility cost, the school's heating and cooling system would need to include some amount of thermal heat and ice storage. This could easily be accommodated into the design of the new school or hospital. Although these technologies exist today, this would likely be the first school or hospital in the U.S. designed to have its energy (electricity and heat) supplied primarily by wind power.

A 900-kW turbine financed with 20-year tax-exempt bonds at 5% interest would result in fixed financing charges of 5.5 ¢ per kWh. With operating and maintenance costs adding another 1.3 ¢ per kWh, the total cost of wind power would be about 7 ¢ per kWh.

Without net metering, the school and hospital would have to sell its excess electricity back to the city at some reduced wholesale cost, perhaps at 5 ¢ per kWh. Since the school's and hospital's electricity needs have not yet been determined, the amount of excess wind generation is unknown. It was also assumed that the city would sell its electricity on an energy basis only, with no peak demand charges. The retail rate was assumed to be 11 ¢ per kWh.

If a thermal and ice storage system is installed, the excess generation will be minimized. A preliminary estimate of this type of storage equipment is $750,000. If this cost is added to the wind turbine, the wind power cost would increase from 7 ¢ to the equivalent of 9 ¢ per kWh.

Even though the wind power and storage equipment costs about 9 ¢ per kWh, which is less than the 11 ¢ retail electricity rate, the project may not be economically attractive due to its high up-front cost. A capital contribution or grant of $500,000 per large wind turbine for the school and/or hospital would reduce the net cost of electricity from 9 ¢ down to about 7.5 ¢ per kWh. At this level, the net investment of about $2.15 million would have a return that might be attractive enough to economically justify the installation.

Option 5: Install Privately Owned Large Wind Turbines at Greensburg

Private investors could install one or two large wind turbines at the edge of Greensburg and sell all of the wind power to the local cooperative at a negotiated price. It is assumed here that the private wind farm would have to offer prices competitive with the large corporately-owned wind farms sited in the windiest sites.

Based on this reasoning, the relatively lower wind resources at Greensburg and its lack of economy of scale would result in the private investors earning a lower return on their investment when compared to other corporate wind farms. Therefore, a private wind farm at Greensburg would require a grant to be economically competitive enough for the local cooperative to purchase the power.

A preliminary estimate of the grant amount would be 33% of the cost of the wind farm. A 5-MW wind farm costing $2 million per MW, or $10 million, would require a $3.3 million grant.

The following table compares the results of this analysis of wind turbine options for Greensburg.

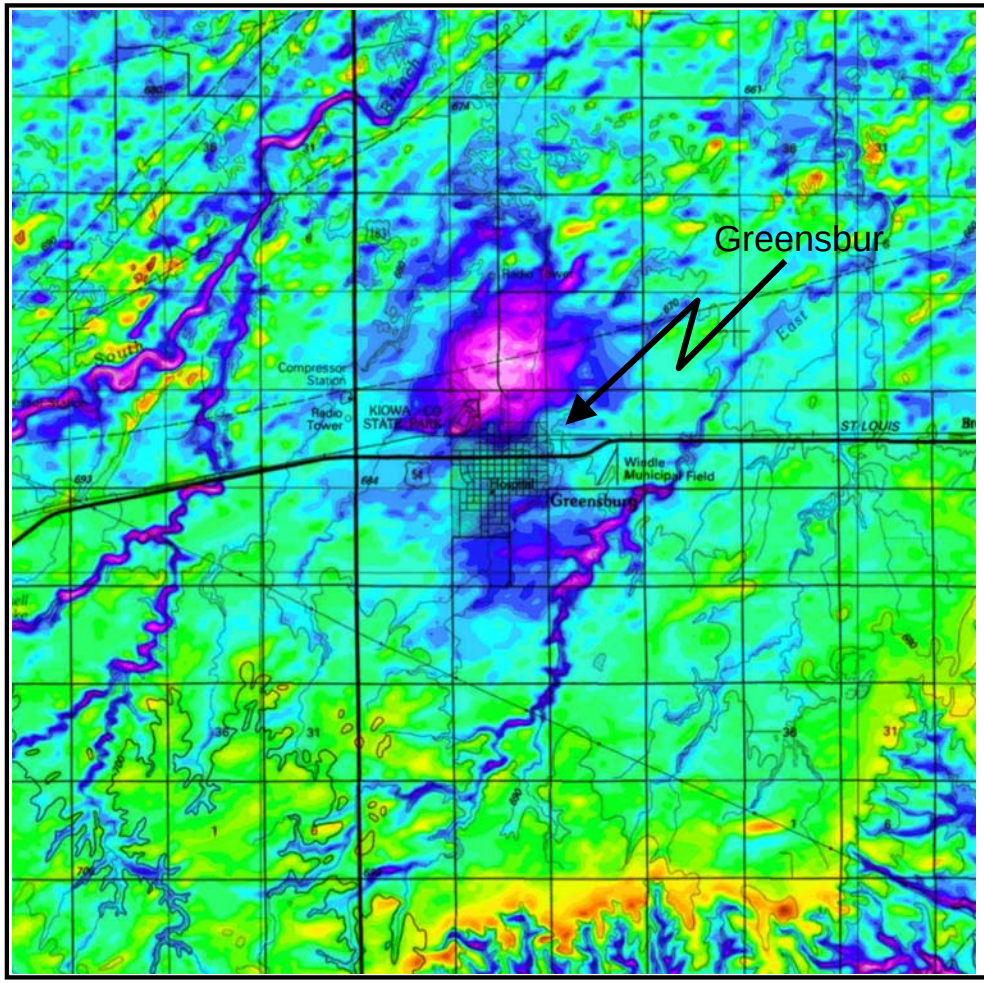
Summary of Analysis of Greensburg Wind Power Options

	Title	Description		Total Capital Cost $ Millions[2]	Contribution Needed to be Viable[3]	Feasi-bility Under Co-op Control	Advantages	Disadvantages
1	Purchase Green Tags	Bulk purchase of green tags	100%	n/a	$80,000 per year average over next 5 years	Yes	Very simple and low cost	There is no visual evidence of using renewable energy, requires annual commitment.
2	Mid-Sized Turbines for Larger Individual Customers	Ten customer-installed 50-kW wind turbines	12%	$1.7	$50,000 times 10 turbines is $500,000	Probably	Ten turbines would be very visible and might appear greener than 2 larger turbines	This option only provides 12% green power and the cost of the green power is much higher
3	City-Owned Large Turbines	2 MW of wind, 6 MW of engine generation	50%	$3.6	$2.7 million or 1.5¢ wind power PPA	No	One or two large wind turbines will be seen for many miles	Special control system for engines and turbines will be required
3-A	City-Owned Large Turbines with Storage	4 MW of wind, 4 MW of engine generation, 2 MW of storage	90%	$3.9	Free Energy Storage System of 3.0¢ wind power PPA	No	Turbines will be very visible; 90% wind power will be revolutionary for being grid connected	A more complicated system would require more utility technicians
4	Large Turbines for School & Hospital	Each: 900-kW turbine with thermal and ice storage systems	15%	$5.3	$500,000 each system; school and hospital both = $1,000,000	No	Innovative demonstration to maximize the use of wind power	Equipment and innovative control systems will require technicians to maintain
5	Privately Owned Wind Farm	5-MW wind farm	N/A	$10.0	$3.3 million	Probably Not	No capital required for the city; wind farm privately owned	The green power will go to the local cooperative and not the city

[1] This column shows the percentage of electricity used in the city that would be from wind power.
[2] This is the total capital cost of generating equipment needed. The capital for the last option would come from private sources.
[3] This is the gift or grant needed to make the options economically viable and attractive for the city or owners of the equipment.

Addendum: Preliminary Estimate of Wind Speeds in the Greensburg Area

In general, the Greensburg area has good wind resources. The following two maps show the approximate wind speeds in a 10-mile by 10-mile and 5-mile by 5-mile area around Greensburg. This map is based on the wind resource database compiled by the Kansas Corporation Commission. The consultants used higher resolution topography and land cover data to develop this higher resolution wind speed map. A more accurate and costly assessment of the wind speeds can be made once a commitment is made to proceed with wind power. The final diagram indicates the prevailing wind directions for Greensburg.



Meters per Second at 50 Meters Height

7.84
7.82
7.8
7.78
7.76
7.74
7.72
7.7
7.68
7.66
7.64
7.62
7.6
7.58
7.56
7.54
7.52
7.5
7.48
7.46
7.44
7.42
7.4
7.38
7.36
7.34
7.32
7.3
7.28
7.26

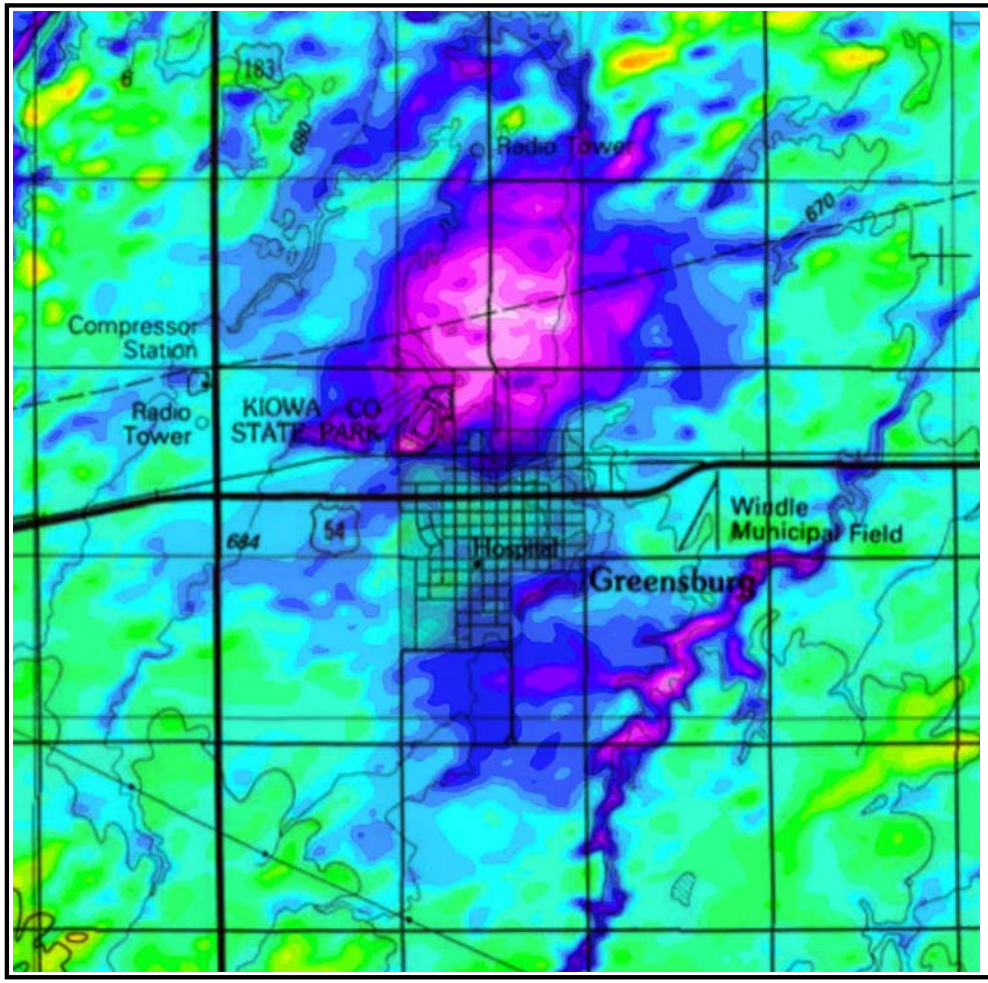
This high-resolution map shows the estimated mean annual wind speeds in a 10- by 10-mile area centered on Greensburg. Since it is based on the state's data, it is no more accurate than their data. However, it accurately shows differences in wind speeds in the area. Therefore, it can be used for determining the best sites for wind generation in the area.



Wind Speed Map around Greensburg, Kansas

Map is based on the Kansas Corporation Commission 1,000-meter resolution wind speed database.

Wind Utility Consulting, PC



Meters per Second at 50 Meters Height

7.84
7.82
7.8
7.78
7.76
7.74
7.72
7.7
7.68
7.66
7.64
7.62
7.6
7.58
7.56
7.54
7.52
7.5
7.48
7.46
7.44
7.42
7.4
7.38
7.36
7.34
7.32
7.3
7.28
7.26

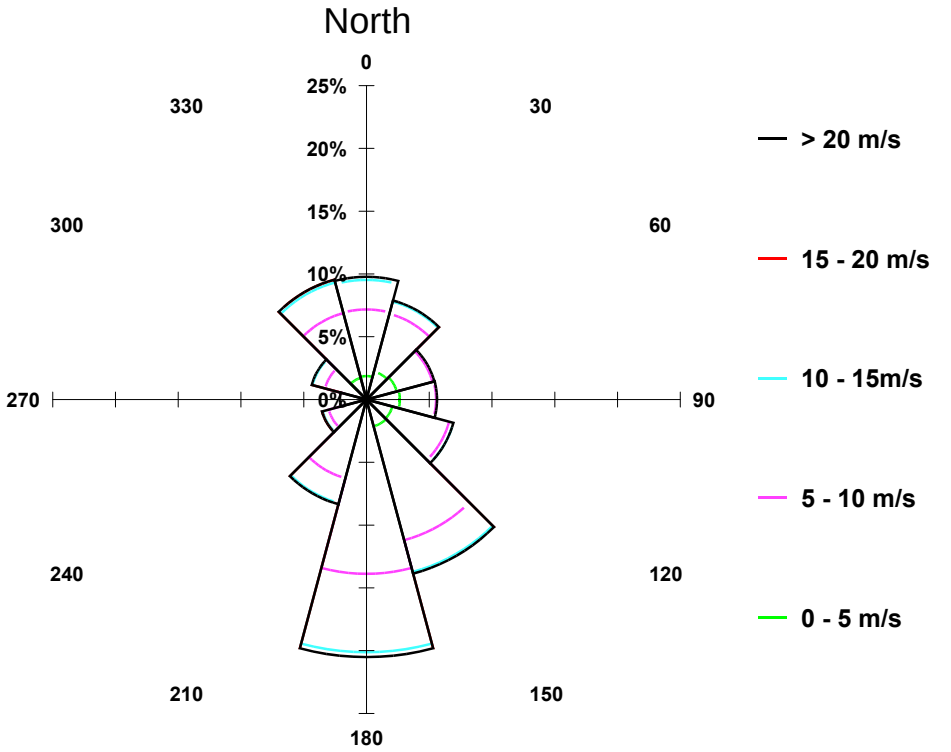
This is an enlarged 5- by 5-mile section of the high-resolution map centered around Greensburg. Although there are many shades of color in this map, there are only modest differences in the wind speed. A large wind turbine could probably be sited within this area and connected to the local distribution system with minimal or modest distribution system reinforcements.



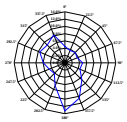
Wind Speed Map around Greensburg, Kansas

Map is based on the Kansas Corporation Commission 1,000-meter resolution wind speed database.

Wind Utility Consulting, PC



This wind rose data is from the closest met tower with publicly available data. It shows the predominant wind directions to be from the south and north.



Wind Rose for
Greensburg, Kansas
Based on Deerfield, Kansas Met Tower

Wind Utility Consulting, PC
September 2007
Wind rose is based on met tower data obtained from the Energy & Environmental Research Center (EERC) for the years of 1996-1998.

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

This publication received minimal editorial review at NREL

Printed on paper containing at least 50% wastepaper, including 20% postconsumer waste

D.5 Analysis of Greensburg Municipal Utility Business Strategies to Become Green

Thomas A. Wind
Wind Utility Consulting

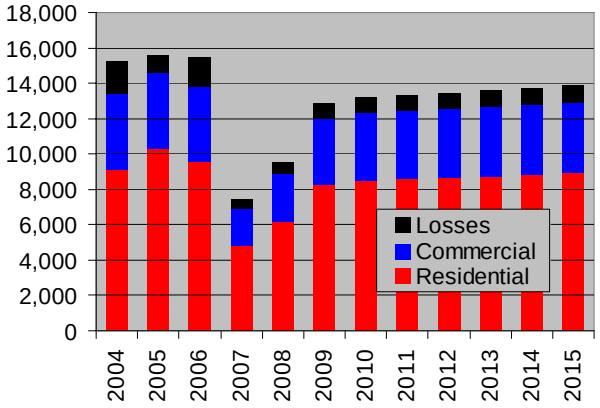
Lynn Billman, Technical Monitor
National Renewable Energy Laboratory

Executive Summary

The purpose of this report is to evaluate the business and economic feasibility of obtaining a significant percentage of Greensburg's electricity from wind power. Lying before the City of Greensburg is an attractive offer by Southern Pioneer Electric Company to take over the electric utility operations now owned and operated by the City. This offer does not include the installation of large wind turbine to supply wind power to Greensburg. Although this attractive offer originally fit the City's needs, the City's needs have since changed. A large wind turbine located at Greensburg has now become an important visual part of Greensburg's mission to be a national model for a green and sustainable community. Therefore, the City must reconsider the option of keeping its electric utility so that it can make sure it can get a significant amount of power from a locally installed wind turbine.

Estimates were made by Wind Utility Consulting, PC ("Consultants") of the future electricity needs of the City and are shown in Figure 1. Although there is a lot of uncertainty in Greensburg's future, the amount of electricity needed after full recovery was projected to be about 13 million kWh, with some modest growth thereafter. Electricity needs are expected to be less than the past due to gains in energy efficiency. These projections were then used in a power supply and financial model specifically developed for the City's electric utility. This model was used to project future electric utility revenues and expenditures to determine the cost of electricity for three basic strategies shown in Table 1 below. Some of the key assumptions used in this analysis are:

FIGURE 1
Historical and Projected Electricity Needs, in Megawatt-hours



1) If the City sells its electric utility system to Southern Pioneer, the local electric generating plant would be retired. A 10% electric city franchise tax would be applied to Southern Pioneer's electricity sales in the city. The proceeds would be used to pay for at least part of the free and discounted services currently provided by the City's electric utility.
2) If the City keeps its electric utility, it would obtain a new long-term wholesale power supply contract that would provide terms favorable for the use of locally-generated wind power. The Kansas Power Pool could potentially provide such a contract which would provide load and generation following services and power purchase rates based on energy needs only, rather than energy and peak demand.
3) Greensburg would commit to 100% green power by using a combination of donated or purchased renewable energy credits and/or locally generated wind power.
4) Future regulations limiting greenhouse gas emissions will raise the cost of electricity generated from fossil fuels for all wholesale power supply providers.

TABLE 1 – Comparison of Strategies

	Strategy 1 Accept MOU and Offer from Southern Pioneer	**Strategy 2** Retain Electric Utility, No Large Wind Turbines	**Strategy 3** Retain Electric Utility, Install 1 to 3 Large Turbines
Advantages	Lower rates, No debt, No management needed, Possible cash gain from utility sale, Future patronage dividends to residents	Local power plant kept for emergency backup, more city jobs, continuation of free and discounted services and income to City	Same as Strategy 2 plus having one or more large wind turbines located at Greensburg
Risks	Extended outages due to transmission line outages and no local generators	Even higher rates if City doesn't grow	Same as Strategy 2 plus wind turbine operational problems
Average Electric Rates			
Years 1-5 (2008-2012)	11.0 ¢	12.3 ¢	12.3 ¢
Years 6-10 (2013-2017)	14.1 ¢	14.5 ¢	≈ 14.6 ¢
Years 1-10 (2008-2017)	12.6 ¢	13.4 ¢	≈ 13.4 ¢
% Difference (2008-2017)	Reference	+ 6 %	≈ 7 %
% of Wind Power Used	13 %	13 %	39-100 %
% of R.E. Credits Used	87 %	87 %	61 - 0 %
Total % of Green Power	100 %	100%	100%

Based on the results of this study, the following conclusions can be made:

1) Under Southern Pioneer service, electric rates in the City will initially average about 1.3¢ per kWh less expensive than they would be under City ownership. The savings narrows to around 0.5¢ per kWh over the longer run.
2) If the City retains ownership of its electric system, electric rates will likely stay about the same for the next three years, followed by average increases of 3.5% per year. In general, rates would be 6 to 7 % higher under City ownership over the next ten years. The higher rates are primarily due to maintaining the local generating plant and providing free and discounted services to the City and its residents.
3) With a favorable new wholesale power supply contract, the City would likely be able to install from one to three large turbines (1.5 to 4.5 MW) with little if any need for electric rates higher than if there were no wind turbines. It would take about 4 MW of wind generation to provide the equivalent of 100% of the City's electricity.

Based on these conclusions, the Consultants recommend that the City retain ownership of its electric utility. This will provide two main benefits: 1) local generation will be maintained that will keep the lights on for extended transmission line outages, and 2) the City can install one or more large wind turbines that will provide a visible source of green power for Greensburg.

Table of Contents

Executive Summary ..... Page 1

Forward ..... Page 4

Introduction and Overview ..... Page 5

Greensburg's Future Electricity Needs ..... Page 6

Overview of Potential Business Strategy Scenarios ..... Page 10

Strategy 1 – Accept MOU and Offer from Southern Pioneer ..... Page 11

Strategy 2 – Retain Electric Utility, No Large Wind Turbine ..... Page 16

Strategy 3 – Retain Electric Utility, Install Large Wind Turbine(s) ..... Page 19

Observations and Conclusions ..... Page 26

Attachment 1 - Summary of Financial Analysis for Four Scenarios ..... 37 pages

Attachment 2 - Correlation of Wind Power and City Loads ..... 4 pages

Forward

A preliminary discussion draft of this report was presented by the Consultants at a January 3rd, 2008 meeting in Greensburg with representatives from the City, Southern Pioneer, Sunflower, NREL, and others. Based on the detailed discussions at the meeting, the Consultants acknowledged that some financial and power supply assumptions needed to be adjusted. Subsequent discussions provided more clarification and information. Therefore, the analysis has been updated with better assumptions and this report reflects the revised analysis. A change in two key assumptions has significantly affected the results and findings in this report. The first key assumption change was the inclusion of a 10% City franchise tax on electricity sold by Southern Pioneer if it acquires the City's electric distribution system and serves the City on a retail basis. The franchise tax will partly compensate the City for the many financial benefits that its electric utility provided the City, such as free and discounted services and labor. The second key assumption change was in the structure of a future wholesale power supply contract if the City continues ownership of the electric system. Originally the analysis assumed a two part wholesale rate with both demand and energy charge components. This revised analysis assumes a postage stamp rate of 4.5 ¢ per kWh, meaning that all power purchased by the City will cost 4.5 ¢ per kWh, regardless of the level of the City's peak demand or its annual load factor. This effectively reduces the cost of purchased power for the City. Collectively, these two key changes in assumptions show much less savings in electricity costs under Southern Pioneer service compared to City ownership of the utility using wind energy.

Introduction and Overview

Because of the devastating damage from the May 4, 2007 EF5 tornado to the City of Greensburg ("City"), most of the City's electric system has been repaired or replaced by all new poles and wires and service is now available when needed for the construction of new homes. Although the generating plant building suffered extensive damage, the five dual-fueled engines suffered only modest damage. The engines and some subsequent water damage can be repaired; however, a complete new building will be required.

Southern Pioneer Electric Company and Mid-Kansas Electric Company ("MKEC") helped the city with managing the distribution system reconstruction. A Memorandum of Understanding ("MOU") between Southern Pioneer and the City was signed with the intent of eventually transferring ownership of the city's electric system to the cooperative. If this MOU is with a follow-up asset sales contract, the City would no longer serve electricity to its residents, nor would the City have any responsibility for procuring future sources of electricity. Signing the MOU clearly brought advantages to the City during the very difficult rebuilding period by eliminating the need to rebuild and manage the electricity system, and by ensuring the City's residents an economical supply of electricity into the future from a consumer-owned utility.

The growing interest in rebuilding Greensburg as a national model for sustainability has brought new attention and interest in using renewable energy as a primary source of energy for the City. Sunflower Electric Power Corporation ("Sunflower") supplies power to MKEC, which would in turn supply power through Southern Pioneer to Greensburg. Although Sunflower generates the vast majority of its electricity with coal, it will be getting about 10% of its electricity from wind power in 2008. If Sunflower meets the State's goals, it will generate 20% with renewables by 2020. Therefore, MKEC's electricity is approximately 10% green at this point in time. In response to the City's request for a larger percentage of green power, MKEC has generously offered to provide Renewable Energy Credits (RECs") for a three-year period at no extra charge to the City, which would make the city's electric supply 100% green for the three-year period. Due to ownership structure, policies, and economics, it would be difficult for MKEC and/or Sunflower to justify the installation of a wind turbine at Greensburg for supplying wind power exclusively to the City.

The City's leaders now believe that the visual impact and prominence of a large wind turbine on the City's skyline is important in fulfilling the vision of a green and sustainable Greensburg. If the City transfers ownership of its electric system to Southern Pioneer, then it would essentially have little need for the power from a utility-scale wind turbine, and could not justify installing a large wind turbine. Although a third party could install a large wind turbine at Greensburg, the wind power would have to be sold to MKEC or another remote power company, and would be blended in with its other power resources. Given the economies of scale of wind generation and the better wind resources in other locations, it would not be economically attractive for a third party to install a large wind turbine at Greensburg for selling into the wholesale market. Even if a large wind turbine were installed, the wind power would not be dedicated to use by Greensburg. This report evaluates the option of retaining ownership of its electric system, so that it can install and use locally generated wind power for the community.

Greensburg's Future Electricity Needs

Prior to May 5, 2007, Greensburg's electricity needs varied from a low of about 1.0 Megawatts ("MW") during the nighttime in spring and fall, to a maximum of 4.5 MW during the hottest day of the summer. Figures 1 and 2 illustrate the daily minimum and maximum loads for most of the year of 2006. The maximum daily load is greatly increased, due to air conditioning loads during the summer.

The black squares in Figures 1 and 2 show the daily average engine generation in kW during the hours when the engines were running. The engines ran for about 250 hours in 2006 and 740 hours in 2005, generating about 1.2% of the City's needs in 2006, and 5% in 2005.

FIGURE 2

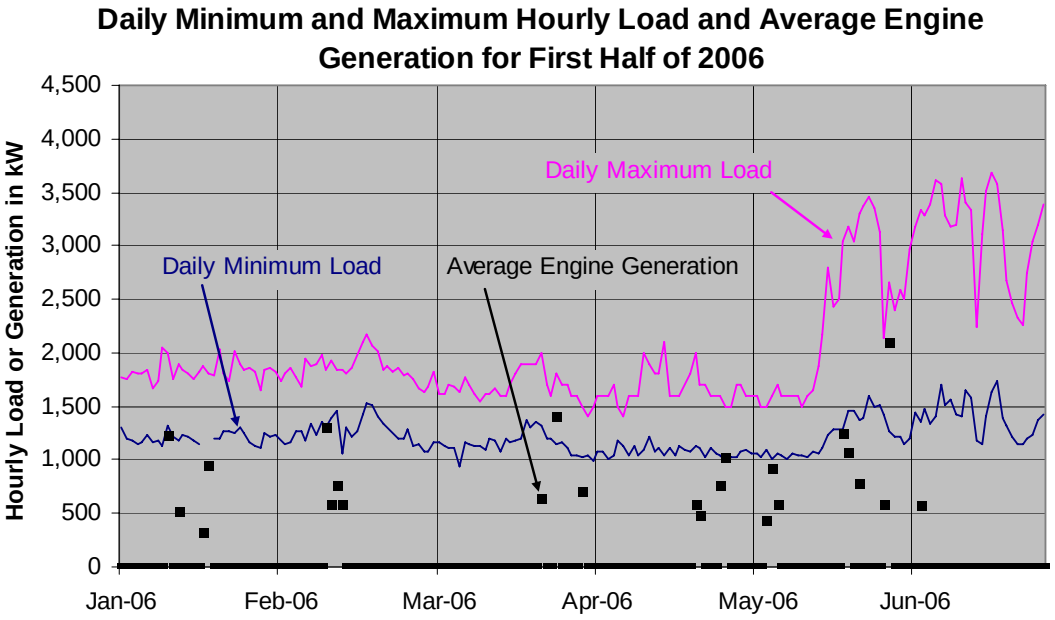


FIGURE 3

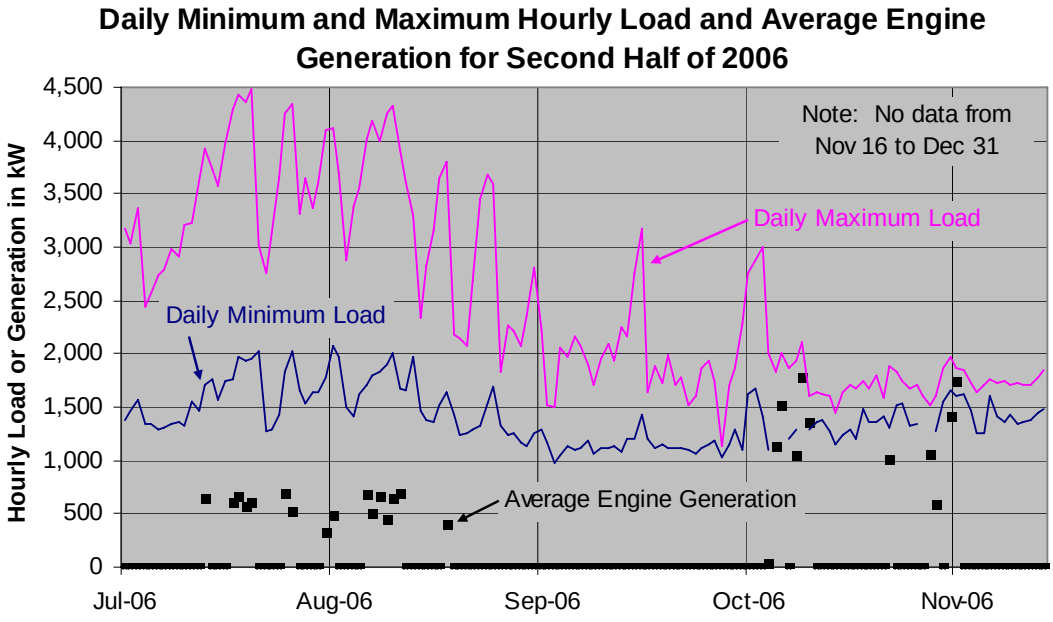


FIGURE 4

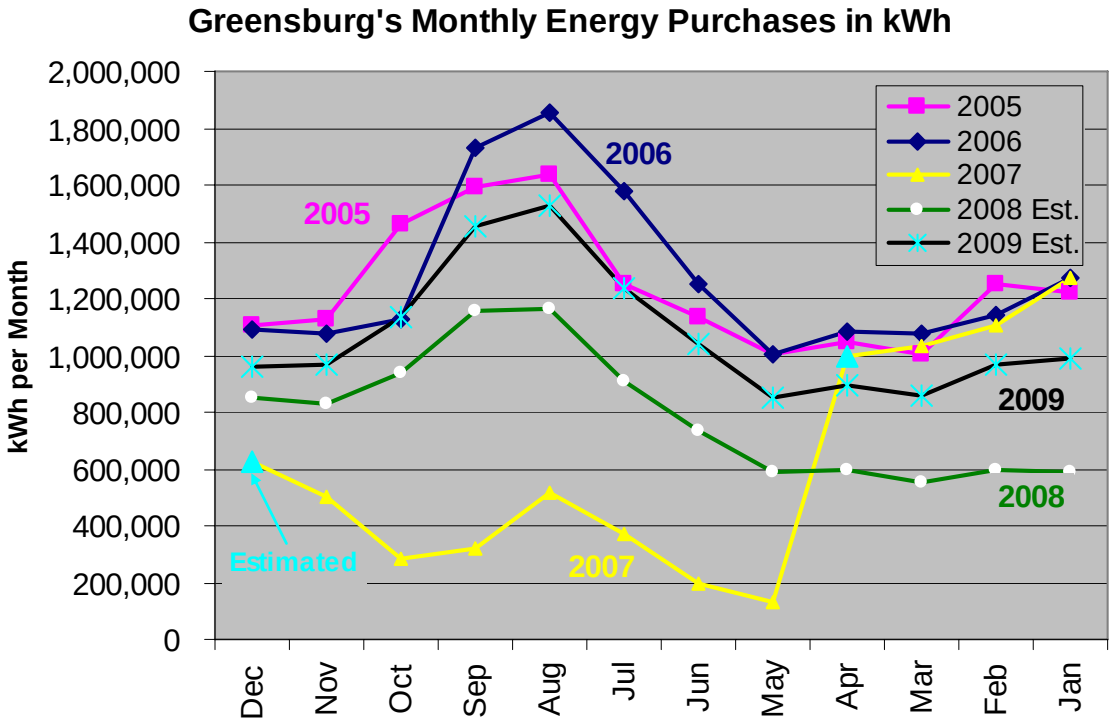
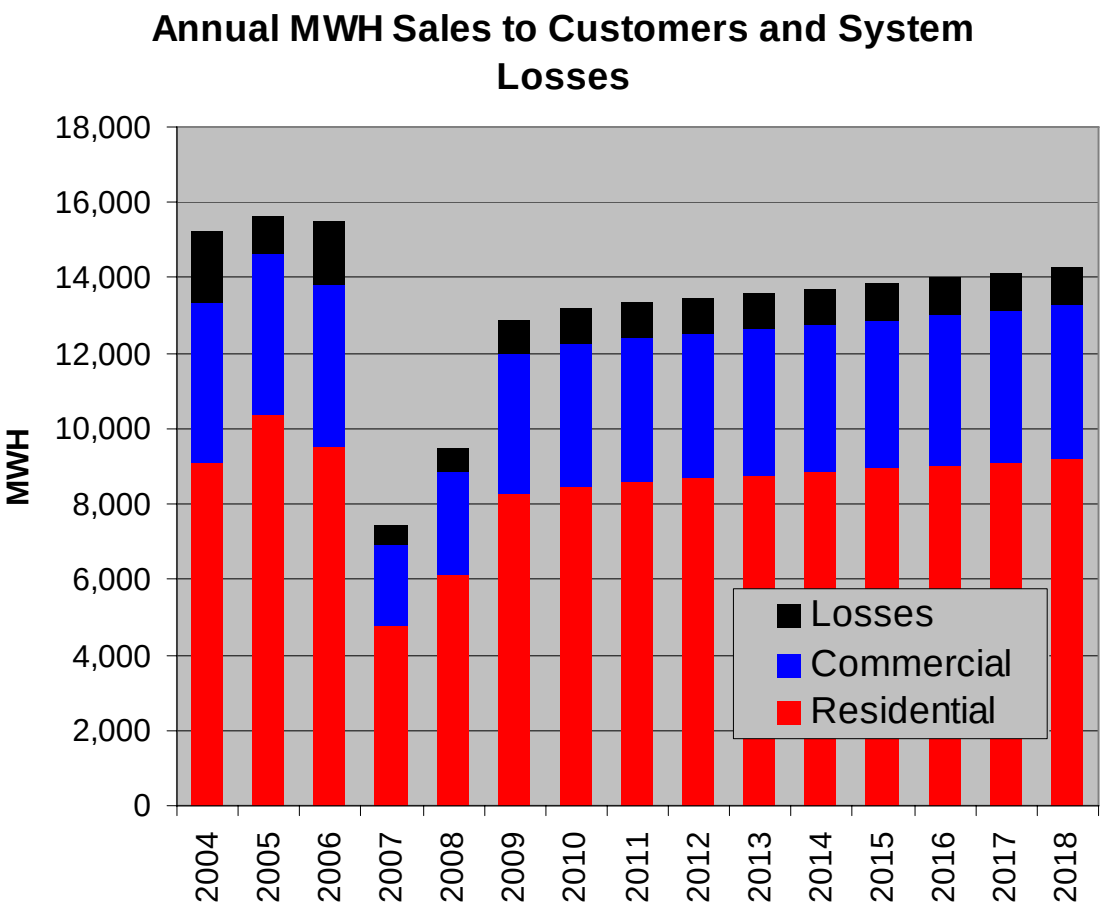


Figure 4 depicts the historical monthly energy purchases from 2005 through 2007, along with the Consultants' estimates for December of 2007, and all of 2008 and 2009. These estimates were primarily based on judgment, and the current pace of new home construction. Energy purchases

historically represented at least 95% of the City's energy needs, with the balance coming from engine generation.

Figure 5 portrays the historical and projected annual electrical energy needs for Greensburg. The electrical needs include residential customer sales, commercial customer sales, and losses. The losses include a small amount of power furnished without charge. System losses are expected to be reduced from around 10% of electric sales down to 7.5% of sales, since the newly built distribution system has a higher 12.47 kV voltage level than the older system's 4.16 kV voltage level.

FIGURE 5



The totals shown in Figure 5 are also shown in tabular form below.

TABLE 2 – Projected Annual kWh Electricity Needs for Greensburg

2007	2008	2009	2010	2011	2012 & On
7.4 million	9.5 million	12.9 million	13.2 million	13.3 million "Full Recovery"	1% growth per year

These projections during the recovery period are much higher than originally assumed in the Consultants' October 2, 2007 wind generation options report, thus reflecting a quicker recovery. These new estimates are based on a more thorough evaluation of recent energy sales trends.
There is a great deal of uncertainty in the future electricity needs of Greensburg. The uncertainty is due to:

- The number of new homes that will be built
- The energy savings due to new appliances and air conditioners
- The number of solar photovoltaic panels used by customers
- Use of wind turbines by larger customers, such as the school and hospital (***Should the City encourage the school and hospital to install wind turbines if the City generates most of its electricity with even larger and more cost-efficient wind turbines?)***
- The amount of electric heating added for new homes (***Should Greensburg adopt an incentive rate to encourage conversion from non-renewable natural gas to electric heating, based on renewable energy generated by the City?)***
- The energy needs of the new biodiesel plant
- Energy charging needs for future plug-in electric vehicles

Given these uncertainties, the amount of energy sales could be significantly different than projected by the Consultants. Nevertheless, the above estimates were used for these business strategy evaluations.

Overview of Potential Business Strategy Scenarios

Several potential business strategy scenarios were developed to provide the City leaders information about the expected costs and electric rates for retaining ownership of their electric utility. The business strategies are:

1) **Strategy 1 – Accept MOU and Offer from Southern Pioneer:** The City would transfer ownership of its electric system per the MOU and dispose of its dual-fuel engine power plant. The City would then work to encourage some entity to install one or more large wind turbines at Greensburg. The power would likely be sold to MKEC and/or Sunflower and blended with their other resources.

2) **Strategy 2 – Retain Electric Utility, No Large Wind Turbines:** The local dual-fuel generating plant would be refurbished or replaced by new units and a new wholesale power supply contract to provide standard grid power would be procured. The percentage of green power used would be equivalent to that from the wholesale provider, unless additional green RECs were purchased. This scenario serves as a cost reference for Scenarios 1 and 3.

3) **Strategy 3 – Retain Electric Utility, Add Large Wind Turbines:** Again, local generation would be used, along with adding from one to three 1.5 MW wind turbines at Greensburg, which would provide three different levels or wind power. Installing only one large wind turbine would likely provide the highest penetration of wind power for any city in the U.S.

Common to the last two scenarios, wherein the city retains the electric utility, is having local engine generators to provide back-up power when the transmission grid is down. This is one of the primary benefits of having a municipally owned electric utility. However, it does add to the cost of electricity. A recent ice storm has proven the value of having local generation available. The local economy and daily course of life grinds to a halt when the lights go out. The large number of city residents that have recently added standby generators for their homes and businesses at great expense proves that having local standby generation is a high priority for Greensburg residents.

There are two options for having local engine generation: 1) refurbishing the existing generating plant, and 2) replacing the existing plant with modern new engine generators. Based on inspections made after the tornado, the existing engines suffered minor physical damage despite the destruction of the building. Refurbishing the existing plant would require a new building, and some repairs for physical and water damage to the five Fairbanks & Morse engines and generators. The cost of the repairs and new building has not been determined, although it would likely cost at least $1.0 million. All of the existing engine generators can burn diesel fuel or natural gas. Using natural gas instead of diesel fuel reduces fuel cost by at least one-third. The second option would be to retire and scrap out the existing engine generators and replace them with newer skid-mounted units that are highly automated and low maintenance. The cost for this was estimated to be somewhere between $2.0 and $4.0 million, depending upon the amount of generating capacity, and whether they are dual-fueled or oil-fueled. It was assumed in this study

that insurance proceeds would fund either of the two options for having local engine-generating capacity.

Each of these three scenarios is discussed in more detail below.

Strategy 1 – Accept MOU and Offer from Southern Pioneer

Under this strategy, the City and Southern Pioneer would continue on with the original plan to turn over and sell the City's electric system to Southern Pioneer. Southern Pioneer has incurred considerable costs for assisting with rebuilding the system. The MOU calls for purchasing the electric system assets at a negotiated price that reflects the value of the electric system from a revenue perspective, less the costs Southern Pioneer incurred for rebuilding. The dual-fuel engine generating plant would be retired and scrapped out. It was assumed that the insurance proceeds would retire the past debt for engine repairs and the recent distribution system improvements. Depending upon the insurance settlement, the City might have some financial gain upon selling its electric system to Southern Pioneer. However, no financial gain was assumed in this analysis.

The action steps required are relatively simple and include:

1) Accept offer from Southern Pioneer
2) Determine appropriate franchise tax on electricity sold by Southern Pioneer
3) Settle with insurance company
4) Dispose of electric generating plant
5) Repay balance of any debt owed for the electric system
6) Acquire renewable energy credits after three years

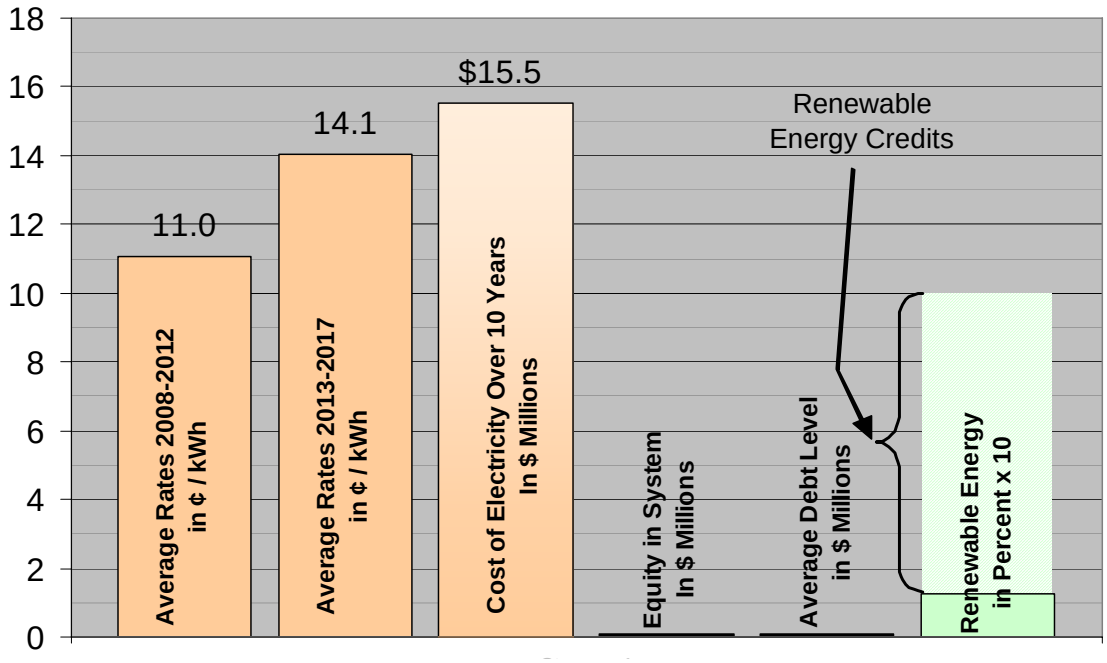
Table 3 below lists the advantages, disadvantages, risks, and uncertainties for Strategy 1.

TABLE 3 - Strategy 1 – Accept MOU Advantages, Disadvantages, Risks, and Uncertainties	
Advantages	Lower electric rates for residents and businesses
	City will likely have a net cash gain after selling its system to Southern Pioneer and repaying its remaining debt. The amount of cash gain is undetermined at this time.
	No bond issues required for the electric system, eliminating financial risk if City does not grow as expected
	City does not have to manage the reconstruction and operation of the electric system
	Residents can eventually receive patronage dividends from cooperative
	Sunflower provides three years of renewable energy credits
Disadvantages	No local generating plant to keep lights on for long transmission outages
	Fewer jobs in City, less financial support for other City employees
	City must implement franchise tax to cover loss of free and discounted services (such as street lighting) now provided by the electric utility and its employees, and loss of net margins from the electric utility
	Will be more difficult to get large wind turbines installed at Greensburg, since City looses control over energy resource decisions
	Southern Pioneer will likely not provide net metering for residents who install PV panels and wind turbines, thus greatly reducing their economics
Risks and Uncertainties	Risk of extended power outage due to major transmission outage
	Percentage of renewable energy used by Greensburg is uncertain, since the installation of large wind turbines is not controlled by the City

The electric utility now provides several financial benefits to the City as listed in the table above. Although no specific analysis was done for Greensburg, information from a national survey and the Kansas Municipal Utility Association was used to project that a typical small Kansas municipal utility might provide financial benefits to a city equal to 13% of electric revenues. Although the lost benefits might be higher for Greensburg, a more conservative 10% loss in benefits was assumed to be compensated by a 10% franchise tax which was added to the cost of Southern Pioneer's electricity. Therefore, a 9 ¢ per kWh average rate from Southern Pioneer will cost the customer 9.9 ¢ per kWh with the franchise tax.

Figure 6 provides a graphical summary of the key financial metrics for this strategy. The left two bars in the chart show the predicted electric rates with the franchise tax for the city residents for the first five-year period from 2008 through 2012 (11.0¢ per kWh), and for a second five-year period from 2013 through 2017 (14.1¢ per kWh). This estimate was based on how the Consultant believes electric rates will generally escalate in the future for Southern Pioneer. It was assumed that 55% of Southern Pioneer's cost is associated with the operations and investments in their distribution system.

FIGURE 6 – Financial Summary for Strategy 1 – Accept MOU



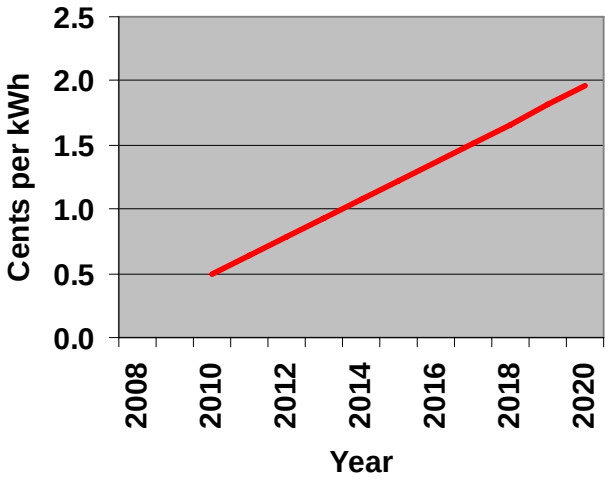
This sector was assumed to escalate at 2.5% per year. The remaining 45% of the electricity cost was assumed to be for power supply costs, which were assumed to escalate at 3% per year, plus an extra amount for expected greenhouse gas emission regulations. Figure 7 depicts the Consultants' estimate of this extra cost adder per kWh in the future. Given the large uncertainty concerning when the extra costs will start and how they will go, a simple trend line was used that reflects a cost penalty of $20 per ton of CO_2 by 2020. This results in an extra 2¢ per kWh for coal-fired generation by the year 2020.

The third bar in Figure 6 shows that the residents in Greensburg will pay a total of $15.5 million to Southern Pioneer for electricity costs and franchise taxes to the City over the next ten years (2008 through 2017), or an average of $1.55 million per year. Nothing was included in the average rate calculations to account for any electric system debt that would be repaid from the City's general fund. Hopefully, all city debt for the electric system will be repaid with the settlement from the insurance company.

The fourth and fifth bars in Figure 6 represent the amount of financial equity and debt the City would have in the electric system. Since the City would not own the electric system, the equity is zero and it was assumed the insurance settlement would cover the existing debt.

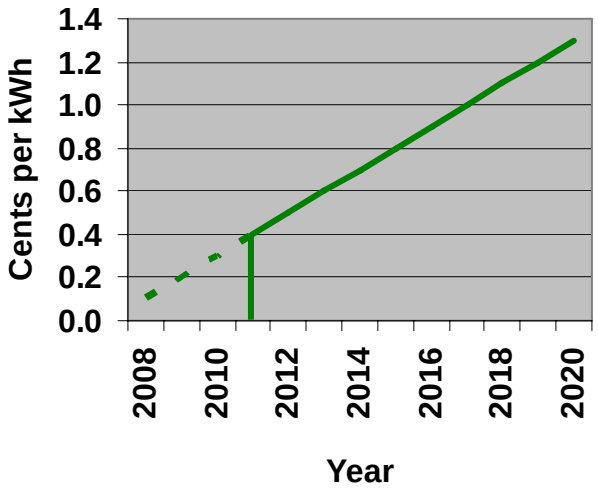
FIGURE 7

Power Cost Adder Used for Future Greenhouse Gas Regulations



The last green bar at the right in Figure 6 depicts the average percentage of renewable electricity the City would be using over the first ten years. The bar has two segments. The bottom solid green segment represents the percentage of renewable electricity in Sunflower's generating resources. Sunflower currently has about 10% from wind generation, and it was assumed Sunflower would increase that gradually to 20% by 2020 to meet the State's goal. This would have a ten-year average of 12.8%. However, Sunflower has agreed to offer renewable energy credits to Greensburg equal to 100% of its energy purchases for the first 3 years. After that in 2011, it was assumed that the City would purchase renewable energy credits from the market for the balance of the electricity used by the City residents that is not renewable. Figure 8 shows the projected cost of those credits, based on a cost of 0.1¢ per kWh in 2008. Therefore, the franchise tax percentage would be increased upwards starting in 2011 to cover this purchase. By continuing to purchase renewable energy credits, 100% of Greensburg's electricity would be renewable in Strategy 1. Therefore, the top part of the green bar (diagonal striped) represents the additional green renewable energy credits either initially provided by Sunflower or later purchased by the City.

FIGURE 8
Projected Cost of Renewable Energy Credits



Strategy 2 – Retain Electric Utility, No Large Wind Turbine

Under this strategy, the City would decline Southern Pioneer's MOU with the intention of retaining ownership of its electric system. Insurance proceeds would be used to either repair the existing dual-fuel engine generating units or be used to purchase new engine generating units. Again, it was assumed that the insurance proceeds would retire the past debt for engine repairs. No large City-owned wind turbines are included in Strategy 2. However, renewable energy credits are purchased so that all power used in Greensburg is green. This provides a comparable basis for comparing the electric rates for the various strategies, since all strategies provide 100% green power, either by purchasing renewable energy credits or installing local wind generation.

The action steps required include:

1) Obtain temporary extension of current power supply contract
2) Decline offer from Southern Pioneer and settle up costs as necessary
3) Settle with insurance company for distribution system and generating plant damage
4) Start process for refurbishing existing generating units or replacement by new units
5) Start process to obtain long-term wholesale power supply contract

Table 4 below lists the advantages, disadvantages, risks, and uncertainties for Strategy 2.

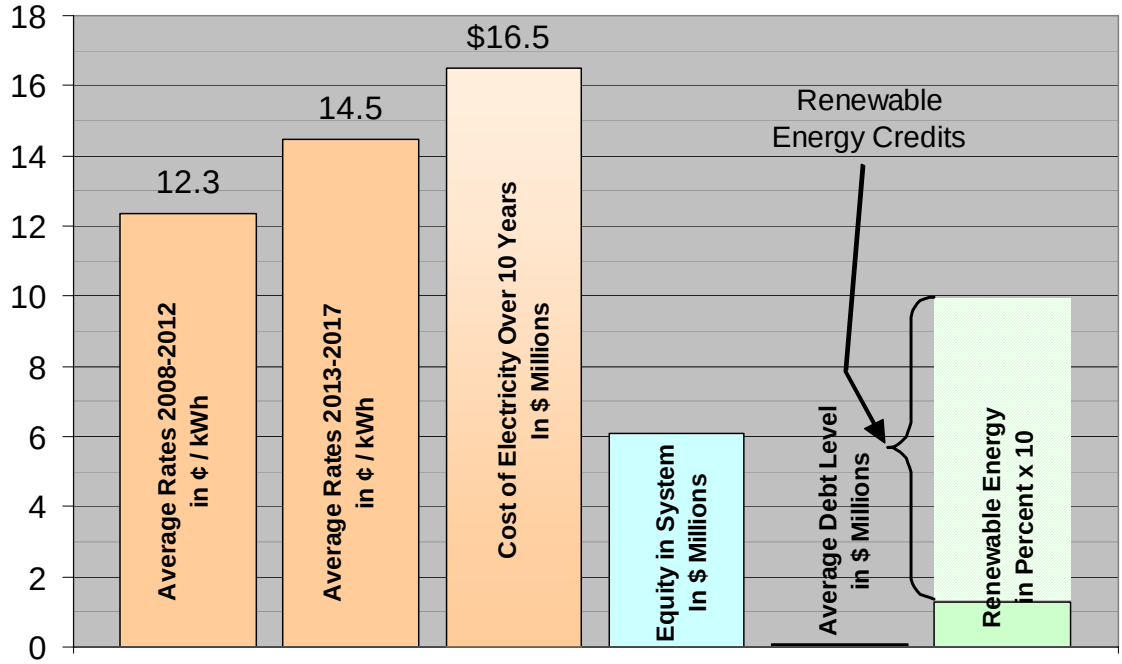
TABLE 4 - Strategy 2 – Retain Utility, No Large Wind Turbine
Advantages, Disadvantages, Risks, and Uncertainties

Advantages	City owns local generating plant to keep lights on for long transmission outages
	Electric utility jobs are retained in City
	City has more assets, including a nearly all-new distribution system, which should generate some income for the City and provide financial support for free and discounted services to the City
	City can provide net metering for residents who install PV panels and wind turbines, thus greatly increasing their installation
Disadvantages	Higher electric rates initially for residents and businesses
	City will forgo any net cash gain since it does not sell its electric system
	City will still have to manage its electric system and incur debt for future capital improvements
	No patronage dividends for residents from cooperative
	City will have to purchase renewable energy credits from a third party to make Greensburg greener
Risks and Uncertainties	Electric rates could go higher if the City does not grow back as planned

Figure 9 provides a similar graphical summary of the key financial metrics for this strategy. Again, the left two bars in the chart show the predicted electric rates for the first five-year period to be 12.3¢ per kWh, while the second five-year average would be 14.5¢ per kWh. For the first

five years, these projected rates are about 1.3 ¢ higher per kWh than if Southern Pioneer serves the City. However, during the second five years, the cost difference narrows to only 0.4 ¢ per kWh. It is likely that no electric rate increases will be needed for three years.

FIGURE 9 – Financial Summary for Strategy 2 – No Turbines



The City's future electric rates were based on a long-term financial model developed specifically for Greensburg. This financial model was based on Greensburg's historical electric utility costs, and projections of future purchased power costs and operating costs. Cost escalation factors and other assumptions were kept as consistent as possible in the analysis of all of the strategies. Future wholesale power costs were based on a preliminary ballpark estimate provided by the Kansas Power Pool ("KPP") of 4.5 ¢ per kWh postage stamp rate for all power used by Greensburg. Even though KPP utilizes a separate energy charge rate and demand charge rate internally, all of power supply resources are blended together and all KPP members pay for all of their power using a single part rate based on kWh sold. Therefore, a municipal utility with a low load factor will pay the same rate per kWh as does a high load factor utility. Although no financial credit was given to Greensburg for keeping its generating plant, it was assumed the plant would result in lower purchased-power costs over time, based on generating power during peak periods. Transmission service charges were also included. Of course, obtaining a new power supply contract will require some negotiation and an in-depth evaluation. Therefore, there is some uncertainty about which power supplier would eventually supply wholesale power to Greensburg. Nevertheless, the ballpark estimates from KPP were used in this analysis.

The financial model was used to evaluate the impact of the different strategies on the City's electric rates. In order to provide valid comparisons, the electric rates were adjusted for each strategy, so that the electric utility provides the same operating margin for the City (which averages $75,000 annually over the ten years from 2008 through 2017).

A summary of the results of the financial model for Strategies 2 and 3 is included in Attachment 1. Since the City does not have an electric system in Strategy 1, no financial model was developed.

The third bar in Figure 9 shows that the residents in Greensburg would pay a total of $16.5 million to the City for electricity for the next ten years (2008 through 2017), or an average of $1.65 million per year. This 10-year average cost of electricity is 6% higher than Strategy 1 under the MOU. The primary reason the rates are higher under City ownership is due to the ownership and operating costs for the local generating plant. The cost of operating labor, commodities, supplies, and fuel averages about 3¢ for every kWh sold to the City's electric customers. These 6% higher rates under City ownership are at least partly justified by having a local generating plant that can keep the lights on during extended transmission outages. Again, no rate increases would be required for about three years.

The fourth and fifth bars represent the average amount of financial equity and debt the City would have in the electric system over the same ten-year period. The equity was estimated to be $5.7 million, and was assumed to essentially be the difference between depreciated book value and remaining long-term debt. The Consultants estimated today's value of the distribution system to be $4.7 million (nearly all provided by State and FEMA funds for new lines), and the generating plant $2.5 million, after its refurbishment. Although these estimates are rough, fairly conservative, and subject to some judgment, the assumptions and methodology used were consistent for evaluation of all strategies. The average equity over the ten-year period reflects deductions for accumulated depreciation over the period. Again, it was assumed that the insurance settlement would be adequate to retire any existing debt owed by the city for its past electric system improvements.

The last bar at the right depicts the percentage of renewable electricity the City would be using. The actual green power purchased was assumed to be the same 12.8% that was estimated for Sunflower, since the wholesale power provider would also likely try to meet the state's goals of 10% by 2010, and 20% by 2020. Again, to make the comparisons of the strategies comparable, it was assumed that the City would purchase additional renewable energy credits so as to obtain 100% renewable energy. This is shown by the green striped upper part of the bar. Therefore, under Strategy 2, all power used in Greensburg would be green.

Strategy 3 – Retain Electric Utility, Install Large Wind Turbine(s)

Under this strategy, the City would again decline Southern Pioneer's MOU and offer with the intention of retaining ownership of its electric system. The existing engine generating plant would be repaired from insurance proceeds. It was assumed that the insurance proceeds would retire the past debt for engine repairs. Also it was assumed the City would install and own from one to three 1.5 MW wind turbines.

The action steps required include:

1) Obtain temporary extension of current power supply contract
2) Decline offer from Southern Pioneer and settle up costs as necessary
3) Settle with insurance company for distribution system and generating plant damage
4) Start process for refurbishing existing generating units or replacement by new units
5) Start process to obtain long-term wholesale power supply contract that allows for favorable economics for the installation of large wind turbines at Greensburg
6) Work with Southern Pioneer and/or Sunflower as necessary for interconnection of wind turbines to either the distribution or the transmission system
7) Start process of obtaining one or more large wind turbines for installation at Greensburg, and work with corporate benefactors

Table 5 below lists the advantages, disadvantages, risks, and uncertainties for Strategy 3.

TABLE 5 - Strategy 3 – Retain Utility, Install Large Wind Turbine(s) Advantages, Disadvantages, Risks, and Uncertainties

Advantages	City owns local generating plant to keep lights on for long transmission outages
	Retention of electric utility jobs in City
	City has more assets, including a nearly all-new distribution system, which should generate some income for the City and provide financial support for free and discounted services to the City
	City will own one or more large wind turbines to be located at Greensburg, thereby providing a highly visible sign of the City being green and potentially providing a hedge against higher purchased power costs.
	City can provide net metering for residents who install PV panels and wind turbines, thus greatly increasing their installation
Disadvantages	Higher electric rates for residents and businesses
	City will still have to manage its electric system
	City will likely incur some level of debt if it owns wind generation
	No patronage dividends for residents from cooperative
Risks and Uncertainties	Electric rates could go higher if the City does not grow back as planned
	There are operational risks with wind generation, such as lower wind speeds, lower reliability, and higher repair costs

Strategy 3 includes scenarios for City ownership of one, two, and three 1.5 MW wind turbines. These scenarios would provide wind generation equal to about 35%, 70%, and 100% of the City's projected electricity sales. Although the wind generation could be used to reduce the City's electricity purchases by installing it "behind the meter", this might not be the most cost-effective arrangement, since it will depend upon the wholesale power supplier and the terms of the new wholesale power contract. For example, if Greensburg joins the KPP, Greensburg would buy all of its wholesale power from KPP. Even if the wind turbines were connected behind the meter on the distribution system, Greensburg would purchase an amount of power equal to its total needs, and the amount purchased which would not change if there was one, two, three, or no wind turbines. All wind power generated would be dedicated to the KPP and blended in with all of KPP's other generation resources. KPP would provide load-following services for Greensburg's load and wind generation. With a growing appetite for wind generation, KPP could likely use the output from three 1.5 MW wind turbines installed at Greensburg. Even though the wind power would contractually be dedicated to KPP, the wind power would physically be used locally by Greensburg assuming the wind turbines were connected to the grid at Greensburg.

Attachment 2 includes the results of some simulations for how wind generation might correlate with the City's load over the period of a year. It also shows how much wind generation would be in excess of the City's load, and flow back to the grid if the City had just enough wind generation to provide 100% of its annual energy needs. This would be equivalent to 100% wind generation penetration. Although the results of the simulation are instructive, these results did not affect the economic analysis done in this study.

It was assumed that the City would purchase the wind turbines using proceeds from Clean Renewable Energy Bonds ("CREB"), which have about 15-year terms, with an effective interest rate of zero percent. Although all authorized CREB funds have been committed, it is widely anticipated that Congress will reauthorize more of these funds in 2008 or 2009.

Wind turbines could possibly be procured from the developer of future large wind farms in Kansas so that the project could piggy-back on a larger project to gain some economies of scale. Alternatively, a turbine could possibly be ordered from a smaller niche wind turbine manufacturer, such as Vensys or Americas Wind Energy.

Based on the financial analysis, it was determined some outside gift would likely be required toward the installation of wind generation to keep the City's electric rates from increasing when compared to Strategy 2. Of course the amount needed will depend upon the particular wind turbine model installed, its cost, and the financial arrangement with the wholesale power supplier. In this analysis, the following wind turbine cost assumptions were used:

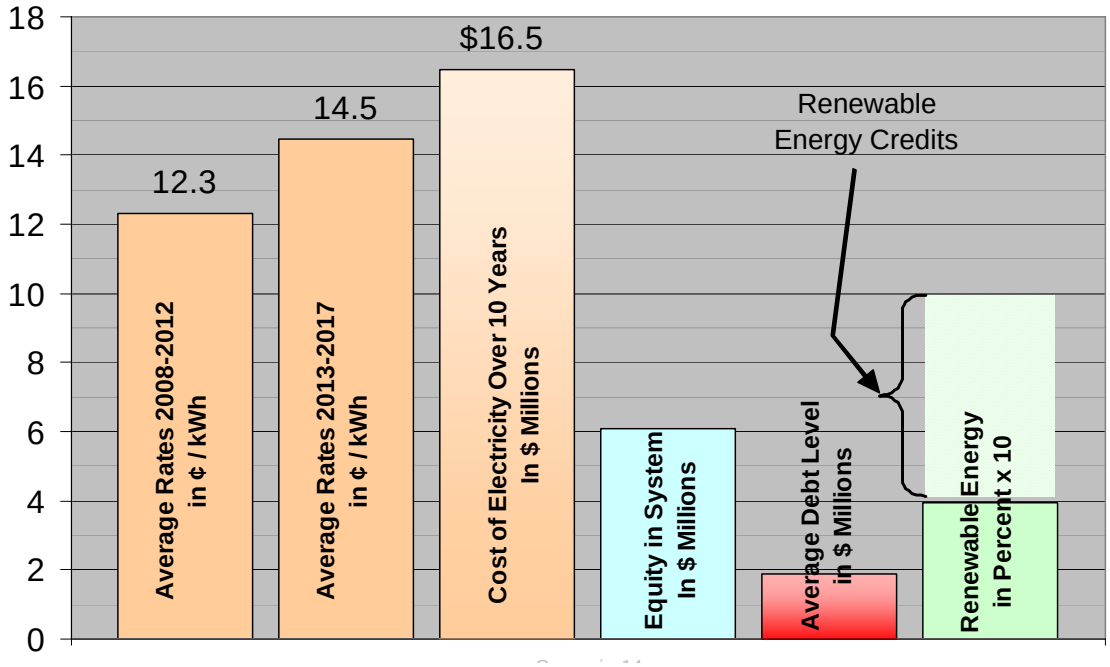
TABLE 6

	One Turbine	Two Turbines	Three Turbines
Total Installed MW	1.50	3.00	4.50
Annual Production, Mwh	5,387	10,696	15,926
Installed Cost, $ Millions	$3.30	$6.30	$9.11
Intial Annual O&M Cost	$57,000	$108,300	$153,900
Notes: The "Annual Production" is based on a 77-meter turbine rotor diameter. The "Annual O&M Cost" includes contributions to a long-term Repair and Replacment fund.			

In this analysis, the Consultants projected that the wind generation would be sold back to the wholesale power supplier at a constant price of 4.5¢ per kWh, which includes the renewable energy credits. Although this selling price might be a little higher than today's market price for wind power from a large new wind farm, the Consultant believes this selling price is obtainable. With this selling price, a one-turbine project would require an outside gift equal to 5% of the $3.3 million cost, or $165,000. With this size of gift, the City's electric rates would likely not be increased, compared to Strategy 2 that has no wind generation but purchase of 100% renewable energy credits.

Figure 10 provides a similar graphical summary of the key financial metrics for this Strategy 3 with one wind turbine. Again, the left three bars in the chart show the predicted electric rates and total cost of electricity to be the same as Strategy 2 without any wind generation. This proves that a gift equal to 5% of the wind turbine's cost would allow the installation of one wind turbine without increasing electric rates compared to simply purchasing renewable energy credits in Strategy 2. These projected electric rates are still about 6% higher per kWh than if Southern Pioneer served the City. Again, the electric rates are higher primarily because the City maintains the local generating plant to keep the lights on for extended transmission outages. As with Strategy 2, no electric rate increases are projected for about three years.

FIGURE 10 – Financial Summary for Strategy 3 – One Turbine
City Installs a 1.5 MW Wind Turbine and Receives a 5% Financial Gift



Again, the fourth and fifth bars represent the average amount of financial equity and debt the City would have in the electric system over the ten-year period. With the addition of a wind turbine, the equity increases slightly to $6.0 million while the debt goes up to $2.0 million respectively.

The last bar at the right indicates that the single wind turbine would generate 39% of the City's annual usage for a normal wind speed year. This would likely be the highest percentage of wind generation for any city in the U.S. To keep the comparison of the various strategies comparable, it was again assumed that the City would purchase additional renewable energy credits so as to provide 100% green power.

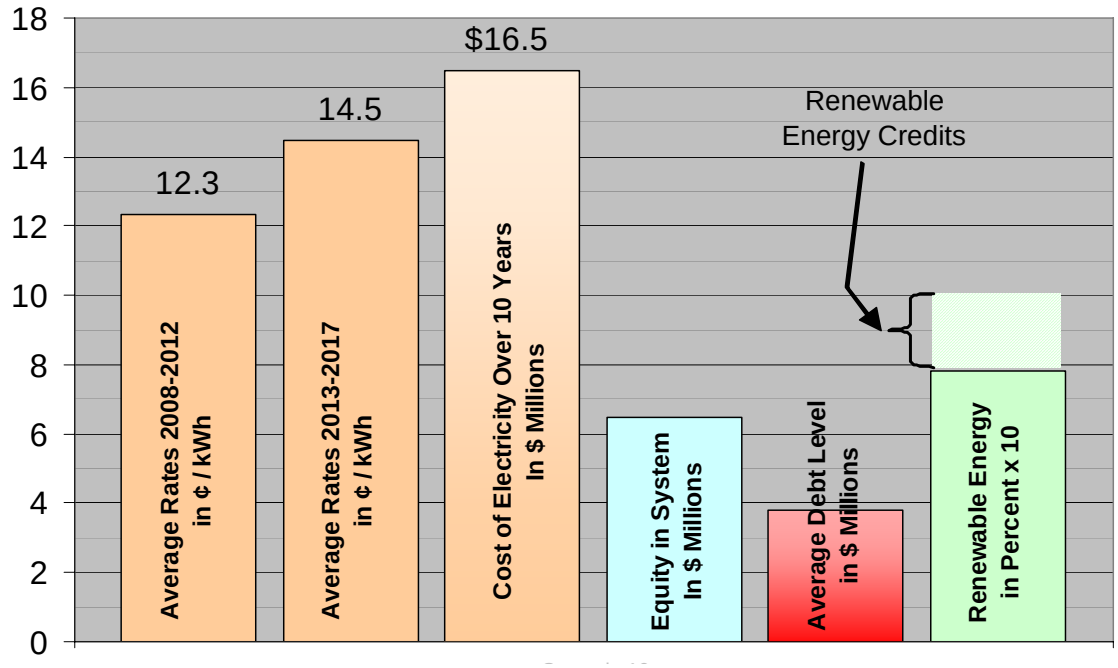
If no financial gift is received and the City pays the full $3.3 million cost for one wind turbine, the City's electric rates would be about the same during the first five years, but about 0.1¢ per kWh on average higher for the second five-year period and beyond, making the average over 10 years 7% higher (instead of 6% higher) than Strategy 1 with the MOU. Therefore, if the City goes it alone on a single wind turbine, its rates would be about 7% higher than under the MOU.

Likewise, a financial gift larger than 5% would tend to reduce the City's electric rates. For example, a gift equal to about 40% of the installed cost of one turbine, or $1.32 million, would result in electric rates that over the long run would be comparable to those under Strategy 1 with the MOU. Of course, if the selling price for the wind power is higher than 4.5¢ per kWh, the economics would improve slightly. For example if the selling price is 5.0¢ per kWh for a single turbine, the electric rates over the long run would be about 3% higher than Strategy 1 with the MOU.

The real economic benefits of wind generation accrue once the debt has been repaid. In this analysis, once the 15-year-term CREB financing is repaid, the profit from ownership of one 1.5 MW wind turbine would allow all rates to drop by about 1.3¢ per kWh. Likewise, ownership of 3 turbines would allow rates to be 4¢ per kWh after the debt is repaid.

A second scenario with two 1.5 MW wind turbines was also analyzed. Figure 11 shows the results of this scenario. No financial gift was required to keep the City's electric rates the same as for Strategy 2 with no wind turbines. The slightly improved economies of scale with a larger two turbine project resulted in no need for a gift. Again this Strategy 3 with two turbines still results in electric rates being 6% higher than Strategy 1 with the MOU. No electric rate increases are projected for three years.

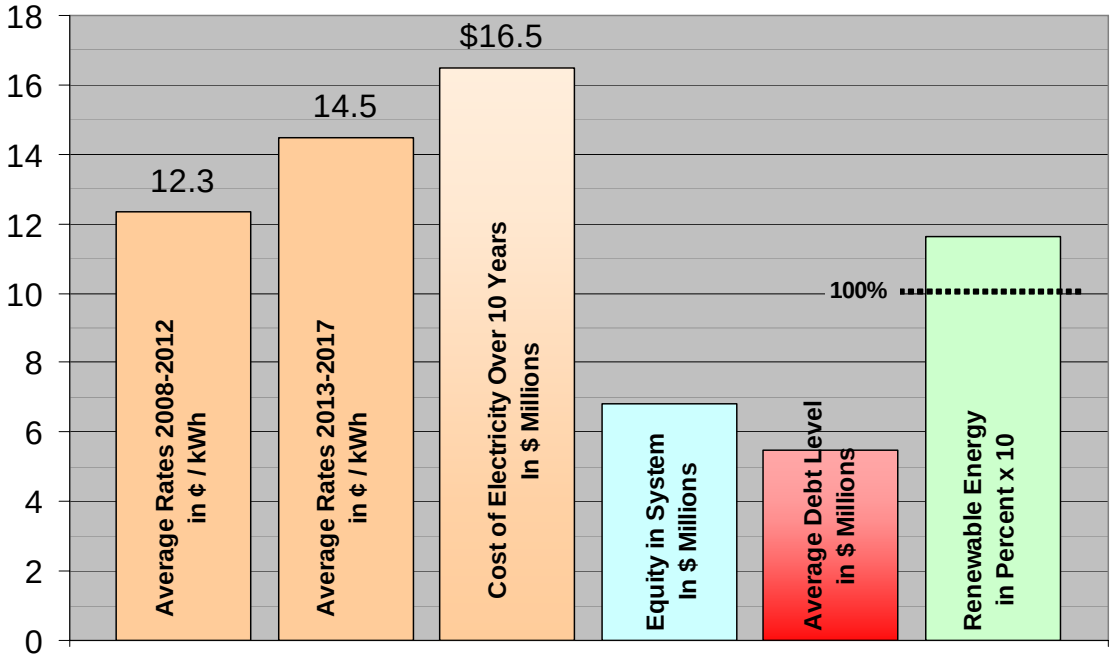
FIGURE 11 – Financial Summary for Strategy 3 – Two Turbines
City Installs Two 1.5 MW Wind Turbines and Receives No Financial Gift



As would be expected, the equity and debt levels increase with two wind turbines, as shown by the fourth and fifth bars in Figure 11 above. The two turbines would generate 78% of the City's electricity needs during the first ten years of operation (2009-2018). Renewable energy credits were purchased for the remaining 22% of energy needs so as to provide 100% green energy to the City.

A third scenario with three 1.5 MW wind turbines was also analyzed. Under this scenario, the turbines would generate about 16% more energy than would be used by the City during the first 10 years of operation. Figure 12 illustrates the results of the financial analysis. Again, no financial gift was needed to keep the rates the same as Strategy 2 with no wind turbine and no electric rate increases are required for three years.

FIGURE 12 – Financial Summary for Strategy 3 – Three Turbines
City Installs Three 1.5 MW Wind Turbines and Receives No Financial Gift



The debt level again increases to $5.5 million. Of course, any financial gift would reduce the City's debt requirements. The green bar in Figure 12 shows that three wind turbines provide 116% of the City's needs. Therefore installing three 1.5 MW wind turbines would essentially allow the City to get all of its power from wind generation. Of course, there would be many times when the City uses more power than the wind turbines would generate; resulting in the use of grid power, which primarily comes from coal-fired power plants. However, there would be many other hours where the wind turbines generate more power than the City would use, with the excess going out to the grid to displace other coal-fired generation. Over the course of the year, the turbines would generate more wind power than the City needed, thus making the City 100+% supplied by wind power.

Table 7 provides a comparison and summary of the analysis in this study.

TABLE 7
Comparison of Strategies

	Strategy 1 MOU	Strategy 2 - Retain Utility But No Turbine		Strategy 3 – Retain Utility and Add Wind Generation			
		No Purchase of R.E. Credits	Purchase R.E. Credits	1.5 MW Wind		3.0 MW Wind No Gift	4.5 MW Wind No Gift
				No Gift	5% Gift ($165,000)		
Figure Number in Report	Figure 6	-	Figure 9	-	Figure 10	Figure 11	Figure 12
Attachment 1 Printout Summary	-	-	Summary 1	Summary 2		Summary 3	Summary 4
Avg. Electric Rates for 2008-2012	11.0 ¢	12.2 ¢	12.3 ¢	12.3 ¢	12.3 ¢	12.3 ¢	12.3 ¢
Avg. Electric Rates for 2013-2017	14.1 ¢	13.7 ¢	14.5 ¢	14.6 ¢	14.5 ¢	14.5 ¢	14.5 ¢
Avg. Annual Electricity Cost	$1.55 mil.	$1.59 mil.	$1.65 mil.	$1.66 mil.	$1.65 mil.	$1.65 mil.	$1.65 mil.
Comparison of Rates, 2008-2017	Reference	+ 3 %	+ 6 %	+ 7 %	+ 6 %	+ 6 %	+ 6 %
Average Equity (2008-2017)	-	$5.7 mil.	$5.7 mil.	$6.1 mil.	$6.0 mil.	$6.5 mil.	$6.8 mil.
Average Debt (2008-2017)	-	-	-	$2.0 mil.	$1.9 mil.	$3.8 mil.	$5.5 mil.
Renew. Energy Purch. (10 Yr. Avg)	12.8%	12.8%	12.8%	39%	39%	78%	116%
Renew. Energy Credits Purchased	87.2%	-	87.2%	61%	61%	22%	0%
Total Renew. Purchases + Credits	100%	12.8%	100%	100%	100%	100%	116%
Probability of One or More Lengthy Power Outages in the Future	High	Low	Low	Low	Low	Low	Low
Probability of Having at Least One Large Wind Turbine at Greensburg	Medium	-	-	Highest	High	Medium	Medium

Observations and Conclusions

The table on previous page summarizes the key findings in this analysis. Based on the analysis in this study, the following observations can be made:

If the City accepts Southern Pioneer's MOU (Strategy 1)

- Electric rates in the City will initially average about 1.3¢ per kWh less expensive than they would be under City ownership. The savings narrows to around 0.5¢ per kWh over the longer run. These projected rates are based on a 10% City electric franchise tax.
- The City would likely have a net cash gain from the sale of its electric system.

If the City retains ownership of its electric system but does not install a wind turbine (Strategy 2)

- Electric rates will likely stay the same for about three years. After that, rates might increase an average of 3.5% per year to allow continuation of a modest annual net margin of about $75,000 per year to the City. On average, rates would be about 6% higher than Strategy 1 with the MOU. This is based on purchasing renewable energy credits to provide 100% green power. Also, the projected rates will depend upon the terms of the new wholesale power supply contract.
- The higher electric rates are due in part to owning, maintaining, and operating the local generating plant, which should effectively limit the length of outages due to transmission line problems.
- The higher rates are also due partly to the free and discounted services now provided by the electric utility to the City and its residents. These services include street lighting, free electricity for some city facilities, and contributions of labor and time by electric utility employees.

If the City retains ownership of its electric system and installs one or more wind turbines (Strategy 3)

- Installing one 1.5 MW wind turbine without any financial gift would tend to make electric rates about 7% higher than Strategy 1, or only 1% higher than Strategy 2. A modest 5% financial gift would make electric rates the same as Strategy 2. Again, it is projected that no increase in electric rates would be needed for three years.
- There is likely no need for higher rates to install either two or three 1.5 MW wind turbines when compared to having no wind turbines in Strategy 2. Again electric rates will likely stay the same for about three years with average annual increases of 3.5% thereafter. On average, rates would be about 6% higher than Strategy 1 with the MOU or essentially the same as Strategy 2. These rate impacts are based on a new wholesale power supply contract similar to that used in the KPP, which would likely allow the installation of two or three wind turbines at Greensburg.
- Three 1.5 MW wind turbines at Greensburg would make the City 100+% supplied by wind power.

The observations are based on the following key assumptions used in the analysis:

1) An insurance settlement that will allow the refurbishment or replacement of the engine generation power plant and retirement of all existing electric utility bonds
2) A wholesale power supply contract:
   a. with a postage stamp rate of about 4.5¢ per kWh and no demand charge
   b. that would accommodate local wind generation by providing load following service for both load and wind generation
   c. that would accommodate the sale of Greensburg's local wind generation for 4.5 ¢ per kWh, which includes the renewable energy credits.
3) Availability of large wind turbines with an installation cost of $2,200 to $2,000 per kW.
4) The ability of Greensburg to sell zero interest Clean Renewable Energy Bonds to finance 100% of the cost of any wind turbines
5) Continued growth in Greensburg's electricity needs to a level of 13.3 million kWh per year, which is 80% more than used in 2007.
6) No consideration was given in the financial analysis to any net cash gain from selling the electric system to Southern Pioneer. A large net cash gain would of course be beneficial to the City and could be used for investment in a wind turbine, perhaps in conjunction with other investors. The power could be sold to Sunflower or other wholesale power suppliers

Using a corporate partner for a wind turbine project may result in slightly lower wind power costs than used in this analysis, depending upon the rate or return requirements of the corporate partner. Such a scenario would of course improve the economics and further reduce the need to increase electric rates in the future.

If the City serves a 4 MW high load factor biodiesel production facility in the future, the economics of adding wind generation would likely be comparable to that found in this study. However, the existing transmission system might not be able to accommodate enough wind turbines to provide 100% wind power for the larger City load without some transmission system reinforcements. A detailed transmission study would be required to determine the need for any system reinforcements.

Given this analysis and these observations, the Consultants have made the following conclusions:

- To avoid having lengthy power outages due to transmission line outages, the City should retain its electric generating plant. This would be most practical if the City also retained ownership of its electric system. Therefore, the City should not accept the MOU.
- Electric rates will average about 6% higher under Strategy 2 with City ownership of the electric utility compared to retail electric service from Southern Pioneer. No electric rate increases would likely be required for about three years and renewable energy credits would be purchased to provide 100% green power.
- With the electric system under City ownership, the installation of one 1.5 MW wind turbine would make rates average about 7% higher than under Strategy 1 with the MOU. One wind turbine would provide an average of about 39% of the City's electricity needs.

A modest gift of $165,000 would make the electric rates about the same as Strategy 2, with no wind turbines.

- Installing two or three 1.5 MW wind turbines would not result in higher rates than having no wind turbines (Strategy 2). Two wind turbines would provide 78% of the City's electricity needs, while 3 turbines would provide 116% of the City's needs.
- Since the installation of large wind turbines has little impact on electricity rates, Greensburg should consider the ownership and installation of wind turbines at or near the City.

Thomas A. Wind, PE
Wind Utility Consulting, PC
January 15, 2008

Attachment 1
Summary of Financial Analysis

This attachment includes the power supply and financial model printouts for on a year-by-year basis for the continued operation of the Greensburg electric system. Although these models are preliminary in nature, they were used for the analysis in this report.

There are eight pages of printouts for each scenario and the following four scenarios are included:

Summary 1 - Strategy 2 - Retain Utility, But No Wind Generation

Summary 2 - Strategy 3 – Retain Utility, 1.5 MW of Wind Generation with No Financial Gift

Summary 3 - Strategy 3 – Retain Utility, 3.0 MW of Wind Generation with No Financial Gift

Summary 4 - Strategy 3 – Retain Utility, 4.5 MW of Wind Generation with No Financial Gift

Summary 1

Strategy 2

Retain Utility

But No Wind Generation

	A	B	C	D	E	F	G	H	I	J
1	**Strategy 2: Retain Utility, No Wind, 100% Green Power**	**Summary of Power Supply and Financial Modeling for Greensburg**								
2		**Preliminary and Confidential**								
3			**YEAR >>**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
4	**Load, Peak, Energy Prices**									
5	Peak Load			0	4,489	0	2,479	3,360	3,444	3,478
6	Storage System Losses, MWH			0	0	0	0	0	0	0
7	Total Energy to System, Including Losses, MWH			15,622	15,474	7,414	9,496	12,867	13,189	13,321
8										
9	Natural Gas Cost $ / MMBTU					$7.00	$7.50	$7.80	$8.11	$8.44
10	Biodiesel Cost, $ / Gal					$2.50	$2.60	$2.70	$2.81	$2.92
11	Diesel Cost, $ / Gal					$2.75	$2.86	$2.97	$3.09	$3.22
12										
13	**Wind Generation**									
14	Wind Generation, Number of Turbines							0	0	0
15	Wind Generation, MW	1.50 Turbine Size, in MW			0.0% Capital Contribution, Gift =			0.00	0.00	0.00
16	Wind Generation, MWH	41.0% Annual Capacity Factor Used				-0.30% Array Delta		0	0	0
17	Wind Generation Capital Cost, $	1	2	3	4	< # of WTs		$0	$0	$0
18	Wind Generation O&M	$2,200	$2,100	$2,025	$1,975	< Total Cost per kW		$0	$0	$0
19	Wind Generation R&R & Warranty	$12	$ / kW in 2009		$26	$ / kW in 2009		$0	$0	$0
20										
21	Wind Generation as a % of Total Load							0.0%	0.0%	0.0%
22	Excess Wind Gen to Grid, %							0.0%	0.0%	0.0%
23	Excess Wind Gen to Grid, MWh							0	0	0
24										
25	**Energy Storage System**									
26	Energy Storage, MW			0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Energy Storage Capital Cost, Mil $			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	Energy Storage Fixed Charges, Mil $			$0	$0	$0	$0	$0	$0	$0
29	Energy Storage O&M Cost, $			$0	$0	$0	$0	$0	$0	$0
30	Energy Storage MWH Net Consumed			0	0	0	0	0	0	0
31	Energy Storage MWH Net Delivered			0	0	0	0	0	0	0
32	Energy Storage MWH Lost			0	0	0	0	0	0	0
33										
34	**Purchases & Sales**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
35	Purchases from Grid			14,823	15,296	7,364	8,846	12,217	12,539	12,671
36	Wind Power Sold to Grid						0	0	0	0
37	Equivalent Net Purchases (Sales to Grid)			14,823	15,296	7,364	8,846	12,217	12,539	12,671
38							0.0%	94.9%	95.1%	95.1%
39	Equivalent Net Purchases as a % of Load									
40	Energy Charge Rate, $/MWH						$45.0	$46.4	$47.7	$49.2
41	Climate Change Costs, $/MWH	Based on TAW 3 Scenario					$0.00	$0.00	$4.89	$6.36
42										
43	Integration Costs	260,000 MWh Pool Base					$0.0	$0.0	$0.0	$0.0
44	Purchased Energy, Dollars			$800,462	$769,694	$371,610	$398,086	$566,279	$659,971	$703,656
45	Cost of Renewable Energy Credits						$8,547	$23,161	$35,611	$47,423
46	Purchased Demand, in kW						2,479	3,360	3,444	3,478
47	Demand Charge Rate, $ / kW-Month						$0.00	$0.00	$0.00	$0.00
48	Demand Charges						$0	$0	$0	$0

	A	B	C	D	E	F	G	H	I	J
49	Total Cost of Purchased Power & REC's, Dollars			$857,584	$701,754	$371,610	$406,633	$589,440	$695,582	$751,079
50	Transmission Service						$60,000	$83,332	$87,551	$90,638
51				$57.85	$45.88	$50.46	$45.97	$48.25	$55.47	$59.27
52	Total Cost of Purchased Power, $ / Mwh									
53	Rate for Sale of Excess Wind Power	$45.00	per Mwh	0.0%	Escalator		$45.00	$45.00	$45.00	$45.00
54	Revenue from Sale of Wind Power						$0	$0	$0	$0
55	Revenue from Sale of RECs	$0.00	per Mwh	0.0%	Escalator		$0	$0	$0	$0
56										
57	**Engine Plant**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
58	Existing Engine Generating Capacity			6.50	6.50	6.50	6.50	6.50	6.50	6.50
59	New Engine Generating Capacity			0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	New Engine Capital Cost per kW			$0	$0	$0	$750	$773	$796	$820
61	New Engine Total Capital Cost, $			$ -	$ -	$ -	$ -	$ -	$ -	$ -
62	New Engine Fixed Charges, $			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
63										
64	**Engine Plant Fuel Costs**			2005	2006	2007	1/2 Year	2009	2010	2011
65	Energy Generated by Engines, MWh			799	178	50	650	650	650	650
66	Percentage from Natural Gas			0.0%	0.0%	90.0%	90.0%	90.0%	90.0%	90.0%
67	Percentage from Diesel			0%	0%	10%	10%	10%	10%	10%
68	Percentage from Biodiesel			0%	0%	0%	0%	0%	0%	0%
69										
70	Natural Gas Cost, $			$ 69,539	$ 104,645	$ 10,395	$ 49,500	$ 51,480	$ 53,539	$ 55,681
71	Diesel Cost, $ as pilot fuel for gas			$ 14,093	$ -	$ 3,312	$ 17,223	$ 17,912	$ 18,628	$ 19,373
72	Biodiesel Cost, $ as pilot or replacement for gas			$ -	$ -	$ -	$ -	$ -	$ -	$ -
73	Total Fuel Cost, $			$ 83,632	$ 104,645	$ 13,707	$ 66,723	$ 69,392	$ 72,167	$ 75,054
74	**Existing Engine Plant O&M**									
75										
76	Existing Plant Personal Services			$ 206,081	$ 193,952	$ 120,010	$ 123,610	$ 127,319	$ 131,138	$ 135,072
77	Existing Plant Contractual Services			$ 171,345	$ 102,954	$ 54,860	$ 141,264	$ 145,502	$ 149,867	$ 154,363
78										
79	**New Engine Plant O&M**									
80	New Plant Personal Services			$0	$0	$0	$0	$0	$0	$0
81	New Plant Contractual Services			0	0	0	0	0	0	0
82										
83	**Cash receipts**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
84	Sales			$1,609,787	$1,791,549	$833,682	$1,067,815	$1,446,878	$1,483,065	$1,572,790
85	Rentals			$0	$0	$0	$0	$0	$0	$0
86	Security Lights			$3,458	$4,218	$1,963	$2,514	$3,407	$3,492	$3,703
87	Service Charge			$1,328	$1,668	$776	$994	$1,347	$1,381	$1,464
88	Materials sold			$0	$3,335	$1,718	$1,769	$1,822	$1,877	$1,933
89	Other			$185	$96	$145	$149	$154	$158	$163
90	Wind Power & REC Sales			$0	$0	$0	$0	$0	$0	$0
91	Total cash receipts			$1,614,758	$1,800,866	$838,283	$1,073,242	$1,453,607	$1,489,972	$1,580,054
92	**Expenditures**									
93	**Production**									
94	Engine Plant Personal Services			$206,081	$193,952	$120,010	$123,610	$127,319	$131,138	$135,072
95	Engine Plant Contractual Services			$171,345	$102,954	$54,860	$141,264	$145,502	$149,867	$154,363
96										
97	Wind Generator O&M, R&R						$0	$0	$0	$0
98	Commodities			$14,969	$17,726	$16,838	$17,343	$17,863	$18,399	$18,951

	A	B	C	D	E	F	G	H	I	J
99	Diesel fuel & oil			$14,093	$0	$4,741	$8,533	$17,066	$17,578	$18,105
100	Electricity, RECs, & Transmission Service			$857,584	$701,754	$371,610	$466,633	$672,772	$783,133	$841,717
101	Natural Gas			$69,539	$104,645	$10,395	$49,500	$51,480	$53,539	$55,681
102	Capital outlay			$89	$0	$0	$0	$0	$0	$0
103	**Transmission & Distribution**									
104	Personal Services			$158,841	$155,983	$162,134	$166,998	$172,008	$177,169	$182,484
105	Contractual Services			$13,493	$8,817	$11,490	$11,834	$12,189	$12,555	$12,932
106	Commodities			$41,809	$47,408	$45,947	$47,325	$48,745	$50,207	$51,713
107	Capital outlay			$0	$3,984	$2,052	$2,113	$2,177	$2,242	$2,309
108	**General & Administrative**									
109	Contractual Services			$2,644	$2,835	$2,822	$2,906	$2,994	$3,083	$3,176
110	Commodities			$0	$0	$0	$0	$0	$0	$0
111	**Transfer to electric debt service**			$175,758	$175,758	$0	$0	$0	$0	$0
112	**Reimbursed expenditures**			($9,928)	($4,315)	($7,335)	($7,555)	($7,782)	($8,015)	($8,256)
113	**Total Expenditures**			$1,716,317	$1,511,501	$795,562	$1,030,505	$1,262,333	$1,390,895	$1,468,247
114										
115	Receipts over (under) expenditures			($101,559)	$289,365	$42,721	$42,737	$191,274	$99,077	$111,807
116	Unencumbered cash (deficit) BOY			$9,040	($92,519)	$196,846	$189,546	$189,546	$294,008	$304,101
117	Trasfer to City			$0	$0	($50,021)	($42,737)	($86,813)	($88,984)	($94,367)
118	Unencumbered cash (deficit), EOY			($92,519)	$196,846	$189,546	$189,546	$294,008	$304,101	$321,540
119										
120	**Retail Sales by Class**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
121										
122	Residential Mwh			10,338	9,533	4,773	6,113	8,284	8,491	8,576
123	Commercial Mwh			4,303	4,288	2,122	2,718	3,683	3,775	3,813
124	Furnished without charges & Losses			981	1,653	519	665	901	923	932
125	Total Mwh to System			15,622	15,474	7,414	9,496	12,867	13,189	13,321
126	Losses as a % of Sales			6.7%	12.0%	10.0%	7.0%	7.0%	7.0%	7.0%
127										
128	Rate Change by Year			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%
129	Residential Cost per kWh			$0.1115	$0.1216	$0.1216	$0.1216	$0.1216	$0.1216	$0.1277
130	Commercial Cost per kWh			$0.1106	$0.1194	$0.1194	$0.1194	$0.1194	$0.1194	$0.1254
131	Residential Revenue			$1,153,000	$1,159,000	$580,292	$743,262	$1,007,112	$1,032,300	$1,094,754
132	Commercial Revenue			$476,000	$512,000	$253,391	$324,553	$439,766	$450,765	$478,036
133	Total Sales Revenue			$1,629,000	$1,671,000	$833,682	$1,067,815	$1,446,878	$1,483,065	$1,572,790
134	Average Retail Sales Revenue ¢ per kWh			11.13	12.09	12.09	12.09	12.09	12.09	12.70
135	Residential Customers			792	783					
136	Commercial Customers			132	148					
137										
138	**Simplified Balance Sheet**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
139	Distribution System - New Investment					$4,500,000	$0	$0	$0	$0
140	Cumulative Investment	Existing Distribution that Survived>			$250,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
141	Annual Depreciation					$142,500	$142,500	$142,500	$142,500	$142,500
142	Accumulated Depreciation					$142,500	$285,000	$427,500	$570,000	$712,500
143	Net Depreciated Investment					$4,607,500	$4,465,000	$4,322,500	$4,180,000	$4,037,500
144										
145	Production Plant - New Investment					$0	$0	$0	$0	$0
146	Cumulative Investment		Existing Diesel Plant >		$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000
147	Annual Depreciation					$100,000	$100,000	$100,000	$100,000	$100,000
148	Accumulated Depreciation					$100,000	$200,000	$300,000	$400,000	$500,000

	A	B	C	D	E	F	G	H	I	J
149	Net Depreciated Investment					$2,400,000	$2,300,000	$2,200,000	$2,100,000	$2,000,000
150										
151	Total Utility Plant					$7,250,000	$7,250,000	$7,250,000	$7,250,000	$7,250,000
152	Less Accumulated Depreciation					$242,500	$485,000	$727,500	$970,000	$1,212,500
153	Total Net Utility Plant					$7,007,500	$6,765,000	$6,522,500	$6,280,000	$6,037,500
154	Current Assets & Other					$100,000	$100,000	$100,000	$100,000	$100,000
155	Total Assets					$7,107,500	$6,865,000	$6,622,500	$6,380,000	$6,137,500
156										
157	Total Equity					$7,057,500	$6,815,000	$6,572,500	$6,330,000	$6,087,500
158	Long-Term Liabilities					$0	$0	$0	$0	$0
159	Current Liabilities					$50,000	$50,000	$50,000	$50,000	$50,000
160	Total Liabilities					$50,000	$50,000	$50,000	$50,000	$50,000
161	Total Liabilities & Equity					$7,107,500	$6,865,000	$6,622,500	$6,380,000	$6,137,500

	K	L	M	N	O	P	Q	R	S	T
1	**Strategy 2: Retain Utility, No Wind, 100% Green Power**	**Summary of Power Supply and Financial Modeling for Greensburg**								
2		**Preliminary and Confidential**								
3		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
4	**Load, Peak, Energy Prices**									
5	Peak Load	3,513	3,548	3,583	3,619	3,655	3,692	3,729	3,766	3,804
6	Storage System Losses, MWH	0	0	0	0	0	0	0	0	0
7	Total Energy to System, Including Losses, MWH	13,454	13,589	13,725	13,862	14,001	14,141	14,282	14,425	14,569
8										
9	Natural Gas Cost $ / MMBTU	$8.77	$9.12	$9.49	$9.87	$10.26	$10.67	$11.10	$11.55	$12.01
10	Biodiesel Cost, $ / Gal	$3.04	$3.16	$3.29	$3.42	$3.56	$3.70	$3.85	$4.00	$4.16
11	Diesel Cost, $ / Gal	$3.35	$3.48	$3.62	$3.76	$3.91	$4.07	$4.23	$4.40	$4.58
12										
13	**Wind Generation**									
14	Wind Generation, Number of Turbines	0	0	0	0	0	0	0	0	0
15	Wind Generation, MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Wind Generation, MWH	0	0	0	0	0	0	0	0	0
17	Wind Generation Capital Cost, $	$0	$0	$0	$0	$0	$0	$0	$0	$0
18	Wind Generation O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0
19	Wind Generation R&R & Warranty	$0	$0	$0	$0	$0	$0	$0	$0	$0
20										
21	Wind Generation as a % of Total Load	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
22	Excess Wind Gen to Grid, %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
23	Excess Wind Gen to Grid, MWh	0	0	0	0	0	0	0	0	0
24										
25	**Energy Storage System**									
26	Energy Storage, MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Energy Storage Capital Cost, Mil $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	Energy Storage Fixed Charges, Mil $	$0	$0	$0	$0	$0	$0	$0	$0	$0
29	Energy Storage O&M Cost, $	$0	$0	$0	$0	$0	$0	$0	$0	$0
30	Energy Storage MWH Net Consumed	0	0	0	0	0	0	0	0	0
31	Energy Storage MWH Net Delivered	0	0	0	0	0	0	0	0	0
32	Energy Storage MWH Lost	0	0	0	0	0	0	0	0	0
33										
34	**Purchases & Sales**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
35	Purchases from Grid	12,804	12,939	13,075	13,212	13,351	13,491	13,632	13,775	13,919
36	Wind Power Sold to Grid	0	0	0	0	0	0	0	0	0
37	Equivalent Net Purchases (Sales to Grid)	12,804	12,939	13,075	13,212	13,351	13,491	13,632	13,775	13,919
38		95.2%	95.2%	95.3%	95.3%	95.4%	95.4%	95.4%	95.5%	95.5%
39	Equivalent Net Purchases as a % of Load									
40	Energy Charge Rate, $/MWH	$50.6	$52.2	$53.7	$55.3	$57.0	$58.7	$60.5	$62.3	$64.2
41	Climate Change Costs, $/MWH	$7.83	$9.29	$10.76	$12.23	$13.70	$15.16	$16.63	$18.10	$19.57
42										
43	Integration Costs	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
44	Purchased Energy, Dollars	$748,733	$795,249	$843,251	$892,789	$943,915	$996,683	$1,051,148	$1,107,367	$1,165,401
45		$59,199	$70,934	$82,623	$94,262	$105,845	$117,368	$128,824	$140,210	$151,519
46	Purchased Demand, in kW	3,513	3,548	3,583	3,619	3,655	3,692	3,729	3,766	3,804
47	Demand Charge Rate, $ / kW-Month	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
48	Demand Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0

	K	L	M	N	O	P	Q	R	S	T
49	Total Cost of Purchased Power & REC's, Dollars	$807,932	$866,183	$925,874	$987,051	$1,049,760	$1,114,051	$1,179,972	$1,247,578	$1,316,921
50	Transmission Service	$93,833	$97,140	$100,564	$104,109	$107,779	$111,578	$115,511	$119,583	$123,799
51		$63.10	$66.94	$70.81	$74.71	$78.63	$82.58	$86.56	$90.57	$94.61
52	Total Cost of Purchased Power, $ / Mwh									
53	Rate for Sale of Excess Wind Power	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00
54	Revenue from Sale of Wind Power	$0	$0	$0	$0	$0	$0	$0	$0	$0
55	Revenue from Sale of RECs	$0	$0	$0	$0	$0	$0	$0	$0	$0
56										
57	**Engine Plant**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**		
58	Existing Engine Generating Capacity	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
59	New Engine Generating Capacity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	New Engine Capital Cost per kW	$844	$869	$896	$922	$950	$979	$1,008	$1,038	$1,069
61	New Engine Total Capital Cost, $	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
62	New Engine Fixed Charges, $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
63										
64	**Engine Plant Fuel Costs**	2012	2013	2014	2015	2016	2017	2018	2019	2020
65	Energy Generated by Engines, MWh	650	650	650	650	650	650	650	650	650
66	Percentage from Natural Gas	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
67	Percentage from Diesel	10%	10%	10%	10%	10%	10%	10%	10%	10%
68	Percentage from Biodiesel	0%	0%	0%	0%	0%	0%	0%	0%	0%
69										
70	Natural Gas Cost, $	$ 57,908	$ 60,224	$ 62,633	$ 65,139	$ 67,744	$ 70,454	$ 73,272	$ 76,203	$ 79,251
71	Diesel Cost, $ as pilot fuel for gas	$ 20,148	$ 20,954	$ 21,792	$ 22,664	$ 23,570	$ 24,513	$ 25,494	$ 26,513	$ 27,574
72	Biodiesel Cost, $ as pilot or replacement for gas	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
73	Total Fuel Cost, $	$ 78,056	$ 81,178	$ 84,425	$ 87,802	$ 91,315	$ 94,967	$ 98,766	$ 102,716	$ 106,825
74	**Existing Engine Plant O&M**									
75										
76	Existing Plant Personal Services	$ 139,124	$ 143,298	$ 147,597	$ 152,025	$ 156,586	$ 161,283	$ 166,122	$ 171,105	$ 176,239
77	Existing Plant Contractual Services	$ 158,994	$ 163,764	$ 168,677	$ 173,737	$ 178,949	$ 184,317	$ 189,847	$ 195,542	$ 201,409
78										
79	**New Engine Plant O&M**									
80	New Plant Personal Services	$0	$0	$0	$0	$0	$0	$0	$0	$0
81	New Plant Contractual Services	0	0	0	0	0	0	0	0	0
82										
83	**Cash receipts**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
84	Sales	$1,588,518	$1,716,712	$1,733,879	$1,891,315	$1,910,228	$2,083,677	$2,104,514	$2,125,559	$2,146,815
85	Rentals	$0	$0	$0	$0	$0	$0	$0	$0	$0
86	Security Lights	$3,740	$4,042	$4,082	$4,453	$4,497	$4,906	$4,955	$5,004	$5,054
87	Service Charge	$1,479	$1,598	$1,614	$1,761	$1,778	$1,940	$1,959	$1,979	$1,999
88	Materials sold	$1,991	$2,051	$2,112	$2,176	$2,241	$2,308	$2,377	$2,449	$2,522
89	Other	$168	$173	$178	$183	$189	$194	$200	$206	$213
90	Wind Power & REC Sales	$0	$0	$0	$0	$0	$0	$0	$0	$0
91	Total cash receipts	$1,595,896	$1,724,576	$1,741,866	$1,899,888	$1,918,934	$2,093,025	$2,114,006	$2,135,197	$2,156,602
92	**Expenditures**									
93	**Production**									
94	Engine Plant Personal Services	$139,124	$143,298	$147,597	$152,025	$156,586	$161,283	$166,122	$171,105	$176,239
95	Engine Plant Contractual Services	$158,994	$163,764	$168,677	$173,737	$178,949	$184,317	$189,847	$195,542	$201,409
96										
97	Wind Generator O&M, R&R	$0	$0	$0	$0	$0	$0	$0	$0	$0
98	Commodities	$19,520	$20,105	$20,709	$21,330	$21,970	$22,629	$23,308	$24,007	$24,727

	K	L	M	N	O	P	Q	R	S	T
99	Diesel fuel & oil	$18,648	$19,208	$19,784	$20,377	$20,989	$21,618	$22,267	$22,935	$23,623
100	Electricity, RECs, & Transmission Service	$901,765	$963,323	$1,026,438	$1,091,160	$1,157,540	$1,225,629	$1,295,484	$1,367,161	$1,440,719
101	Natural Gas	$57,908	$60,224	$62,633	$65,139	$67,744	$70,454	$73,272	$76,203	$79,251
102	Capital outlay	$0	$0	$0	$0	$0	$0	$0	$0	$0
103	**Transmission & Distribution**									
104	Personal Services	$187,958	$193,597	$199,405	$205,387	$211,549	$217,895	$224,432	$231,165	$238,100
105	Contractual Services	$13,320	$13,719	$14,131	$14,555	$14,991	$15,441	$15,904	$16,381	$16,873
106	Commodities	$53,265	$54,863	$56,509	$58,204	$59,950	$61,749	$63,601	$65,509	$67,474
107	Capital outlay	$2,379	$2,450	$2,523	$2,599	$2,677	$2,757	$2,840	$2,925	$3,013
108	**General & Administrative**									
109	Contractual Services	$3,271	$3,369	$3,470	$3,574	$3,682	$3,792	$3,906	$4,023	$4,144
110	Commodities	$0	$0	$0	$0	$0	$0	$0	$0	$0
111	**Transfer to electric debt service**	$0	$0	$0	$0	$0	$0	$0	$0	$0
112	**Reimbursed expenditures**	($8,503)	($8,759)	($9,021)	($9,292)	($9,571)	($9,858)	($10,154)	($10,458)	($10,772)
113	**Total Expenditures**	$1,547,648	$1,629,162	$1,712,855	$1,798,795	$1,887,055	$1,977,707	$2,070,829	$2,166,499	$2,264,800
114										
115	Receipts over (under) expenditures	$48,248	$95,414	$29,011	$101,093	$31,879	$115,318	$43,177	($31,302)	($108,197)
116	Unencumbered cash (deficit) BOY	$321,540	$321,540	$321,540	$321,540	$321,540	$321,540	$321,540	$321,540	$290,239
117	Trasfer to City	($48,248)	($95,414)	($29,011)	($101,093)	($31,879)	($115,318)	($43,177)	$0	$0
118	Unencumbered cash (deficit), EOY	$321,540	$321,540	$321,540	$321,540	$321,540	$321,540	$321,540	$290,239	$182,042
119										
120	**Retail Sales by Class**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
121										
122	Residential Mwh	8,662	8,748	8,836	8,924	9,013	9,103	9,194	9,286	9,379
123	Commercial Mwh	3,851	3,890	3,928	3,968	4,007	4,047	4,088	4,129	4,170
124	Furnished without charges & Losses	942	951	961	970	980	990	1,000	1,010	1,020
125	Total Mwh to System	13,454	13,589	13,725	13,862	14,001	14,141	14,282	14,425	14,569
126	Losses as a % of Sales	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
127										
128	Rate Change by Year	0.0%	7.0%	0.0%	8.0%	0.0%	8.0%	0.0%	0.0%	0.0%
129	Residential Cost per kWh	$0.1277	$0.1366	$0.1366	$0.1475	$0.1475	$0.1593	$0.1593	$0.1593	$0.1593
130	Commercial Cost per kWh	$0.1254	$0.1341	$0.1341	$0.1449	$0.1449	$0.1565	$0.1565	$0.1565	$0.1565
131	Residential Revenue	$1,105,702	$1,194,932	$1,206,881	$1,316,466	$1,329,631	$1,450,361	$1,464,865	$1,479,513	$1,494,309
132	Commercial Revenue	$482,817	$521,780	$526,998	$574,849	$580,598	$633,316	$639,649	$646,045	$652,506
133	Total Sales Revenue	$1,588,518	$1,716,712	$1,733,879	$1,891,315	$1,910,228	$2,083,677	$2,104,514	$2,125,559	$2,146,815
134	Average Retail Sales Revenue ¢ per kWh	12.70	13.58	13.58	14.67	14.67	15.84	15.84	15.84	15.84
135	Residential Customers									
136	Commercial Customers									
137										
138	**Simplified Balance Sheet**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
139	Distribution System - New Investment	$0	$0	$0	$0	$0	$0	$0	$0	$0
140	Cumulative Investment	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
141	Annual Depreciation	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500
142	Accumulated Depreciation	$855,000	$997,500	$1,140,000	$1,282,500	$1,425,000	$1,567,500	$1,710,000	$1,852,500	$1,995,000
143	Net Depreciated Investment	$3,895,000	$3,752,500	$3,610,000	$3,467,500	$3,325,000	$3,182,500	$3,040,000	$2,897,500	$2,755,000
144										
145	Production Plant - New Investment	$0	$0	$0	$0	$0	$0	$0	$0	$0
146	Cumulative Investment	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,500,000
147	Annual Depreciation	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
148	Accumulated Depreciation	$600,000	$700,000	$800,000	$900,000	$1,000,000	$1,100,000	$1,200,000	$1,300,000	$1,400,000

	K	L	M	N	O	P	Q	R	S	T
149	Net Depreciated Investment	$1,900,000	$1,800,000	$1,700,000	$1,600,000	$1,500,000	$1,400,000	$1,300,000	$1,200,000	$1,100,000
150										
151	Total Utility Plant	$7,250,000	$7,250,000	$7,250,000	$7,250,000	$7,250,000	$7,250,000	$7,250,000	$7,250,000	$7,250,000
152	Less Accumulated Depreciation	$1,455,000	$1,697,500	$1,940,000	$2,182,500	$2,425,000	$2,667,500	$2,910,000	$3,152,500	$3,395,000
153	Total Net Utility Plant	$5,795,000	$5,552,500	$5,310,000	$5,067,500	$4,825,000	$4,582,500	$4,340,000	$4,097,500	$3,855,000
154	Current Assets & Other	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
155	Total Assets	$5,895,000	$5,652,500	$5,410,000	$5,167,500	$4,925,000	$4,682,500	$4,440,000	$4,197,500	$3,955,000
156										
157	Total Equity	$5,845,000	$5,602,500	$5,360,000	$5,117,500	$4,875,000	$4,632,500	$4,390,000	$4,147,500	$3,905,000
158	Long-Term Liabilities	$0	$0	$0	$0	$0	$0	$0	$0	$0
159	Current Liabilities	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
160	Total Liabilities	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
161	Total Liabilities & Equity	$5,895,000	$5,652,500	$5,410,000	$5,167,500	$4,925,000	$4,682,500	$4,440,000	$4,197,500	$3,955,000

Summary 2

Strategy 3

Retain Utility

1.5 MW of Wind Generation

with No Financial Gift

	A	B	C	D	E	F	G	H	I	J
1	**Strategy 3: 1.5 MW Wind, No Gift, 100% Green Power**	**Summary of Power Supply and Financial Modeling for Greensburg**								
2		**Preliminary and Confidential**								
3			**YEAR >>**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
4	**Load, Peak, Energy Prices**									
5	Peak Load			0	4,489	0	2,479	3,360	3,444	3,478
6	Storage System Losses, MWH			0	0	0	0	0	0	0
7	Total Energy to System, Including Losses, MWH			15,622	15,474	7,414	9,496	12,867	13,189	13,321
8										
9	Natural Gas Cost $ / MMBTU					$7.00	$7.50	$7.80	$8.11	$8.44
10	Biodiesel Cost, $ / Gal					$2.50	$2.60	$2.70	$2.81	$2.92
11	Diesel Cost, $ / Gal					$2.75	$2.86	$2.97	$3.09	$3.22
12										
13	**Wind Generation**									
14	Wind Generation, Number of Turbines							1	1	1
15	Wind Generation, MW	1.50 Turbine Size, in MW			0.0% Capital Contribution, Gift =			1.50	1.50	1.50
16	Wind Generation, MWH	41.0% Annual Capacity Factor Used				-0.30% Array Delta		5,387	5,387	5,387
17	Wind Generation Capital Cost, $	1	2	3	4	< # of WTs		$3,300,000	$0	$0
18	Wind Generation O&M	$2,200	$2,100	$2,025	$1,975	< Total Cost per kW		$39,000	$40,170	$41,375
19	Wind Generation R&R & Warranty	$12	$ / kW in 2009		$26	$ / kW in 2009		$18,000	$18,540	$19,096
20										
21	Wind Generation as a % of Total Load							41.9%	40.8%	40.4%
22	Excess Wind Gen to Grid, %							5.3%	5.3%	5.3%
23	Excess Wind Gen to Grid, MWh							284	284	284
24										
25	**Energy Storage System**									
26	Energy Storage, MW			0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Energy Storage Capital Cost, Mil $			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	Energy Storage Fixed Charges, Mil $			$0	$0	$0	$0	$0	$0	$0
29	Energy Storage O&M Cost, $			$0	$0	$0	$0	$0	$0	$0
30	Energy Storage MWH Net Consumed			0	0	0	0	0	0	0
31	Energy Storage MWH Net Delivered			0	0	0	0	0	0	0
32	Energy Storage MWH Lost			0	0	0	0	0	0	0
33										
34	**Purchases & Sales**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
35	Purchases from Grid			14,823	15,296	7,364	8,846	12,217	12,539	12,671
36	Wind Power Sold to Grid						0	5,387	5,387	5,387
37	Equivalent Net Purchases (Sales to Grid)			14,823	15,296	7,364	8,846	6,830	7,152	7,284
38							0.0%	53.1%	54.2%	54.7%
39	Equivalent Net Purchases as a % of Load									
40	Energy Charge Rate, $/MWH						$45.0	$46.4	$47.7	$49.2
41	Climate Change Costs, $/MWH	Based on TAW 3 Scenario					$0.00	$0.00	$4.89	$6.36
42										
43	Integration Costs	260,000 MWh Pool Base					$0.0	$0.2	$0.2	$0.2
44	Purchased Energy, Dollars			$800,462	$769,694	$371,610	$398,086	$568,316	$662,061	$705,769
45	Cost of Renewable Energy Credits						$8,547	$12,387	$19,449	$25,874
46	Purchased Demand, in kW						2,479	3,360	3,444	3,478
47	Demand Charge Rate, $ / kW-Month						$0.00	$0.00	$0.00	$0.00
48	Demand Charges						$0	$0	$0	$0

	A	B	C	D	E	F	G	H	I	J
49	Total Cost of Purchased Power & REC's, Dollars			$857,584	$701,754	$371,610	$406,633	$580,703	$681,510	$731,642
50	Transmission Service						$60,000	$83,332	$87,551	$90,638
51				$57.85	$45.88	$50.46	$45.97	$47.53	$54.35	$57.74
52	Total Cost of Purchased Power, $ / Mwh									
53	Rate for Sale of Excess Wind Power	$45.00	per Mwh		0.0% Escalator		$45.00	$45.00	$45.00	$45.00
54	Revenue from Sale of Wind Power						$0	$242,433	$242,433	$242,433
55	Revenue from Sale of RECs	$0.00	per Mwh		0.0% Escalator		$0	$0	$0	$0
56										
57	**Engine Plant**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
58	Existing Engine Generating Capacity			6.50	6.50	6.50	6.50	6.50	6.50	6.50
59	New Engine Generating Capacity			0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	New Engine Capital Cost per kW			$0	$0	$0	$750	$773	$796	$820
61	New Engine Total Capital Cost, $			$ -	$ -	$ -	$ -	$ -	$ -	$ -
62	New Engine Fixed Charges, $			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
63										
64	**Engine Plant Fuel Costs**			2005	2006	2007	1/2 Year	2009	2010	2011
65	Energy Generated by Engines, MWh			799	178	50	650	650	650	650
66	Percentage from Natural Gas			0.0%	0.0%	90.0%	90.0%	90.0%	90.0%	90.0%
67	Percentage from Diesel			0%	0%	10%	10%	10%	10%	10%
68	Percentage from Biodiesel			0%	0%	0%	0%	0%	0%	0%
69										
70	Natural Gas Cost, $			$ 69,539	$ 104,645	$ 10,395	$ 49,500	$ 51,480	$ 53,539	$ 55,681
71	Diesel Cost, $ as pilot fuel for gas			$ 14,093	$ -	$ 3,312	$ 17,223	$ 17,912	$ 18,628	$ 19,373
72	Biodiesel Cost, $ as pilot or replacement for gas			$ -	$ -	$ -	$ -	$ -	$ -	$ -
73	Total Fuel Cost, $			$ 83,632	$ 104,645	$ 13,707	$ 66,723	$ 69,392	$ 72,167	$ 75,054
74	**Existing Engine Plant O&M**									
75										
76	Existing Plant Personal Services			$ 206,081	$ 193,952	$ 120,010	$ 123,610	$ 127,319	$ 131,138	$ 135,072
77	Existing Plant Contractual Services			$ 171,345	$ 102,954	$ 54,860	$ 141,264	$ 145,502	$ 149,867	$ 154,363
78										
79	**New Engine Plant O&M**									
80	New Plant Personal Services			$0	$0	$0	$0	$0	$0	$0
81	New Plant Contractual Services			0	0	0	0	0	0	0
82										
83	**Cash receipts**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
84	Sales			$1,609,787	$1,791,549	$833,682	$1,067,815	$1,446,878	$1,483,065	$1,572,790
85	Rentals			$0	$0	$0	$0	$0	$0	$0
86	Security Lights			$3,458	$4,218	$1,963	$2,514	$3,407	$3,492	$3,703
87	Service Charge			$1,328	$1,668	$776	$994	$1,347	$1,381	$1,464
88	Materials sold			$0	$3,335	$1,718	$1,769	$1,822	$1,877	$1,933
89	Other			$185	$96	$145	$149	$154	$158	$163
90	Wind Power & REC Sales			$0	$0	$0	$0	$242,433	$242,433	$242,433
91	Total cash receipts			$1,614,758	$1,800,866	$838,283	$1,073,242	$1,696,040	$1,732,405	$1,822,487
92	**Expenditures**									
93	**Production**									
94	Engine Plant Personal Services			$206,081	$193,952	$120,010	$123,610	$127,319	$131,138	$135,072
95	Engine Plant Contractual Services			$171,345	$102,954	$54,860	$141,264	$145,502	$149,867	$154,363
96										
97	Wind Generator O&M, R&R						$0	$57,000	$58,710	$60,471
98	Commodities			$14,969	$17,726	$16,838	$17,343	$17,863	$18,399	$18,951

	A	B	C	D	E	F	G	H	I	J
99	Diesel fuel & oil			$14,093	$0	$4,741	$8,533	$17,066	$17,578	$18,105
100	Electricity, RECs, & Transmission Service			$857,584	$701,754	$371,610	$466,633	$664,034	$769,062	$822,280
101	Natural Gas			$69,539	$104,645	$10,395	$49,500	$51,480	$53,539	$55,681
102	Capital outlay			$89	$0	$0	$0	$0	$0	$0
103	**Transmission & Distribution**									
104	Personal Services			$158,841	$155,983	$162,134	$166,998	$172,008	$177,169	$182,484
105	Contractual Services			$13,493	$8,817	$11,490	$11,834	$12,189	$12,555	$12,932
106	Commodities			$41,809	$47,408	$45,947	$47,325	$48,745	$50,207	$51,713
107	Capital outlay			$0	$3,984	$2,052	$2,113	$2,177	$2,242	$2,309
108	**General & Administrative**									
109	Contractual Services			$2,644	$2,835	$2,822	$2,906	$2,994	$3,083	$3,176
110	Commodities			$0	$0	$0	$0	$0	$0	$0
111	**Transfer to electric debt service**			$175,758	$175,758	$0	$0	$220,000	$220,000	$220,000
112	**Reimbursed expenditures**			($9,928)	($4,315)	($7,335)	($7,555)	($7,782)	($8,015)	($8,256)
113	**Total Expenditures**			$1,716,317	$1,511,501	$795,562	$1,030,505	$1,530,595	$1,655,534	$1,729,282
114										
115	Receipts over (under) expenditures			($101,559)	$289,365	$42,721	$42,737	$165,445	$76,872	$93,205
116	Unencumbered cash (deficit) BOY			$9,040	($92,519)	$196,846	$189,546	$189,546	$268,179	$268,179
117	Trasfer to City			$0	$0	($50,021)	($42,737)	($86,813)	($76,872)	($93,205)
118	Unencumbered cash (deficit), EOY			($92,519)	$196,846	$189,546	$189,546	$268,179	$268,179	$268,179
119										
120	**Retail Sales by Class**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
121										
122	Residential Mwh			10,338	9,533	4,773	6,113	8,284	8,491	8,576
123	Commercial Mwh			4,303	4,288	2,122	2,718	3,683	3,775	3,813
124	Furnished without charges & Losses			981	1,653	519	665	901	923	932
125	Total Mwh to System			15,622	15,474	7,414	9,496	12,867	13,189	13,321
126	Losses as a % of Sales			6.7%	12.0%	10.0%	7.0%	7.0%	7.0%	7.0%
127										
128	Rate Change by Year			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%
129	Residential Cost per kWh			$0.1115	$0.1216	$0.1216	$0.1216	$0.1216	$0.1216	$0.1277
130	Commercial Cost per kWh			$0.1106	$0.1194	$0.1194	$0.1194	$0.1194	$0.1194	$0.1254
131	Residential Revenue			$1,153,000	$1,159,000	$580,292	$743,262	$1,007,112	$1,032,300	$1,094,754
132	Commercial Revenue			$476,000	$512,000	$253,391	$324,553	$439,766	$450,765	$478,036
133	Total Sales Revenue			$1,629,000	$1,671,000	$833,682	$1,067,815	$1,446,878	$1,483,065	$1,572,790
134	Average Retail Sales Revenue ¢ per kWh			11.13	12.09	12.09	12.09	12.09	12.09	12.70
135	Residential Customers			792	783					
136	Commercial Customers			132	148					
137										
138	**Simplified Balance Sheet**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
139	Distribution System - New Investment					$4,500,000	$0	$0	$0	$0
140	Cumulative Investment	Existing Distribution that Survived>			$250,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
141	Annual Depreciation					$142,500	$142,500	$142,500	$142,500	$142,500
142	Accumulated Depreciation					$142,500	$285,000	$427,500	$570,000	$712,500
143	Net Depreciated Investment					$4,607,500	$4,465,000	$4,322,500	$4,180,000	$4,037,500
144										
145	Production Plant - New Investment					$0	$0	$3,300,000	$0	$0
146	Cumulative Investment		Existing Diesel Plant >		$2,500,000	$2,500,000	$2,500,000	$5,800,000	$5,800,000	$5,800,000
147	Annual Depreciation					$100,000	$100,000	$232,000	$232,000	$232,000
148	Accumulated Depreciation					$100,000	$200,000	$432,000	$664,000	$896,000

	A	B	C	D	E	F	G	H	I	J
149	Net Depreciated Investment					$2,400,000	$2,300,000	$5,368,000	$5,136,000	$4,904,000
150										
151	Total Utility Plant					$7,250,000	$7,250,000	$10,550,000	$10,550,000	$10,550,000
152	Less Accumulated Depreciation					$242,500	$485,000	$859,500	$1,234,000	$1,608,500
153	Total Net Utility Plant					$7,007,500	$6,765,000	$9,690,500	$9,316,000	$8,941,500
154	Current Assets & Other					$100,000	$100,000	$100,000	$100,000	$100,000
155	Total Assets					$7,107,500	$6,865,000	$9,790,500	$9,416,000	$9,041,500
156										
157	Total Equity					$7,057,500	$6,815,000	$6,660,500	$6,506,000	$6,351,500
158	Long-Term Liabilities					$0	$0	$3,080,000	$2,860,000	$2,640,000
159	Current Liabilities					$50,000	$50,000	$50,000	$50,000	$50,000
160	Total Liabilities					$50,000	$50,000	$3,130,000	$2,910,000	$2,690,000
161	Total Liabilities & Equity					$7,107,500	$6,865,000	$9,790,500	$9,416,000	$9,041,500

	K	L	M	N	O	P	Q	R	S	T
1	**Strategy 3: 1.5 MW Wind, No Gift, 100% Green Power**	**Summary of Power Supply and Financial Modeling for Greensburg**								
2		**Preliminary and Confidential**								
3		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
4	**Load, Peak, Energy Prices**									
5	Peak Load	3,513	3,548	3,583	3,619	3,655	3,692	3,729	3,766	3,804
6	Storage System Losses, MWH	0	0	0	0	0	0	0	0	0
7	Total Energy to System, Including Losses, MWH	13,454	13,589	13,725	13,862	14,001	14,141	14,282	14,425	14,569
8										
9	Natural Gas Cost $ / MMBTU	$8.77	$9.12	$9.49	$9.87	$10.26	$10.67	$11.10	$11.55	$12.01
10	Biodiesel Cost, $ / Gal	$3.04	$3.16	$3.29	$3.42	$3.56	$3.70	$3.85	$4.00	$4.16
11	Diesel Cost, $ / Gal	$3.35	$3.48	$3.62	$3.76	$3.91	$4.07	$4.23	$4.40	$4.58
12										
13	**Wind Generation**									
14	Wind Generation, Number of Turbines	1	1	1	1	1	1	1	1	1
15	Wind Generation, MW	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
16	Wind Generation, MWH	5,387	5,387	5,387	5,368	5,368	5,368	5,368	5,368	5,368
17	Wind Generation Capital Cost, $	$0	$0	$0	$0	$0	$0	$0	$0	$0
18	Wind Generation O&M	$42,616	$43,895	$45,212	$46,568	$47,965	$49,404	$50,886	$52,413	$53,985
19	Wind Generation R&R & Warranty	$19,669	$20,259	$20,867	$21,493	$22,138	$22,802	$23,486	$24,190	$24,916
20										
21	Wind Generation as a % of Total Load	40.0%	39.6%	39.3%	38.7%	38.3%	38.0%	37.6%	37.2%	36.8%
22	Excess Wind Gen to Grid, %	5.3%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%
23	Excess Wind Gen to Grid, MWh	284	150	150	149	149	149	149	149	149
24										
25	**Energy Storage System**									
26	Energy Storage, MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Energy Storage Capital Cost, Mil $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	Energy Storage Fixed Charges, Mil $	$0	$0	$0	$0	$0	$0	$0	$0	$0
29	Energy Storage O&M Cost, $	$0	$0	$0	$0	$0	$0	$0	$0	$0
30	Energy Storage MWH Net Consumed	0	0	0	0	0	0	0	0	0
31	Energy Storage MWH Net Delivered	0	0	0	0	0	0	0	0	0
32	Energy Storage MWH Lost	0	0	0	0	0	0	0	0	0
33										
34	**Purchases & Sales**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
35	Purchases from Grid	12,804	12,939	13,075	13,212	13,351	13,491	13,632	13,775	13,919
36	Wind Power Sold to Grid	5,387	5,387	5,387	5,368	5,368	5,368	5,368	5,368	5,368
37	Equivalent Net Purchases (Sales to Grid)	7,417	7,552	7,687	7,844	7,983	8,123	8,264	8,407	8,551
38		55.1%	55.6%	56.0%	56.6%	57.0%	57.4%	57.9%	58.3%	58.7%
39	Equivalent Net Purchases as a % of Load									
40	Energy Charge Rate, $/MWH	$50.6	$52.2	$53.7	$55.3	$57.0	$58.7	$60.5	$62.3	$64.2
41	Climate Change Costs, $/MWH	$7.83	$9.29	$10.76	$12.23	$13.70	$15.16	$16.63	$18.10	$19.57
42										
43	Integration Costs	$0.2	$0.2	$0.2	$0.2	$0.2	$0.2	$0.2	$0.2	$0.2
44	Purchased Energy, Dollars	$750,868	$797,406	$845,431	$894,980	$946,129	$998,920	$1,053,408	$1,109,652	$1,167,710
45		$32,262	$38,610	$44,912	$51,320	$57,536	$63,691	$69,780	$75,798	$81,739
46	Purchased Demand, in kW	3,513	3,548	3,583	3,619	3,655	3,692	3,729	3,766	3,804
47	Demand Charge Rate, $ / kW-Month	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
48	Demand Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0

	K	L	M	N	O	P	Q	R	S	T
49	Total Cost of Purchased Power & REC's, Dollars	$783,130	$836,016	$890,342	$946,300	$1,003,665	$1,062,611	$1,123,188	$1,185,449	$1,249,449
50	Transmission Service	$93,833	$97,140	$100,564	$104,109	$107,779	$111,578	$115,511	$119,583	$123,799
51		$61.16	$64.61	$68.10	$71.62	$75.18	$78.77	$82.39	$86.06	$89.76
52	Total Cost of Purchased Power, $ / Mwh									
53	Rate for Sale of Excess Wind Power	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00
54	Revenue from Sale of Wind Power	$242,433	$242,433	$242,433	$241,546	$241,546	$241,546	$241,546	$241,546	$241,546
55	Revenue from Sale of RECs	$0	$0	$0	$0	$0	$0	$0	$0	$0
56										
57	**Engine Plant**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**		
58	Existing Engine Generating Capacity	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
59	New Engine Generating Capacity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	New Engine Capital Cost per kW	$844	$869	$896	$922	$950	$979	$1,008	$1,038	$1,069
61	New Engine Total Capital Cost, $	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
62	New Engine Fixed Charges, $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
63										
64	**Engine Plant Fuel Costs**	2012	2013	2014	2015	2016	2017	2018	2019	2020
65	Energy Generated by Engines, MWh	650	650	650	650	650	650	650	650	650
66	Percentage from Natural Gas	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
67	Percentage from Diesel	10%	10%	10%	10%	10%	10%	10%	10%	10%
68	Percentage from Biodiesel	0%	0%	0%	0%	0%	0%	0%	0%	0%
69										
70	Natural Gas Cost, $	$ 57,908	$ 60,224	$ 62,633	$ 65,139	$ 67,744	$ 70,454	$ 73,272	$ 76,203	$ 79,251
71	Diesel Cost, $ as pilot fuel for gas	$ 20,148	$ 20,954	$ 21,792	$ 22,664	$ 23,570	$ 24,513	$ 25,494	$ 26,513	$ 27,574
72	Biodiesel Cost, $ as pilot or replacement for gas	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
73	Total Fuel Cost, $	$ 78,056	$ 81,178	$ 84,425	$ 87,802	$ 91,315	$ 94,967	$ 98,766	$ 102,716	$ 106,825
74	**Existing Engine Plant O&M**									
75										
76	Existing Plant Personal Services	$ 139,124	$ 143,298	$ 147,597	$ 152,025	$ 156,586	$ 161,283	$ 166,122	$ 171,105	$ 176,239
77	Existing Plant Contractual Services	$ 158,994	$ 163,764	$ 168,677	$ 173,737	$ 178,949	$ 184,317	$ 189,847	$ 195,542	$ 201,409
78										
79	**New Engine Plant O&M**									
80	New Plant Personal Services	$0	$0	$0	$0	$0	$0	$0	$0	$0
81	New Plant Contractual Services	0	0	0	0	0	0	0	0	0
82										
83	**Cash receipts**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
84	Sales	$1,588,518	$1,732,756	$1,750,083	$1,908,991	$1,928,081	$2,103,151	$2,124,182	$2,145,424	$2,166,878
85	Rentals	$0	$0	$0	$0	$0	$0	$0	$0	$0
86	Security Lights	$3,740	$4,080	$4,120	$4,495	$4,539	$4,952	$5,001	$5,051	$5,102
87	Service Charge	$1,479	$1,613	$1,629	$1,777	$1,795	$1,958	$1,978	$1,997	$2,017
88	Materials sold	$1,991	$2,051	$2,112	$2,176	$2,241	$2,308	$2,377	$2,449	$2,522
89	Other	$168	$173	$178	$183	$189	$194	$200	$206	$213
90	Wind Power & REC Sales	$242,433	$242,433	$242,433	$241,546	$241,546	$241,546	$241,546	$241,546	$241,546
91	Total cash receipts	$1,838,329	$1,983,105	$2,000,557	$2,159,168	$2,178,391	$2,354,109	$2,375,285	$2,396,674	$2,418,278
92	**Expenditures**									
93	**Production**									
94	Engine Plant Personal Services	$139,124	$143,298	$147,597	$152,025	$156,586	$161,283	$166,122	$171,105	$176,239
95	Engine Plant Contractual Services	$158,994	$163,764	$168,677	$173,737	$178,949	$184,317	$189,847	$195,542	$201,409
96										
97	Wind Generator O&M, R&R	$62,285	$64,154	$66,079	$68,061	$70,103	$72,206	$74,372	$76,603	$78,901
98	Commodities	$19,520	$20,105	$20,709	$21,330	$21,970	$22,629	$23,308	$24,007	$24,727

	K	L	M	N	O	P	Q	R	S	T
99	Diesel fuel & oil	$18,648	$19,208	$19,784	$20,377	$20,989	$21,618	$22,267	$22,935	$23,623
100	Electricity, RECs, & Transmission Service	$876,963	$933,156	$990,907	$1,050,410	$1,111,444	$1,174,189	$1,238,700	$1,305,033	$1,373,247
101	Natural Gas	$57,908	$60,224	$62,633	$65,139	$67,744	$70,454	$73,272	$76,203	$79,251
102	Capital outlay	$0	$0	$0	$0	$0	$0	$0	$0	$0
103	**Transmission & Distribution**									
104	Personal Services	$187,958	$193,597	$199,405	$205,387	$211,549	$217,895	$224,432	$231,165	$238,100
105	Contractual Services	$13,320	$13,719	$14,131	$14,555	$14,991	$15,441	$15,904	$16,381	$16,873
106	Commodities	$53,265	$54,863	$56,509	$58,204	$59,950	$61,749	$63,601	$65,509	$67,474
107	Capital outlay	$2,379	$2,450	$2,523	$2,599	$2,677	$2,757	$2,840	$2,925	$3,013
108	**General & Administrative**									
109	Contractual Services	$3,271	$3,369	$3,470	$3,574	$3,682	$3,792	$3,906	$4,023	$4,144
110	Commodities	$0	$0	$0	$0	$0	$0	$0	$0	$0
111	**Transfer to electric debt service**	$220,000	$220,000	$220,000	$220,000	$220,000	$220,000	$220,000	$220,000	$220,000
112	**Reimbursed expenditures**	($8,503)	($8,759)	($9,021)	($9,292)	($9,571)	($9,858)	($10,154)	($10,458)	($10,772)
113	**Total Expenditures**	$1,805,131	$1,883,149	$1,963,401	$2,046,106	$2,131,062	$2,218,473	$2,308,417	$2,400,974	$2,496,229
114										
115	Receipts over (under) expenditures	$33,198	$99,957	$37,155	$113,062	$47,329	$135,636	$66,868	($4,300)	($77,951)
116	Unencumbered cash (deficit) BOY	$268,179	$268,179	$268,179	$268,179	$268,179	$268,179	$277,625	$277,625	$273,325
117	Trasfer to City	($33,198)	($99,957)	($37,155)	($113,062)	($47,329)	($126,189)	($66,868)	$0	$0
118	Unencumbered cash (deficit), EOY	$268,179	$268,179	$268,179	$268,179	$268,179	$277,625	$277,625	$273,325	$195,374
119										
120	**Retail Sales by Class**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
121										
122	Residential Mwh	8,662	8,748	8,836	8,924	9,013	9,103	9,194	9,286	9,379
123	Commercial Mwh	3,851	3,890	3,928	3,968	4,007	4,047	4,088	4,129	4,170
124	Furnished without charges & Losses	942	951	961	970	980	990	1,000	1,010	1,020
125	Total Mwh to System	13,454	13,589	13,725	13,862	14,001	14,141	14,282	14,425	14,569
126	Losses as a % of Sales	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
127										
128	Rate Change by Year	0.0%	8.0%	0.0%	8.0%	0.0%	8.0%	0.0%	0.0%	0.0%
129	Residential Cost per kWh	$0.1277	$0.1379	$0.1379	$0.1489	$0.1489	$0.1608	$0.1608	$0.1608	$0.1608
130	Commercial Cost per kWh	$0.1254	$0.1354	$0.1354	$0.1462	$0.1462	$0.1579	$0.1579	$0.1579	$0.1579
131	Residential Revenue	$1,105,702	$1,206,100	$1,218,161	$1,328,769	$1,342,057	$1,463,916	$1,478,555	$1,493,341	$1,508,274
132	Commercial Revenue	$482,817	$526,656	$531,923	$580,222	$586,024	$639,235	$645,627	$652,083	$658,604
133	Total Sales Revenue	$1,588,518	$1,732,756	$1,750,083	$1,908,991	$1,928,081	$2,103,151	$2,124,182	$2,145,424	$2,166,878
134	Average Retail Sales Revenue ¢ per kWh	12.70	13.71	13.71	14.81	14.81	15.99	15.99	15.99	15.99
135	Residential Customers									
136	Commercial Customers									
137										
138	**Simplified Balance Sheet**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
139	Distribution System - New Investment	$0	$0	$0	$0	$0	$0	$0	$0	$0
140	Cumulative Investment	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
141	Annual Depreciation	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500
142	Accumulated Depreciation	$855,000	$997,500	$1,140,000	$1,282,500	$1,425,000	$1,567,500	$1,710,000	$1,852,500	$1,995,000
143	Net Depreciated Investment	$3,895,000	$3,752,500	$3,610,000	$3,467,500	$3,325,000	$3,182,500	$3,040,000	$2,897,500	$2,755,000
144										
145	Production Plant - New Investment	$0	$0	$0	$0	$0	$0	$0	$0	$0
146	Cumulative Investment	$5,800,000	$5,800,000	$5,800,000	$5,800,000	$5,800,000	$5,800,000	$5,800,000	$5,800,000	$5,800,000
147	Annual Depreciation	$232,000	$232,000	$232,000	$232,000	$232,000	$232,000	$232,000	$232,000	$232,000
148	Accumulated Depreciation	$1,128,000	$1,360,000	$1,592,000	$1,824,000	$2,056,000	$2,288,000	$2,520,000	$2,752,000	$2,984,000

	K	L	M	N	O	P	Q	R	S	T
149	Net Depreciated Investment	$4,672,000	$4,440,000	$4,208,000	$3,976,000	$3,744,000	$3,512,000	$3,280,000	$3,048,000	$2,816,000
150										
151	Total Utility Plant	$10,550,000	$10,550,000	$10,550,000	$10,550,000	$10,550,000	$10,550,000	$10,550,000	$10,550,000	$10,550,000
152	Less Accumulated Depreciation	$1,983,000	$2,357,500	$2,732,000	$3,106,500	$3,481,000	$3,855,500	$4,230,000	$4,604,500	$4,979,000
153	Total Net Utility Plant	$8,567,000	$8,192,500	$7,818,000	$7,443,500	$7,069,000	$6,694,500	$6,320,000	$5,945,500	$5,571,000
154	Current Assets & Other	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
155	Total Assets	$8,667,000	$8,292,500	$7,918,000	$7,543,500	$7,169,000	$6,794,500	$6,420,000	$6,045,500	$5,671,000
156										
157	Total Equity	$6,197,000	$6,042,500	$5,888,000	$5,733,500	$5,579,000	$5,424,500	$5,270,000	$5,115,500	$4,961,000
158	Long-Term Liabilities	$2,420,000	$2,200,000	$1,980,000	$1,760,000	$1,540,000	$1,320,000	$1,100,000	$880,000	$660,000
159	Current Liabilities	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
160	Total Liabilities	$2,470,000	$2,250,000	$2,030,000	$1,810,000	$1,590,000	$1,370,000	$1,150,000	$930,000	$710,000
161	Total Liabilities & Equity	$8,667,000	$8,292,500	$7,918,000	$7,543,500	$7,169,000	$6,794,500	$6,420,000	$6,045,500	$5,671,000

Summary 3

Strategy 3

Retain Utility

3.0 MW of Wind Generation

with No Financial Gift

	A	B	C	D	E	F	G	H	I	J
1	**Strategy 3: 3 MW Wind, No Gift, 100% Green Power**	**Summary of Power Supply and Financial Modeling for Greensburg**								
2		**Preliminary and Confidential**								
3			**YEAR >>**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
4	**Load, Peak, Energy Prices**									
5	Peak Load			0	4,489	0	2,479	3,360	3,444	3,478
6	Storage System Losses, MWH			0	0	0	0	0	0	0
7	Total Energy to System, Including Losses, MWH			15,622	15,474	7,414	9,496	12,867	13,189	13,321
8										
9	Natural Gas Cost $ / MMBTU					$7.00	$7.50	$7.80	$8.11	$8.44
10	Biodiesel Cost, $ / Gal					$2.50	$2.60	$2.70	$2.81	$2.92
11	Diesel Cost, $ / Gal					$2.75	$2.86	$2.97	$3.09	$3.22
12										
13	**Wind Generation**									
14	Wind Generation, Number of Turbines							2	2	2
15	Wind Generation, MW	1.50 Turbine Size, in MW			0.0% Capital Contribution, Gift =			3.00	3.00	3.00
16	Wind Generation, MWH	41.0% Annual Capacity Factor Used				-0.30% Array Delta		10,696	10,696	10,696
17	Wind Generation Capital Cost, $	1	2	3	4	< # of WTs		$6,300,000	$0	$0
18	Wind Generation O&M	$2,200	$2,100	$2,025	$1,975	< Total Cost per kW		$74,100	$76,323	$78,613
19	Wind Generation R&R & Warranty	$12	$ / kW in 2009		$26	$ / kW in 2009		$34,200	$35,226	$36,283
20										
21	Wind Generation as a % of Total Load							83.1%	81.1%	80.3%
22	Excess Wind Gen to Grid, %							30.0%	30.0%	30.0%
23	Excess Wind Gen to Grid, MWh							3,205	3,205	3,205
24										
25	**Energy Storage System**									
26	Energy Storage, MW			0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Energy Storage Capital Cost, Mil $			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	Energy Storage Fixed Charges, Mil $			$0	$0	$0	$0	$0	$0	$0
29	Energy Storage O&M Cost, $			$0	$0	$0	$0	$0	$0	$0
30	Energy Storage MWH Net Consumed			0	0	0	0	0	0	0
31	Energy Storage MWH Net Delivered			0	0	0	0	0	0	0
32	Energy Storage MWH Lost			0	0	0	0	0	0	0
33										
34	**Purchases & Sales**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
35	Purchases from Grid			14,823	15,296	7,364	8,846	12,217	12,539	12,671
36	Wind Power Sold to Grid						0	10,696	10,696	10,696
37	Equivalent Net Purchases (Sales to Grid)			14,823	15,296	7,364	8,846	1,521	1,843	1,975
38							0.0%	11.8%	14.0%	14.8%
39	Equivalent Net Purchases as a % of Load									
40	Energy Charge Rate, $/MWH						$45.0	$46.4	$47.7	$49.2
41	Climate Change Costs, $/MWH	Based on TAW 3 Scenario					$0.00	$0.00	$4.89	$6.36
42										
43	Integration Costs	260,000 MWh Pool Base					$0.0	$0.5	$0.5	$0.5
44	Purchased Energy, Dollars			$800,462	$769,694	$371,610	$398,086	$571,978	$665,820	$709,566
45	Cost of Renewable Energy Credits						$8,547	$1,769	$3,523	$4,640
46	Purchased Demand, in kW						2,479	3,360	3,444	3,478
47	Demand Charge Rate, $ / kW-Month						$0.00	$0.00	$0.00	$0.00
48	Demand Charges						$0	$0	$0	$0

	A	B	C	D	E	F	G	H	I	J
49	Total Cost of Purchased Power & REC's, Dollars			$857,584	$701,754	$371,610	$406,633	$573,747	$669,343	$714,206
50	Transmission Service						$60,000	$83,332	$87,551	$90,638
51	Total Cost of Purchased Power, $ / Mwh			$57.85	$45.88	$50.46	$45.97	$46.96	$53.38	$56.36
52										
53	Rate for Sale of Excess Wind Power	$45.00	per Mwh	0.0%	Escalator		$45.00	$45.00	$45.00	$45.00
54	Revenue from Sale of Wind Power						$0	$481,318	$481,318	$481,318
55	Revenue from Sale of RECs	$0.00	per Mwh	0.0%	Escalator		$0	$0	$0	$0
56										
57	**Engine Plant**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
58	Existing Engine Generating Capacity			6.50	6.50	6.50	6.50	6.50	6.50	6.50
59	New Engine Generating Capacity			0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	New Engine Capital Cost per kW			$0	$0	$0	$750	$773	$796	$820
61	New Engine Total Capital Cost, $			$ -	$ -	$ -	$ -	$ -	$ -	$ -
62	New Engine Fixed Charges, $			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
63										
64	**Engine Plant Fuel Costs**			2005	2006	2007	1/2 Year	2009	2010	2011
65	Energy Generated by Engines, MWh			799	178	50	650	650	650	650
66	Percentage from Natural Gas			0.0%	0.0%	90.0%	90.0%	90.0%	90.0%	90.0%
67	Percentage from Diesel			0%	0%	10%	10%	10%	10%	10%
68	Percentage from Biodiesel			0%	0%	0%	0%	0%	0%	0%
69										
70	Natural Gas Cost, $			$ 69,539	$ 104,645	$ 10,395	$ 49,500	$ 51,480	$ 53,539	$ 55,681
71	Diesel Cost, $ as pilot fuel for gas			$ 14,093	$ -	$ 3,312	$ 17,223	$ 17,912	$ 18,628	$ 19,373
72	Biodiesel Cost, $ as pilot or replacement for gas			$ -	$ -	$ -	$ -	$ -	$ -	$ -
73	Total Fuel Cost, $			$ 83,632	$ 104,645	$ 13,707	$ 66,723	$ 69,392	$ 72,167	$ 75,054
74	**Existing Engine Plant O&M**									
75										
76	Existing Plant Personal Services			$ 206,081	$ 193,952	$ 120,010	$ 123,610	$ 127,319	$ 131,138	$ 135,072
77	Existing Plant Contractual Services			$ 171,345	$ 102,954	$ 54,860	$ 141,264	$ 145,502	$ 149,867	$ 154,363
78										
79	**New Engine Plant O&M**									
80	New Plant Personal Services			$0	$0	$0	$0	$0	$0	$0
81	New Plant Contractual Services			0	0	0	0	0	0	0
82										
83	**Cash receipts**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
84	Sales			$1,609,787	$1,791,549	$833,682	$1,067,815	$1,446,878	$1,483,065	$1,572,790
85	Rentals			$0	$0	$0	$0	$0	$0	$0
86	Security Lights			$3,458	$4,218	$1,963	$2,514	$3,407	$3,492	$3,703
87	Service Charge			$1,328	$1,668	$776	$994	$1,347	$1,381	$1,464
88	Materials sold			$0	$3,335	$1,718	$1,769	$1,822	$1,877	$1,933
89	Other			$185	$96	$145	$149	$154	$158	$163
90	Wind Power & REC Sales			$0	$0	$0	$0	$481,318	$481,318	$481,318
91	Total cash receipts			$1,614,758	$1,800,866	$838,283	$1,073,242	$1,934,925	$1,971,291	$2,061,372
92	**Expenditures**									
93	**Production**									
94	Engine Plant Personal Services			$206,081	$193,952	$120,010	$123,610	$127,319	$131,138	$135,072
95	Engine Plant Contractual Services			$171,345	$102,954	$54,860	$141,264	$145,502	$149,867	$154,363
96										
97	Wind Generator O&M, R&R						$0	$108,300	$111,549	$114,895
98	Commodities			$14,969	$17,726	$16,838	$17,343	$17,863	$18,399	$18,951

	A	B	C	D	E	F	G	H	I	J
99	Diesel fuel & oil			$14,093	$0	$4,741	$8,533	$17,066	$17,578	$18,105
100	Electricity, RECs, & Transmission Service			$857,584	$701,754	$371,610	$466,633	$657,079	$756,894	$804,843
101	Natural Gas			$69,539	$104,645	$10,395	$49,500	$51,480	$53,539	$55,681
102	Capital outlay			$89	$0	$0	$0	$0	$0	$0
103	**Transmission & Distribution**									
104	Personal Services			$158,841	$155,983	$162,134	$166,998	$172,008	$177,169	$182,484
105	Contractual Services			$13,493	$8,817	$11,490	$11,834	$12,189	$12,555	$12,932
106	Commodities			$41,809	$47,408	$45,947	$47,325	$48,745	$50,207	$51,713
107	Capital outlay			$0	$3,984	$2,052	$2,113	$2,177	$2,242	$2,309
108	**General & Administrative**									
109	Contractual Services			$2,644	$2,835	$2,822	$2,906	$2,994	$3,083	$3,176
110	Commodities			$0	$0	$0	$0	$0	$0	$0
111	**Transfer to electric debt service**			$175,758	$175,758	$0	$0	$420,000	$420,000	$420,000
112	**Reimbursed expenditures**			($9,928)	($4,315)	($7,335)	($7,555)	($7,782)	($8,015)	($8,256)
113	**Total Expenditures**			$1,716,317	$1,511,501	$795,562	$1,030,505	$1,774,940	$1,896,205	$1,966,269
114										
115	Receipts over (under) expenditures			($101,559)	$289,365	$42,721	$42,737	$159,986	$75,085	$95,103
116	Unencumbered cash (deficit) BOY			$9,040	($92,519)	$196,846	$189,546	$189,546	$262,719	$262,719
117	Trasfer to City			$0	$0	($50,021)	($42,737)	($86,813)	($75,085)	($94,367)
118	Unencumbered cash (deficit), EOY			($92,519)	$196,846	$189,546	$189,546	$262,719	$262,719	$263,455
119										
120	**Retail Sales by Class**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
121										
122	Residential Mwh			10,338	9,533	4,773	6,113	8,284	8,491	8,576
123	Commercial Mwh			4,303	4,288	2,122	2,718	3,683	3,775	3,813
124	Furnished without charges & Losses			981	1,653	519	665	901	923	932
125	Total Mwh to System			15,622	15,474	7,414	9,496	12,867	13,189	13,321
126	Losses as a % of Sales			6.7%	12.0%	10.0%	7.0%	7.0%	7.0%	7.0%
127										
128	Rate Change by Year			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%
129	Residential Cost per kWh			$0.1115	$0.1216	$0.1216	$0.1216	$0.1216	$0.1216	$0.1277
130	Commercial Cost per kWh			$0.1106	$0.1194	$0.1194	$0.1194	$0.1194	$0.1194	$0.1254
131	Residential Revenue			$1,153,000	$1,159,000	$580,292	$743,262	$1,007,112	$1,032,300	$1,094,754
132	Commercial Revenue			$476,000	$512,000	$253,391	$324,553	$439,766	$450,765	$478,036
133	Total Sales Revenue			$1,629,000	$1,671,000	$833,682	$1,067,815	$1,446,878	$1,483,065	$1,572,790
134	Average Retail Sales Revenue ¢ per kWh			11.13	12.09	12.09	12.09	12.09	12.09	12.70
135	Residential Customers			792	783					
136	Commercial Customers			132	148					
137										
138	**Simplified Balance Sheet**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
139	Distribution System - New Investment					$4,500,000	$0	$0	$0	$0
140	Cumulative Investment	Existing Distribution that Survived>			$250,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
141	Annual Depreciation					$142,500	$142,500	$142,500	$142,500	$142,500
142	Accumulated Depreciation					$142,500	$285,000	$427,500	$570,000	$712,500
143	Net Depreciated Investment					$4,607,500	$4,465,000	$4,322,500	$4,180,000	$4,037,500
144										
145	Production Plant - New Investment					$0	$0	$6,300,000	$0	$0
146	Cumulative Investment		Existing Diesel Plant >		$2,500,000	$2,500,000	$2,500,000	$8,800,000	$8,800,000	$8,800,000
147	Annual Depreciation					$100,000	$100,000	$352,000	$352,000	$352,000
148	Accumulated Depreciation					$100,000	$200,000	$552,000	$904,000	$1,256,000

	A	B	C	D	E	F	G	H	I	J
149	Net Depreciated Investment					$2,400,000	$2,300,000	$8,248,000	$7,896,000	$7,544,000
150										
151	Total Utility Plant					$7,250,000	$7,250,000	$13,550,000	$13,550,000	$13,550,000
152	Less Accumulated Depreciation					$242,500	$485,000	$979,500	$1,474,000	$1,968,500
153	Total Net Utility Plant					$7,007,500	$6,765,000	$12,570,500	$12,076,000	$11,581,500
154	Current Assets & Other					$100,000	$100,000	$100,000	$100,000	$100,000
155	Total Assets					$7,107,500	$6,865,000	$12,670,500	$12,176,000	$11,681,500
156										
157	Total Equity					$7,057,500	$6,815,000	$6,740,500	$6,666,000	$6,591,500
158	Long-Term Liabilities					$0	$0	$5,880,000	$5,460,000	$5,040,000
159	Current Liabilities					$50,000	$50,000	$50,000	$50,000	$50,000
160	Total Liabilities					$50,000	$50,000	$5,930,000	$5,510,000	$5,090,000
161	Total Liabilities & Equity					$7,107,500	$6,865,000	$12,670,500	$12,176,000	$11,681,500

	K	L	M	N	O	P	Q	R	S	T
1	**Strategy 3: 3 MW Wind, No Gift, 100% Green Power**	**Summary of Power Supply and Financial Modeling for Greensburg**								
2		**Preliminary and Confidential**								
3		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
4	**Load, Peak, Energy Prices**									
5	Peak Load	3,513	3,548	3,583	3,619	3,655	3,692	3,729	3,766	3,804
6	Storage System Losses, MWH	0	0	0	0	0	0	0	0	0
7	Total Energy to System, Including Losses, MWH	13,454	13,589	13,725	13,862	14,001	14,141	14,282	14,425	14,569
8										
9	Natural Gas Cost $ / MMBTU	$8.77	$9.12	$9.49	$9.87	$10.26	$10.67	$11.10	$11.55	$12.01
10	Biodiesel Cost, $ / Gal	$3.04	$3.16	$3.29	$3.42	$3.56	$3.70	$3.85	$4.00	$4.16
11	Diesel Cost, $ / Gal	$3.35	$3.48	$3.62	$3.76	$3.91	$4.07	$4.23	$4.40	$4.58
12										
13	**Wind Generation**									
14	Wind Generation, Number of Turbines	2	2	2	2	2	2	2	2	2
15	Wind Generation, MW	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
16	Wind Generation, MWH	10,696	10,696	10,696	10,617	10,617	10,617	10,617	10,617	10,617
17	Wind Generation Capital Cost, $	$0	$0	$0	$0	$0	$0	$0	$0	$0
18	Wind Generation O&M	$80,971	$83,400	$85,902	$88,479	$91,134	$93,868	$96,684	$99,584	$102,572
19	Wind Generation R&R & Warranty	$37,371	$38,492	$39,647	$40,837	$42,062	$43,324	$44,623	$45,962	$47,341
20										
21	Wind Generation as a % of Total Load	79.5%	78.7%	77.9%	76.6%	75.8%	75.1%	74.3%	73.6%	72.9%
22	Excess Wind Gen to Grid, %	27.3%	27.3%	27.3%	27.3%	27.3%	27.3%	24.6%	24.6%	24.6%
23	Excess Wind Gen to Grid, MWh	2,924	2,924	2,924	2,903	2,903	2,903	2,607	2,607	2,607
24										
25	**Energy Storage System**									
26	Energy Storage, MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Energy Storage Capital Cost, Mil $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	Energy Storage Fixed Charges, Mil $	$0	$0	$0	$0	$0	$0	$0	$0	$0
29	Energy Storage O&M Cost, $	$0	$0	$0	$0	$0	$0	$0	$0	$0
30	Energy Storage MWH Net Consumed	0	0	0	0	0	0	0	0	0
31	Energy Storage MWH Net Delivered	0	0	0	0	0	0	0	0	0
32	Energy Storage MWH Lost	0	0	0	0	0	0	0	0	0
33										
34	**Purchases & Sales**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
35	Purchases from Grid	12,804	12,939	13,075	13,212	13,351	13,491	13,632	13,775	13,919
36	Wind Power Sold to Grid	10,696	10,696	10,696	10,617	10,617	10,617	10,617	10,617	10,617
37	Equivalent Net Purchases (Sales to Grid)	2,108	2,243	2,379	2,595	2,734	2,874	3,015	3,158	3,302
38		15.7%	16.5%	17.3%	18.7%	19.5%	20.3%	21.1%	21.9%	22.7%
39	Equivalent Net Purchases as a % of Load									
40	Energy Charge Rate, $/MWH	$50.6	$52.2	$53.7	$55.3	$57.0	$58.7	$60.5	$62.3	$64.2
41	Climate Change Costs, $/MWH	$7.83	$9.29	$10.76	$12.23	$13.70	$15.16	$16.63	$18.10	$19.57
42										
43	Integration Costs	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5
44	Purchased Energy, Dollars	$754,705	$801,284	$849,349	$898,884	$950,074	$1,002,906	$1,057,436	$1,113,722	$1,171,822
45		$5,719	$6,758	$7,752	$9,325	$10,291	$11,197	$12,036	$12,805	$13,497
46	Purchased Demand, in kW	3,513	3,548	3,583	3,619	3,655	3,692	3,729	3,766	3,804
47	Demand Charge Rate, $ / kW-Month	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
48	Demand Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0

	K	L	M	N	O	P	Q	R	S	T
49	Total Cost of Purchased Power & REC's, Dollars	$760,425	$808,042	$857,101	$908,209	$960,365	$1,014,103	$1,069,472	$1,126,526	$1,185,319
50	Transmission Service	$93,833	$97,140	$100,564	$104,109	$107,779	$111,578	$115,511	$119,583	$123,799
51		$59.39	$62.45	$65.55	$68.74	$71.93	$75.17	$78.45	$81.78	$85.16
52	Total Cost of Purchased Power, $ / Mwh									
53	Rate for Sale of Excess Wind Power	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00
54	Revenue from Sale of Wind Power	$481,318	$481,318	$481,318	$477,770	$477,770	$477,770	$477,770	$477,770	$477,770
55	Revenue from Sale of RECs	$0	$0	$0	$0	$0	$0	$0	$0	$0
56										
57	**Engine Plant**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**		
58	Existing Engine Generating Capacity	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
59	New Engine Generating Capacity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	New Engine Capital Cost per kW	$844	$869	$896	$922	$950	$979	$1,008	$1,038	$1,069
61	New Engine Total Capital Cost, $	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
62	New Engine Fixed Charges, $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
63										
64	**Engine Plant Fuel Costs**	2012	2013	2014	2015	2016	2017	2018	2019	2020
65	Energy Generated by Engines, MWh	650	650	650	650	650	650	650	650	650
66	Percentage from Natural Gas	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
67	Percentage from Diesel	10%	10%	10%	10%	10%	10%	10%	10%	10%
68	Percentage from Biodiesel	0%	0%	0%	0%	0%	0%	0%	0%	0%
69										
70	Natural Gas Cost, $	$ 57,908	$ 60,224	$ 62,633	$ 65,139	$ 67,744	$ 70,454	$ 73,272	$ 76,203	$ 79,251
71	Diesel Cost, $ as pilot fuel for gas	$ 20,148	$ 20,954	$ 21,792	$ 22,664	$ 23,570	$ 24,513	$ 25,494	$ 26,513	$ 27,574
72	Biodiesel Cost, $ as pilot or replacement for gas	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
73	Total Fuel Cost, $	$ 78,056	$ 81,178	$ 84,425	$ 87,802	$ 91,315	$ 94,967	$ 98,766	$ 102,716	$ 106,825
74	**Existing Engine Plant O&M**									
75										
76	Existing Plant Personal Services	$ 139,124	$ 143,298	$ 147,597	$ 152,025	$ 156,586	$ 161,283	$ 166,122	$ 171,105	$ 176,239
77	Existing Plant Contractual Services	$ 158,994	$ 163,764	$ 168,677	$ 173,737	$ 178,949	$ 184,317	$ 189,847	$ 195,542	$ 201,409
78										
79	**New Engine Plant O&M**									
80	New Plant Personal Services	$0	$0	$0	$0	$0	$0	$0	$0	$0
81	New Plant Contractual Services	0	0	0	0	0	0	0	0	0
82										
83	**Cash receipts**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
84	Sales	$1,588,518	$1,716,712	$1,733,879	$1,891,315	$1,910,228	$2,083,677	$2,104,514	$2,125,559	$2,146,815
85	Rentals	$0	$0	$0	$0	$0	$0	$0	$0	$0
86	Security Lights	$3,740	$4,042	$4,082	$4,453	$4,497	$4,906	$4,955	$5,004	$5,054
87	Service Charge	$1,479	$1,598	$1,614	$1,761	$1,778	$1,940	$1,959	$1,979	$1,999
88	Materials sold	$1,991	$2,051	$2,112	$2,176	$2,241	$2,308	$2,377	$2,449	$2,522
89	Other	$168	$173	$178	$183	$189	$194	$200	$206	$213
90	Wind Power & REC Sales	$481,318	$481,318	$481,318	$477,770	$477,770	$477,770	$477,770	$477,770	$477,770
91	Total cash receipts	$2,077,214	$2,205,894	$2,223,184	$2,377,658	$2,396,704	$2,570,796	$2,591,776	$2,612,968	$2,634,373
92	**Expenditures**									
93	**Production**									
94	Engine Plant Personal Services	$139,124	$143,298	$147,597	$152,025	$156,586	$161,283	$166,122	$171,105	$176,239
95	Engine Plant Contractual Services	$158,994	$163,764	$168,677	$173,737	$178,949	$184,317	$189,847	$195,542	$201,409
96										
97	Wind Generator O&M, R&R	$118,342	$121,893	$125,549	$129,316	$133,195	$137,191	$141,307	$145,546	$149,913
98	Commodities	$19,520	$20,105	$20,709	$21,330	$21,970	$22,629	$23,308	$24,007	$24,727

	K	L	M	N	O	P	Q	R	S	T
99	Diesel fuel & oil	$18,648	$19,208	$19,784	$20,377	$20,989	$21,618	$22,267	$22,935	$23,623
100	Electricity, RECs, & Transmission Service	$854,257	$905,182	$957,665	$1,012,318	$1,068,144	$1,125,681	$1,184,984	$1,246,110	$1,309,117
101	Natural Gas	$57,908	$60,224	$62,633	$65,139	$67,744	$70,454	$73,272	$76,203	$79,251
102	Capital outlay	$0	$0	$0	$0	$0	$0	$0	$0	$0
103	**Transmission & Distribution**									
104	Personal Services	$187,958	$193,597	$199,405	$205,387	$211,549	$217,895	$224,432	$231,165	$238,100
105	Contractual Services	$13,320	$13,719	$14,131	$14,555	$14,991	$15,441	$15,904	$16,381	$16,873
106	Commodities	$53,265	$54,863	$56,509	$58,204	$59,950	$61,749	$63,601	$65,509	$67,474
107	Capital outlay	$2,379	$2,450	$2,523	$2,599	$2,677	$2,757	$2,840	$2,925	$3,013
108	**General & Administrative**									
109	Contractual Services	$3,271	$3,369	$3,470	$3,574	$3,682	$3,792	$3,906	$4,023	$4,144
110	Commodities	$0	$0	$0	$0	$0	$0	$0	$0	$0
111	**Transfer to electric debt service**	$420,000	$420,000	$420,000	$420,000	$420,000	$420,000	$420,000	$420,000	$420,000
112	**Reimbursed expenditures**	($8,503)	($8,759)	($9,021)	($9,292)	($9,571)	($9,858)	($10,154)	($10,458)	($10,772)
113	**Total Expenditures**	$2,038,483	$2,112,914	$2,189,631	$2,269,269	$2,350,855	$2,434,950	$2,521,636	$2,610,994	$2,703,110
114										
115	Receipts over (under) expenditures	$38,731	$92,980	$33,553	$108,390	$45,850	$135,845	$70,140	$1,974	($68,738)
116	Unencumbered cash (deficit) BOY	$263,455	$263,455	$263,455	$263,455	$263,455	$263,455	$274,280	$274,280	$274,280
117	Trasfer to City	($38,731)	($92,980)	($33,553)	($108,390)	($45,850)	($125,021)	($70,140)	($1,974)	$0
118	Unencumbered cash (deficit), EOY	$263,455	$263,455	$263,455	$263,455	$263,455	$274,280	$274,280	$274,280	$205,542
119										
120	**Retail Sales by Class**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
121										
122	Residential Mwh	8,662	8,748	8,836	8,924	9,013	9,103	9,194	9,286	9,379
123	Commercial Mwh	3,851	3,890	3,928	3,968	4,007	4,047	4,088	4,129	4,170
124	Furnished without charges & Losses	942	951	961	970	980	990	1,000	1,010	1,020
125	Total Mwh to System	13,454	13,589	13,725	13,862	14,001	14,141	14,282	14,425	14,569
126	Losses as a % of Sales	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
127										
128	Rate Change by Year	0.0%	7.0%	0.0%	8.0%	0.0%	8.0%	0.0%	0.0%	0.0%
129	Residential Cost per kWh	$0.1277	$0.1366	$0.1366	$0.1475	$0.1475	$0.1593	$0.1593	$0.1593	$0.1593
130	Commercial Cost per kWh	$0.1254	$0.1341	$0.1341	$0.1449	$0.1449	$0.1565	$0.1565	$0.1565	$0.1565
131	Residential Revenue	$1,105,702	$1,194,932	$1,206,881	$1,316,466	$1,329,631	$1,450,361	$1,464,865	$1,479,513	$1,494,309
132	Commercial Revenue	$482,817	$521,780	$526,998	$574,849	$580,598	$633,316	$639,649	$646,045	$652,506
133	Total Sales Revenue	$1,588,518	$1,716,712	$1,733,879	$1,891,315	$1,910,228	$2,083,677	$2,104,514	$2,125,559	$2,146,815
134	Average Retail Sales Revenue ¢ per kWh	12.70	13.58	13.58	14.67	14.67	15.84	15.84	15.84	15.84
135	Residential Customers									
136	Commercial Customers									
137										
138	**Simplified Balance Sheet**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
139	Distribution System - New Investment	$0	$0	$0	$0	$0	$0	$0	$0	$0
140	Cumulative Investment	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
141	Annual Depreciation	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500
142	Accumulated Depreciation	$855,000	$997,500	$1,140,000	$1,282,500	$1,425,000	$1,567,500	$1,710,000	$1,852,500	$1,995,000
143	Net Depreciated Investment	$3,895,000	$3,752,500	$3,610,000	$3,467,500	$3,325,000	$3,182,500	$3,040,000	$2,897,500	$2,755,000
144										
145	Production Plant - New Investment	$0	$0	$0	$0	$0	$0	$0	$0	$0
146	Cumulative Investment	$8,800,000	$8,800,000	$8,800,000	$8,800,000	$8,800,000	$8,800,000	$8,800,000	$8,800,000	$8,800,000
147	Annual Depreciation	$352,000	$352,000	$352,000	$352,000	$352,000	$352,000	$352,000	$352,000	$352,000
148	Accumulated Depreciation	$1,608,000	$1,960,000	$2,312,000	$2,664,000	$3,016,000	$3,368,000	$3,720,000	$4,072,000	$4,424,000

	K	L	M	N	O	P	Q	R	S	T
149	Net Depreciated Investment	$7,192,000	$6,840,000	$6,488,000	$6,136,000	$5,784,000	$5,432,000	$5,080,000	$4,728,000	$4,376,000
150										
151	Total Utility Plant	$13,550,000	$13,550,000	$13,550,000	$13,550,000	$13,550,000	$13,550,000	$13,550,000	$13,550,000	$13,550,000
152	Less Accumulated Depreciation	$2,463,000	$2,957,500	$3,452,000	$3,946,500	$4,441,000	$4,935,500	$5,430,000	$5,924,500	$6,419,000
153	Total Net Utility Plant	$11,087,000	$10,592,500	$10,098,000	$9,603,500	$9,109,000	$8,614,500	$8,120,000	$7,625,500	$7,131,000
154	Current Assets & Other	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
155	Total Assets	$11,187,000	$10,692,500	$10,198,000	$9,703,500	$9,209,000	$8,714,500	$8,220,000	$7,725,500	$7,231,000
156										
157	Total Equity	$6,517,000	$6,442,500	$6,368,000	$6,293,500	$6,219,000	$6,144,500	$6,070,000	$5,995,500	$5,921,000
158	Long-Term Liabilities	$4,620,000	$4,200,000	$3,780,000	$3,360,000	$2,940,000	$2,520,000	$2,100,000	$1,680,000	$1,260,000
159	Current Liabilities	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
160	Total Liabilities	$4,670,000	$4,250,000	$3,830,000	$3,410,000	$2,990,000	$2,570,000	$2,150,000	$1,730,000	$1,310,000
161	Total Liabilities & Equity	$11,187,000	$10,692,500	$10,198,000	$9,703,500	$9,209,000	$8,714,500	$8,220,000	$7,725,500	$7,231,000

Summary 4

Strategy 3

Retain Utility

4.5 MW of Wind Generation

with No Financial Gift

	A	B	C	D	E	F	G	H	I	J
1	**Strategy 3: 4.5 MW Wind, No Gift, 100% Green Power**	**Summary of Power Supply and Financial Modeling for Greensburg**								
2		**Preliminary and Confidential**								
3			**YEAR >>**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
4	**Load, Peak, Energy Prices**									
5	Peak Load			0	4,489	0	2,479	3,360	3,444	3,478
6	Storage System Losses, MWH			0	0	0	0	0	0	0
7	Total Energy to System, Including Losses, MWH			15,622	15,474	7,414	9,496	12,867	13,189	13,321
8										
9	Natural Gas Cost $ / MMBTU					$7.00	$7.50	$7.80	$8.11	$8.44
10	Biodiesel Cost, $ / Gal					$2.50	$2.60	$2.70	$2.81	$2.92
11	Diesel Cost, $ / Gal					$2.75	$2.86	$2.97	$3.09	$3.22
12										
13	**Wind Generation**									
14	Wind Generation, Number of Turbines							3	3	3
15	Wind Generation, MW	1.50 Turbine Size, in MW			0.0% Capital Contribution, Gift =			4.50	4.50	4.50
16	Wind Generation, MWH	41.0% Annual Capacity Factor Used				-0.30% Array Delta		15,926	15,926	15,926
17	Wind Generation Capital Cost, $	1	2	3	4	< # of WTs		$9,112,500	$0	$0
18	Wind Generation O&M	$2,200	$2,100	$2,025	$1,975	< Total Cost per kW		$105,300	$108,459	$111,713
19	Wind Generation R&R & Warranty	$12	$ / kW in 2009		$26	$ / kW in 2009		$48,600	$50,058	$51,560
20										
21	Wind Generation as a % of Total Load							123.8%	120.7%	119.6%
22	Excess Wind Gen to Grid, %							46.1%	46.1%	42.7%
23	Excess Wind Gen to Grid, MWh							7,341	7,341	6,806
24										
25	**Energy Storage System**									
26	Energy Storage, MW			0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Energy Storage Capital Cost, Mil $			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	Energy Storage Fixed Charges, Mil $			$0	$0	$0	$0	$0	$0	$0
29	Energy Storage O&M Cost, $			$0	$0	$0	$0	$0	$0	$0
30	Energy Storage MWH Net Consumed			0	0	0	0	0	0	0
31	Energy Storage MWH Net Delivered			0	0	0	0	0	0	0
32	Energy Storage MWH Lost			0	0	0	0	0	0	0
33										
34	**Purchases & Sales**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
35	Purchases from Grid			14,823	15,296	7,364	8,846	12,217	12,539	12,671
36	Wind Power Sold to Grid						0	15,926	15,926	15,926
37	Equivalent Net Purchases (Sales to Grid)			14,823	15,296	7,364	8,846	(3,708)	(3,386)	(3,255)
38							0.0%	-28.8%	-25.7%	-24.4%
39	Equivalent Net Purchases as a % of Load									
40	Energy Charge Rate, $/MWH						$45.0	$46.4	$47.7	$49.2
41	Climate Change Costs, $/MWH	Based on TAW 3 Scenario					$0.00	$0.00	$4.89	$6.36
42										
43	Integration Costs	260,000 MWh Pool Base					$0.0	$0.8	$0.8	$0.8
44	Purchased Energy, Dollars			$800,462	$769,694	$371,610	$398,086	$576,633	$670,597	$714,394
45	Cost of Renewable Energy Credits						$8,547	$0	$0	$0
46	Purchased Demand, in kW						2,479	3,360	3,444	3,478
47	Demand Charge Rate, $ / kW-Month						$0.00	$0.00	$0.00	$0.00
48	Demand Charges						$0	$0	$0	$0

	A	B	C	D	E	F	G	H	I	J
49	Total Cost of Purchased Power & REC's, Dollars			$857,584	$701,754	$371,610	$406,633	$576,633	$670,597	$714,394
50	Transmission Service						$60,000	$83,332	$87,551	$90,638
51	Total Cost of Purchased Power, $ / Mwh			$57.85	$45.88	$50.46	$45.97	$47.20	$53.48	$56.38
52										
53	Rate for Sale of Excess Wind Power	$45.00	per Mwh	0.0%	Escalator		$45.00	$45.00	$45.00	$45.00
54	Revenue from Sale of Wind Power						$0	$716,656	$716,656	$716,656
55	Revenue from Sale of RECs	$0.00	per Mwh	0.0%	Escalator		$0	$0	$0	$0
56										
57	**Engine Plant**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
58	Existing Engine Generating Capacity			6.50	6.50	6.50	6.50	6.50	6.50	6.50
59	New Engine Generating Capacity			0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	New Engine Capital Cost per kW			$0	$0	$0	$750	$773	$796	$820
61	New Engine Total Capital Cost, $			$ -	$ -	$ -	$ -	$ -	$ -	$ -
62	New Engine Fixed Charges, $			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
63										
64	**Engine Plant Fuel Costs**			2005	2006	2007	1/2 Year	2009	2010	2011
65	Energy Generated by Engines, MWh			799	178	50	650	650	650	650
66	Percentage from Natural Gas			0.0%	0.0%	90.0%	90.0%	90.0%	90.0%	90.0%
67	Percentage from Diesel			0%	0%	10%	10%	10%	10%	10%
68	Percentage from Biodiesel			0%	0%	0%	0%	0%	0%	0%
69										
70	Natural Gas Cost, $			$ 69,539	$ 104,645	$ 10,395	$ 49,500	$ 51,480	$ 53,539	$ 55,681
71	Diesel Cost, $ as pilot fuel for gas			$ 14,093	$ -	$ 3,312	$ 17,223	$ 17,912	$ 18,628	$ 19,373
72	Biodiesel Cost, $ as pilot or replacement for gas			$ -	$ -	$ -	$ -	$ -	$ -	$ -
73	Total Fuel Cost, $			$ 83,632	$ 104,645	$ 13,707	$ 66,723	$ 69,392	$ 72,167	$ 75,054
74	**Existing Engine Plant O&M**									
75										
76	Existing Plant Personal Services			$ 206,081	$ 193,952	$ 120,010	$ 123,610	$ 127,319	$ 131,138	$ 135,072
77	Existing Plant Contractual Services			$ 171,345	$ 102,954	$ 54,860	$ 141,264	$ 145,502	$ 149,867	$ 154,363
78										
79	**New Engine Plant O&M**									
80	New Plant Personal Services			$0	$0	$0	$0	$0	$0	$0
81	New Plant Contractual Services			0	0	0	0	0	0	0
82										
83	**Cash receipts**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
84	Sales			$1,609,787	$1,791,549	$833,682	$1,067,815	$1,446,878	$1,483,065	$1,572,790
85	Rentals			$0	$0	$0	$0	$0	$0	$0
86	Security Lights			$3,458	$4,218	$1,963	$2,514	$3,407	$3,492	$3,703
87	Service Charge			$1,328	$1,668	$776	$994	$1,347	$1,381	$1,464
88	Materials sold			$0	$3,335	$1,718	$1,769	$1,822	$1,877	$1,933
89	Other			$185	$96	$145	$149	$154	$158	$163
90	Wind Power & REC Sales			$0	$0	$0	$0	$716,656	$716,656	$716,656
91	Total cash receipts			$1,614,758	$1,800,866	$838,283	$1,073,242	$2,170,263	$2,206,628	$2,296,709
92	**Expenditures**									
93	**Production**									
94	Engine Plant Personal Services			$206,081	$193,952	$120,010	$123,610	$127,319	$131,138	$135,072
95	Engine Plant Contractual Services			$171,345	$102,954	$54,860	$141,264	$145,502	$149,867	$154,363
96										
97	Wind Generator O&M, R&R						$0	$153,900	$158,517	$163,273
98	Commodities			$14,969	$17,726	$16,838	$17,343	$17,863	$18,399	$18,951

	A	B	C	D	E	F	G	H	I	J
99	Diesel fuel & oil			$14,093	$0	$4,741	$8,533	$17,066	$17,578	$18,105
100	Electricity, RECs, & Transmission Service			$857,584	$701,754	$371,610	$466,633	$659,964	$758,148	$805,031
101	Natural Gas			$69,539	$104,645	$10,395	$49,500	$51,480	$53,539	$55,681
102	Capital outlay			$89	$0	$0	$0	$0	$0	$0
103	**Transmission & Distribution**									
104	Personal Services			$158,841	$155,983	$162,134	$166,998	$172,008	$177,169	$182,484
105	Contractual Services			$13,493	$8,817	$11,490	$11,834	$12,189	$12,555	$12,932
106	Commodities			$41,809	$47,408	$45,947	$47,325	$48,745	$50,207	$51,713
107	Capital outlay			$0	$3,984	$2,052	$2,113	$2,177	$2,242	$2,309
108	**General & Administrative**									
109	Contractual Services			$2,644	$2,835	$2,822	$2,906	$2,994	$3,083	$3,176
110	Commodities			$0	$0	$0	$0	$0	$0	$0
111	**Transfer to electric debt service**			$175,758	$175,758	$0	$0	$607,500	$607,500	$607,500
112	**Reimbursed expenditures**			($9,928)	($4,315)	($7,335)	($7,555)	($7,782)	($8,015)	($8,256)
113	**Total Expenditures**			$1,716,317	$1,511,501	$795,562	$1,030,505	$2,010,925	$2,131,928	$2,202,334
114										
115	Receipts over (under) expenditures			($101,559)	$289,365	$42,721	$42,737	$159,338	$74,700	$94,375
116	Unencumbered cash (deficit) BOY			$9,040	($92,519)	$196,846	$189,546	$189,546	$262,071	$262,071
117	Trasfer to City			$0	$0	($50,021)	($42,737)	($86,813)	($74,700)	($94,367)
118	Unencumbered cash (deficit), EOY			($92,519)	$196,846	$189,546	$189,546	$262,071	$262,071	$262,079
119										
120	**Retail Sales by Class**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
121										
122	Residential Mwh			10,338	9,533	4,773	6,113	8,284	8,491	8,576
123	Commercial Mwh			4,303	4,288	2,122	2,718	3,683	3,775	3,813
124	Furnished without charges & Losses			981	1,653	519	665	901	923	932
125	Total Mwh to System			15,622	15,474	7,414	9,496	12,867	13,189	13,321
126	Losses as a % of Sales			6.7%	12.0%	10.0%	7.0%	7.0%	7.0%	7.0%
127										
128	Rate Change by Year			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%
129	Residential Cost per kWh			$0.1115	$0.1216	$0.1216	$0.1216	$0.1216	$0.1216	$0.1277
130	Commercial Cost per kWh			$0.1106	$0.1194	$0.1194	$0.1194	$0.1194	$0.1194	$0.1254
131	Residential Revenue			$1,153,000	$1,159,000	$580,292	$743,262	$1,007,112	$1,032,300	$1,094,754
132	Commercial Revenue			$476,000	$512,000	$253,391	$324,553	$439,766	$450,765	$478,036
133	Total Sales Revenue			$1,629,000	$1,671,000	$833,682	$1,067,815	$1,446,878	$1,483,065	$1,572,790
134	Average Retail Sales Revenue ¢ per kWh			11.13	12.09	12.09	12.09	12.09	12.09	12.70
135	Residential Customers			792	783					
136	Commercial Customers			132	148					
137										
138	**Simplified Balance Sheet**			**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
139	Distribution System - New Investment					$4,500,000	$0	$0	$0	$0
140	Cumulative Investment	Existing Distribution that Survived>			$250,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
141	Annual Depreciation					$142,500	$142,500	$142,500	$142,500	$142,500
142	Accumulated Depreciation					$142,500	$285,000	$427,500	$570,000	$712,500
143	Net Depreciated Investment					$4,607,500	$4,465,000	$4,322,500	$4,180,000	$4,037,500
144										
145	Production Plant - New Investment					$0	$0	$9,112,500	$0	$0
146	Cumulative Investment		Existing Diesel Plant >		$2,500,000	$2,500,000	$2,500,000	$11,612,500	$11,612,500	$11,612,500
147	Annual Depreciation					$100,000	$100,000	$464,500	$464,500	$464,500
148	Accumulated Depreciation					$100,000	$200,000	$664,500	$1,129,000	$1,593,500

	A	B	C	D	E	F	G	H	I	J
149	Net Depreciated Investment					$2,400,000	$2,300,000	$10,948,000	$10,483,500	$10,019,000
150										
151	Total Utility Plant					$7,250,000	$7,250,000	$16,362,500	$16,362,500	$16,362,500
152	Less Accumulated Depreciation					$242,500	$485,000	$1,092,000	$1,699,000	$2,306,000
153	Total Net Utility Plant					$7,007,500	$6,765,000	$15,270,500	$14,663,500	$14,056,500
154	Current Assets & Other					$100,000	$100,000	$100,000	$100,000	$100,000
155	Total Assets					$7,107,500	$6,865,000	$15,370,500	$14,763,500	$14,156,500
156										
157	Total Equity					$7,057,500	$6,815,000	$6,815,500	$6,816,000	$6,816,500
158	Long-Term Liabilities					$0	$0	$8,505,000	$7,897,500	$7,290,000
159	Current Liabilities					$50,000	$50,000	$50,000	$50,000	$50,000
160	Total Liabilities					$50,000	$50,000	$8,555,000	$7,947,500	$7,340,000
161	Total Liabilities & Equity					$7,107,500	$6,865,000	$15,370,500	$14,763,500	$14,156,500

	K	L	M	N	O	P	Q	R	S	T
1	**Strategy 3: 4.5 MW Wind, No Gift, 100% Green Power**	**Summary of Power Supply and Financial Modeling for Greensburg**								
2		**Preliminary and Confidential**								
3		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
4	**Load, Peak, Energy Prices**									
5	Peak Load	3,513	3,548	3,583	3,619	3,655	3,692	3,729	3,766	3,804
6	Storage System Losses, MWH	0	0	0	0	0	0	0	0	0
7	Total Energy to System, Including Losses, MWH	13,454	13,589	13,725	13,862	14,001	14,141	14,282	14,425	14,569
8										
9	Natural Gas Cost $ / MMBTU	$8.77	$9.12	$9.49	$9.87	$10.26	$10.67	$11.10	$11.55	$12.01
10	Biodiesel Cost, $ / Gal	$3.04	$3.16	$3.29	$3.42	$3.56	$3.70	$3.85	$4.00	$4.16
11	Diesel Cost, $ / Gal	$3.35	$3.48	$3.62	$3.76	$3.91	$4.07	$4.23	$4.40	$4.58
12										
13	**Wind Generation**									
14	Wind Generation, Number of Turbines	3	3	3	3	3	3	3	3	3
15	Wind Generation, MW	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50
16	Wind Generation, MWH	15,926	15,926	15,926	15,748	15,748	15,748	15,748	15,748	15,748
17	Wind Generation Capital Cost, $	$0	$0	$0	$0	$0	$0	$0	$0	$0
18	Wind Generation O&M	$115,064	$118,516	$122,072	$125,734	$129,506	$133,391	$137,393	$141,514	$145,760
19	Wind Generation R&R & Warranty	$53,107	$54,700	$56,341	$58,031	$59,772	$61,565	$63,412	$65,314	$67,274
20										
21	Wind Generation as a % of Total Load	118.4%	117.2%	116.0%	113.6%	112.5%	111.4%	110.3%	109.2%	108.1%
22	Excess Wind Gen to Grid, %	42.7%	42.7%	42.7%	42.7%	42.7%	42.7%	42.7%	39.0%	39.0%
23	Excess Wind Gen to Grid, MWh	6,806	6,806	6,806	6,730	6,730	6,730	6,730	6,144	6,144
24										
25	**Energy Storage System**									
26	Energy Storage, MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Energy Storage Capital Cost, Mil $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
28	Energy Storage Fixed Charges, Mil $	$0	$0	$0	$0	$0	$0	$0	$0	$0
29	Energy Storage O&M Cost, $	$0	$0	$0	$0	$0	$0	$0	$0	$0
30	Energy Storage MWH Net Consumed	0	0	0	0	0	0	0	0	0
31	Energy Storage MWH Net Delivered	0	0	0	0	0	0	0	0	0
32	Energy Storage MWH Lost	0	0	0	0	0	0	0	0	0
33										
34	**Purchases & Sales**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
35	Purchases from Grid	12,804	12,939	13,075	13,212	13,351	13,491	13,632	13,775	13,919
36	Wind Power Sold to Grid	15,926	15,926	15,926	15,748	15,748	15,748	15,748	15,748	15,748
37	Equivalent Net Purchases (Sales to Grid)	(3,121)	(2,987)	(2,851)	(2,536)	(2,398)	(2,258)	(2,116)	(1,973)	(1,829)
38		-23.2%	-22.0%	-20.8%	-18.3%	-17.1%	-16.0%	-14.8%	-13.7%	-12.6%
39	Equivalent Net Purchases as a % of Load									
40	Energy Charge Rate, $/MWH	$50.6	$52.2	$53.7	$55.3	$57.0	$58.7	$60.5	$62.3	$64.2
41	Climate Change Costs, $/MWH	$7.83	$9.29	$10.76	$12.23	$13.70	$15.16	$16.63	$18.10	$19.57
42										
43	Integration Costs	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8
44	Purchased Energy, Dollars	$759,584	$806,214	$854,331	$903,799	$955,041	$1,007,925	$1,062,508	$1,118,846	$1,177,001
45		$0	$0	$0	$0	$0	$0	$0	$0	$0
46	Purchased Demand, in kW	3,513	3,548	3,583	3,619	3,655	3,692	3,729	3,766	3,804
47	Demand Charge Rate, $ / kW-Month	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
48	Demand Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0

	K	L	M	N	O	P	Q	R	S	T
49	Total Cost of Purchased Power & REC's, Dollars	$759,584	$806,214	$854,331	$903,799	$955,041	$1,007,925	$1,062,508	$1,118,846	$1,177,001
50	Transmission Service	$93,833	$97,140	$100,564	$104,109	$107,779	$111,578	$115,511	$119,583	$123,799
51		$59.32	$62.31	$65.34	$68.41	$71.53	$74.71	$77.94	$81.22	$84.56
52	Total Cost of Purchased Power, $ / Mwh									
53	Rate for Sale of Excess Wind Power	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00	$45.00
54	Revenue from Sale of Wind Power	$716,656	$716,656	$716,656	$708,673	$708,673	$708,673	$708,673	$708,673	$708,673
55	Revenue from Sale of RECs	$0	$0	$0	$0	$0	$0	$0	$0	$0
56										
57	**Engine Plant**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**		
58	Existing Engine Generating Capacity	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
59	New Engine Generating Capacity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	New Engine Capital Cost per kW	$844	$869	$896	$922	$950	$979	$1,008	$1,038	$1,069
61	New Engine Total Capital Cost, $	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
62	New Engine Fixed Charges, $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
63										
64	**Engine Plant Fuel Costs**	2012	2013	2014	2015	2016	2017	2018	2019	2020
65	Energy Generated by Engines, MWh	650	650	650	650	650	650	650	650	650
66	Percentage from Natural Gas	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
67	Percentage from Diesel	10%	10%	10%	10%	10%	10%	10%	10%	10%
68	Percentage from Biodiesel	0%	0%	0%	0%	0%	0%	0%	0%	0%
69										
70	Natural Gas Cost, $	$ 57,908	$ 60,224	$ 62,633	$ 65,139	$ 67,744	$ 70,454	$ 73,272	$ 76,203	$ 79,251
71	Diesel Cost, $ as pilot fuel for gas	$ 20,148	$ 20,954	$ 21,792	$ 22,664	$ 23,570	$ 24,513	$ 25,494	$ 26,513	$ 27,574
72	Biodiesel Cost, $ as pilot or replacement for gas	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
73	Total Fuel Cost, $	$ 78,056	$ 81,178	$ 84,425	$ 87,802	$ 91,315	$ 94,967	$ 98,766	$ 102,716	$ 106,825
74	**Existing Engine Plant O&M**									
75										
76	Existing Plant Personal Services	$ 139,124	$ 143,298	$ 147,597	$ 152,025	$ 156,586	$ 161,283	$ 166,122	$ 171,105	$ 176,239
77	Existing Plant Contractual Services	$ 158,994	$ 163,764	$ 168,677	$ 173,737	$ 178,949	$ 184,317	$ 189,847	$ 195,542	$ 201,409
78										
79	**New Engine Plant O&M**									
80	New Plant Personal Services	$0	$0	$0	$0	$0	$0	$0	$0	$0
81	New Plant Contractual Services	0	0	0	0	0	0	0	0	0
82										
83	**Cash receipts**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
84	Sales	$1,588,518	$1,716,712	$1,733,879	$1,891,315	$1,910,228	$2,083,677	$2,104,514	$2,125,559	$2,146,815
85	Rentals	$0	$0	$0	$0	$0	$0	$0	$0	$0
86	Security Lights	$3,740	$4,042	$4,082	$4,453	$4,497	$4,906	$4,955	$5,004	$5,054
87	Service Charge	$1,479	$1,598	$1,614	$1,761	$1,778	$1,940	$1,959	$1,979	$1,999
88	Materials sold	$1,991	$2,051	$2,112	$2,176	$2,241	$2,308	$2,377	$2,449	$2,522
89	Other	$168	$173	$178	$183	$189	$194	$200	$206	$213
90	Wind Power & REC Sales	$716,656	$716,656	$716,656	$708,673	$708,673	$708,673	$708,673	$708,673	$708,673
91	Total cash receipts	$2,312,552	$2,441,231	$2,458,521	$2,608,561	$2,627,607	$2,801,699	$2,822,679	$2,843,870	$2,865,276
92	**Expenditures**									
93	**Production**									
94	Engine Plant Personal Services	$139,124	$143,298	$147,597	$152,025	$156,586	$161,283	$166,122	$171,105	$176,239
95	Engine Plant Contractual Services	$158,994	$163,764	$168,677	$173,737	$178,949	$184,317	$189,847	$195,542	$201,409
96										
97	Wind Generator O&M, R&R	$168,171	$173,216	$178,412	$183,765	$189,278	$194,956	$200,805	$206,829	$213,034
98	Commodities	$19,520	$20,105	$20,709	$21,330	$21,970	$22,629	$23,308	$24,007	$24,727

	K	L	M	N	O	P	Q	R	S	T
99	Diesel fuel & oil	$18,648	$19,208	$19,784	$20,377	$20,989	$21,618	$22,267	$22,935	$23,623
100	Electricity, RECs, & Transmission Service	$853,417	$903,354	$954,895	$1,007,908	$1,062,820	$1,119,503	$1,178,019	$1,238,430	$1,300,799
101	Natural Gas	$57,908	$60,224	$62,633	$65,139	$67,744	$70,454	$73,272	$76,203	$79,251
102	Capital outlay	$0	$0	$0	$0	$0	$0	$0	$0	$0
103	**Transmission & Distribution**									
104	Personal Services	$187,958	$193,597	$199,405	$205,387	$211,549	$217,895	$224,432	$231,165	$238,100
105	Contractual Services	$13,320	$13,719	$14,131	$14,555	$14,991	$15,441	$15,904	$16,381	$16,873
106	Commodities	$53,265	$54,863	$56,509	$58,204	$59,950	$61,749	$63,601	$65,509	$67,474
107	Capital outlay	$2,379	$2,450	$2,523	$2,599	$2,677	$2,757	$2,840	$2,925	$3,013
108	**General & Administrative**									
109	Contractual Services	$3,271	$3,369	$3,470	$3,574	$3,682	$3,792	$3,906	$4,023	$4,144
110	Commodities	$0	$0	$0	$0	$0	$0	$0	$0	$0
111	**Transfer to electric debt service**	$607,500	$607,500	$607,500	$607,500	$607,500	$607,500	$607,500	$607,500	$607,500
112	**Reimbursed expenditures**	($8,503)	($8,759)	($9,021)	($9,292)	($9,571)	($9,858)	($10,154)	($10,458)	($10,772)
113	**Total Expenditures**	$2,274,970	$2,349,908	$2,427,224	$2,506,808	$2,589,113	$2,674,038	$2,761,669	$2,852,097	$2,945,413
114										
115	Receipts over (under) expenditures	$37,581	$91,323	$31,298	$101,753	$38,494	$127,661	$61,010	($8,226)	($80,138)
116	Unencumbered cash (deficit) BOY	$262,079	$262,079	$262,079	$262,079	$262,079	$262,079	$264,719	$264,719	$256,493
117	Trasfer to City	($37,581)	($91,323)	($31,298)	($101,753)	($38,494)	($125,021)	($61,010)	$0	$0
118	Unencumbered cash (deficit), EOY	$262,079	$262,079	$262,079	$262,079	$262,079	$264,719	$264,719	$256,493	$176,355
119										
120	**Retail Sales by Class**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
121										
122	Residential Mwh	8,662	8,748	8,836	8,924	9,013	9,103	9,194	9,286	9,379
123	Commercial Mwh	3,851	3,890	3,928	3,968	4,007	4,047	4,088	4,129	4,170
124	Furnished without charges & Losses	942	951	961	970	980	990	1,000	1,010	1,020
125	Total Mwh to System	13,454	13,589	13,725	13,862	14,001	14,141	14,282	14,425	14,569
126	Losses as a % of Sales	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
127										
128	Rate Change by Year	0.0%	7.0%	0.0%	8.0%	0.0%	8.0%	0.0%	0.0%	0.0%
129	Residential Cost per kWh	$0.1277	$0.1366	$0.1366	$0.1475	$0.1475	$0.1593	$0.1593	$0.1593	$0.1593
130	Commercial Cost per kWh	$0.1254	$0.1341	$0.1341	$0.1449	$0.1449	$0.1565	$0.1565	$0.1565	$0.1565
131	Residential Revenue	$1,105,702	$1,194,932	$1,206,881	$1,316,466	$1,329,631	$1,450,361	$1,464,865	$1,479,513	$1,494,309
132	Commercial Revenue	$482,817	$521,780	$526,998	$574,849	$580,598	$633,316	$639,649	$646,045	$652,506
133	Total Sales Revenue	$1,588,518	$1,716,712	$1,733,879	$1,891,315	$1,910,228	$2,083,677	$2,104,514	$2,125,559	$2,146,815
134	Average Retail Sales Revenue ¢ per kWh	12.70	13.58	13.58	14.67	14.67	15.84	15.84	15.84	15.84
135	Residential Customers									
136	Commercial Customers									
137										
138	**Simplified Balance Sheet**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	2019	2020
139	Distribution System - New Investment	$0	$0	$0	$0	$0	$0	$0	$0	$0
140	Cumulative Investment	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
141	Annual Depreciation	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500	$142,500
142	Accumulated Depreciation	$855,000	$997,500	$1,140,000	$1,282,500	$1,425,000	$1,567,500	$1,710,000	$1,852,500	$1,995,000
143	Net Depreciated Investment	$3,895,000	$3,752,500	$3,610,000	$3,467,500	$3,325,000	$3,182,500	$3,040,000	$2,897,500	$2,755,000
144										
145	Production Plant - New Investment	$0	$0	$0	$0	$0	$0	$0	$0	$0
146	Cumulative Investment	$11,612,500	$11,612,500	$11,612,500	$11,612,500	$11,612,500	$11,612,500	$11,612,500	$11,612,500	$11,612,500
147	Annual Depreciation	$464,500	$464,500	$464,500	$464,500	$464,500	$464,500	$464,500	$464,500	$464,500
148	Accumulated Depreciation	$2,058,000	$2,522,500	$2,987,000	$3,451,500	$3,916,000	$4,380,500	$4,845,000	$5,309,500	$5,774,000

	K	L	M	N	O	P	Q	R	S	T
149	Net Depreciated Investment	$9,554,500	$9,090,000	$8,625,500	$8,161,000	$7,696,500	$7,232,000	$6,767,500	$6,303,000	$5,838,500
150										
151	Total Utility Plant	$16,362,500	$16,362,500	$16,362,500	$16,362,500	$16,362,500	$16,362,500	$16,362,500	$16,362,500	$16,362,500
152	Less Accumulated Depreciation	$2,913,000	$3,520,000	$4,127,000	$4,734,000	$5,341,000	$5,948,000	$6,555,000	$7,162,000	$7,769,000
153	Total Net Utility Plant	$13,449,500	$12,842,500	$12,235,500	$11,628,500	$11,021,500	$10,414,500	$9,807,500	$9,200,500	$8,593,500
154	Current Assets & Other	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
155	Total Assets	$13,549,500	$12,942,500	$12,335,500	$11,728,500	$11,121,500	$10,514,500	$9,907,500	$9,300,500	$8,693,500
156										
157	Total Equity	$6,817,000	$6,817,500	$6,818,000	$6,818,500	$6,819,000	$6,819,500	$6,820,000	$6,820,500	$6,821,000
158	Long-Term Liabilities	$6,682,500	$6,075,000	$5,467,500	$4,860,000	$4,252,500	$3,645,000	$3,037,500	$2,430,000	$1,822,500
159	Current Liabilities	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
160	Total Liabilities	$6,732,500	$6,125,000	$5,517,500	$4,910,000	$4,302,500	$3,695,000	$3,087,500	$2,480,000	$1,872,500
161	Total Liabilities & Equity	$13,549,500	$12,942,500	$12,335,500	$11,728,500	$11,121,500	$10,514,500	$9,907,500	$9,300,500	$8,693,500

Attachment 2
Correlation of Wind Power and City Loads

A simulation of correlation between the City load and wind generation output was made to estimate the amount of time that the wind turbines would generate more power than used by the City. The simulation is based on the wind turbines generating the same amount of energy as the City uses. An annual city load of 13 million kWh was used, which required about 3.6 MW of wind generation at a 41% annual capacity factor. Load and wind generation data was taken from the municipal utility at Algona, Iowa which has a 2.25 MW wind farm. Both load and generation levels were scaled to match Greensburg's annual energy needs. Since Algona has a higher annual load factor, the simulation resulted in slightly lower peaks than Greensburg would have. However, the annual energy needs were adjusted to match Greensburg's projected full recovery energy needs. Each of the following four graphs show the hourly load (blue line), hourly generation (green line), and the excess wind power that would flow back to the grid (red dots labeled "Sold") for a three-month period.

FIGURE 1

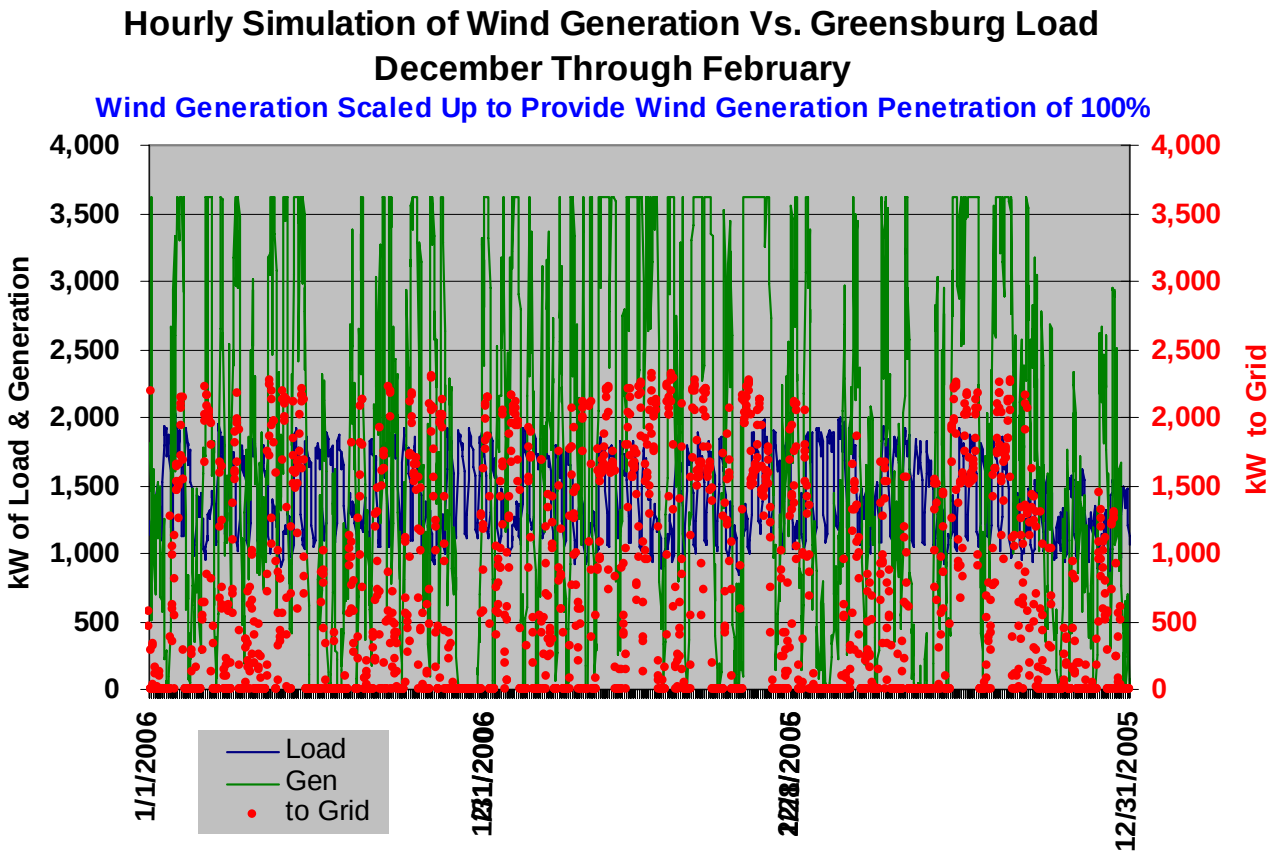


FIGURE 2

Hourly Simulation of Wind Generation Vs. Greensburg Load
March Through May

Wind Generation Scaled Up to Provide Wind Generation Penetration of 100%

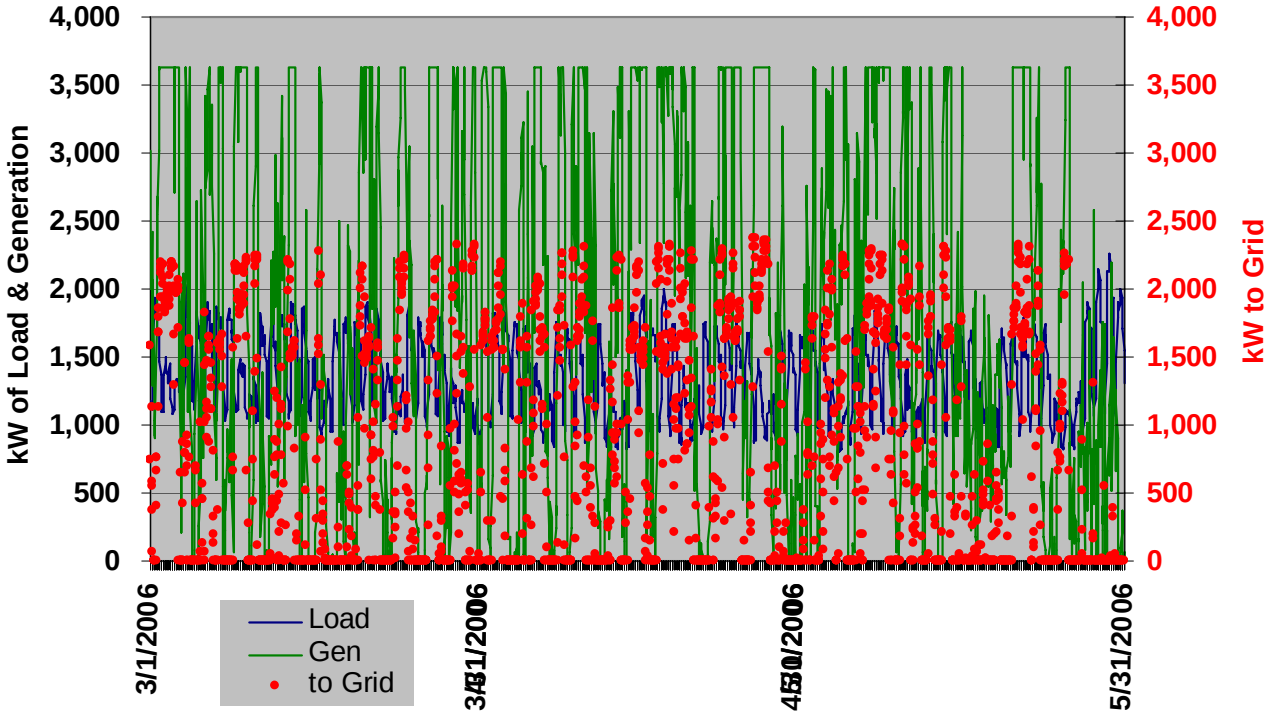


FIGURE 3

Hourly Simulation of Wind Generation Vs. Greensburg Load
June Through August

Wind Generation Scaled Up to Provide Wind Generation Penetration of 100%

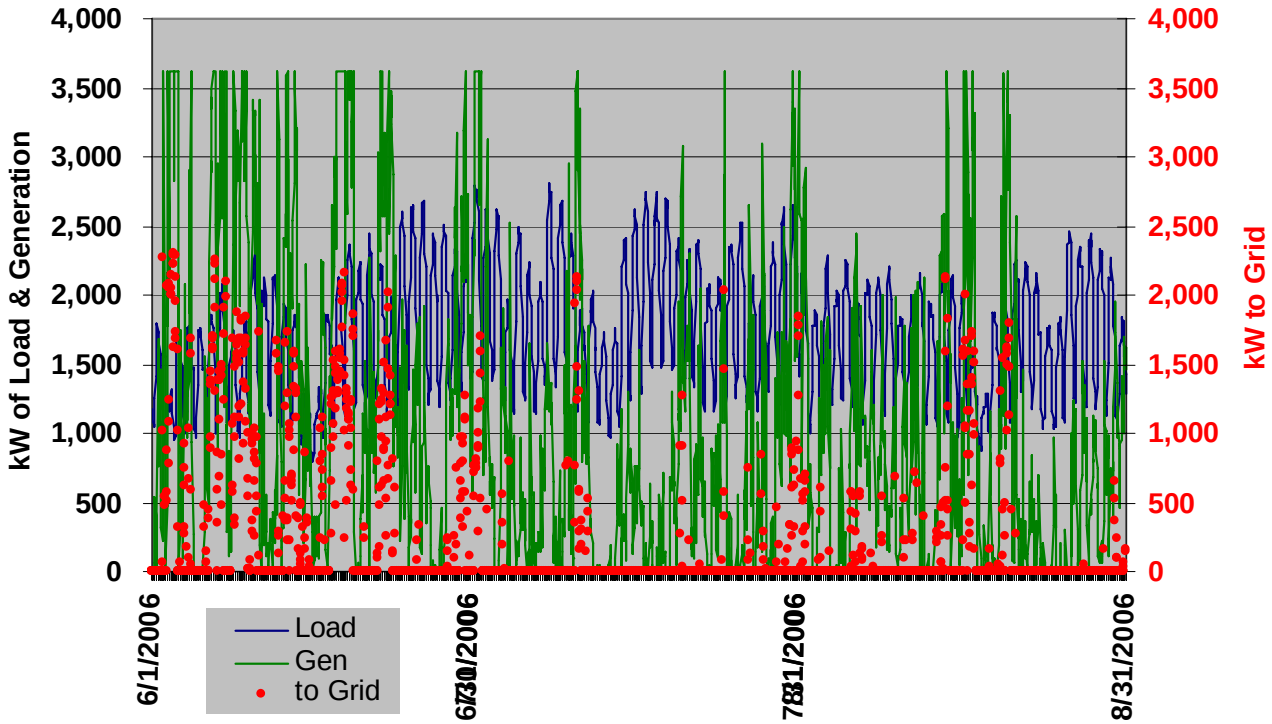


FIGURE 4

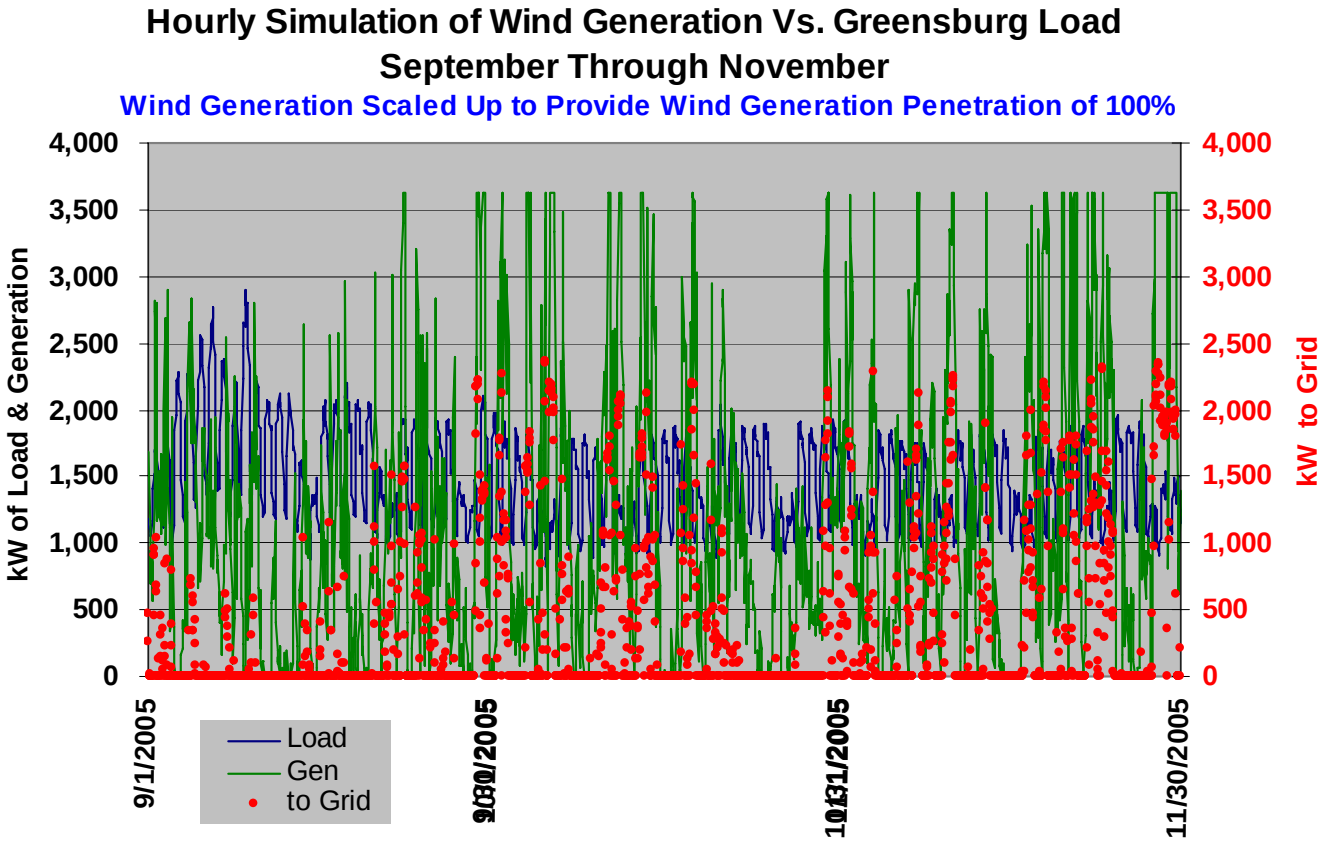

Hourly Simulation of Wind Generation Vs. Greensburg Load
September Through November
Wind Generation Scaled Up to Provide Wind Generation Penetration of 100%
kW of Load & Generation
kW to Grid
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
9/1/2005
11/30/2005
Load
Gen
to Grid

Figure 5 below shows the amount of wind generation during a year that would be in excess of a city's load for various wind generation penetration levels. For example, if the local "behind the meter" wind generation produces the same amount of energy as this city uses during the year (100% penetration level on "X" axis), then 39% of the wind energy would flow back to the grid. This is because the wind turbines would be producing more power than the city would need at various times. This implies that the city would have to likewise import 39% of its energy from the grid during those times when the wind turbines weren't generating enough power.

FIGURE 5

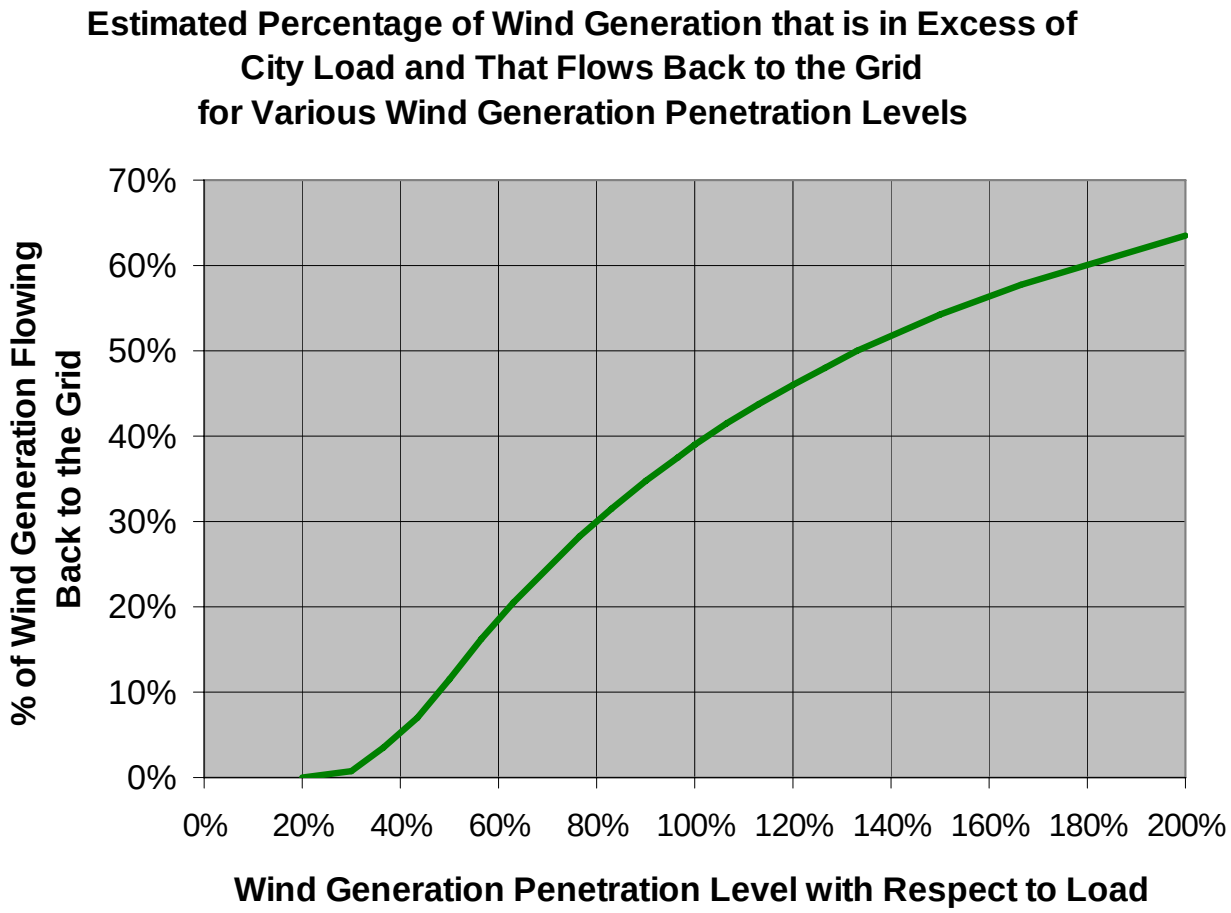


Figure 5 was based on time-synchronized city load and wind generation levels for one year of data from Algona, Iowa. Slightly different results would be obtained using data from different specific years. There are eight full years of time-synchronized data for this project.

D.6 Presentation: Refined Wind Speed Maps for Greensburg

Trudy Forsyth
National Renewable Energy Laboratory

Thomas A. Wind
Wind Utility Consulting

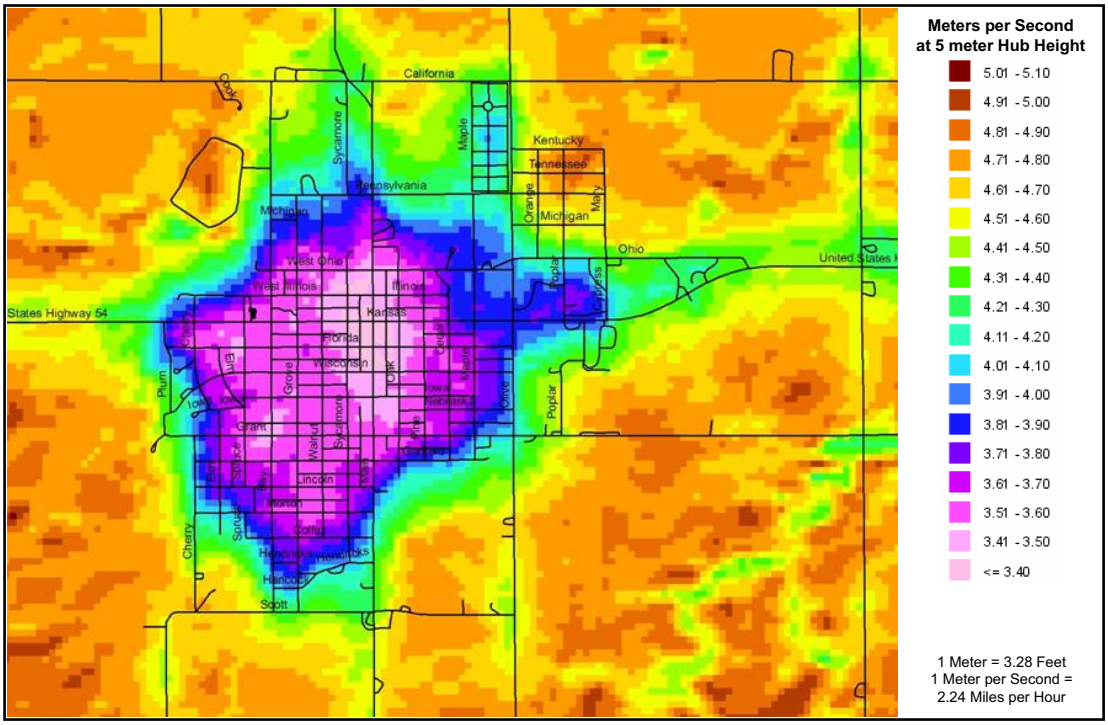
Refined Wind Speed Maps for Greensburg

- More refined mean annual wind speed maps were developed for Greensburg to help city residents determine how many kWh wind turbines would generate over the course of a year.
- These refined wind speed maps used much more detailed land use data from the USGS. All of this land use data, which includes tree cover, was based on data prior to the tornado.
- The following slides show the estimated wind speeds around Greensburg at 5, 10, 15, 20, 25, 30, and 50 meter heights above ground. One meter is 3.3 feet.
- These average annual wind speeds can be used with wind turbine manufacturer's data to estimate the annual kWh generation from a wind turbine.

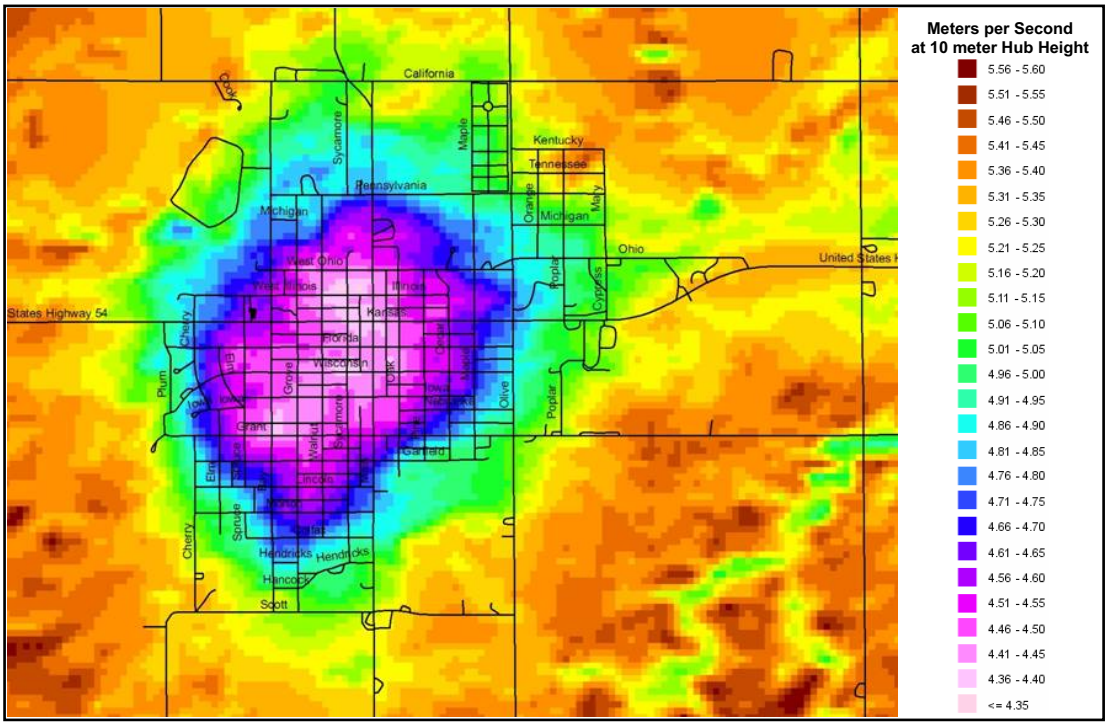
Thomas A. Wind
Wind Utility Consulting, PC
February 18, 2008

Estimate of Impact of Reduced Tree Cover and Fewer Buildings on Wind Speeds in Greensburg

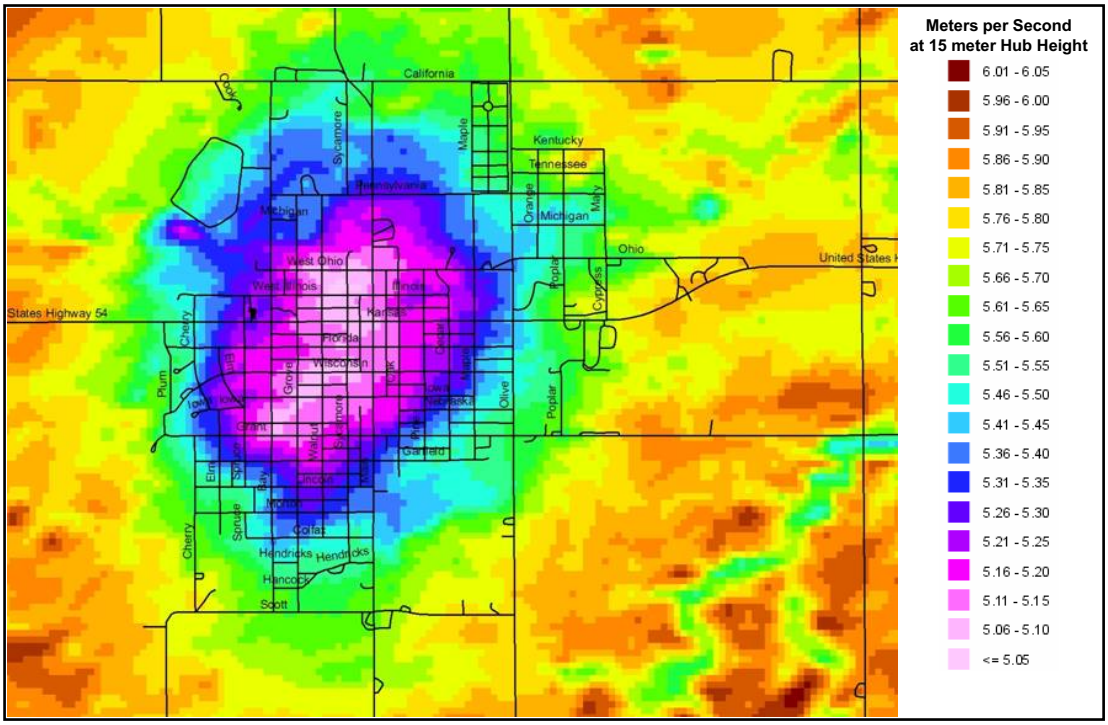
- Trees and buildings slow winds down, especially at lower wind turbine hub heights typically used for smaller wind turbines.
- All of the preceding maps were based on tree cover and buildings that existed prior to the tornado. Since many trees and buildings in Greensburg were lost, the winds will be faster than they were prior to the tornado.
- A rough estimate of the higher wind speeds was made at the 20 meter hub height, or 65 feet with today's reduced hub heights.
- In general, the average wind speed over the course of a year is perhaps 5% higher at 65 feet with today's reduced tree cover. The percentage difference is more at lower hub heights than higher hub heights



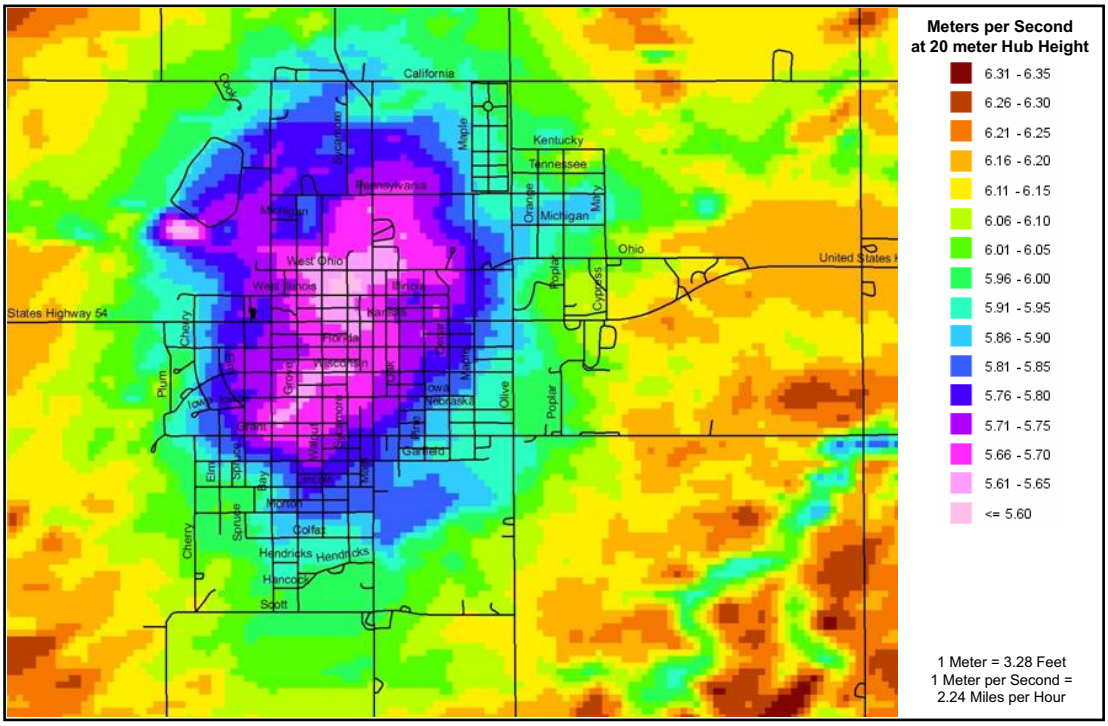
Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Preliminary Wind Speed Estimates around Greensburg, Kansas**	This is a detailed high resolution mean annual wind speed map developed by Wind Utility Consulting, PC. It is based in part on the Kansas Corporation wind speed map.



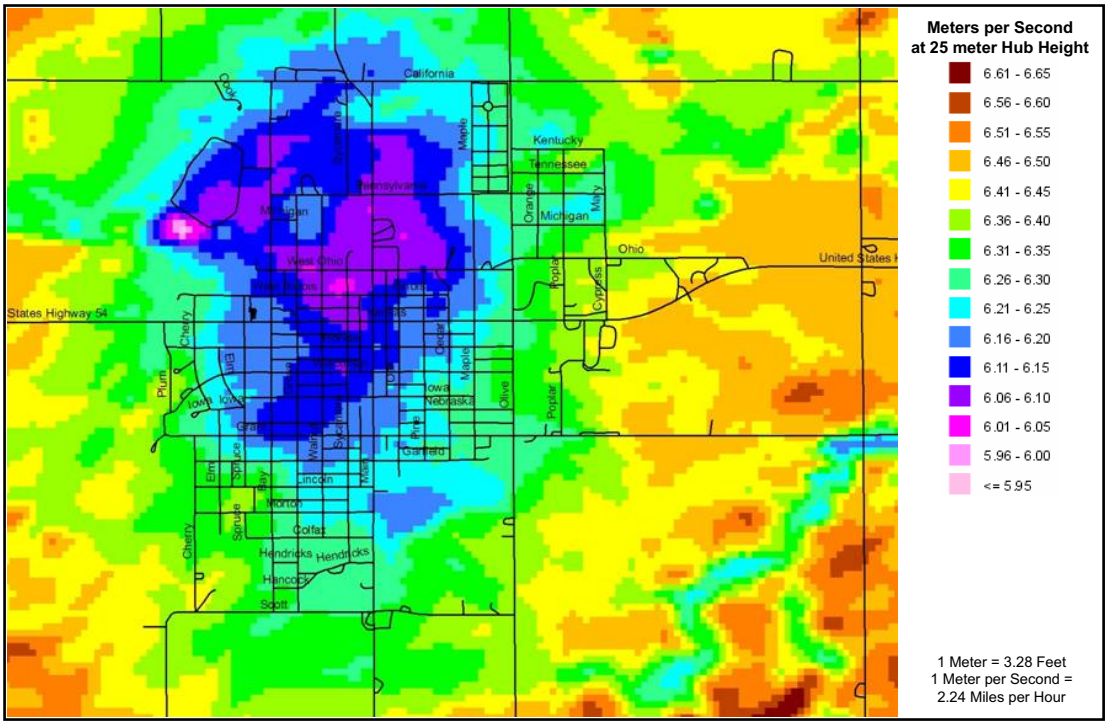
Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Preliminary Wind Speed Estimates around Greensburg, Kansas**	This is a detailed high resolution mean annual wind speed map developed by Wind Utility Consulting, PC. It is based in part on the Kansas Corporation wind speed map.



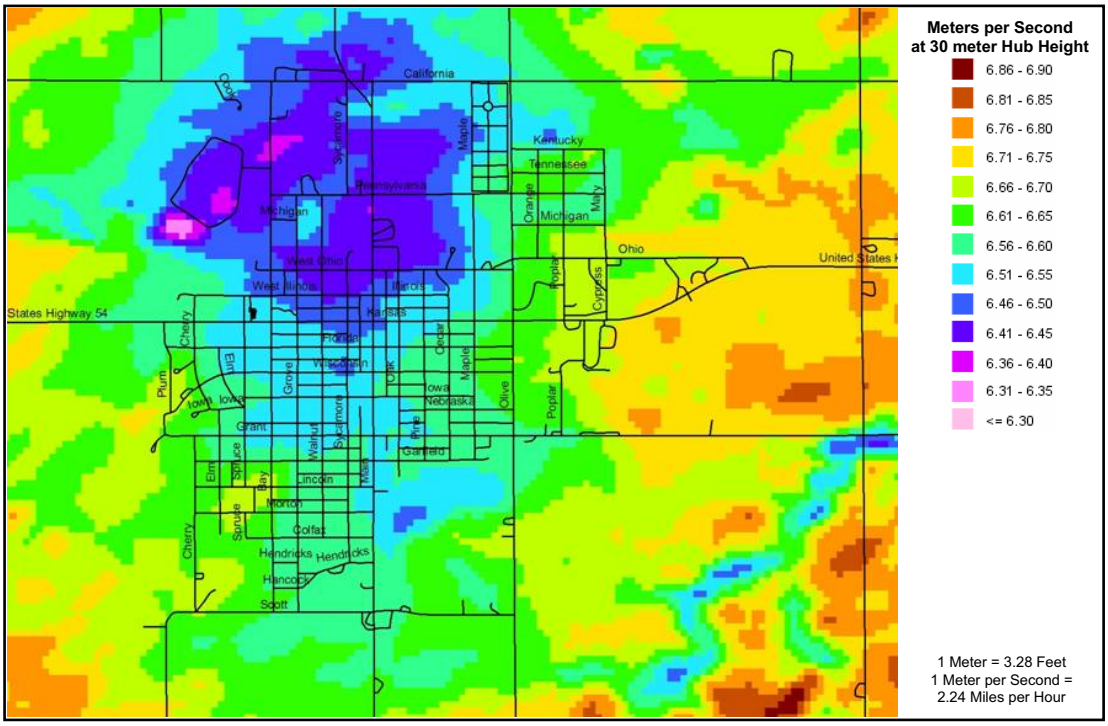
Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Preliminary Wind Speed Estimates around Greensburg, Kansas**	This is a detailed high resolution mean annual wind speed map developed by Wind Utility Consulting, PC. It is based in part on the Kansas Corporation wind speed map.



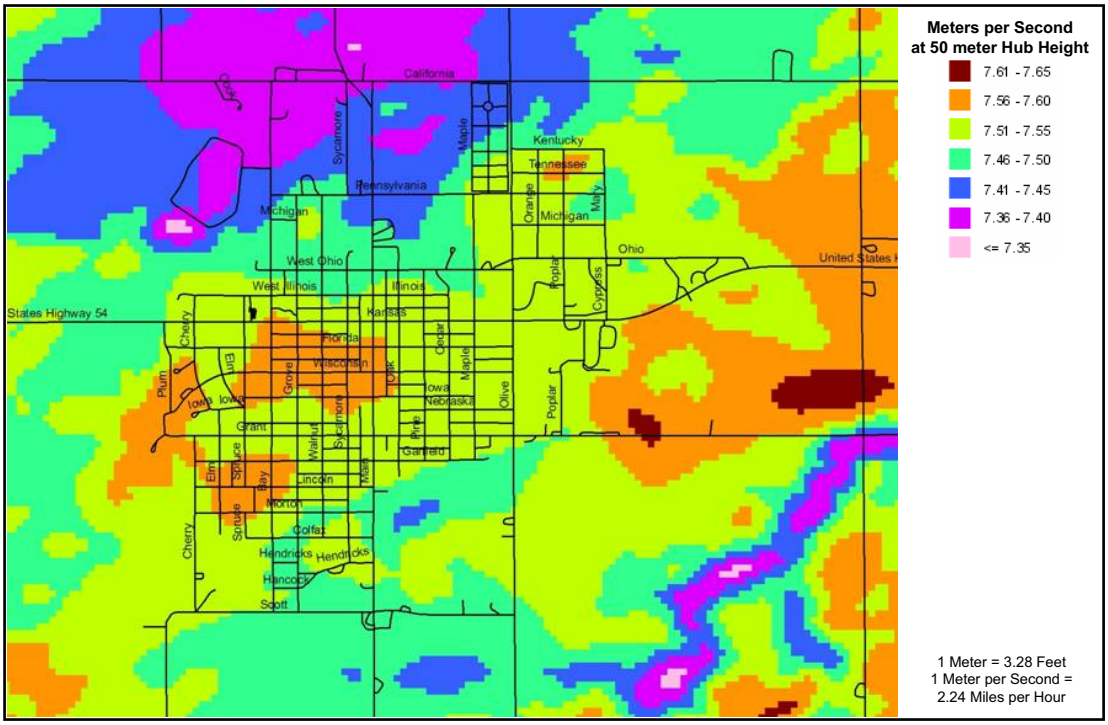
Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Preliminary Wind Speed Estimates around Greensburg, Kansas**	This is a detailed high resolution mean annual wind speed map developed by Wind Utility Consulting, PC. It is based in part on the Kansas Corporation wind speed map.



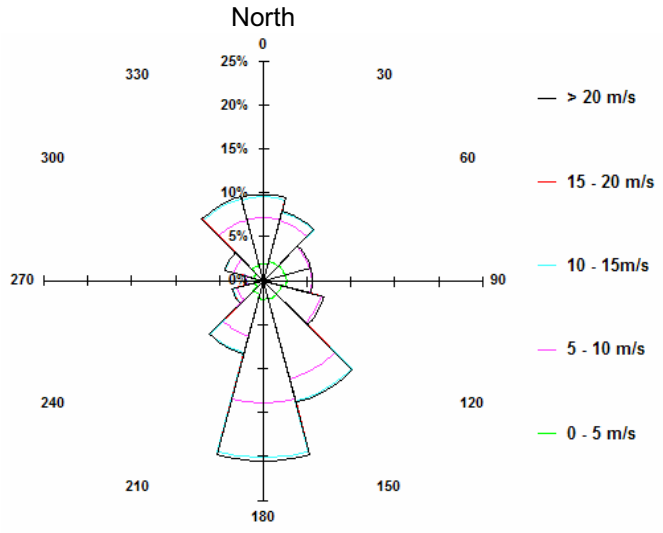
Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Preliminary Wind Speed Estimates around Greensburg, Kansas**	This is a detailed high resolution mean annual wind speed map developed by Wind Utility Consulting, PC. It is based in part on the Kansas Corporation wind speed map.



Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Preliminary Wind Speed Estimates around Greensburg, Kansas**	This is a detailed high resolution mean annual wind speed map developed by Wind Utility Consulting, PC. It is based in part on the Kansas Corporation wind speed map.

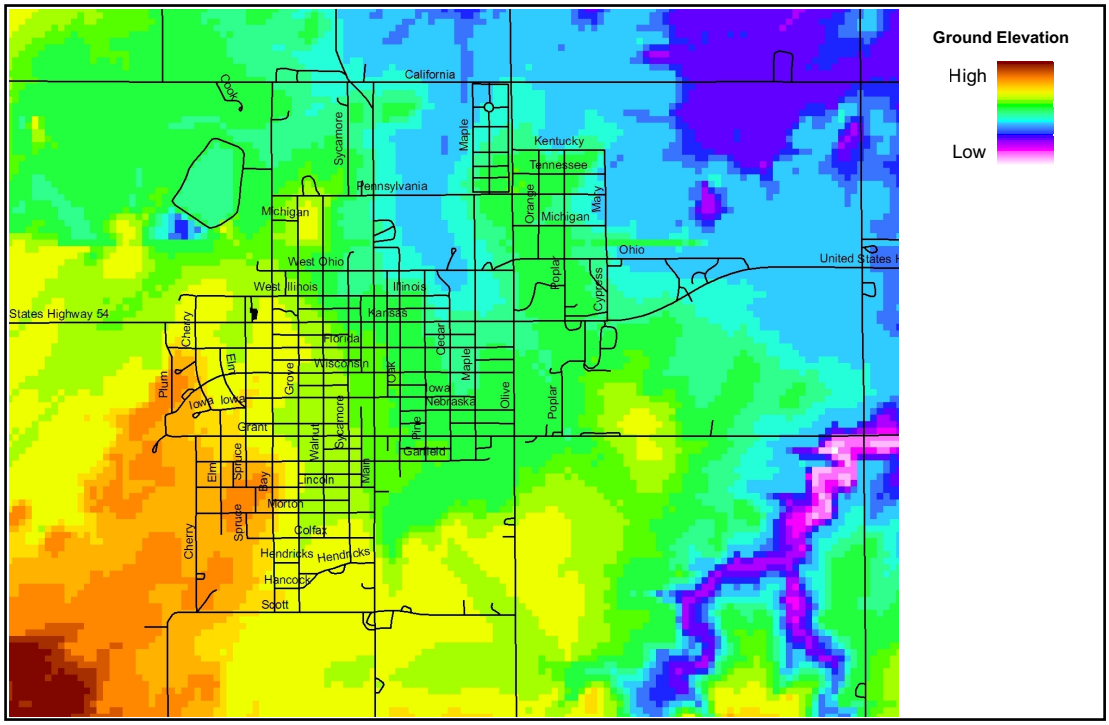


Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Preliminary Wind Speed Estimates around Greensburg, Kansas**	This is a detailed high resolution mean annual wind speed map developed by Wind Utility Consulting, PC. It is based in part on the Kansas Corporation wind speed map.

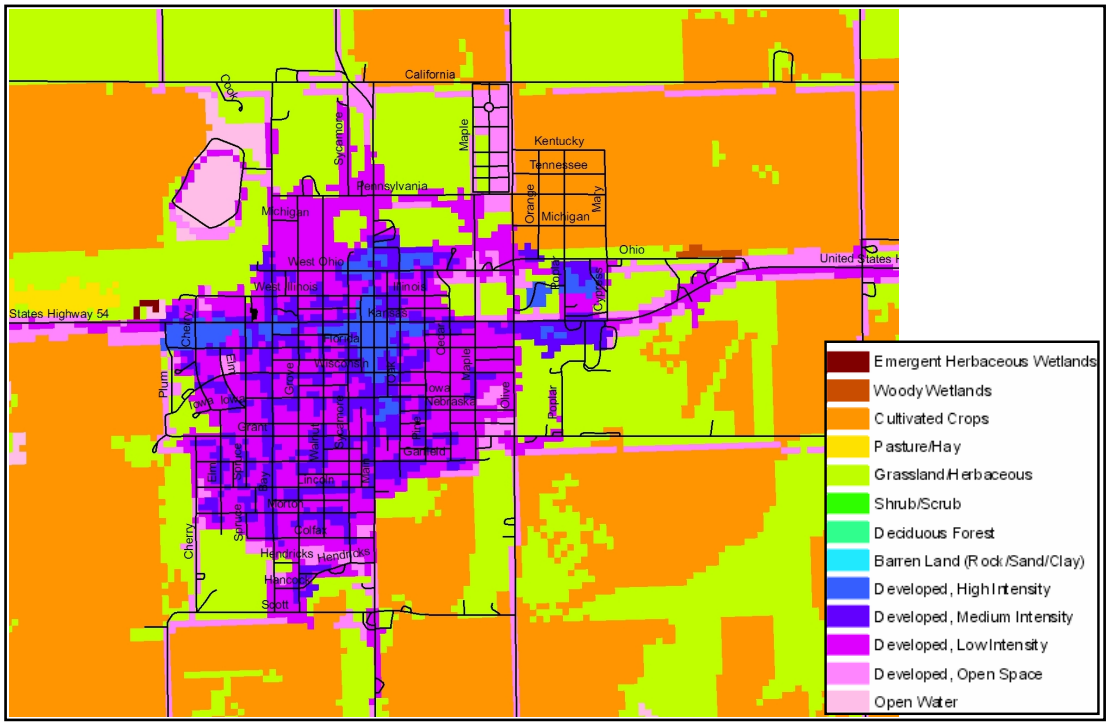


This wind rose directional data is from the closest meteorological test tower with publicly available data. It shows the predominant wind directions to be from the south and north.

Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Directional Wind Rose Applicable to Greensburg, Kansas Based on Deerfield, Kansas Data**	This wind rose is based on meteorological test tower data obtained from the Energy & Environmental Research Center (EERC) for the years of 1996-1998



Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Land Elevation around Greensburg, Kansas**	This map shows the ground elevation and is based on Digital Elevation Model data released by the United States Geological Survey.



Wind Utility Consulting, PC Jefferson, Iowa February 2008	**Land Use Data around Greensburg, Kansas**	This map shows the detailed land use types and is from the United States Geological Survey.

D.7 Recommendation: Only Very Small Wind Turbines Should be Building Mounted and Primarily for Architectural Purposes, not Primarily for Energy-generation Purposes

Jim Green

National Renewable Energy Laboratory

D.7.1 Specifications

- Building-mounted, or infrastructure-mounted, wind turbines in Greensburg should be 500 watts or less, and weigh 50 pounds or less.
- A rule of thumb in the wind industry is to install any turbine so the bottom of the rotor is 30 ft above any obstacle within a 500-ft radius.

D.7.2 Rationale

- Wind turbines mounted on buildings or infrastructure features such as light poles or communication towers can be a valuable visible statement architecturally.
- However, wind turbines have limited performance in electricity output, and can create unanticipated difficulties.

D.7.3 Advantages of building- or infrastructure-mounted wind turbines

- Using an existing or dual-use structure, part of a building or adjacent infrastructure, lowers wind turbine installation cost.
- Wind turbines visible on a building, or on site infrastructure immediately adjacent to the building, makes a strong statement of the building owner's commitment to renewable energy.

D.7.4 Disadvantages of building- or infrastructure-mounted wind turbines

- The vibration of the wind turbine can lead to acoustic noise inside the building.
- The vibration of the wind turbine can lead to structural vulnerabilities, especially for wood-frame construction.
- The weight of the wind turbine adds to the structural load on the building or structure, and must be considered in compliance with building codes.
- The building or structure itself will alter the wind pattern, introducing acceleration, turbulence, and/or flow separation. These effects will be specific to roof configuration, location on or above the roof, and local wind direction, making prediction of energy performance very difficult.
- Turbulent environments, such as adjacent to buildings, reduce both performance and life of wind turbines, adding to maintenance issues and reducing reliability.
- The very small-scale of wind turbines, as required to avoid other problems such as vibration, acoustics, and structural load, do not take advantage of economies of scale of larger wind turbines or wind turbine farms, raising the cost of energy.

D.8 Analysis of Photovoltaic Generation Options for Greensburg, Kansas

John P. Thornton, P.E.
Consultant
Littleton, Colorado
March 13, 2007

Lynn Billman
National Renewable Energy Laboratory

Executive Summary

There are many opportunities for the deployment of photovoltaic (PV) power systems to produce electricity for municipal, commercial and residential applications during the reconstruction of Greensburg, Kansas. The area has a good solar resource. There appear to be no major technical barriers; however, financial and institutional challenges exist.

The intention of this analysis is to provide a database of sufficiently accurate cost and performance data to be incorporated in strategic planning and used to attract financing, in finding state and federal incentives that may apply, and in educating stakeholders.

Most of the reconstruction effort is still in the discussion or conceptual design stage. Electrical loads were assumed in many cases, as were some basic building dimensions and the percentage of rooftop space available for PV. Information was gleaned from municipal planning documents and discussions with various stakeholders. It is important to remember that one of the major attributes of PV is its design flexibility. Each of the design options discussed in the report can be scaled down (or increased in size) to fit a budget.

The importance of the role of energy efficient buildings in the successful deployment of PV cannot be overstated. Implementing energy efficiency measures first will reduce the amount of PV needed by three or more times.

There are also excellent opportunities for the deployment of both active and passive solar space heating, as well as for solar hot water heating. Discussions of these options are not included in this report.

Numerous steps can be taken by the Greensburg City Council and staff, and organizations such as the Kiowa County Business Redevelopment Board to accelerate the pace of PV and other renewable projects. Some of these steps – such as city ordinances governing community and individual solar access and renewable interconnection requirements – are essential and should be given the highest priority. These steps are discussed in greater detail in Section 6, *A Suggested Implementation Strategy*.

Analysis, Discussion and Recommendations

1. Introduction

This report summarizes the results of investigations into the feasibility of incorporating PV electric power generation for municipal, commercial, industrial and residential applications during the reconstruction of Greensburg, Kansas. Greensburg, a municipality located in Kiowa County in the southwestern Kansas, was devastated by an EF5[1] hurricane on May 4, 2007. Approximately 95% of the buildings in the city were destroyed, with the remaining 5% being severely damaged. Tragically, 12 people were killed.

The investigations described in this report were performed as part of the support that the Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) are providing to Greensburg.

2. The Solar Resource in Greensburg, Kansas

The area around Greensburg has a substantial solar resource. The solar resource map shown in Figure 1 indicates that the area around Greensburg receives an average of approximately 5.0 kilowatt hours (kWh) to 5.5 kWh per square meter (m^2) per day of insolation, or approximately 1,825 kWh to 2,008 kWh per m^2 annually.

The closest sites to Greensburg where a reliable database of solar resource data has been collected are Dodge City and Wichita, Kansas. These sites are both part of the National Solar Radiation Data Base (NSRDB), a repository of solar resource data that covers the years 1961 to the present.[2] Data for the city of Wichita, Kansas most closely represents the solar resource at Greensburg and so has been utilized as a surrogate in estimates of PV performance at Greensburg.

The suitability of Greensburg for solar deployment is shown in Table 1. The table provides a comparison of the insolation captured by a fixed-tilt, non-tracking PV array for selected NSRDB sites around the U.S. As can be seen, Greensburg receives approximately the average insolation for the continental United States and, therefore, has a sufficient solar resource for the efficient use of photovoltaic technologies.

3. PV Deployment in Greensburg

There are four basic PV system configurations that should be considered for deployment in Greensburg. These are: a. fixed-tilt, non-tracking, flat plate (Figure 2), b. single-axis tracking, flat-plate (Figure 3), c. two-axis tracking, flat-plate (also Figure 3), and d. concentrating (Figure 4). The potential of each configuration for Greensburg will be discussed below.

[1] EF5 describes the most powerful category of tornado. Tornados are rated on the Fujita scale from EF0 to EF5, where EF5 is the most severe.

[2] The NSRDB, which is maintained by NREL, is the nationally recognized source of solar radiation data for the United States. There are 239 stations in the U.S. and its territories. More information about the NSRDB may be obtained at http://www.nrel.gov and searching for "NSRDB."

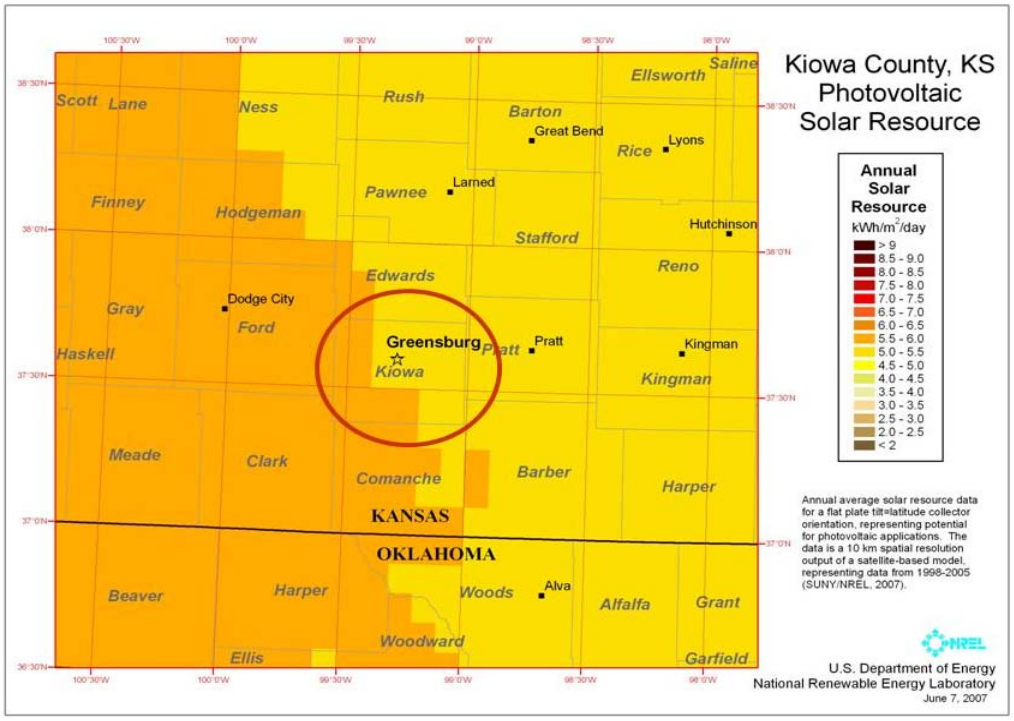


Figure 1. The solar resource available at Greensburg, Kansas[1]

Table 1. Comparison of Insolation Collected by a Fixed-Tilt, Non-Tracking, PV Array for Selected NSRDB Sites in the United States [2,3]

NSRDB Site	Average Solar Insolation ($kWh/m^2/day$)	Comparison with Wichita, KS
Colorado Springs, CO	5.6	1.08
Des Moines, IA	4.8	0.92
Dodge City, KS	5.6	1.08
Goodland, KS	5.6	1.08
Kansas City, MO	4.9	0.94
Omaha, NE	4.9	0.94
Sacramento, CA	5.5	1.06
San Diego, CA	5.7	1.10
Tucson, AZ	6.5	1.25
Tulsa, OK	5.1	0.98
Wichita, KS	5.2	1.00

3.1 Discussion of the Four PV Options

Table 2 provides a comparison of both the insolation-capturing abilities and the energy production potential of all four system configurations. The fixed-tilt, non-tracking, flat-plate configuration will collect up to 5.2 kWh/m^2/day on average over a year. Because of their superior collection abilities, the one-axis and two-axis tracking configurations will collect 6.8 kWh/m^2/day and 7.0 kWh/m^2/day on average, respectively. A concentrating collector, because of its narrow field-of-view, will collect 3.7 kWh/m^2/day to 4.8 kWh/m^2/day on average.

For flat-plate configurations, PV systems will produce electricity proportional to the amount of energy collected. For a specific PV module, the tracking flat-plate configurations can be expected to produce about 28% to 36% more electricity annually than the fixed-tilt, non-tracking, flat-plate configuration.

The performance of concentrators cannot be directly compared to the flat-plate configurations. Although their narrow field-of-view collects less solar radiation, concentrators depend upon high PV cell efficiencies and a minimal use of expensive PV material to produce electricity on a cost-equivalent basis with the flat-plate configurations.

One of the main points to consider when selecting a PV configuration, other factors being equal, is the final cost of electricity (cents per kWh_{AC}).

The fixed-tilt, non-tracking, flat-plate system is the most frequently deployed configuration and is used for both ground- and roof-mounted applications. For each KW_{DC}[3] of rated capacity, a south-facing array will provide between 1,191 kWh_{AC} and 1,401 kWh_{AC} of electricity annually in Greensburg (Table 3).[4] Table 3 provides estimates, based on computer simulations, of the energy that will be produced by one KW_{DC} of rated capacity. The highest annual performance, i.e., the most kWh_{AC} of electricity, is achieved by a south-facing PV array tilted at an angle of 37.7 degrees, the latitude of Greensburg.

Table 3 also demonstrates how the orientation, or tilt, of a fixed-tilt, non-tracking, flat-plate PV array may be adjusted as needed to optimize performance during either winter or summer, or to accommodate pitched or flat roofs.

There are numerous opportunities for the deployment of PV in Greensburg. All of the identified possibilities are still in the discussion or conceptual stage. However, enough is known about these opportunities to provide preliminary estimates of cost and performance for planning purposes, to identify design approaches, to describe potential federal and state incentives, and to suggest a strategy for implementing some or all of these opportunities.

---

[3] PV modules and arrays are rated in watts or kilowatts, respectively, and produce direct current electricity. Hence the module and array ratings are shown as W_{DC} or KW_{DC}, as measured under an internationally recognized system. These ratings are similar in nature to those on a car engine or power plant. One KW_{DC} of PV will provide different amounts of energy depending upon the intensity of the solar resource. The electricity produced by a PV array must be changed, or inverted, to alternating current (AC) electricity to be of use in a utility grid.

[4] The energy predictions in Table 3 are based upon computer simulations performed using PVWatts. PVWatts is a nationally recognized program that uses the NSRDB from 239 sites around the U.S. to predict the monthly and annual energy produced by a PV array based on the rated capacity of the array (KW_{DC}).



Figure 2. Typical fixed-tilt, non-tracking, flat-plate PV system (J. Thornton)



Figure 3. Typical one or two-axis tracking, flat-plate PV system (J. Thornton)



Figure 4. Typical utility-scale concentrating PV system (NREL PIX 13735)

Table 2. Comparison of Collection Abilities and Estimated Annual Electricity Production for Four Types of PV System Configurations at Greensburg, Kansas[1]

System Configuration	Insolation Collected ($kWh/m^2/day$)[1]	Relative Collection Ability	Estimated Annual Energy Production Per KW_{DC} (kWh_{AC})[3]
Fixed-Tilt, Non-Tracking, Flat-Plate[2]	5.2	1.0	1,401
1 Axis Tracking Flat Plate	6.8	1.28	1,796
1 Axis Tracking Flat Plate	7.0	1.36	1,900
Concentrator	3.7 – 4.8	N/A	N/A

[1] Derived from data for Wichita, Kansas (WBAN No. 03928) in the Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors, NREL/TP-463-5607, NREL, Golden, CO, April 1994.
[2] Tilted at an angle equivalent to the latitude for maximum annual electricity production.
[3] Estimates of annual energy production based upon PVWatts simulations.

Table 3. Simulated Monthly and Annual AC Energy Output (kWh) of a 1 Kilowatt-Rated, South-Facing, Fixed-Tilt, Non-Tracking PV Array in Greensburg, KS [1,2]

Month	Tilt Angle From Horizontal (degrees)						
	0	10	20	30	37.7 Latitude	45	60
January	58	75	89	100	106	111	115
February	71	84	95	103	107	109	110
March	100	109	116	120	121	120	114
April	121	127	130	130	127	123	110
May	135	137	136	132	127	120	101
June	140	140	136	130	124	116	94
July	143	143	141	136	130	122	100
August	132	137	138	136	133	128	111
September	101	109	115	117	117	116	108
October	84	98	109	116	120	122	120
November	58	72	84	93	98	102	105
December	47	62	75	84	90	94	98
Annual	1191	1284	1364	1398	1401	1384	1286

[1] Based upon PVWatts simulations using Wichita, KS, NSRDB data as a surrogate insolation profile for Greensburg, KS. These values may vary by ±9% for specific months and/or years.
[2] To estimate the monthly or annual energy output of a PV array, multiply the rated capacity of the array in KW_{DC} by the monthly or annual output in the chart above for the desired tilt angle. For example, the estimated output of a 5 KW_{DC} array tilted at 37.7 degrees during July will be 5 x 139 or 695 kWh.

3.2 Solar Electric Opportunities in Greensburg

Several upcoming projects will provide opportunities to incorporate PV technologies into the city of Greensburg's infrastructure. Incentives may apply to some of these opportunities. See Section 5 and the Addendum for further details.

The costs used below are broad estimates based upon the 2007 nationwide market for PV. They include estimates of maintenance over an expected lifetime of 25 years. These estimated costs should be used for planning only. Firmer cost estimates will become possible as designs mature.

3.2.1 Courthouse (221 E. Florida)

The courthouse is one of the few buildings that survived the tornado, although not without significant damage. If repaired, the building appears to be suitable for mounting PV on the roof, although this would have to be confirmed by an inspection and a structural analysis. The roof has an estimated area of 8,000 ft.^{2}. Although it was not examined because of safety concerns, an area of 6,000 ft.^{2} is assumed to be usable, with the rest of the space being occupied by vents, air conditioners, etc.

Depending on the choice of PV module selected and the method of mounting, an estimated 48.7 KW_{DC} to 97.9 KW_{DC} of PV capacity could be mounted in 6,000 ft.^{2}, generating from 63,018 kWh_{AC} to116,599 kWh_{AC} of electricity per year. The installed system cost will range from about $636,000 to $735,000. The electrical requirements of the courthouse after renovation has not been estimated yet, so it is not possible to project what percentage of the building's annual load could be supplied by PV. The resulting cost of energy from the PV system is estimated at 25 cents per kWh_{AC} (¢/kWh_{AC}) to 30 ¢/kWh_{AC}. The system would be connected to the utility grid.

3.2.2 The School

The school is expected to have an estimated flat roof area of 80,000 ft^2. The annual electrical load is expected to be 1,500,000 kWh_{AC}. An area of 60,000 ft^2 was assumed as useable space for PV. The school is assumed to be grid-connected with no electrical storage capability.

3.2.2.1 Roof-Mounted Options

Two roof-mounted configurations using fixed-tilt, non-tracking, flat-plate arrays have been examined. The first configuration assumes that modules will be mounted flat on the roof's surface. Depending on the choice of PV module selected and the method of mounting, an estimated 747.3 KW_{DC} to 979.0 KW_{DC} of PV capacity could be mounted in 60,000 ft.^{2}, generating about 890,034 kWh_{AC} to 1,165,989 kWh_{AC} of electricity per year. The installed system cost will range from about $3,736,500 to $4,895,000. It will displace between 59% and 78% of the electrical energy consumed by the school annually at an estimated lifecycle cost, including maintenance, of 18 ¢/kWh_{AC} . Of the two roof configurations investigated, the flat-mounted option permits the highest capacity PV array to be installed on the roof with the most energy produced annually.

Possible drawbacks to a flat-mounted system include material incompatibility between the underside of the PV module and the roofing material and the collection of moisture leading to mold or fungal growth. These issues should be thoroughly discussed with manufacturers and installers as well as the supplier of the roofing material.

The second roof-mounted configuration tilts the modules to the south at an angle of 10º. Spacing will be required between rows to minimize shadowing of modules, which will reduce the rated capacity (KW_{DC}) of the PV array that can be installed. The slight tilt from 0º to 10º does increase the annual performance slightly from 1,191 kWh_{AC} per KW_{DC} to 1,284 kWh_{AC} per KW_{DC}, an improvement of nearly 8%.

Tilting fixed-tilt, non-tracking, flat-plate PV modules toward the south up to an angle equivalent to the latitude of the location does improve performance (Table 3). At a tilt equivalent to the latitude of Greensburg (37.7º), the estimated annual output is 1,401 kWh_{AC} per KW_{DC} of installed capacity, an improvement of nearly 18%. However, spacing between rows becomes much greater with a substantially reduced array capacity being possible.

Module tilts of 10º are commonly used on flat-roofed buildings to obtain improved performance over a flat array, while keeping wind loading to reasonable levels. An array with a 10º tilt will usually be less than parapet height. The structure can also be designed to allow air circulation that keeps moisture accumulation to a minimum. As a result, material incompatibility problems tend to be reduced.

Depending on the choice of PV module selected and the method of mounting, an estimated 487.2 KW_{DC} to 645.0 KW_{DC} of PV capacity could be mounted in 60,000 $ft.^2$, generating about 630,437 kWh_{AC} to 834,630 kWh_{AC} of electricity per year. The installed system cost will range from about $3,736,500 to $4,895,000. It will displace between 42% and 55% of the electrical energy consumed by the school annually at an estimated lifecycle cost, including maintenance, of 16 ¢/kWh_{AC}.

3.2.2.2 Alternative Options

Alternative options include generating some or all of the 1,500,000 kWh_{AC} annual load using a field of ground-mounted, one or two-axis tracking or concentrator arrays located in a nearby field (Figures 3 and 4). A one-axis tracking system rated at approximately 835 KW_{DC} could supply the full annual electrical load of the school. The installed system cost would be approximately $4,592,500, with electricity costing about 0.13 ¢/kWh_{AC} over the expected 25-year lifetime of the system. The system would occupy about 2 acres to 2.5 acres of land.

Similarly, a two-axis tracking system rated at approximately 793 KW_{DC} could supply the full annual electrical load of the school.

3.2.3 Other Municipal Buildings

The courthouse and school PV system concepts described above in Sections 3.2.1 and 3.2.2 represent typical PV systems on small and large buildings, respectively, in a small municipality.

Other potential projects for roof-mounted PV, such as the Business Incubator or a hospital, should have similar costs and performance. PV system costs and performance for other projects can be estimated as soon as preliminary designs become available that provide the dimensions, orientation and pitch of available roof space.

In addition to mounting on flat or pitched roofs, or in open fields, PV awnings can be used as shades, facades, and other architectural features (Figures 5 and 6).

3.2.4 Municipal Utility Applications

To be effective, a grid-connected PV system does not have to be located on or next to its point of application to be effective. It can be sited in any open area, although proximity to an existing distribution point serves to keep the overall installation costs to a minimum. Any electricity generated by the PV system can be used by the grid while the utility reduces the use of traditional sources of energy, such as diesel generators or combustion turbines.



Figure 5. PV modules being used as awnings to provide shade as well as electric power



Figure 6. PV modules being used as an overhead shade on a commercial building

Any of the four system configurations will provide the required electricity, although significant economic advantages will probably be realized by using a one or two-axis tracking or a tracking concentrator system. A utility-scale PV system with a capacity of 1,000 KW_{DC} or greater would probably cost about $5,000 per KW_{DC} installed. During its lifetime of 25 years, the system could be expected to produce electricity for about 13¢/ kWh_{AC}.

A system that supplied Greensburg's annual energy load would be quite large. Greensburg's estimated 2008 annual electricity requirement has been estimated to be 6.6 million kWh_{AC}[2]. A one-axis tracking PV system rated at 3,675 KW_{DC} and covering about 10 acres would be required to generate that amount of electricity. The installation cost would probably be $18 million to 19 million.

3.2.5 PV Lighting Opportunities

PV lighting can be both cost-effective and affordable, especially when combined with modern, super-bright LED lamps. Solar-generated electricity is used to charge batteries during daylight hours, with the energy used to power the lights at night. There are many possible sites for small, self-contained, stand-alone PV signs in and around Greensburg, including the courthouse lawn, the highway approaches and city parks. Lighting projects are usually modest in size and can be implemented quickly.

There are many PV lighting systems available off-the-shelf that are applicable to nearly every lighting application. Ordering a pre-built system complete with warranties and adapting it to a special need is usually the most cost-effective way of obtaining PV lighting. It is also possible to assemble custom-made systems for unique applications.

Larger projects, such as sports fields that require intense, color-balanced lighting are best supplied directly from the grid. PV can be used to contribute to the load by generating energy during the day that is used to offset the electrical use at night.

3.2.5 PV-Powered Streetlamps

Several PV-powered streetlights are currently available. Various models use both high- and low-pressure sodium, incandescent, compact fluorescent and LED luminaries. All operate by charging self-contained batteries during daylight hours and using the stored energy to light the lamps during nighttime or on dark days. Luminosity ranges from about 1,800 lumens to 5,800 lumens. Each type of light has unique features as well as disadvantages.

High-pressure sodium and fluorescent lamps provide good color-balance. Yet both use ballasts, which require energy from the batteries. In addition, the ballasts of fluorescent lamps are affected by temperature, and on cold nights these lights may lose a substantial amount of illumination.

Low-pressure sodium lamps provide reliable service and are not significantly affected by temperature. However, the orange cast to the light distorts colors and is not generally pleasing to passersby.

Several manufactures have incorporated super bright, white LEDs into streetlights. These streetlights feature low-energy-consuming lamps that provide a luminance of 1,800 lumens or greater, have near-normal color balance and have rated lifetimes of 40,000 hours to 50,000 hours. LEDs significantly reduce the amount of PV and batteries needed to provide power. In addition, they contain no mercury, and are considered environmentally friendly. For these reasons, LED lamps are recommended for either solar- or non-solar-powered streetlights.

PV-powered streetlights are available as complete units including the solar panels, batteries and control electronics. Because of this extra equipment, they are more expensive as compared to conventional streetlights that are connected to the grid. PV streetlights can be purchased for approximately $3,000 to $4,600 each.

When comparing the cost of PV streetlights against traditional grid-powered models, many factors must be taken into consideration, including the relative costs of installation, digging up streets to connect to the grid.

3.3 Privately Funded Opportunities

There are numerous opportunities to incorporate energy efficiency and PV in the rebuilding of commercial, residential and farm properties as well.

3.3.1 General Motors Dealership

One of the first structures to be rebuilt will be the General Motors (GM) dealership. The building will have a 100 ft. by 70 ft. floor area. The roof will face east-west with a pitch of 1/12, giving it a minimum area of approximately 7,014 ft^2. The roof construction will likely be screw-down metal rather than standing-seam for cost consideration. The screw-down metal roof will allow a higher packing density for PV modules.

Energy production from the roof will still be substantial in spite of the east-west orientation. Computer simulations indicate that the annual energy output from the roof will be about 1,191 kWh_{AC} or 97% of that produced by a south-facing PV array.

The GM dealer is currently negotiating with Energy Conversion Devices for the installation and possible donation of Uni-Solar roofing laminates. While a system configuration is not available at this time, a 7,014 ft^2 roof would support an estimated 38.4 KW_{DC}, or possibly even greater. A PV system capacity of 38.4 KW_{DC} will generate an estimated 45,734 kWh_{AC} per year. The building's projected annual energy requirements are not known at this time.

3.3.2 Other Commercial Building Opportunities

Other opportunities exist for incorporating PV during reconstruction, including on the John Deere dealership and Kwik Stop gas station and convenience store. These buildings can expect similar performance and costs as the public buildings described earlier.

The Kwik Stop could utilize a PV canopy, a unique feature that is being adopted by stations worldwide (Figure 7). The canopy generates electric power while allowing a reduced level of sunlight to penetrate to the pump level. The PV modules in the canopy are grid-connected, and since they have no backup storage systems, will operate only during daylight hours when



Figure 7. PV canopies are often used to shade gasoline pumps at service stations. (NREL PIX 11979)

the grid is operational. Their primary purpose is to trim high daytime loads, such as those from air conditioning. The canopies are very visual and attract a lot of attention from customers. The translucent modules are available from BP Solar.

3.3.3 Grid-Connected Residential Opportunities

Grid-connected PV systems are often used on residential structures to provide energy to offset the local utility. They are often used to net meter or "trade" electricity with the local utility. When an excess of PV-generated energy over and above what is needed to operate the residence is available, the excess is fed *into* the grid, giving the homeowner a credit. When the PV system cannot supply sufficient energy, extra energy is drawn *from* the grid to make up the deficit. At some interval, usually annually, the homeowner's account is balanced by the utility. The utility

will provide credit, or sometimes pay, for the surplus provided by the homeowner. Similarly, the homeowner will pay for any electricity provided by the utility.

Residential PV systems usually range from two KW_{DC} to four KW_{DC} in size, and on homes in Greensburg will supply from 1,191 kWh_{AC} to 1,401 kWh_{AC} per installed KW_{DC} annually, depending upon the roof orientation, pitch and tilt of the array. The cost of a fully installed two to four KW_{DC} grid-connected system will typically range from $16,000 to $32,000, not including incentives, which is equivalent to an electricity charge of 30¢/ kWh_{AC} to 35¢/ kWh_{AC}.

3.3.4 Grid-Independent (Stand-Alone) Residential Opportunities

PV systems for grid-independent residences are larger because of the need to keep batteries charged in addition to operating the home without assistance from the grid. These systems will typically be rated from three KW_{DC} to six KW_{DC}. They will supply from 1,191 to 1,401 kWh_{AC} per installed KW_{DC} annually, depending upon the roof orientation, pitch and tilt of the array. They are more expensive because of the cost of the inverter capable of independent operation and the batteries needed for storage of the electricity, costing from $12,000 to $15,000 per installed KW_{DC}, not including incentives.

3.3.5 Farm and Agricultural Opportunities

Typically rural parts of America have many needs for power to control irrigation, pump water, run workshops, provide heat and cooling, maintain communications and ensure financial operations (Figures 8 and 9). PV can supply the electricity needed for many of these applications. Federal grants and loans from the United States Department of Agriculture are available. See Section 5 for further details.

4. PV Design Considerations

PV is a mature technology with a demonstrated history of supplying reliable and cost-effective power for many applications. The design considerations described below will help ensure that PV is applied in the most effective ways for Greensburg.

4.1 Flexibility of PV

One of the main advantages of PV is its modularity. A system capable of supplying the full energy need for an application may be desirable, but may not be absolutely necessary if tight budgets are a consideration. Grid-connected PV systems can be designed to shave peak loads or supply power at critical times, while relying on the utility to provide the balance of electricity when needed. PV systems can be tailored in size to meet a budget.



Figure 8. A PV-powered electric fence charger (NREL PIX 04347)



Figure 9. A PV-powered irrigation controller (Shell Solar, NREL PIX 03352)

4.2 The Importance of Energy Efficiency in PV System Design

Conducting energy efficiency measures first in a building will reduce the amount of PV needed by three or more times.

4.3 Grid-Connected Versus Grid-Independent Operation

Grid-connected PV systems have the lowest capital and maintenance costs. However, their operation is controlled by the local grid for safety reasons. If the utility grid loses power, the inverter that controls the PV system will sense the fault and automatically shut down the PV system. Most grid-connected systems do not have storage and, therefore, cannot be relied upon to provide emergency power during blackouts.

In the United States, the most cost-effective grid-connected systems are usually designed to generate the equivalent amount of electricity that a building will use in a year. Excess energy purchased from a customer by a utility will be at the utility's avoided cost. The avoided cost is substantially less than the retail price of electricity, plus taxes, that is paid by the consumer to the utility for electricity.

Stand-alone or grid-independent PV systems incorporate storage. Energy is collected by the PV system during daylight hours and stored in batteries for use at night or during cloudy weather. Two to three days of storage are usually sufficient for a typical residence. High-value applications, such as telecommunications, uninterruptible power supply (UPS), or security systems, often have even greater storage capacity.

Stand-alone systems require more PV modules than a grid-connected PV system because of the need to supply daily electricity while also keeping the batteries charged. These systems are more expensive than grid-tied systems, often costing twice as much, or more. An advantage of these systems is that once they are purchased, the price of electricity is fixed.

A stand-alone or grid-independent PV system should be located near its point of application for reliability. Overhead power lines are vulnerable during wind and hail storms. There are many cases on record where the loss of power lines during a disaster has disabled a PV system, even though the PV system remains operational. If a grid-independent PV system must be remotely located, the use of underground power lines is strongly suggested.

Systems that are both grid-connected and capable of independent operation can also be procured. When the utility grid fails, the PV system disconnects from the grid and switches over to independent operation, relying on electricity stored in batteries (Figure 10).



Figure 10. A PV UPS system at NREL that supplies electricity to XCEL Energy during normal operation and emergency power to the laboratory during power interruptions (J. Thornton).

4.4 PV/Wind Hybrid Operation

PV is synergistic with other technologies, such as wind, and can be used in hybrid systems. The wind resource is often available when the sun is not, and visa versa. The availability of both the wind and solar resources is often seasonal in the mid-western U.S. Wind/solar hybrid systems are used throughout the Midwestern states (Figure 11).

Hybrid wind and solar systems can usually be installed in rural areas without a problem. In more densely populated areas, such as Greensburg, noise ordinances and tower height restrictions may limit their use.

5. PV-Related Incentives Available to Greensburg

Table 4 shows the incentives that are available to the City of Greensburg, its businesses and residents. Table 5 and the addendum describe these incentives in greater detail. Of particular note is the Renewable Energy Production Incentive (REPI), which provides financial incentive payments for electricity produced and sold by new qualifying renewable energy-generation facilities. Qualifying facilities are eligible for annual incentive payments of 1.5¢ per kilowatt-hour (in 1993 dollars and indexed for inflation) for the first ten-year period of their operation, subject to the availability of annual appropriations in each federal fiscal year of operation. Originally designed to terminate in 2003, the Energy Policy Act of 2005 reauthorized appropriations for fiscal years 2006 through 2026.



Figure 11. A wind farm maintenance shop in Woodstock, Minnesota that uses a hybrid wind and PV system as a source of power

6. A Suggested Implementation Strategy

Most potential PV applications for Greensburg are still in the discussion stage and can best be approached using generalized estimates. A few applications, such as the Business Incubator, the school and the General Motors dealer, have been sufficiently defined to the point where preliminary estimates of performance and price can be established.

Even at this early stage, there are numerous steps that can be taken by the Greensburg City Council and staff, and organizations such as the Kiowa County Business Redevelopment Board to accelerate the pace of PV and other renewable projects. Some of these steps, e.g., city codes governing community and individual solar access and renewable interconnection standards, are essential and should be given the highest priority.

Table 4. Solar-Related Incentives Available From the Federal Government and State of Kansas[1,2]

Incentive	Type	Entity			
		Municipal Government	Municipal Utility/REC	Commercial/ Industrial/ Agricultural	Residential
USDA Grant Program	Federal			X	
USDA Loan Program	Federal			X	
Solar Tax Credit	Federal			X	X
Accelerated Depreciation	Federal			X	
R/E Production Incentive	Federal	X	X		
Property Tax Exemption	State			X	X

[1] Excerpted from the DSIRE database; http://www.dsireusa.org.
[2] Incentives may also apply to other renewable technologies, such as wind. Please refer to the Addendum for more detail.

Table 5. Financial Incentives for Energy Efficiency and Renewable Energy[1,2]

Incentive	Type/Name	Amount / Maximum / Notes	Timing
1	Federal Grant Program (USDA 9006)	25% of eligible project costs (grants and guaranteed loans together, see below, cannot exceed 50% of eligible project costs). Maximum grant for renewable energy projects is $500,000; maximum grant for energy efficiency improvements is $250,000. http://www.rurdev.usda.gov/rbs/farmbill	Annual application process and competition. FY2007 awards averaged $53,000 per project in grants and/or loans. Another application process for FY2008 is hopeful.
2	Federal Guaranteed Loan Program (USDA 9006)	Up to 50% of eligible project costs (grants and guaranteed loans together, see above, cannot exceed 50% of eligible project costs). Maximum loan guarantee is $10M. http://www.rurdev.usda.gov/rbs/farmbill	Annual application process and competition. FY2007 awards averaged $53,000 per project in grants and/or loans. Another application process for FY2008 is hopeful.
3	Federal Tax Credit - Commercial Solar	30% of the total costs of solar systems (photovoltaic electricity and hot water), solar hybrid lighting, and fuel cells, and 10% for geothermal electric, direct use geothermal, and microturbines. Excludes geothermal heat pumps. Other restrictions and requirements apply. http://www.irs.gov/pub/irs-pdf/f3468.pdf	Valid on systems installed before December 31, 2008.
4	Federal Tax Credit – Residential Solar	30% of the total costs of solar systems (photovoltaic electricity and hot water), solar hybrid lighting, and fuel cells, and 10% for geothermal electric, direct use geothermal, and microturbines up to a maximum of $2,000. Excludes geothermal heat pumps. Other restrictions and requirements apply. http://www.irs.gov/pub/irs-pdf/f3468.pdf	Valid on systems installed before December 31, 2008

(Continued on next page)

Table 4. (continued) Financial Incentives for Energy Efficiency and Renewable Energy[1,2]

Incentive	Type/Name	Amount / Maximum / Notes	Comments
5	Federal Corporate Depreciation (Modified Accelerated Cost-Recovery System	Corporate and industrial solar investments can be depreciated in five years. http://www.dsireusa.org See Federal incentives section.	Annual application process and competition. FY2007 awards averaged $53,000 per project in grants and/or loans. Another application process for FY2008 is hopeful.
6	Renewable Energy Production Incentive	Provides 1.5¢/kWh incentive payments for electricity produced and sold for first 10 years by qualified renewable energy generation facilities	Open to municipal utilities, rural electric cooperatives and state/local governments that sell electricity
7	Kansas State Property Tax Exemption	100% of investment is exempted from property taxes in Kansas. Does not apply to solar hot water. Kansas Statute KSA 79-102(11). http://www.dsireusa.org	Applies to residential, commercial and industrial properties

[1] Excerpted from the DSIRE database; http://www.dsireusa.org.
[2] Some of these incentives may apply to other renewable technologies, such as wind. Please refer to the Addendum for more details.

6.1 Municipal Government

Steps that may be taken by the municipal government include the following:

- Develop a city statement-of-purpose that promotes a standard for community reconstruction. Such a statement could suggest that municipal buildings should at least be built to a LEED standard, with encouragement to build to a higher standard, such as the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) that achieve 30% energy savings, or even a zero-energy building. The statement-of-purpose should also encourage commercial building owners and homeowners to build to equivalent codes and standards.
- Establish city codes governing community and individual solar access.[5]
- Implement a renewable interconnection plan that considers both PV and wind.
- Encourage the use of solar hot water systems for municipal, commercial, and residential projects.
- Rate municipal projects, e.g. the Courthouse, school and business incubator,

[5] Solar access is the availability of (or access to) unobstructed, direct sunlight. For more information and resources, see www.eere.energy.gov/consumer/renewable_energy/solar.

according to priority and the potential for incorporating energy efficiency and renewable technologies, including PV. Focus on short-term efforts to develop the one or two (depending upon available budget and other resources) highest priority projects as examples that can be followed by others.

- Establish municipal guidelines for citizens. Produce a *Greensburg Citizens' Guide to Renewable Energy* that includes these guidelines and outlines a process for initiating and completing a renewable energy project. The guide could include information specifically relating to municipal codes and ordinances. It could be distributed free-of-charge to all citizens. There are many renewable consumer guidelines available that could be used as examples.
- Spearhead a community education program that would conduct workshops to educate city workers, business owners and residents on how to implement an energy efficiency or renewable energy project and to provide realistic expectations as to the use of these technologies. Use nationally recognized experts to provide impartial information to consumers.
- Implement a priority building permitting process that would give priority to energy-efficient and renewable-powered projects. Time is money to most builders and developers, and an enhanced permitting process may provide the incentive to "go green." These types of programs have worked well in California.
- In conjunction with economic development groups, e.g. the Kiowa County Business Redevelopment Board, and service groups, e.g. Rotary Club, develop a process to attract potential sponsors to fund both municipal and private renewable projects.
- Encourage the Governor and Kansas State Legislature to pass bills that establish a state Renewable Energy Standard (RPS) providing incentives for the use of PV and other renewables.

6.2 Community Organizations

Community organizations have a very significant role to play in the reconstruction of Greensburg as a "green" community. There are at numerous major areas where they can have a substantial impact, including, but not limited to:

- Support one of the privately-funded commercial renewable-energy projects in Greensburg to ensure the project becomes an exemplary model for others to follow.
- Support the municipal government in its efforts to establish codes and ordinances for renewable use.
- Collaborate with municipal government to provide citizen workshops and other educational programs, including providing space and partial funding to conduct these workshops.
- Help to attract national sponsors to help finance renewable projects.
- Support municipal leaders' efforts to promote legislative bills that establish a state RPS that will provide incentives for the use of PV and other renewables.

7.0 Useful Websites

The following websites will be informative to homeowners, business owners and city staff interested in using PV and energy efficiency.

Glossary of Energy Terms
This section of the DOE Web site (Solar Glossary of Terms) contains helpful definitions of common and rarely used energy-related terms.
http://www1.eere.energy.gov/solar/solar_glossary.html

Photovoltaic Basics
Have you ever wondered how electricity is produced by a photovoltaic — what we often call a PV or solar electric — system? We'll help you understand by covering the basics of PV technology, which includes the underlying physics, how various PV devices are designed and become fully functional systems, and what's happening today in PV research and development.
www1.eere.energy.gov/solar/pv_basics.html

Home Power Magazine
This bimonthly magazine is full of articles and ideas for the do-it-yourselfer and contains advertisements from suppliers nationwide. www.homepower.com

National Renewable Energy Laboratory
What is renewable energy? Why is it important? And why is energy efficiency important? Visit this site for answers to these questions. You'll also find specific information for the homeowner, business owner, and farmer or rancher. http://www.nrel.gov/learning/using_re.html

Database of State Incentives for Renewable Energy (DSIRE)
This comprehensive source provides information on state, local, utility, and selected federal incentives that promote renewable energy. www.dsireusa.org

How to Build a Better Home
Learn to use solar energy and the whole-building approach to reduce your environmental impact, live comfortably, and save money. www.nrel.gov/docs/fy00osti/26582.pdf

Energy-Efficient Water Heating
Water heating constitutes 14% of the total energy consumption of residential buildings. Learn how to reduce that energy expenditure by using efficient practices.
http://www1.eere.energy.gov/solar/sh_basics_water.html

Solar Hot Water and Space Heating and Cooling
Do you have trouble telling the difference between a thermosiphon and a draindown system? Don't give it another thought. Visit this Web site and you'll soon see that these technologies are relatively easy to understand. Solar water heating is among the most practical, affordable, and durable renewable energy technologies available.
http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12850

Photovoltaics
Here's an excellent introduction to solar electricity. You'll see simple diagrams of how solar cells operate and how they are joined together to form modules and arrays. There's also a batch

of Frequently Asked Questions, which just may answer some of yours.
www.flasolar.com/photovol_main.htm

A Consumer's Guide to Buying a Solar Electric System
This booklet is designed to guide you through the process of buying a solar electric system. A solar electric system can be a substantial investment — but careful planning will help ensure that you make the right decisions. www.nrel.gov/docs/fy99osti/26591.pdf

Making the Most of Residential Photovoltaic Systems
Read this booklet to see how far you can stretch solar energy by adding energy efficiency features to your home. www.nrel.gov/docs/fy99osti/26373.pdf

Build It Solar
This site is for everyone who is interested in solar energy: what it is, whether you need it, and how and where you get it. www.builditsolar.com/Projects/PV/pv.htm

8.0 References

1. Renewable Resource Availability in Greensburg, National Renewable Energy Laboratory, Golden, CO, June 8, 2007.

2. National Solar Radiation Data Base 1961-1990, National Renewable Energy Laboratory, Golden, CO, 1992.

3. National Solar Radiation Data Base 1991-2005 Update, National Renewable Energy Laboratory, Golden, CO, June 8, 2007.

4. Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors, NREL/TP-463-5607, NREL, Golden, CO, April 1994.

Addendum
Federal and State Incentives for Solar Systems

Excerpted from the Database of State Incentives for Renewables and Efficiency (DSIRE)
(http://www.dsireusa.org)

USDA Renewable Energy Systems and Energy Efficiency Improvements Program

Incentive Type: Federal Grant Program

Eligible Efficiency Technologies: Yes; specific technologies not identified

Eligible Renewable/Other Technologies: Solar Water Heat, Solar Space Heat, Photovoltaics, Wind, Biomass, Geothermal Electric, Geothermal Heat Pumps, Hydrogen, Direct-Use Geothermal, Anaerobic Digestion, Renewable Fuels, Fuel Cells using Renewable Fuels

Applicable Sectors: Commercial, Agricultural

Amount: Grants: 25% of eligible project costs; Guaranteed loans: 50% of eligible project costs

Max. Limit: Grants: $500,000 per renewable-energy project; Guaranteed loans: $10 million

Authority 1: Farm Security And Rural Investment Act of 2002 (Sec. 9006)

Date Enacted: 5/13/2002

Effective Date: FY 2003

Expiration Date: FY 2007

Authority 2: Renewable Energy Systems and Energy Efficiency Improvements Program (Final Rule: 7 CFR 42480)

Effective Date: 7/18/2005

Website: http://www.rurdev.usda.gov/rbs/farmbill/

Summary:

Note: The deadlines for Grant Applications and Guaranteed Loan and Combined Guaranteed Loan and Grant Applications for FY 2007 have passed. This program is up for reauthorization in the 2007 Farm Bill.

Section 9006 of the 2002 Farm Bill required the U.S. Department of Agriculture (USDA) to create a program to make direct loans, loan guarantees, and grants to agricultural producers and rural small businesses to purchase renewable-energy systems and make energy-efficiency improvements. Funding in the amount of $23 million per year was appropriated for FY 2003 through FY 2007. This program is known as the *Renewable Energy Systems and Energy Efficiency Improvements Program.*

The maximum ***grant*** award is 25% of eligible project costs up to $500,000 for renewable energy projects and up to $250,000 for energy efficiency improvements. Assistance to one individual or entity is not to exceed $750,000. The minimum grant request is $2,500 for renewable energy projects and $1,500 for efficiency projects. Eligible renewable energy projects include wind, solar, biomass and geothermal; and

hydrogen derived from biomass or water using wind, solar or geothermal energy sources. Applications must be submitted to the appropriate Rural Development State Office.

Under the ***guaranteed loan*** option, funds up to 50% of eligible project costs (with a maximum project cost of $10 million) are available. The minimum amount of a guaranteed loan made to a borrower is $5,000. A combined grant and guaranteed loan under this program cannot exceed 50% of eligible project costs, and the applicant or borrower is responsible for having other funding sources for the remaining funds. The maximum percentage of guarantee ranges from 70% to 85% depending on the loan value; the percentage for a given project will be negotiated between the lender and the Rural Business-Cooperative Service. The interest rate will be negotiated between the lender and the applicant and the repayment term must not exceed 30 years for real estate, 20 years for machinery and equipment, and seven years for working capital.

The USDA has implemented this program through a Notice of Funds Availability (NOFA) for each of the last five years. The fifth round of funding was made available in March 2007 in the form of grants, guaranteed loans, and combined guaranteed loans and grant applications. Grant Applications were due May 18, 2007. Guaranteed Loans and Combined Guaranteed Loans and Grants Applications were July 2, 2007.

USDA announced in September 2007 that 345 proposals in 37 states were selected to receive a total of $18.2 million for renewable energy and energy efficiency projects as a result of the FY 2007 solicitation. Of the $18.2 million total, $13.4 million are grants and $4.8 million are guaranteed loans.

USDA Renewable Energy Systems and Energy Efficiency Improvements Program

Incentive Type: Federal Loan Program

Eligible Efficiency Technologies: Yes; specific technologies not identified

Eligible Renewable/Other Technologies: Solar Water Heat, Solar Space Heat, Photovoltaics, Wind, Biomass, Geothermal Electric, Geothermal Heat Pumps, Hydrogen, Direct-Use Geothermal, Anaerobic Digestion, Renewable Fuels, Fuel Cells using Renewable Fuels

Applicable Sectors: Commercial, Agricultural

Amount: Grants: 25% of eligible project costs; Guaranteed loans: 50% of eligible project costs

Max. Limit: Grants: $500,000 per renewable-energy project; Guaranteed loans: $10 million

Authority 1: Farm Security And Rural Investment Act of 2002 (Sec. 9006)

Date Enacted: 5/13/2002

Effective Date: 2003

Expiration Date: FY 2007

Authority 2: Renewable Energy Systems and Energy Efficiency Improvements Program (Final Rule: 7 CFR 42480)

Effective Date: 7/18/2005

Website: http://www.rurdev.usda.gov/rbs/farmbill/

Summary:

Note: The deadlines for Grant Applications and Guaranteed Loan and Combined Guaranteed Loan and Grant Applications for FY 2007 have passed. This program is up for reauthorization in the 2007 Farm Bill.

Section 9006 of the 2002 Farm Bill required the U.S. Department of Agriculture (USDA) to create a program to make direct loans, loan guarantees, and grants to agricultural producers and rural small businesses to purchase renewable-energy systems and make energy-efficiency improvements. Funding in the amount of $23 million per year was appropriated for FY 2003 through FY 2007. This program is known as the *Renewable Energy Systems and Energy Efficiency Improvements Program.*

The maximum ***grant*** award is 25% of eligible project costs up to $500,000 for renewable energy projects and up to $250,000 for energy efficiency improvements. Assistance to one individual or entity is not to exceed $750,000. The minimum grant request is $2,500 for renewable energy projects and $1,500 for efficiency projects. Eligible renewable energy projects include wind, solar, biomass and geothermal; and

hydrogen derived from biomass or water using wind, solar or geothermal energy sources. Applications must be submitted to the appropriate Rural Development State Office.

Under the ***guaranteed loan*** option, funds up to 50% of eligible project costs (with a maximum project cost of $10 million) are available. The minimum amount of a guaranteed loan made to a borrower is $5,000. A combined grant and guaranteed loan under this program cannot exceed 50% of eligible project costs, and the applicant or borrower is responsible for having other funding sources for the remaining funds. The maximum percentage of guarantee ranges from 70% to 85% depending on the loan value; the percentage for a given project will be negotiated between the lender and the Rural Business-Cooperative Service. The interest rate will be negotiated between the lender and the applicant and the repayment term must not exceed 30 years for real estate, 20 years for machinery and equipment, and seven years for working capital.

The USDA has implemented this program through a Notice of Funds Availability (NOFA) for each of the last five years. The fifth round of funding was made available in March 2007 in the form of grants, guaranteed loans, and combined guaranteed loans and grant applications. Grant Applications were due May 18, 2007. Guaranteed Loans and Combined Guaranteed Loans and Grants Applications were July 2, 2007.

USDA announced in September 2007 that 345 proposals in 37 states were selected to receive a total of $18.2 million for renewable energy and energy efficiency projects as a result of the FY 2007 solicitation. Of the $18.2 million total, $13.4 million are grants and $4.8 million are guaranteed loans.

Business Energy Tax Credit

Incentive Type: Corporate Tax Credit

Eligible Renewable/Other Technologies: Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Geothermal Electric, Fuel Cells, Solar Hybrid Lighting, Direct Use Geothermal, Microturbines

Applicable Sectors: Commercial, Industrial

Amount: For equipment placed in service from January 1, 2006 until December 31, 2008, the credit is 30% for solar, solar hybrid lighting, and fuel cells, and 10% for microturbines. The geothermal credit remains at 10%.

Maximum Incentive: $500 per 0.5 kW for fuel cells; $200 per kW for microturbines; no maximum specified for other technologies

Eligible System Size: Microturbines less than 2 MW; fuel cells at least 0.5 kW

Authority 1: 26 USC § 48

Authority 2: IRS Form 3468 (Tax Year 2006)

Summary:

The federal Energy Policy Act of 2005 (H.R. 6) expanded the federal business energy tax credit for solar and geothermal energy property to include fuel cells and microturbines installed in 2006 and 2007, and to hybrid solar lighting systems installed on or after January 1, 2006. These provisions of the tax credit were later extended through December 31, 2008, by Section 207 of the Tax Relief and Health Care Act of 2006 (H.R. 6111). (A 10% federal energy tax credit was available to businesses that invested in or purchased solar or geothermal energy property in the United States prior to January 1, 2006.)

For eligible equipment installed from January 1, 2006, through December 31, 2008, the credit is set at 30% of expenditures for solar technologies, fuel cells and solar hybrid lighting; microturbines are eligible for a 10% credit during this two-year period. For equipment installed on or after January 1, 2009, the tax credit for solar energy property and solar hybrid lighting reverts to 10% and expires for fuel cells and microturbines. The geothermal credit remains unchanged at 10%.

The credit for fuel cells is capped at $500 per 0.5 kilowatt (kW) of capacity. The maximum microturbine credit is $200 per kW of capacity. No maximum is specified for the other technologies.

Solar energy property includes equipment that uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat. Hybrid solar lighting systems are those that use solar energy to illuminate the inside of a structure using fiber-optic distributed sunlight. Geothermal energy property includes equipment used to produce, distribute, or use energy derived from a

geothermal deposit. It does **not** include geothermal heat pumps. For electricity produced by geothermal power, equipment qualifies only up to, but not including, the electrical transmission stage. Energy property does not include public utility property, passive solar systems, or pool heating equipment.

To qualify, the original use of the equipment must begin with the taxpayer or it must be constructed by the taxpayer. The equipment must also meet any performance and quality standards in effect at the time the equipment is acquired. The energy property must be operational in the year in which the credit is first taken.

If the project is financed in whole or in part by subsidized energy financing or by tax-exempt private activity bonds, the basis on which the credit is calculated must be reduced. (The formula is described in the tax credit instructions.) Subsidized energy financing means "financing provided under a federal, state, or local program, a principal purpose of which is to provide subsidized financing for projects designed to conserve or produce energy." Therefore, a business must reduce the basis for calculating the credit by the amount of any such incentives received.

Contact:

Public Information - IRS
Internal Revenue Service
1111 Constitution Avenue, N.W.
Washington, DC 20224
Phone: (800) 829-1040
Web site: http://www.irs.gov

Residential Solar and Fuel Cell Tax Credit

Incentive Type: Personal Tax Credit

Eligible Renewable/Other Technologies: Solar Water Heat, Photovoltaics, Fuel Cells, Other Solar Electric Technologies

Applicable Sectors: Residential

Amount: 30%

Maximum Incentive: $2,000 for solar electric and solar water heating; $500 per 0.5 kW for fuel cells

Carryover Provisions: Excess credit may be carried forward to succeeding tax year

Eligible System Size: Not specified

Equipment/Installation Requirements: Solar water heating property must be certified by SRCC or by comparable entity endorsed by the state. At least half the energy used to heat the dwelling's water must be from solar in order for the solar water heating property expenditures to be eligible.

Authority 1: 26 USC § 25D

Date Enacted: 8/8/2005

Effective Date: 1/1/2006

Expiration Date: 12/31/2008

Summary:

Now available: IRS Form 5695 & Instructions: Residential Energy Credits for Tax Year 2006

The Energy Policy Act of 2005 (H.R. 6, Sec. 1335) established a 30% tax credit up to $2,000 for the purchase and installation of residential solar electric and solar water heating property. An individual can take both a 30% credit up to the $2,000 cap for a photovoltaic system and a 30% credit up to a separate $2,000 cap for a solar water heating system. A 30% tax credit up to $500 per 0.5 kilowatt (kW) is also available for fuels cells. Initially scheduled to expire at the end of 2007, the tax credits were extended through December 31, 2008, by Section 206 of the Tax Relief and Health Care Act of 2006 (H.R. 6111).

Solar water heating property must be certified for performance by the Solar Rating Certification Corporation (SRCC) or a comparable entity endorsed by the government of the state in which the property is installed. Note that the tax credit does not apply to solar water heating property for swimming pools or hot tubs.

The credit is calculated based on the individual's expenditures excluding subsidized energy financing, which is defined as "financing provided under a Federal, State, or local

program a principal purpose of which is to provide subsidized financing for projects designed to conserve or produce energy." *Consumers who receive other incentives are advised to consult with a tax professional regarding how to calculate this federal tax credit.*

If the federal tax credit exceeds tax liability, the excess amount may be carried forward to the succeeding taxable year. Expenditures include labor costs for the onsite preparation, assembly, or original installation of the system and for piping or wiring to interconnect the system to the dwelling.

To be eligible for the credit, a system must be "placed in service" or activated on or after January 1, 2006, and on or before December 31, 2008. Expenditures with respect to the equipment are treated as made when the installation is completed. If the installation is on a new home, the "placed in service" date is the date of occupancy by the homeowner.

Contact:

Public Information - IRS
Internal Revenue Service
1111 Constitution Avenue, N.W.
Washington, DC 20224
Phone: (800) 829-1040
Web site: http://www.irs.gov

Modified Accelerated Cost-Recovery System (MACRS)

Incentive Type: Corporate Depreciation

Eligible Renewable/Other Technologies: Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Wind, Geothermal Electric, Fuel Cells, Solar Hybrid Lighting, Direct Use Geothermal, Microturbines

Applicable Sectors: Commercial, Industrial

Authority 1: 26 USC § 168 (2005)

Effective Date: 1986

Summary:

Under the Modified Accelerated Cost-Recovery System (MACRS), businesses can recover investments in certain property through depreciation deductions. The MACRS establishes a set of class lives for various types of property, ranging from three to 50 years, over which the property may be depreciated. For solar, wind and geothermal property placed in service after 1986, the current MACRS property class is five years. With the passage of the Energy Policy Act of 2005, fuel cells, microturbines, and solar hybrid lighting technologies are now classified as 5-year property as well. 26 USC § 168 references 26 USC § 48(a)(3)(A) with respect to classifying property as "5-year property" and EPAct 2005 added these technologies definition of energy property in § 48 as part of the business energy tax credit expansion.

For more information, see *IRS Publication 946, IRS Form 4562: Depreciation and Amortization*, and *Instructions for Form 4562*. The IRS web site provides a search mechanism for forms and publications. Enter the relevant form, publication name or number, and click "GO" to receive the requested form or publication.

Contact:

Public Information - IRS
Internal Revenue Service
1111 Constitution Avenue, N.W.
Washington, DC 20224
Phone: (800) 829-1040
Web site: http://www.irs.gov

Renewable Energy Production Incentive (REPI)

Incentive Type: Production Incentive

Eligible Renewable/Other Technologies: Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Geothermal Electric, Livestock Methane, Tidal Energy, Wave Energy, Ocean Thermal, Fuel Cells using Renewable Fuels

Applicable Sectors: Tribal Government, Municipal Utility, Rural Electric Cooperative, State/local gov't that sell project's electricity

Amount: 1.5¢/kWh (1993 dollars, indexed for inflation)

Terms: 10 years

Authority 1: 42 USCS § 13317

Date Enacted: 1992 (subsequently amended)

Authority 2: 10 CFR 451

Website: http://www.eere.energy.gov/repi

Summary:

The Renewable Energy Production Incentive (REPI) provides financial incentive payments for electricity produced and sold by new qualifying renewable energy generation facilities. Qualifying facilities are eligible for annual incentive payments of 1.5¢ per kilowatt-hour (in 1993 dollars and indexed for inflation) for the first 10-year period of their operation, subject to the availability of annual appropriations in each federal fiscal year of operation.

REPI was originally authorized under Section 1212 of the Energy Policy Act of 1992 and had expired for new projects as of September 30, 2003. However, Section 202 of the Energy Policy Act of 2005 (H.R. 6) reauthorized appropriations for fiscal years 2006 through 2026 and expanded the list of eligible technologies and facilities owners. See 42 USCS § 13317 above for the current REPI statute.

Eligible electric production facilities include not-for-profit electrical cooperatives, public utilities, state governments, Commonwealths, territories, possessions of the U.S., the District of Columbia, Indian tribal governments, or a political subdivision thereof, or Native Corporations that sell the project's electricity to someone else.

Qualifying facilities must use solar, wind, geothermal (with certain restrictions as contained in the rulemaking), or biomass (except for municipal solid waste combustion), landfill gas, livestock methane, and ocean (including tidal, wave, current, and thermal) generation technologies. Fuel cells using hydrogen derived from eligible biomass facilities are also considered an eligible technology.

If there are insufficient appropriations to make full payments for electric production from all qualified facilities for a fiscal year, 60% of appropriated funds are to be assigned to facilities that use solar, wind, ocean (including tidal, wave, current, and thermal), geothermal, or closed-loop biomass technologies; and 40% of appropriated funds for the

fiscal year to other projects.

REPI complements Sections 1914 and 1916 of the Energy Policy Act of 1992, which provide tax incentives to certain private sector entities for certain types of new renewable energy generation facilities.

For questions concerning REPI policy issues and the availability of appropriations, email repi@ee.doe.gov. The point of contact on REPI implementation (facility qualifications, applications, and payments) is Christine Carter.

Contact:

Christine Carter
U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, CO 80401-3393
E-Mail: christine.carter@go.doe.gov
Web site: http://www.eere.energy.gov/

Information Specialist - REPI
Department of Energy
Weatherization and Intergovernmental Program
Washington, DC
E-Mail:repi@ee.doe.gov
Web site: http://www.eere.energy.gov/

Renewable Energy Property Tax Exemption

Incentive Type: Property Tax Exemption
Eligible Renewable/Other Technologies: Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric
Applicable Sectors: Commercial, Industrial, Residential
Amount: 100%
Authority 2: Kansas Statutes 79-201
Effective Date: 1/1/99

Summary:

This statute exempts renewable energy equipment from property taxes. Renewable energy includes wind, solar thermal electric, photovoltaic, biomass, hydropower, geothermal, and landfill gas resources or technologies that are actually and regularly used predominantly to produce and generate electricity .

Contact:

Jim Ploger
Kansas Corporation Commission
Energy Office
1500 SW Arrowhead Road
Topeka, KS 66604-4027
Phone: (785) 271-3349
Fax: (785) 271-3268
E-Mail: j.ploger@kcc.ks.gov
Web site: http://kcc.ks.gov/energy/

D.9 Greensburg, Kansas, Biomass Resource Assessment and Opportunities for Converting and Using Fuels from Biomass

Chris Gaul
March 2008

This report examines biomass resources in Greensburg and Kiowa County and opportunities to create value-added products, including solid fuel pellets, from locally available materials.

Greensburg, Kansas, is located on the southern Great Plains. It is the county seat of Kiowa County. The local economy is based on agriculture. Annual rainfall is 23 inches. Kiowa County in 2006 harvested 23,500 acres of corn and 12,500 acres of soybeans. These crops are grown using center-pivot irrigation drawing water from the Ogallala aquifer. In 2003 there were 53,337 non-irrigated acres in the Conservation Reserve Program (CRP).

Kiowa County Biomass Resource Assessment

Southwest Kansas biomass resources are crop residue and purpose grown energy crops. Residues include corn stover, bean stubble, and wheat straw. Switchgrass is an example of a purpose grown energy crop.

The recent rapid increase in ethanol production has put pressure on corn supply. Corn prices have more than doubled since 2000. High corn prices have led to more corn acres being planted. This makes corn stover the most abundant crop residue in Kiowa County and an attractive solid biofuel resource.

Corn stover includes the stalks, leaves, and roots left in the field after grain is harvested. Stover can be gathered using hay baling equipment. Of primary concern to farmers is the affect removing stover has on soil fertility.

Jim Hettenhaus provides a detailed discussion of corn stover and soil fertility in his article, "The Carbohydrate Economy."[1]

For no-till corn fields yielding 180 bu/acre, available stover is 3.5 tons to 4.5 tons per acre using USDA Best Management Practices. Sokhansanj, Turhollow, and Perlack in 2002[2] calculated stover yield with round balers to be 1.1 tons to 1.5 tons per acre. This was done using typical hay harvest methods of cutting, windrowing, and baling.

Corncobs can be collected during grain harvest with a cob collection attachment to the combine chaff discharge chute. Corncob yields range from 1 ton to 2 tons per acre depending on the corn variety.

---

[1] J. Hettenhaus, 2002. Institute for Local Self-Reliance, Vol. 4, Issue No. 2, "The Carbohydrate Economy."

[2] S. Sokhansanj, A. Turhollow, and R. Perlack 2002. Stochastic Modeling of Costs of Corn Stover Costs Delivered to an Intermediate Storage Facility. ASAE Paper 024190 presented at 2002 ASAE Annual International Meeting/CIGR XVth World Congress.

Planting switchgrass on CRP ground yields 6 tons to 8 tons per acre. Switchgrass is a perennial that takes three years to reach full production. When managed for energy production it can be harvested one or two times per year. David Bransby of Auburn University provides a switchgrass profile in a paper with the same title. [3]

Assuming an increase in corn acres and 30% farmer participation, crop residue could be collected from 8,000 acres in Kiowa County. Table 1 shows biomass potentials for Kiowa County.

Table 1. Biomass Potentials for Kiowa County

Biomass	Low tonnage/acre	High tonnage/acre	Kiowa County tons Low	Kiowa County tons High
Corncobs	1	2	8,000	16,000
Corn stover	1.1	4.5	8,800	36,000
Switchgrass on 30% CRP ground	6	8	95,400	127,200

Converting CRP ground to switchgrass production could greatly increase biomass production in the long term. Since CRP contracts run 10 years to 15 years this change would require a decade or more to complete or a change in USDA regulations governing CRP ground.

Crop Residue Recovery Costs

Crop residues have typically been collected using hay baling equipment. This requires additional passes over the filed to cut, windrow, and bale. In 2002 Hettenhaus[1] put stover delivered to processor price at $25 per ton. A sensitivity analysis by Sokhansanj showed diesel fuel cost to have nominal impact on delivered stover price. Adjusting for higher fuel prices and 20% inflation for 2002-2009 stover delivered to Greensburg is assumed to cost $35 per ton.

Before combines became the norm, corn was harvested with corn pickers that took the entire ear from the stalk. Corn was air dried and shelled. This multistep operation accumulated mostly intact cobs in a pile. Cobs were used as feedstock to produce furfural using the Quaker Oats process or more commonly spread on roads during muddy season. Combine harvesters separate grain from cobs in one combined machine, hence the name *combine*. Cobs are ejected out the rear of combines onto the field along with leaves and chaff. At this point they are basically impossible to collect. If field collection machinery was available the cobs would be contaminated with dirt.

Cobs need to be collected before they hit the field. Two methods have been tested by combine manufacturers. One mixes grain and broken cobs in the grain tank. They are separated in a

[3] D. Branby. Auburn University, "Switchgrass Profile," (archived at ORNL Bioenergy Feedstock Development Program).

second process after the grain/cob mix is unloaded. The other method uses a towed "cob caddy" to collect cobs from the rear of the combine.

Cobco® of Nebraska City, NE, has a well developed cob collection attachment that captures corncobs at the rear of a combine and stores them in a separate top tank. Leaves and chaff are ejected to the field. The Cobco® collector does not use a towed wagon which simplifies harvest in small fields or hilly terrain. Like other cob collection methods both grain and cobs are collected in one pass over the field.

Cob collection on a large scale is a harvest problem that likely will be solved soon. Poet LLC, a large ethanol producer, is projecting its Project Liberty to come on-line in 2011. It will require corncobs from 275,000 acres to supply its cellulosic ethanol plant in Emmetsburg, Iowa. In addition to cob collection the best methods to store cobs are being developed. Cobs are harvested in the fall but ethanol production is year around. The same storage techniques will be needed for a pellet fuel plant.

Cob production costs are driven by equipment costs. Cobco® equipment, while not in serial production, is projected to cost on the order of $50,000. Amortizing over two years and harvesting 3,000 tons per year puts cob production costs at less than $10 per ton.

Liquid Fuels

Corn Ethanol

Corn ethanol production is rapidly expanding in Kansas[4] . By 2010 Kansas may have 1,300 million gallons/year of ethanol production from corn and milo. Extrapolating from existing grain consumption this will require about 500 million bushels of grain. This exceeds the 2006 Kansas crop. In 2007 corn and milo production increased to 711 million bushels. This increase was driven by higher prices for ethanol feedstock grains[5] .

The Greensburg area has corn-ethanol plants up and running. Pratt, 30 miles east, has a 55 million gallon per year (MGY) plant. Garden City, 100 miles west, also has a 55 MGY plant, and Russell 120 miles north a 48 MGY ethanol production facility.

Greensburg is as well situated as these other cities for ethanol production. It is on a railroad line, has water, grain, and natural gas. The local grain supply may become overwhelmed by ethanol demand. For example, the Gateway Ethanol plant in Pratt produces 55 MGY. Assuming 2.5 gallons/bushel corn and 200 bushels/acre irrigated corn this one plant will require 110,000 acres of corn. This is more than all the corn grown in Kiowa and Pratt Counties in 2006.

Corn ethanol production is now an established industry using mature technology. This report will not delve further into constructing a corn ethanol plant in Greensburg.

---

[4] December 21, 2007. Kansas Ethanol Clean Fuel from Kansas Farms: Kansas Ethanol Production. www.ksgrains.com/ethanol/kseth.html

[5] Eldon Thiessen. November 9, 2007. U.S. Department of Agriculture, National Statistics Service, "November Crop Estimate Shows 45% increase for Kansas Feed Grains."

Cellulosic Ethanol

Cellulosic ethanol is made from crop residues such as corn stalks (stover) and wheat straw or purpose grown energy crops such as pulp wood and switchgrass,

The appeal of cellulosic ethanol is that it does not divert food crops to energy production. Using corn stover or wheat straw to make ethanol is using a resource that typically decomposes in the field. For every ton of corn grain there is a ton of residue that a portion can be used for ethanol production. The resource is there ready to be gathered. There is no need to convert land to growing another crop.

A common concern among farmers is that removing crop residue will reduce soil fertility. While some of the crop residue returns to the soil to maintain fertility, not all of it is necessary. Studies have shown that when using no-till farming techniques, typically 50% of corn stover can be removed without adversely affecting fertility. One reason is as microorganisms decompose the stover above ground, the plant carbon goes straight to the atmosphere as CO2. It never reaches the soil to add fertility for the next crop.

Southwest Kansas is heavily irrigated using Ogallala Aquifer water. This essentially non-renewable resource has been depleted in some regions, especially the Texas Panhandle. Corn production would fall dramatically if the region had to depend on 23 inches of natural rainfall. A sustainable alternative to corn and stover for ethanol feedstock is switchgrass. This native prairie grass grows three to six feet tall. Its deep roots can tap subsoil moisture out of reach to corn plants. It is adapted to the harsh climate of the Great Plains. Switchgrass does not need irrigation or annual field preparation. It is a perennial that, like hay, yields multiple annual cuttings.

Looking to the future the demand for ethanol has really just begun. In 2000, the U.S. produced 1.63 billion gallons of ethanol. Under legislation signed December 19, 2007, the federal government is calling for 36 billion gallons by 2022, of which 21 billion gallons will be based on feedstocks other than corn. Cellulosic ethanol will surpass corn-ethanol production as the technology matures. Ten years ago corn-ethanol technology was a risky proposition. Today the risk lies in corn, ethanol, and fossil fuel prices being aligned to make a plant profitable. The engineering knowledge base has matured to the point that the technology to convert corn into ethanol is no longer risky.

The U.S. Dept. of Energy (DOE) has researched cellulosic or biomass ethanol production for 30 years at its National Renewable Energy Laboratory (NREL) and other labs. Cellulosic ethanol has moved from the lab to production facilities. In Hugoton, 125 miles west of Greensburg, Abengoa is building a 30 MGY cellulosic ethanol plant along with an 85 MGY corn plant[6].

The U.S. DOE is providing funds toward construction of six cellulosic ethanol plants. With government support and favorable market conditions cellulosic ethanol technology should develop along the same lines at corn ethanol.

Greensburg could be well situated for a cellulosic ethanol plant. It has the necessary transportation and energy infrastructure. In the near term there will be abundant residues from

[6] T. Carpenter, November 11, 2007. The Capital Journal, "Other Sources Emerge for Ethanol Creation."

grain fields feeding corn and milo ethanol plants. In the long term if irrigation water is no longer available, cellulosic ethanol plants can be supplied with switchgrass instead of corn stover.

Biodiesel

Biodiesel is produced from oilseed crops such as soybeans and canola. On December 4, 2007, Torsten Energy announced plans for a 30 MGY to 40 MGY biodiesel plant in Greensburg. The primary feedstock is expected to be soybean oil brought by railcar from Kansas processing bean plants[7].

Solid Fuels

Biomass is the original solid fuel. For thousands of years humans depended on wood fuel. Coal mining at one time was actually an environmental benefit because it reduced pressure on forests to supply fuel for the Industrial Revolution.

Greensburg and Kiowa County obviously do not have enough trees for a large firewood industry. However, there are abundant crop residues that, unlike trees, provide a harvest every year. Biomass can be converted into solid fuel with much less effort than liquid fuels.

Compacted Biomass

Biomass pressed into pellets and other forms are used for solid fuel applications. Corn stover, corncobs, wheat straw, switchgrass, and wood can be formed into an easily handled product that can be distributed in bulk or bag.

Wood pellets are widely used in forested regions such as New England and the Rocky Mountains. The pellets are made to standard specifications for size and moisture content. They are typically sold in 40 pound sacks for use in residential and light commercial heating equipment. Greensburg crop residues could be extruded into pellet fuel.

Larger than pellets are bripells. Bripells originated in Brazil where they are made from bagasse, the residue of sugarcane harvest, to fire steam boilers. Bripells are new to the American market. They are similar to pellets but are larger in diameter ranging from 1.5 to 10 inches. Bripells require 75% less energy to extrude than pellets giving them a $15/ton production cost advantage.

Biomass pellets or bripells represent a business opportunity for Greensburg. A single bripell line can produce 12-15,000 tons/year of product. It would take 4,000 acres of corn stover to supply the raw material for one bripell line.

Bripells and pellets can be produced from corncobs, corn stover, and wheat middlings. These solid fuels could be used locally to heat homes and businesses. A bulk truck could deliver pellet fuel to a storage hopper much as propane is delivered. More distant deliveries would be in conventional 40-pound sacks shipped by the pallet and truckload.

[7] M. Anderson, December 4, 2007. The Pratt Tribune, "Biodiesel in the Offing for Greensburg." http://pratttribune.com/articles/2007/12/04/news/01.eml

An export market is developing for compressed biomass pellets, bripells and briquettes. The EU is importing compressed biomass as a carbon-neutral substitute for coal. Greensburg is on a main railroad line with access to seaports. The shipping distance may be too far even by rail to keep costs low enough to compete with compressed biomass plants located near seaports.

Biomass co-firing in coal electric generating stations

Biomass can be used in conventional power plants to reduce greenhouse gas (GHG) emissions. For example, the coal-fueled 725 MW Ottumwa Generating Station in Chillicothe, Iowa is being co-fired with biomass to cut GHG. The plant will consume 200,000 tons of switchgrass per year. This energy crop will require 80,000 acres to 100,000 acres.

GHG emissions are now a consideration for Kansas electric power producers. On October 18, 2007, KDHE denied Sunflower Electric licenses to build three coal burning electric generating stations at Holcomb because they would produce 11 million tons per year of GHG.

Kiowa County in 2003, had 53,337 acres of Conservation Reserve Program (CRP) land. Based on Ottumwa area yields of 2 tons/acre this land area could produce 100,000 tons of switchgrass. In 2006 the county had 23,500 acres of corn from which another 100,000 tons of stover and cobs could be collected. Together there would be sufficient biomass to co-fire a Kansas electric generating station. While biomass could not compete with cheap coal on price alone, it represents a relatively simple way for a coal-based utility to reduce its GHG emissions. With its excellent location on the Union Pacific Railroad, Greensburg could ship compressed biomass to many coal-fired electric generating stations.

Residue collection

Crop residues are typically baled after grain is harvested. Corn will produce as much stover as grain by weight, typically 4 tons to 6 tons per acre of which half can be removed in a sustainable manner. A 130 acre circle of irrigated corn yields 260 tons to 390 tons per acre of stover.

Corncob yields vary from 1 ton to 2 tons per acre depending on what variety of corn is planted. Corncobs are difficult to collect once they are ejected from a combine onto the field. There are a few prototype cob collection systems. Cobco of Nebraska City, Nebraska, has a well developed cob collection attachment that captures corncobs at the rear of a combine and stores them in a separate top tank. This device keeps the cobs clean, does not require a separate towed wagon, and does not require additional passes over the field.

Cogeneration using biomass pellets

The simplest use for compressed biomass is to burn it. This works fine for thermal loads but is inefficient for electric generation. Community Power Corporation of Littleton, Colorado, builds Biomax modular biomass fueled generators. It converts biomass into gaseous fuel that is burned in a piston engine. In addition to electric power waste heat is captured from the engine water jacket and exhaust gas stream. Biomax systems range from 5 KW to 100 kW of electricity. They can be configured to run on most crop residues and are well-suited to compressed biomass pellets and bripells. These units require more maintenance and operation than a standard diesel or propane engine generator. Community Power says a Biomax is a 24/6 machine that requires weekly attention.

Manure

Southwest Kansas has been cattle country since the 19th century. Dodge City, 50 miles west of Greensburg, has a thriving beef packing industry supplied by numerous feedlots. All these bovines produce an abundance of the plain's original renewable energy-manure.

Handling manure in an environmentally sound manner is a serious problem for confined animal feeding operations (CAFO). E3 BioFuels of Shawnee, Kansas has developed an integrated system combining ethanol production with cattle or dairy operations. In a typical corn ethanol plant the fermentation residue, called distillers grain, is sold for cattle feed. Distillers grain is typically dried so it does not spoil during shipment using natural gas fuel. This increases ethanol cost and hurts the energy balance of fossil-fuel input versus renewable energy output.

The E3 system collects cow manure into a digester that makes methane gas to power the plant. After digestion the manure still has value as fertilizer. Distillers' grain does not have to be dried because it is produced adjacent to the feedlot and fed before it can spoil. This reduces energy demand. A properly proportioned system uses little off-site energy. It takes in corn and produces beef or milk, ethanol and fertilizer.

E3 Biofuels recently filed bankruptcy. The company states it was due to start up problems typical of any new technology plant affecting cash flow. Despite the E3 business setback, Panda Ethanol and Chippewa Valley Ethanol are working along similar lines.

Greensburg could pursue this in several ways. It could establish large cattle feeding operations combined with ethanol production. Cattle would supply the Dodge City market. Large feedlots are well known but large dairies are relatively new[8] . Instead of a few dozen Herefords, new large dairies have thousands of cows. Dairy is a growth industry in western Kansas. Kansas State University Animal Sciences and Industry had this perspective:

"Kansas has become a major dairy state during the past decade. In 1996, Kansas ranked 30th in total milk production, 29th in dairy cow numbers and 34th in milk production per cow in the U.S. About 1,000 permitted dairy herds existed in 1996. Since then, a major expansion of the dairy industry has occurred in western Kansas and in long-established dairy enterprises elsewhere in the state. At the end of 2006, Kansas ranked 17th in total milk production, 19th in dairy cows and 9th in milk production per cow. At the end of 2006, Kansas had 112,000 dairy cows on 441 permitted dairies. Kansas is considered to be a major dairy expansion state and likely will continue to expand."

Greensburg could follow this industry trend and profit from jobs associated with a dairy/ethanol plant. It could also purchase surplus electric power generated from manure.

Economics

Wood pellets are a high volume, low-margin business. According to Forest Energy Products President Rob Davis, the cost to build an optimum sized 8 ton per hour (65,000 tons per year)

[8] B. Jackson, March 4, 2007. Greeley Tribune, "Building one big barn: Dairy structure will be world's largest of its kind." bjackson@greeleytribune.com

plant processing wood into pellets is $8 million. Shipping cost for bagged product limit distribution to 300 miles from the pellet mill to market. If the truck line has a back haul, product shipping costs can be reduced.

The Pellet Fuel Institute is a trade organization that set specifications for fuel pellets. The grades are: standard, premium and super premium. Standard pellets are less than 2% ash content, premium 1%, and super premium 0.5%. Corn stover in lab tests is 1.5% ash content. This is too high for the most widely sold pellet fuel grades. High ash content produces clinkers and firing problems in residential pellet stoves.

The selling price for standard-grade pellets would be driven by natural gas prices, which is the primary source for residential heat in the Greensburg market area. Arranging for contracts with mass marketers such as Lowe's and Home Depot is highly competitive.

Bert & Wetta Sales, an alfalfa pellet mill in Larned, Kansas, has pelletized wood and some agricultural waste. They were able to do this to fill in between their main alfalfa pellet. In this case, the plant was fully amortized. A new pellet mill would have much higher costs to pay for plant equipment.

Prospects

The biomass potential in Kiowa County ranges from 8,000 tons per year to more than 100,000 tons per year. There does not seem to be a viable market for pellet fuels exported from the county. The best prospect is to use local biomass to displace fossil fuel in a local energy-intensive business. Instead of trying to enter a mass market such as wood fuel pellets, this approach would require only one or a few large customers.

Such businesses exist near Greensburg. Dodge City's meat packing plants require natural gas fuel. Ethanol plants typically use natural gas to dry distillers grain. By modifying gas boilers to burn biomass these large users could switch to a renewable fuel less prone to price increases.

The business model would be biomass, which would be collected and processed at Greensburg and shipped by truck or rail end users. At the current natural gas price of $10/million BTU, the delivered price would need to be under $130 per dry ton. An industrial plant could depend on a steady fuel cost instead of wild fluctuations.

An example of this business model is Prairie Fire BioEnergy Cooperative in Healy, Kansas. This town is similar to Greensburg in many ways. It has the same agricultural based economy, it is located on a railroad line, and has been challenged by a declining population. The Prairie Fire Coop is building a local business to produce biofuels for large users. They have entered into negotiations with Sunflower Electric to provide biofuels to co-fire in the utility's coal fired electric generating stations.[9, 10]

[9] S. Miller. 2008. Sunflower Electric Corporation. Media Release. www.sunflower.net; smiller@sunflower.net
[10] Mike Corn. October 2007. The Hays Daily News, "Biomass Looks for a Boost."

Conclusions

The barriers to converting Kiowa County crop residues into pellet stove fuel are high ash content, substantial startup costs, low profit margin and distant markets.

Biomass could be converted into a lower grade industrial fuel for large users such as meat packinghouses or ethanol plants. It could be co-fired with coal in electric generating stations. With Greensburg's transportation connections biomass fuel could be shipped by rail or truck to Kansas markets. If Greensburg develops and industrial park the biomass processing plant could provide heat to the park and solid fuels to export outside Kiowa County.

Recommendation

Greensburg business leaders should contact Prairie Fire Coop and see if a similar business could be established in Greensburg.

Contacts

Prairie Fire BioEnergy Cooperative of Healy, Kansas is a non-profit, producer owned, cooperative founded to support the development of renewable biomass energy sources in western Kansas. Prairie Fire will manufacture a biomass fuel for use in industrial furnace and electrical power generation. Ingredients in their biosolid fuel are renewable biomass inputs such as baled hay, out of condition hay, seed hulls, crop stubble, and other products. Visit Prairie Fire's website at: http://www.prairiefirecoop.com/
Media Contact**:** Brad Applegarth – Telephone 620. 398.2370
Email: info@prairiefirecoop.com

Equipment suppliers

Earth Care Products Inc.
P.O. Box 787
800 N. 21st Street
Independence, KS 67301
(620) 331-0090
(620) 331-0095 FAX
ecpi@ecpisystems.com
www.ecpisystems.com

Bripells

LA Consultants

Paul Nikitovitch
pnikitovich@laconsultants.info
Business (303) 789-3195

D.10 Biomass Pellet Options for Greensburg and Surrounding Regions

Scott Haase
National Renewable Energy Laboratory

National Renewable Energy Laboratory
Innovation for Our Energy Future

Biomass Pellet Options for Greensburg and Surrounding Regions



Scott Haase

February 11, 2009

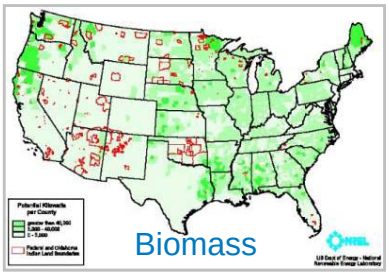
Greensburg, KS

NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC

Presentation Outline

- Project goal and objectives
- Product definition
- Biomass resource assessment
  - Quantity, cost, characteristics
- Market demand
  - Comparative costs of various fuels
  - Regional natural gas use
  - Potential customers
- Equipment
  - Pellets and conversion appliances
- Suggested next steps





Project Goal and Objectives

Goal

- Identify and evaluate opportunities to create a pellet plant in or around Greensburg

Objectives

- Understand the local biomass resource base
- Assess characteristics of pellets made from local feedstocks
- Understand economics of the process
- Assess the local market and potential demand
- Suggestions for next steps

Product definition

Ag residue and wood blend pellets (or briquettes, bripells)

- Similar to pellets made by Show Me Energy Co-operative of Centerview, MO
  - 7,000 – 7,500 Btu/lb
  - High ash (between 3 and 10 percent)
  - High alkalis (leads to slagging)
- Pellet market is presently dominated by low ash, low alkali products – “premium pellets”
- Classic “chicken and egg” problem to develop this opportunity



Business Overview

- Procure local biomass feedstocks
- Densify at centralized plant
- Provide bulk delivery to local and regional customers
- Local customers burn pellets instead of fossil fuels for thermal energy needs









Local Biomass Resources and Issues







Wood Residues
Eastern Red Cedar

Agricultural Residues
Corn stover
Wheat straw
Sorghum residue
Soybean residues

Energy Crops
Convert CRP land to switchgrass

Cost
- Production
- Collection and transportation
- Quantity available
- Supply infrastructure
- Storage

Sustainability
- Land, air and water resources

Quality
- Composition

Ease of Conversion

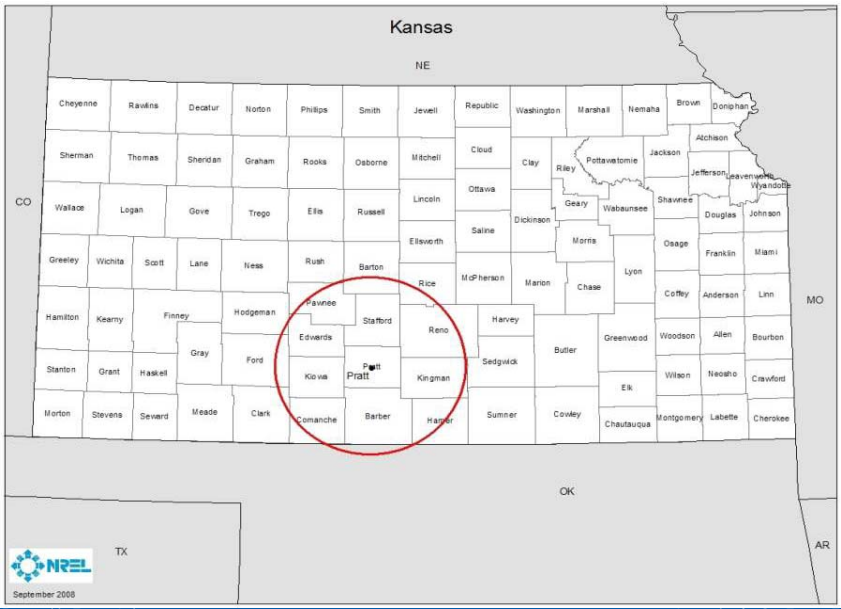
Others
Landfill gas, manure
Municipal solid waste
Not considered



50 Mile Radius from Greensburg



50 Mile Radius from Pratt



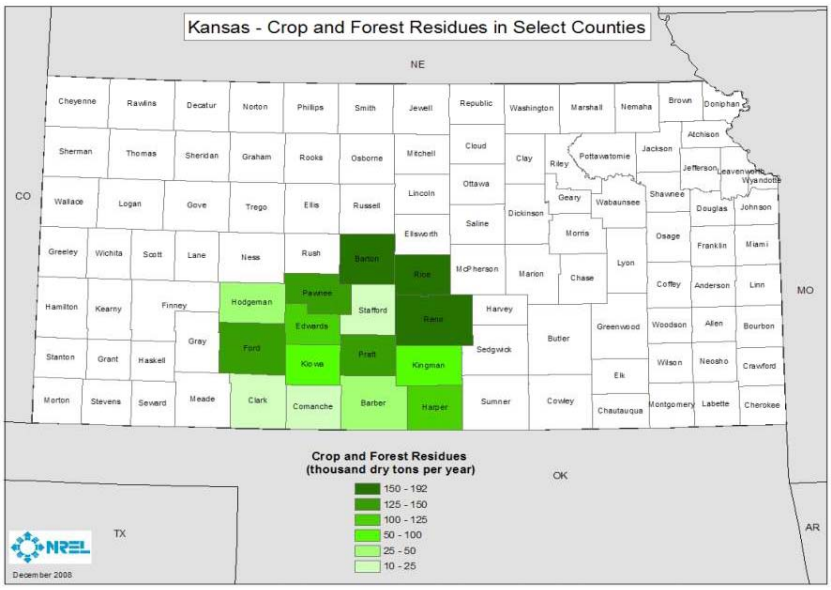
Biomass Assessment - Methodology

- Developed list of counties within 50 miles of Pratt and Greensburg
- Obtained 10 years worth of data from USDA National Agricultural Statistics Service
  - Calculated 10 year averages of acres planted, acres harvested, crop yield
- Calculated residue quantities based on crop production
- Calculated "residue leave" factors for nutrient cycling and erosion protection
  - Cotton, sorghum, soybeans > assume 35% is available
  - Corn, wheat > based on factors by Richard Nelson, Kansas State University

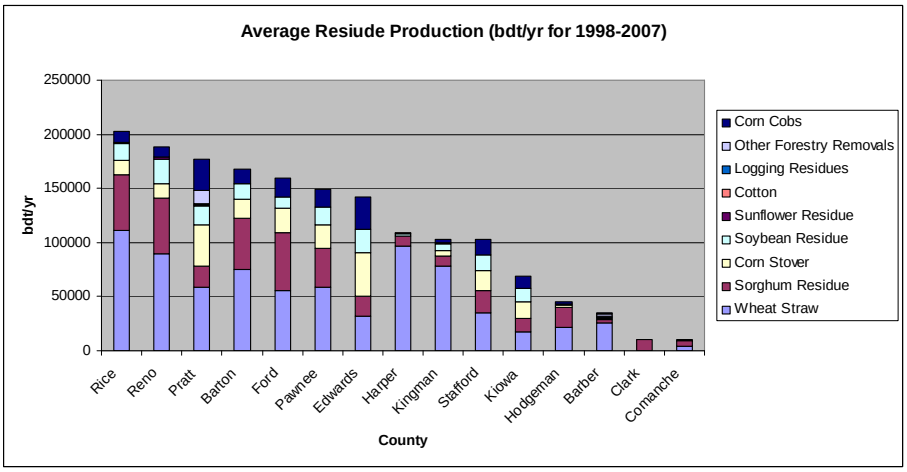
Summary of Major Residues in Region

	Residues Available (bdt/yr)									
County	Wheat	Corn	Sorghum	Soybean	Sunflower	Cotton	Logging Residues	Other Forestry Removals	Corn Cobs	Total
Barber	25,283	407	4,004	1,337	46	210	161	2,818	623	34,888
Barton	74,604	17,556	47,399	14,320	222	-	22		14,760	168,882
Clark	469		9,681	345	-	-	-		218	10,713
Comanche	3,835	285	5,357	627	-	-	-		450	10,554
Edwards	31,955	39,921	18,599	21,961	60	-	-		31,913	144,409
Ford	55,368	22,632	53,883	10,214	136	-	-		21,533	163,765
Harper	96,815	146	9,270	1,821	65	436	0		135	108,687
Hodgeman	21,536	2,228	18,130	1,287	-	-	-		4,200	47,380
Kingman	78,586	5,270	8,869	6,458	185	-	-		3,810	103,177
Kiowa	17,281	15,562	12,205	12,255	24	-	-		15,113	72,438
Pawnee	59,127	21,710	35,327	16,494	52	-	-		18,915	151,626
Pratt	58,679	38,472	19,270	17,711	377	1,122		12,500	33,533	181,663
Reno	89,693	13,495	51,240	22,829	1,253	-	15		13,118	191,642
Rice	111,254	14,194	50,816	15,130	931	-	24		8,190	200,539
Stafford	35,258	18,182	20,366	14,845	85	-	-		31,935	120,670
Total	**759,742**	**210,058**	**364,416**	**157,632**	**3,435**	**1,768**	**222**	**15,318**	**198,443**	**1,711,034**

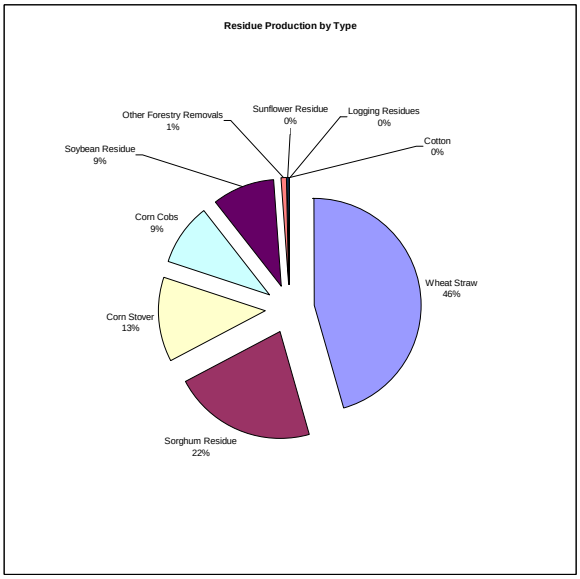
Residue Distribution



Residue Distribution by County



Residue Production, by Type



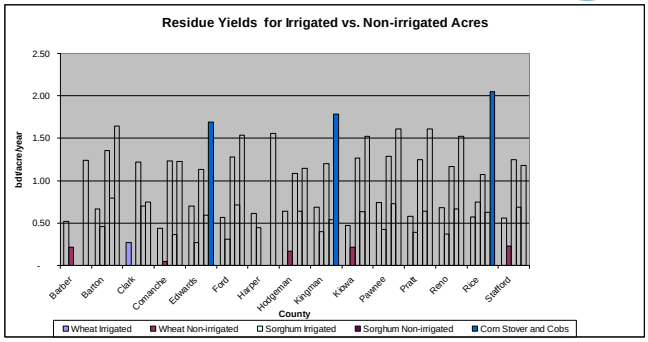
Corn, Wheat, and Sorghum

County	Wheat (bdt/yr)			Sorghum Residues (bdt/yr)			Corn (bdt/yr)			Total
	Irrigated	Non-irrigated	Total	Irrigated	Non-irrigated	Total	Irrigated	Non-irrigated	Total	
Barber	881	24,401	25,283	-	-	4,004	407	-	407	29,694
Barton	795	73,809	74,604	2,965	23,686	47,399	17,556	-	17,556	139,559
Clark	469	-	469	232	4,313	9,681	-	-	-	10,150
Comanche	979	2,856	3,835	443	899	5,357	285	-	285	9,477
Edwards	9,198	22,757	31,955	3,490	9,488	18,599	39,921	-	39,921	90,476
Ford	8,846	46,522	55,368	12,791	41,092	53,883	22,632	-	22,632	131,882
Harper	18	96,797	96,815	-	-	9,270	146	-	146	106,231
Hodgeman	5,167	16,369	21,536	2,911	13,951	18,130	2,228	-	2,228	41,893
Kingman	3,746	74,840	78,586	825	3,450	8,869	5,270	-	5,270	92,725
Kiowa	4,025	13,256	17,281	2,569	5,239	12,205	15,562	-	15,562	45,047
Pawnee	9,040	50,087	59,127	5,898	18,477	35,327	21,710	-	21,710	116,165
Pratt	6,375	52,304	58,679	2,895	8,558	19,270	38,472	-	38,472	116,420
Reno	5,528	84,165	89,693	3,424	29,647	51,240	13,495	-	13,495	154,428
Rice	658	110,596	111,254	824	9,894	50,816	14,194	-	14,194	176,264
Stafford	7,116	28,142	35,258	2,985	10,960	20,366	18,182	-	18,182	73,805
Total	62,841	696,901	759,742	42,252	179,653	364,416	210,058	-	210,058	1,334,216

County	Irrigated Corn Acres	Non-irrigated Corn Acres	Total Corn Acres	Irrigated Sorghum Acres	Non-irrigated Sorghum Acres	Total Sorghum Acres	All Irrigated Wheat Acres	All Non-irrigated Wheat Acres	Total Wheat Acres
Barber	830	610	2,300	0	0	8,030	1,690	112,340	114,030
Barton	19,680	6,640	26,320	2,190	29,770	55,230	1,190	160,470	161,660
Clark	290	90	1,030	190	6,150	14,910	1,720	57,230	58,950
Comanche	600	140	1,260	360	2,450	9,800	2,240	60,060	62,300
Edwards	42,550	8,850	62,370	3,080	15,920	26,300	13,110	84,440	97,550
Ford	28,710	1,900	46,860	9,990	57,700	67,690	15,540	150,570	166,110
Harper	180	250	1,080	0	0	16,300	30	218,790	218,820
Hodgeman	5,600	1,510	9,680	2,680	21,800	26,100	8,080	96,690	104,770
Kingman	5,080	1,440	7,950	690	6,380	14,970	5,460	187,270	192,730
Kiowa	20,150	4,440	27,610	2,030	8,270	16,710	8,540	60,720	69,260
Pawnee	25,220	3,900	31,400	4,580	25,330	42,760	12,170	118,640	130,810
Pratt	44,710	8,650	59,780	2,320	13,420	27,440	11,040	134,620	145,660
Reno	17,490	7,860	25,350	2,930	44,360	71,870	8,130	225,930	234,060
Rice	10,920	10,770	21,690	770	15,760	59,820	1,150	147,870	149,020
Stafford	42,580	18,870	61,450	2,400	15,910	27,210	12,780	123,420	136,200
Total	264,590	75,920	386,130	49,100	339,970	578,040	158,790	2,108,690	2,267,480

Residue Yields Per Acre

County	Wheat (bdt/acre)			Sorghum Residues (bdt/acre)			Corn (bdt/acre)
	Wheat Irrigated	Wheat Non-irrigated	Wheat Total	Sorghum Irrigated	Sorghum Non-irrigated	Sorghum Total	Corn Stover and Cobs
Barber	0.52	0.22	0.22			0.50	1.24
Barton	0.67	0.46	0.46	1.35	0.80	0.86	1.64
Clark	0.27	-	0.01	1.22	0.70	0.65	0.75
Comanche	0.44	0.05	0.06	1.23	0.37	0.55	1.23
Edwards	0.70	0.27	0.33	1.13	0.60	0.71	1.69
Ford	0.57	0.31	0.33	1.28	0.71	0.80	1.54
Harper	0.61	0.44	0.44			0.57	1.56
Hodgeman	0.64	0.17	0.21	1.09	0.64	0.69	1.15
Kingman	0.69	0.40	0.41	1.20	0.54	0.59	1.79
Kiowa	0.47	0.22	0.25	1.27	0.63	0.73	1.52
Pawnee	0.74	0.42	0.45	1.29	0.73	0.83	1.61
Pratt	0.58	0.39	0.40	1.25	0.64	0.70	1.61
Reno	0.68	0.37	0.38	1.17	0.67	0.71	1.52
Rice	0.57	0.75	0.75	1.07	0.63	0.85	2.05
Stafford	0.56	0.23	0.26	1.24	0.69	0.75	1.18
Average	**0.51**	**0.26**	**0.28**	**1.05**	**0.52**	**0.58**	**1.47**



Highest yields per acre come from irrigated corn and irrigated sorghum

Eastern Red Cedar

- Important regional feedstock for pellet plant
- Will be needed to blend with ag residues to reduce ash and alkali content
- May be the limiting factor on the size of the plant
- Don Queal estimates at least 25,000 green tons per year could be collected





CRP Land Conversion

- Potential to convert CRP lands to switchgrass
- 4.5 bone dry tons (bdt)/acre/yr yield
- Assume 10% of CRP land is converted
- 120,000 bdt/year
- Switchgrass is not a great feedstock for pellets (more later)
- Another approach being done in MN is to grow mixed prairie grasses for feedstock – higher yields than switchgrass

County	CRP Acres
Kiowa	53,337
Comanche	43010
Clark	52,114
Barber	21,018
Pratt	47,750
Ford	59,469
Edwards	34,101
Total	**310,799**

Corn Cobs

- Poet Ethanol is implementing cob collection in Iowa for cellulosic ethanol
  - Working with equipment vendors (John Deere) to develop process
- We estimate 0.75 bdt/acre from irrigated lands
- About 200,000 bdt/year in region



County	Irrigated Corn Acres	Non-irrigated Corn Acres	Total Corn Acres
Barber	830	610	2,300
Barton	19,680	6,640	26,320
Clark	290	90	1,030
Comanche	600	140	1,260
Edwards	42,550	8,850	62,370
Ford	28,710	1,900	46,860
Harper	180	250	1,080
Hodgeman	5,600	1,510	9,680
Kingman	5,080	1,440	7,950
Kiowa	20,150	4,440	27,610
Pawnee	25,220	3,900	31,400
Pratt	44,710	8,650	59,780
Reno	17,490	7,860	25,350
Rice	10,920	10,770	21,690
Stafford	42,580	18,870	61,450
Total	264,590	75,920	386,130

Overall Resource Potential

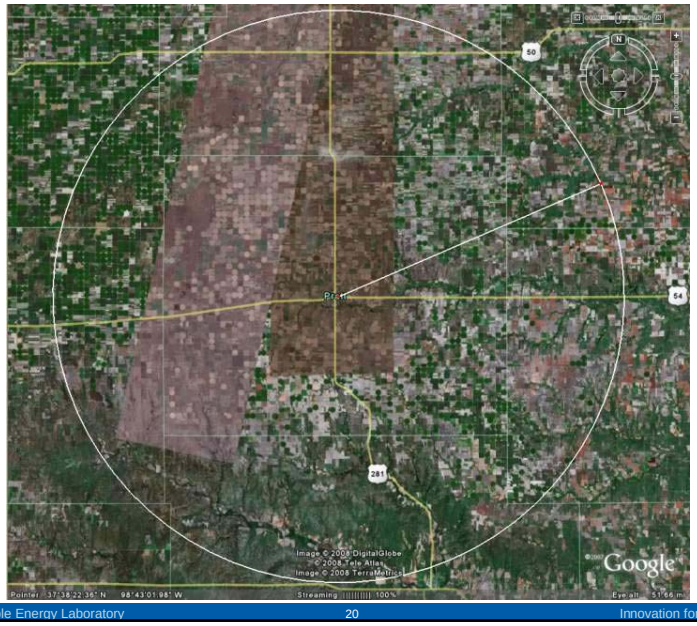
Feedstock	Bone dry tons/year	Energy equivalent (MMBtu/yr)	Equivalent Therms/yr
Agricultural residues	1,497,051	23,054,588	230,545,879
Cedar and other wood	15,540	273,501	2,735,014
10% CRP Land	120,000	1,752,000	17,520,000
Corn cobs	198,000	3,168,000	31,680,000
Total	**1,830,591**	28,248,089	282,480,893

Average natural gas use of 280,000 homes

	BDT/yr within 25 Mile Radius				BDT/yr within 50 mile radius			
	Crop Residues	Logging and Primary Mill Residues	Urban Wood and Secondary Mill Residues	Total	Crop Residues	Logging and Primary Mill Residues	Urban Wood and Secondary Mill Residues	Total
Pratt	199,100	16,755	1,470	217,325	1,320,000	16,777	9,363	1,346,140
Greensburg	266,200	-	-	266,200	1,100,000	16,755	7,480	1,124,235

- There should be at least 3x the resource above the needs of the plant
- To keep biomass collection costs low, estimate pellet plant should be no larger than 70k – 80k tons/yr input, which will be 50k – 70k tons output, depending on moisture content
- **But the plant size may be limited by cedar resource base (more later)**

25 Mile Radius from Pratt



So Why Is Yield Important?

Assume access to 25,000 bdt/yr cedar, and we want a 50-50 blend of wood and ag residues

How much land area is needed for 25,000 bdt/yr ag residues?

Feedstock Type	Acres Needed/yr	Sections	Number of Center Pivot Circles (126 acre)
Irrigated Wheat	48,804	76	387
Non-irrigated Wheat	95,907	150	
Irrigated Sorghum	23,756	37	189
Non-irrigated Sorghum	47,972	75	
Irrigated Corn Stover	34,654	54	275
Corn cobs from irigated corn	33,333	52	265
Half corn stover/half cob	16,997	27	135
Switchgrass @ 5 bdt/acre	5,000	8	40

Biomass Physical And Chemical Properties

Value	Wheat Straw	Freshly Cut Cedar	Seasoned Cedar	SMEC Pellets
Btu content as received HHV (Btu/lb)	7,125	8,143	8,056	7,059
Btu content bone dry (Btu/lb)	7,709	8,827	8,976	7,680
Moisture content as received (%)	7.57	7.75	10.25	8.09
Percentage Ash (%)	7.83	1.63	0.88	9.04
Lbs Alkali/Mmbtu	1.3	0.08	0.05	1.44
Lbs ash/MMBtu	10.99	2.00	1.09	12.81
Potassium in ash as K2O (%)	11.4	3.25	4.55	10.8

- Ag residues are high in ash and alkalis, moderate energy content
- Values greater than 0.4 lbs alkali/MMBtu have been found to lead to significant risks for slagging and forming clinkers in boilers
- Cedar is highest quality feedstock in the region and likely needs to be blended with ag residues to create quality pellet

Biomass Collection Costs ($/bdt)

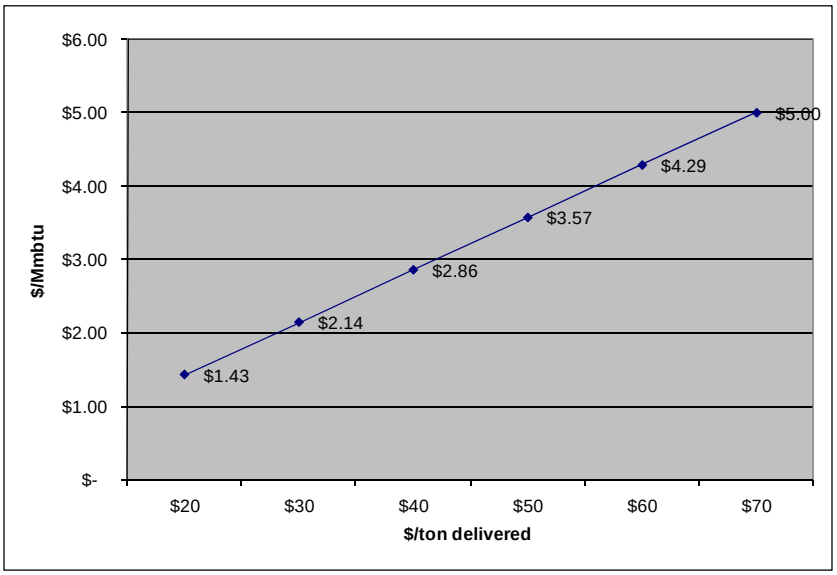
Feedstock	Source	Delivered Cost ($/bdt)
Corn stover (500 to 2000 bdt/day)	ORNL, 2002	**$52.00 - $56.00** (in 2008 $)
Corn stover	CARD, 2007	**$68.50** ($58.26 per 15% moisture content ton)
Corn stover	Campbell	**$61.52**
Soybean straw	Campbell	**$40.70**
Wheat straw	Campbell	**$62.90**

- Feedstock is 40% - 60% of pellet cost (cost of making pellets is $80 - $120 ton)
- Cost must be low for pellet mill, but high enough for producers to participate

Interview With Local Producer

- $20 - cost to bale the straw (summer 2008)
- $5 - to get it to roadside
- $5 - bale profit
- $5 - bale transportation ($0.25/mile for 20 miles)
- $7 - bale loading and unloading for hauler
- Total $42/bale
  - Assume 5 ft x 6 ft round bale weighs 0.75 ton
  - Equates to **$56/green ton delivered ($67 bdt)**
- Show Me Energy states that paying more than $60/ton makes economics very tough

Biomass Feedstock Costs ($/MMBtu)

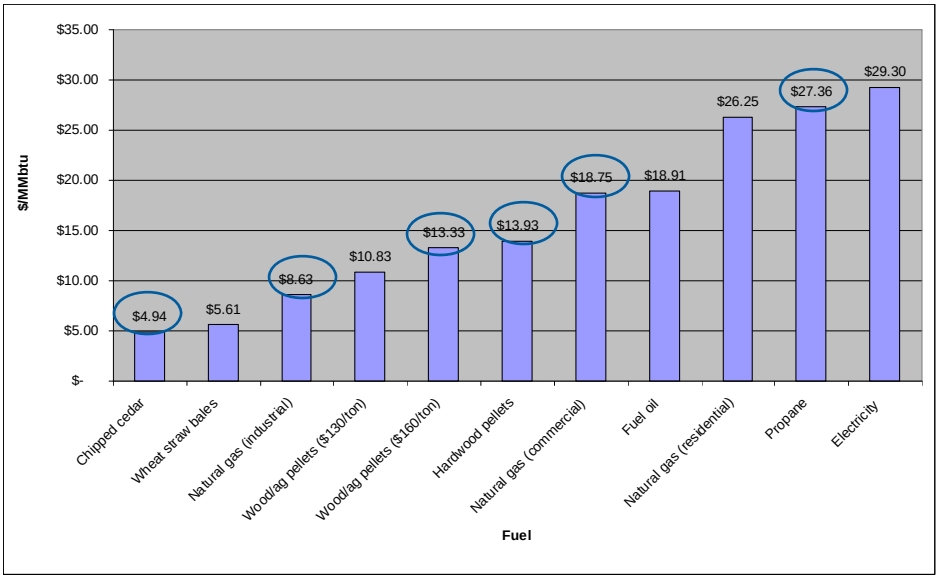


Cost Comparison of Various Fuels

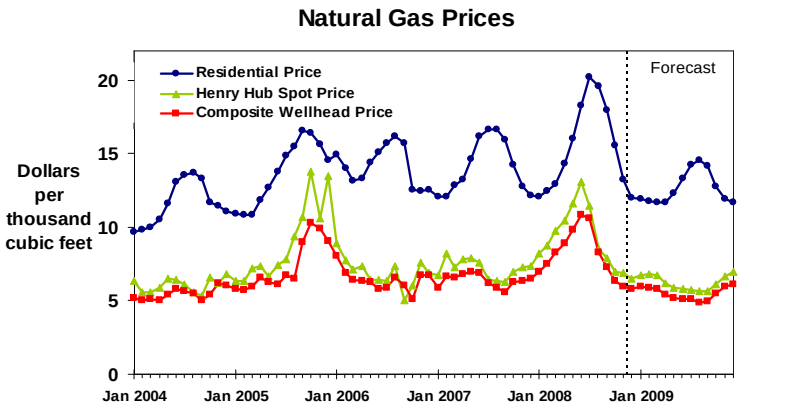
Source	Units	Cost to User ($)	Efficiency	Btu/unit	$/MMBtu
Chipped cedar	$/green ton	$ 50.00	75%	13,500,000	$ 4.94
Wheat straw bales	$/ton	$ 55.00	70%	14,000,000	$ 5.61
Natural gas (industrial)	$/therm	$ 0.69	80%	100,000	$ 8.63
Wood/ag pellets ($130/ton)	$/ton	$ 130.00	80%	15,000,000	$ 10.83
Wood/ag pellets ($160/ton)	$/ton	$ 160.00	80%	15,000,000	$ 13.33
Hardwood pellets	$/ton	$ 185.00	80%	16,600,000	$ 13.93
Natural gas (commercial)	$/therm	$ 1.50	80%	100,000	$ 18.75
Fuel oil	$/gallon	$ 2.17	85%	135,000	$ 18.91
Natural gas (residential)	$/therm	$ 2.10	80%	100,000	$ 26.25
Propane	$/gallon	$ 2.13	85%	91,600	$ 27.36
Electricity	$/kWh	$ 0.10	100%	3,413	$ 29.30

This table and chart on next page accounts for appliance efficiency, hence this is the delivered cost to the building

Various Fuel Costs ($/MMBtu)



U.S. Natural Gas Price – 5-Year History



Short-Term Energy Outlook, December 2008

- EIA projects 2009 natural gas price to average $6.25/MMBtu
- Current wholesale natural gas price (2/10/09) = $4.54/MMBtu (NYMEX March Futures Contract)

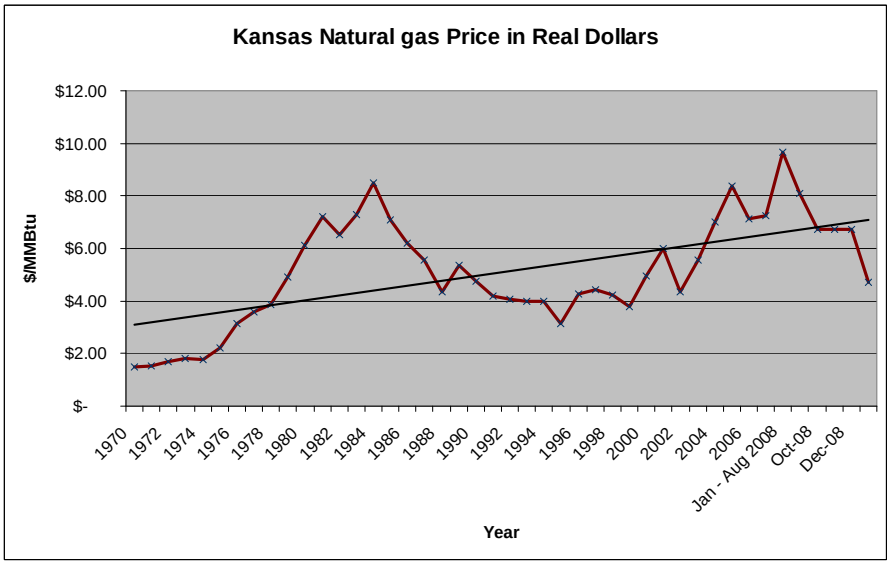
2008 Average Kansas Gas Prices

Sector / $/MMBtu	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08
Residential Price	15.29	17.14	22.41	23.81	24.90	21.82	18.73
Commercial Price	14.57	15.71	18.61	19.11	19.32	17.54	15.15
Industrial Price	9.30	9.64	10.09	11.09	10.11	8.35	6.95
Electric Power Price	10.22	10.98	11.65	10.85	8.97	6.67	N/A

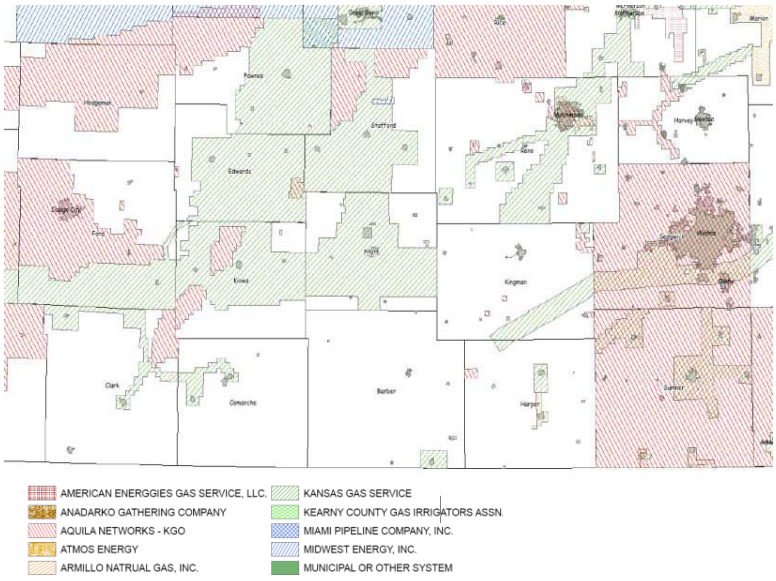
Source: U.S. DOE, EIA

- Industrial users pay the lowest cost
- Commercial and residential are best targets
- Steady downward trend since August 2008

Kansas Gas Prices – 38 Year History



Regional Gas Providers



Regional Gas Use by Customer Type

	RESIDENTIAL			COMMERCIAL			INDUSTRIAL			Total	
County	Therms	# of Users	Average Use	Therms	# of Users	Average Use	Therms	# of Users	Average Use	Therms	# of Users
Barber	1,040,442	1,481	702	391,788	256	1,532	0	0	0	1,432,230	1,737
Clark	576,868	777	743	181,722	133	1,366	233,991	7	33,427	992,581	917
Comanche	457,942	626	732	266,810	128	2,089	0	0	0	724,752	753
Edwards	691,173	911	758	500,976	188	2,660	142,831	16	8,927	1,334,980	1,116
Ford	6,609,854	10,616	623	4,433,399	1,071	4,139	14,841,118	189	78,524	25,884,371	11,876
Kingman	1,354,386	1,990	680	588,138	306	1,919	180,679	5	35,543	2,123,203	2,302
Kiowa	634,912	689	922	285,830	135	2,111	408,839	37	11,050	1,329,581	861
Pawnee	1,528,536	2,029	753	529,844	256	2,069	169,351	8	21,169	2,227,731	2,293
Prattt	2,386,993	3,201	746	1,498,291	487	3,074	234,771	18	13,043	4,120,055	3,706
Reno	13,864,507	20,655	671	4,683,720	1,907	2,457	23,068,579	27	854,392	41,616,806	22,588
Sedgwick	106,217,438	162,805	652	34,022,082	12,565	2,708	11,267,245	75	150,230	151,506,766	175,445
Stafford	1,032,418	1,348	766	398,222	257	1,549	84,910	9	9,434	1,515,550	1,615
Total	**136,395,468**	**207,128**		**47,780,823**	**17,690**		**50,632,314**	**391**		**234,808,605**	**225,209**

- Not every user is captured – some are on wellhead gas
- Sedgwick dominates the user base (65% of the use, 77% of the customers)
- Reno, Ford, and Sedgwick dominate industrial usage
- Sedgwick dominates commercial usage

“Pellet Equivalents” of Regional Natural Gas Use

	RESIDENTIAL			COMMERCIAL			INDUSTRIAL			Total	
County	Tons	# of Users	Average Use	Tons	# of Users	Average Use	Tons	# of Users	Average Use	Tons	# of Users
Barber	7,432	1,481	5.02	2,798	256	10.95	0	0		10,230	1,737
Clark	4,120	777	5.30	1,298	133	9.76	1,671	7	238.77	7,090	917
Comanche	3,271	626	5.23	1,906	128	14.92	0	0		5,177	753
Edwards	4,937	911	5.42	3,578	188	19.00	1,020	16	63.76	9,536	1,116
Ford	47,213	10,616	4.45	31,667	1,071	29.56	106,008	189	560.89	184,888	11,876
Kingman	9,674	1,990	4.86	4,201	306	13.71	1,291	5	253.88	15,166	2,302
Kiowa	4,535	689	6.59	2,042	135	15.08	2,920	37	78.93	9,497	861
Pawnee	10,918	2,029	5.38	3,785	256	14.78	1,210	8	151.21	15,912	2,293
Prattt	17,050	3,201	5.33	10,702	487	21.96	1,677	18	93.16	29,429	3,706
Reno	99,032	20,655	4.79	33,455	1,907	17.55	164,776	27	6,102.80	297,263	22,588
Sedgwick	758,696	162,805	4.66	243,015	12,565	19.34	80,480	75	1,073.07	1,082,191	175,445
Stafford	7,374	1,348	5.47	2,844	257	11.06	606	9	67.39	10,825	1,615
Total	**974,253**	**207,128**		**341,292**	**17,690**		**361,659**	**391**		**1,677,204**	**225,209**

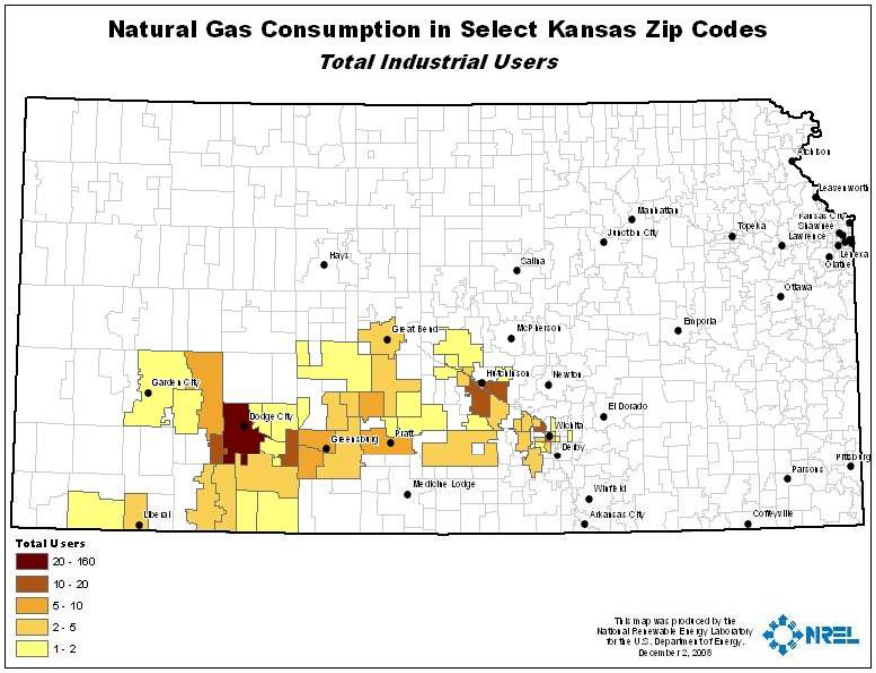
Remember, total biomass resource base was about 1.8 Million bdt/yr

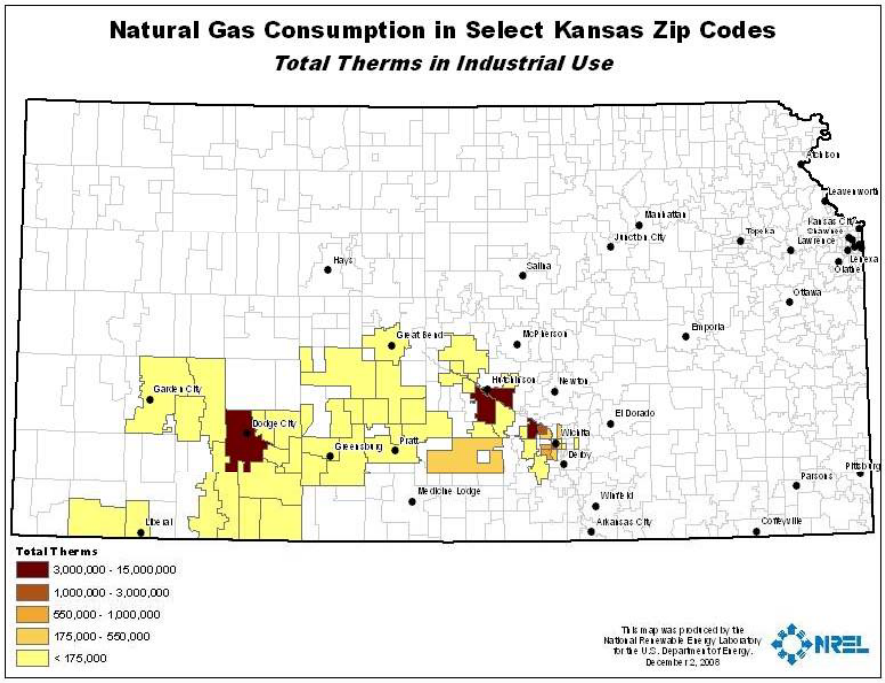
Counties within 25 miles of Greensburg

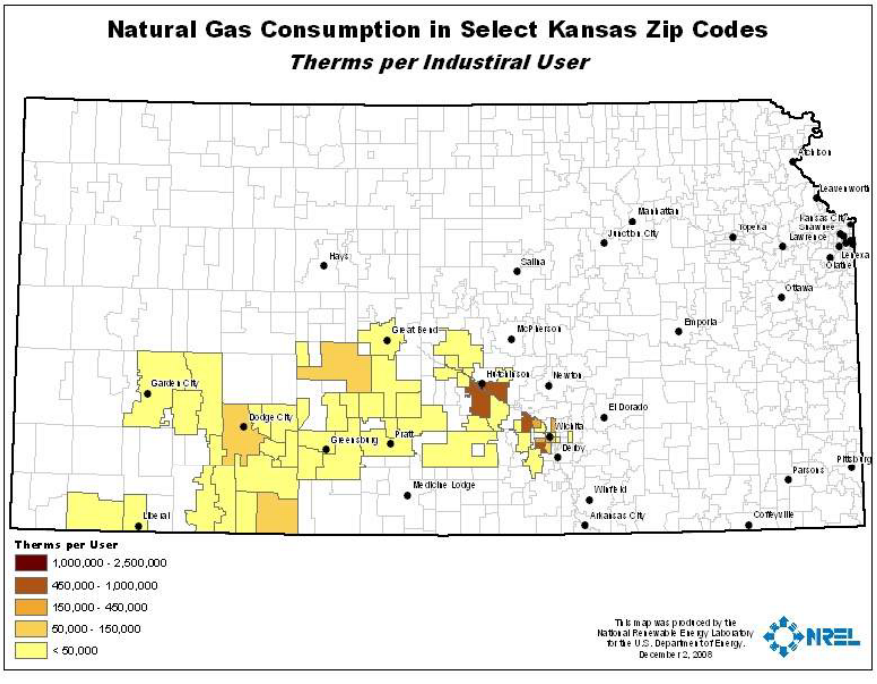
County	Residential	Commercial	Industrial	Total
Barber	7,432	2,798	N/A	10,230
Clark	4,120	1,298	1,671	7,090
Comanche	3,271	1,906	N/A	5,177
Edwards	4,937	3,578	1,020	9,536
Ford	47,213	31,667	106,008	184,888
Kiowa	4,535	2,042	2,920	9,497
Prattt	17,050	10,702	1,677	29,429
Total	88,558	53,992	113,297	255,847

Counties within 25 miles of Pratt

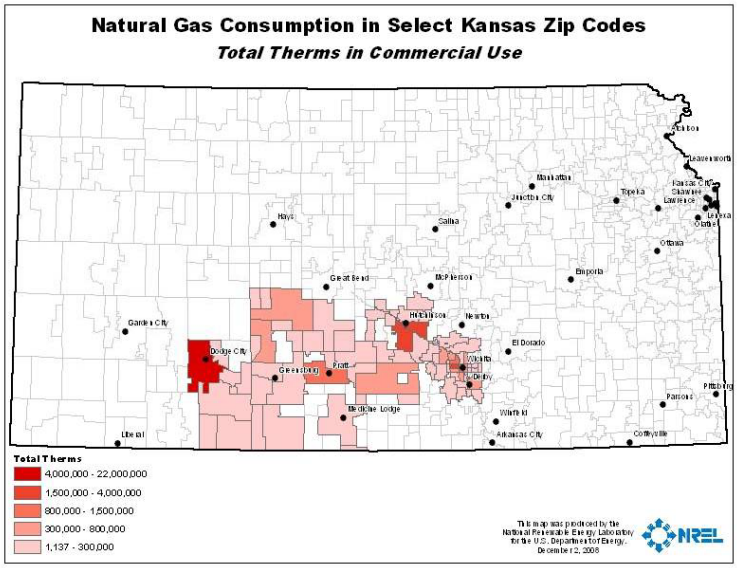
County	Residential	Commercial	Industrial	Total
Barber	7,432	2,798	N/A	
Edwards	4,937	3,578	1,020	9,536
Kingman	9,674	4,201	1,291	15,166
Kiowa	4,535	2,042	9,497	16,074
Prattt	17,050	10,702	29,429	57,181
Reno	99,032	33,455	297,263	429,750
Stafford	7,374	2,844	10,825	21,044
Total	150,035	59,621	349,325	558,981



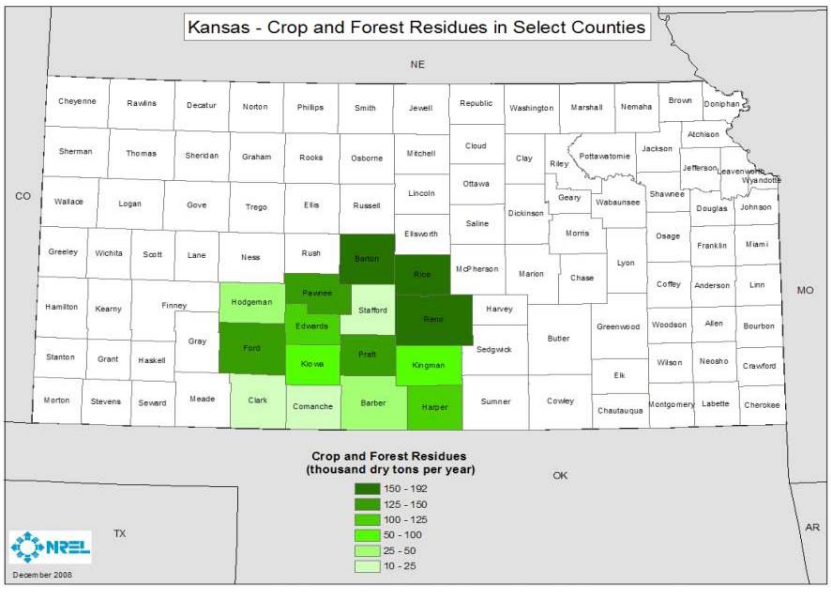

Natural Gas Consumption in Select Kansas Zip Codes
Total Therms in Industrial Use
Hays
Salina
Manhattan
Junction City
Topeka
Kansas City
Lawrence
Leavenworth
Ottawa
Emporia
Great Bend
McPherson
Hutchinson
Newton
Garden City
Dodge City
El Dorado
Wichita
Derby
Greensburg
Pratt
Medicine Lodge
Winfield
Arkansas City
Coffeyville
Parsons
Liberal
Total Therms
3,000,000 - 15,000,000
1,000,000 - 3,000,000
550,000 - 1,000,000
175,000 - 550,000
< 175,000
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.
December 2, 2008
NREL


Natural Gas Consumption in Select Kansas Zip Codes
Therms per Industiral User
Hays
Salina
Manhattan
Junction City
Topeka
Kansas City
Lawrence
Leavenworth
Ottawa
Emporia
Great Bend
McPherson
Hutchinson
Newton
Garden City
Dodge City
El Dorado
Wichita
Derby
Greensburg
Pratt
Medicine Lodge
Winfield
Arkansas City
Coffeyville
Parsons
Liberal
Therms per User
1,000,000 - 2,500,000
450,000 - 1,000,000
150,000 - 450,000
50,000 - 150,000
< 50,000
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.
December 2, 2008
NREL

Same Patterns for Commercial Sector



Residue Distribution



Competitor Analysis – Show Me Energy Co-op (SMEC), Centerview, MO

- First large-scale plant of its kind that we know of
- About 240 miles from Wichita
- Producing 30k tons/yr now; capacity of 60k
- 50-50 blend of ag (straw, old hay) and wood
- 7,000 Btu/lb, 1.4 lbs alkali/MMBtu and 9% ash [Pellet Fuels Institute (PFI) utility grade pellet]
- Selling for $130 FOB plant ($9/MMBtu)
- Also selling un-pelletized biomass
- Appliances that use these pellets need to handle high ash and slagging
- Target market appears to be large coal-fired utilities





Ozark Hardwood Products, Seymour, MO

- Closest hardwood (super-premium) supplier to the region (~400 miles to Greensburg, 300 to Wichita)
- 8,000 Btu/lb and < .5% ash, low alkalis
- $130 FOB plant, $55 bulk freight to Greensburg ($10.80/MMbtu)
- Only 60 cents more than wood-ag pellets at $160/ton ($10.20/MMBtu)
- Providing customers with packaged furnaces in a shipping container, with multi-year supply contract
- Pellets can be burned in any appliance on the market







Prairie Fire Bioenergy Co-op, Healy, KS

- Started Fall 2008
- 279 miles to Wichita, 137 to Greensburg
- 85% wood, 15% ag residues
- Make standard grade pellets (< 3% ash)
- Selling bagged pellets for now, trying to develop bulk markets (price is $130/ton FOB plant)
- 26k tons/yr production
  - on ag residues capacity would be 50k tons/yr
- Initial plan was to sell pellets to SMEC for bulk sales to Europe (then recession hit)
- Approached local ethanol producer and proposed:
  - Prairie Fire would finance an AES gasifier (Uniconfort) and sell the ethanol plant thermal energy at $6.25/MMBtu when the plant was then paying $8/MMbtu. Plant was not interested.





Abengoa Ethanol Plant, Hugoton, KS

- 490,000 "as is" tons/year biomass (12 million gals/yr ethanol and replaces natural gas for plant)
  - Focused on irrigated wheat, irrigated corn stover, milo stubble, switchgrass, and CRP lands
  - Not likely to pull from Greensburg area
  - 200,000 – 250,000 acres of land
- 32 million bushels of grain for 88 million gal/yr ethanol plant
- Will require 10%-12% of biomass within 50 mile radius of Hugoton
- Complex fuel procurement contract
  - Nutrient obligation (phosphorus and alkalis back from plant, coupon for nitrogen)
  - Abengoa controls (or subcontracts) all aspects of biomass collection
  - Abengoa handles biomass loading, hauling, and storage





First plant in Spain

Proposed Abengoa Payments

- Contract signing bonus ($1/acre)
- Annual reservation payment ($0.50/acre)
  - Paid to supplier every year even if Abengoa does not need the biomass from that supplier
- Base payment
  - Abengoa pays a single negotiated price to every supplier in its network
  - Abengoa equipment and labor collect the biomass (or use contract harvester)
- Revenue sharing payment (optional)
  - Producer accepts lower base payment for some biomass and takes share of ethanol plant profit

Potential Local Customers

- National Gypsum Plant, Medicine Lodge, KS
  - See next slide
- Orion Ethanol Plant, Pratt, KS (maybe someday?)
- Veterans Administration (VA) Hospital in Wichita, KS
  - Federal agencies must meet requirements for renewable energy under Executive Order 13423 and Energy Independence and Security Act of 2007
  - VA conducting nation-wide screening for biomass combined heat and power (CHP)
  - Supposed to be providing facility data to NREL
- Many others listed in Appendix in report

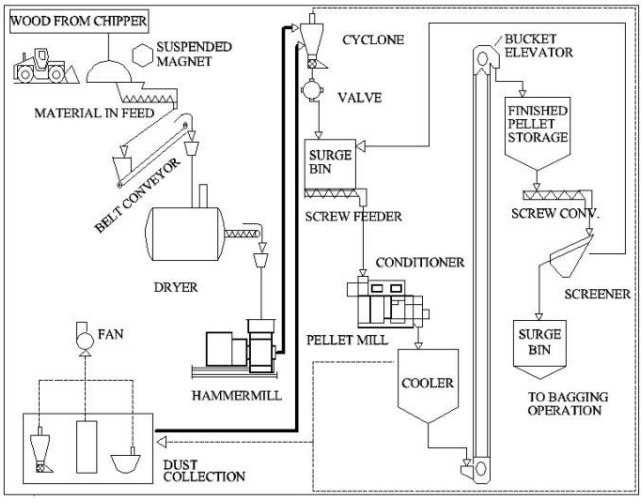




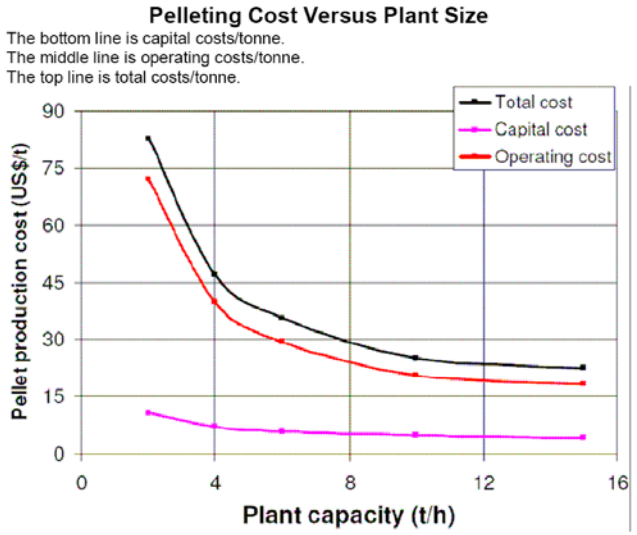
National Gypsum, Medicine Lodge

- Located about 30 miles from Pratt, 60 from Greensburg
- Consumes about 900,000 MMBtu natural gas per year
  - Direct-fired in furnace for drying gypsum and product
- Gas price: New York Mercantile Exchange plus $0.45 for delivery
- Interested in biofuels, but must compete with gas
- Interested in storable product as they “do not want yard to look like a paper mill”
- Replacing 75% of thermal load with pellets equates to about 45,000 tons/year
- Are interested in conducting detailed cost-benefit analysis

Illustrative Pellet Plant Layout



Manufacturing Costs per Tonne (Exclusive of Feedstock Cost)



- Trend in North America and Europe is towards bigger and bigger plants to maximize economies of scale and produce at low costs

Source: Campbell

Pellet Business Success Factors

- Price
  - Must compete with fossil fuels and other renewable options
  - Feedstock cost is number one driver
  - Ag pellets produce a lot of ash and are high in alkalis, therefore consumers will expect price concession to offset the inconvenience factor and higher labor
- Quality
  - Poor pellet quality can kill a company's reputation
  - Some ag materials do not bind as well as wood, thereby producing a lot of fines – hence wood blends are common
  - Consistency is key – end users want to know what they are getting

Summary

- More than enough feedstock in local area
- Pratt and Greensburg about equal in terms of feedstock
  - But least-cost delivery point of cedar is most important
- Pratt is closer to Medicine Lodge, Orion ethanol plant, and Wichita
- Greensburg closer to Dodge City, KS
- Pellets cannot compete with industrial gas at these prices
  - Can compete with commercial gas (for now), propane, and electricity
  - End-users will expect price concession for using high ash, high alkali fuels
- Cedar chips and unprocessed straw bales are least cost biomass resource in the area
  - Sell cedar chips to Medicine Lodge?

Summary (cont.)

- The fact that end-users will need to buy a new boiler or furnace is a barrier to market development
- Consider third party financing model (pellet plant installs the boiler and sells Btus to the end user)
  - Will be tough to finance this arrangement in today's market
- Related to plant economics, bigger plants will out-compete smaller plants in terms of price
  - as long as sufficient feedstock can be obtained at same delivery price

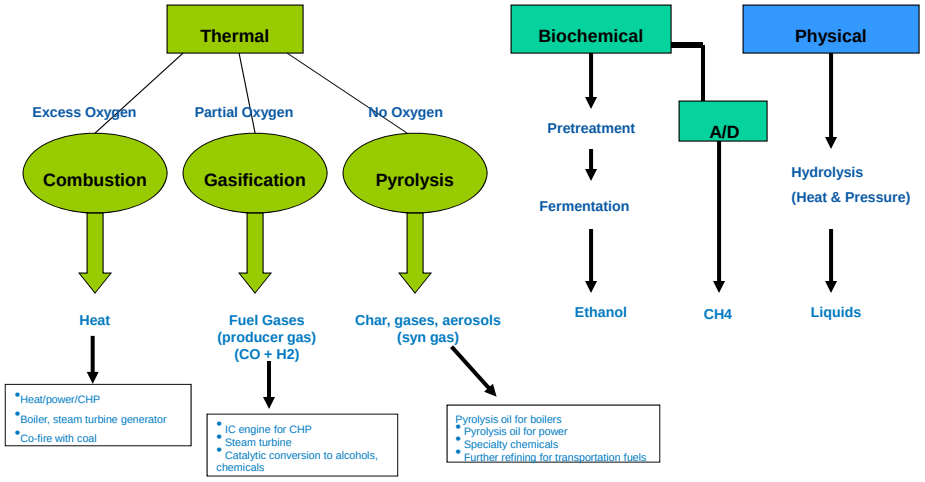
Summary (cont.)

- Considerable market development efforts are still needed
  - There are not a lot of incentives for users to switch
  - There are not a lot of incentives to be the first plant owner (as Campbell describes it, “the advantage of being second”)
- Carbon tax or national Renewable Portfolio Standard may change the game, so keep monitoring the process
  - But what is the carbon footprint of this entire process???
- National Gypsum plant should conduct detailed economic analysis of converting to pellets, chips, or even straw

Suggestions for Next Steps

- Test local corn stover, cobs, and sorghum residues at lab
- Refine collection costs and quantity for cedar
- Talk to local producers (irrigated corn, sorghum) and develop supply network – identify as many large scale producers as close to the plant as possible
- Develop test blend of cedar/stover/sorghum pellets
- Test fire the pellets in potential appliances and see how they work
- Continue market development efforts with large commercial and industrial customers
  - National Gypsum, VA Hospital, others
- Monitor local and national market conditions
- NREL to complete draft report

Biomass Energy Pathways



Technical Issues - Combustion





- 20% - 30% efficient
- Mineral management issues (slagging and fouling of the boiler)
- Emissions: NO_x, CO, particulate
- Wide range of fuel types
- Multiple vendors
- Equipment warranties
- Tried and true; trusted by lenders
- Needs water

Biomass Gasification





- Pre-commercial, early demo
- Potentially better suited to small scales
- More efficient than combustion, 30%- 40%
- Manages mineral matter
- Fuel gas ($CO + H_2 + CH_4$) can be used in IC engines, gas turbines, steam turbines or to make liquid fuels
- Installed cost of $3,500 and up per kW
- Levelized Cost of Energy: $0.15 - $0.20+

Pellet Boiler for Thermal Energy

- Harney Hospital, Burns, OR
  - 25 bed facility
- KÖB – Austrian technology shipped in container and connected in 2 days
- Commercial technology
- $250,000 cost, saving $37,000 per year
- 750 sq ft footprint



Biopower Summary

- 2006 capacity – 10.5 GWe
  - 5 GW pulp and paper
  - 2 GW dedicated biomass
  - 3 GW MSW and landfill gas
  - 0.5 GW cofiring
- Cost – $0.06 – $0.20 USD/kWh
- Requires production tax credit to compete in wholesale markets
  - Half the tax credit that wind gets
- High capacity factor, baseload
- Usually requires significant water
- CO_2 neutral



Close-coupled Gasification

- North Country Hospital, VT
- Chiptec C-Series close-coupled gasifier
  - (gas is combusted to make steam for a turbine)
- Commercial technology, hundreds of systems
- 265 kW CHP system
- 500 Hp, 300 PSI Hurst boiler
- Saving $250,000/year





D.11 Assessment of Biomass Pelletization Options for Greensburg, Kansas – Executive Summary

Scott Haase
National Renewable Energy Laboratory

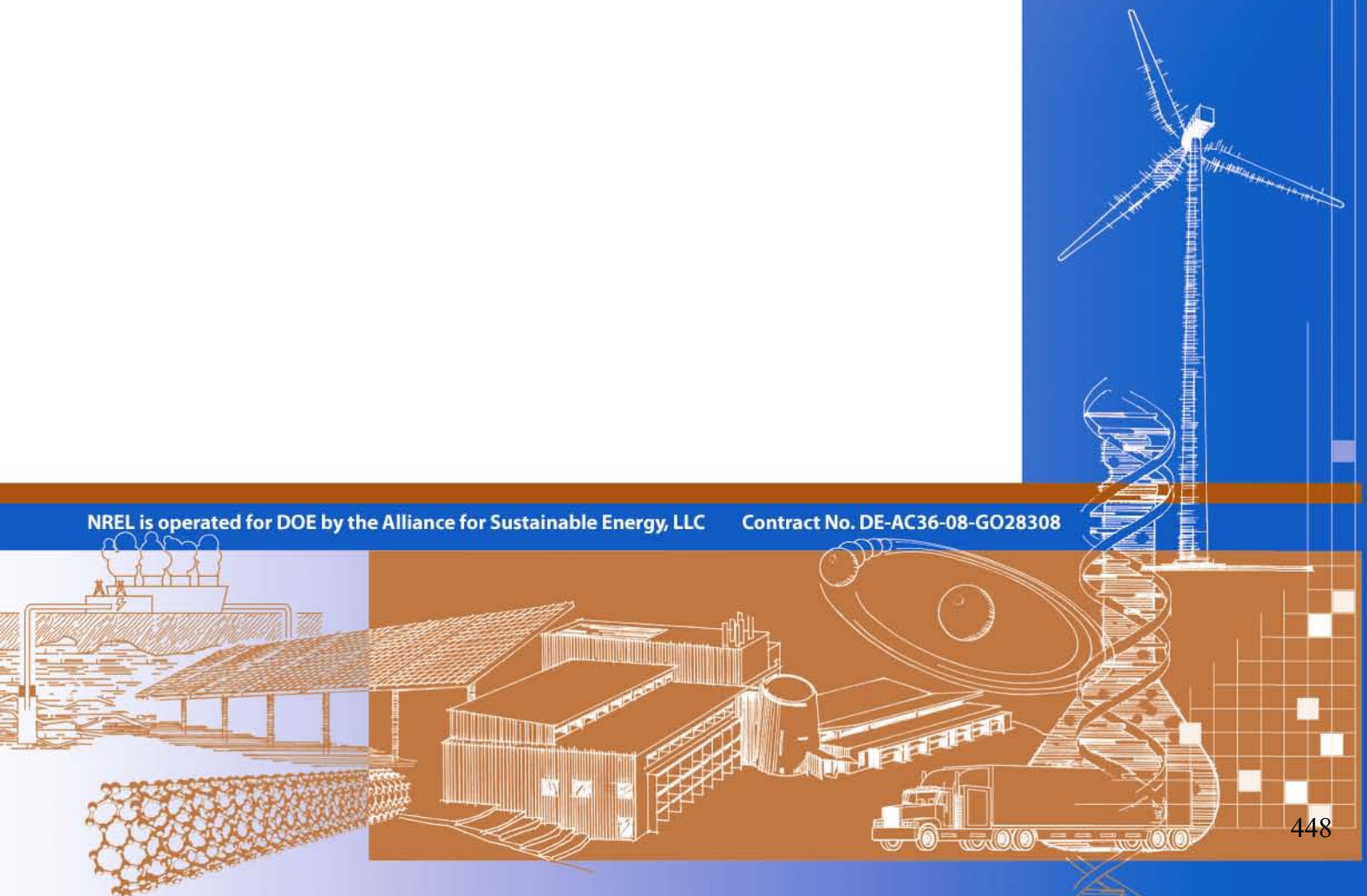
National Renewable Energy Laboratory
A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Innovation for Our Energy Future

Assessment of Biomass Pelletization Options for Greensburg, Kansas

Executive Summary

S. Haase

Technical Report
NREL/TP-7A2-45843
November 2009



NREL is operated for DOE by the Alliance for Sustainable Energy, LLC Contract No. DE-AC36-08-GO28308

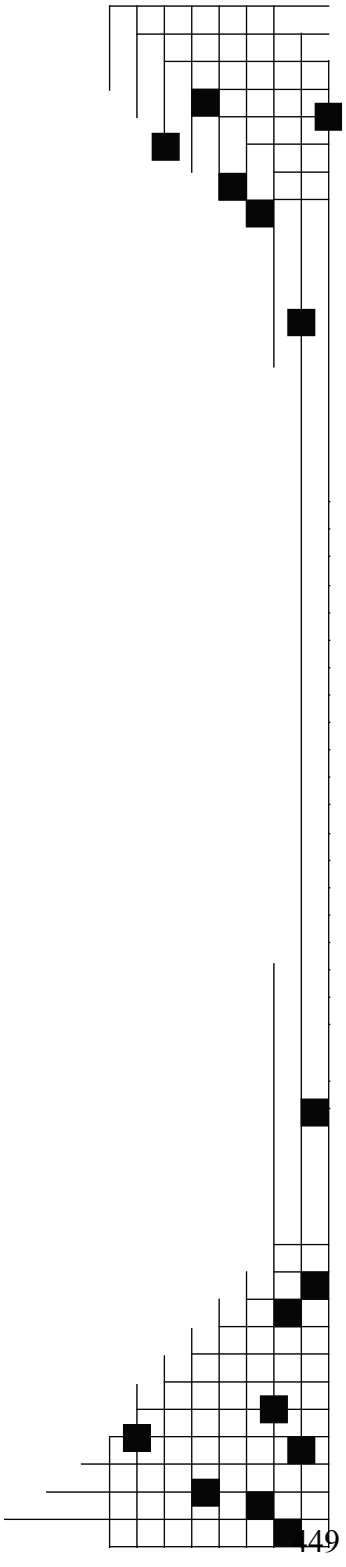
Assessment of Biomass Pelletization Options for Greensburg, Kansas

Executive Summary

S. Haase

Prepared under Task No. IDKS.1070

Technical Report
NREL/TP-7A2-45843
November 2009



National Renewable Energy Laboratory
1617 Cole Boulevard, Golden, Colorado 80401-3393
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

Contract No. DE-AC36-08-GO28308

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

Printed on paper containing at least 50% wastepaper, including 20% postconsumer waste

NREL Contacts

Laboratory Point of Contact:	**Scott Haase** **Phone: 303-275-3057** scott.haase@nrel.gov
Project Team:	**Scott Haase** **Lynn Billman** **Anelia Milbrandt** **Dave Peterson** **Chris Gaul** **Rachel Gelman** **Alexander Dane**
Project Name:	Assessment of Biomass Pelletization Options for Greensburg, Kansas: Executive Summary

Acknowledgments

This work was conducted by the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) to provide input on the potential to establish a biomass pelletization or briquetting plant in or around the community of Greensburg, Kansas.

A number of organizations and individuals contributed information that was useful in the analysis. The authors wish to thank the following persons and organizations for their assistance with this project (listed alphabetically):

- Bob Dickson, Mayor of Greensburg, Kansas
- Kelly Estes, BTI Industries
- Mike Estes, BTI Industries
- Josh Harden, Biomass Energy Development Company
- Steve Hewitt, Greensburg City Administrator
- Brian Hoffman, Pratt Area Chamber of Commerce
- Roger Masenthin, USDA, Sunflower Resource Conservation and Development (RC&D) Program
- Mike Mayberry, USDA, Sunflower RC&D Program
- Don Queal, Queal Enterprises
- Jeanette Siemens, Kiowa County Economic Development
- Terry Studer, Local Agricultural Producer.

At NREL, staff who contributed to the effort in addition to the main author include: Lynn Billman, Alexander Dane, Chris Gaul, Rachel Gelman, Anelia Milbrandt, and Dave Peterson.

Executive Summary

In May 2007, the town of Greensburg, Kansas, was struck by a large tornado that destroyed more than 90% of the buildings and infrastructure of the town. After this devastating event, the citizens of Greensburg decided to rebuild their town in a green manner, incorporating the most efficient energy technologies possible in the reconstruction effort. The U.S. Department of Energy, through the National Renewable Energy Laboratory (NREL), has been providing technical assistance to Greensburg to help facilitate the various efforts. As part of this support, NREL conducted an assessment of potential opportunities to develop a biomass pelletization or briquetting plant in the region.

Major activities conducted for this assessment include the following:

- Detailed analysis of the biomass resource base in the region, including quantity, physical and chemical properties, availability, cost, and collection potential
- Assessment of demand for thermal energy in the region, and opportunities for biomass to be utilized to meet some of that demand
- Overview of the pellet manufacturing process, including equipment needs, capital costs, and manufacturing costs
- Overview of briquette and bripell manufacturing technologies and costs
- Discussion of end-use conversion technologies
- Conclusions and recommendations for next steps.

Biomass Resource Assessment

Biomass Quantity and Geographic Distribution. NREL conducted a detailed, county-level assessment of the biomass residues found in the region. The primary agricultural biomass types located in the region include corn stover, corn cobs, sorghum residue, and wheat straw. There is also significant potential to collect woody biomass in the form of eastern red cedar. Eastern red cedar is considered an invasive species, and it is spreading rapidly from Oklahoma into southwestern Kansas. Cedar trees are being aggressively cut and removed to prevent its continued spread into agricultural lands.

Counties were included in the analysis if all or most of the county boundary is located within a 50-mile radius of either Pratt or Greensburg, Kansas. Using data available from the U.S. Department of Agriculture National Agricultural Statistics Service (NASS), NREL estimated the quantities of residues that are produced in the region. NREL used a 10-year average of values to account for potential year-to-year fluctuations in market conditions, weather patterns, and harvest. Based on total residue produced, NREL then used standard factors to estimate the amount of biomass that could safely be removed from agricultural lands while still maintaining nutrient cycling, soil health, and erosion mitigation. We estimated the quantity of eastern red cedar available through interviews with a local cedar clearing company. The full methodology is documented in Appendix A of this report.

Table ES-1 shows the total residues available in the study area, by county. A total of 1.7 million bone dry tons per year (bdt/yr) are available within counties that intersect 50 miles of Pratt and Greensburg. The value under "other forestry removals" for Pratt County is an estimate of the quantity of eastern red cedar available in the area. Even though this material is collected from many counties in the region, this quantity has been assigned to Pratt County because it is the location of the contractor's business. It should also be noted that the values for corn are based only on residues available from irrigated acres. We found that non-irrigated corn is in a net-deficit situation, meaning that more residue should be left on the land than is actually being produced.

Table ES-1. Summary of Biomass Residues

	Residues Available (bdt/yr)									
County	**Wheat**	**Corn**	**Sorghum**	**Soybean**	**Sunflower**	**Cotton**	**Logging Residues**	**Other Forestry Removals**	**Corn Cobs**	**Total**
Barber	25,283	407	4,004	1,337	46	210	161	2,818	623	34,888
Barton	74,604	17,556	47,399	14,320	222	-	22		14,760	168,882
Clark	469		9,681	345	-	-	-		218	10,713
Comanche	3,835	285	5,357	627	-	-	-		450	10,554
Edwards	31,955	39,921	18,599	21,961	60	-	-		31,913	144,409
Ford	55,368	22,632	53,883	10,214	136	-	-		21,533	163,765
Harper	96,815	146	9,270	1,821	65	436	0		135	108,687
Hodgeman	21,536	2,228	18,130	1,287	-	-	-		4,200	47,380
Kingman	78,586	5,270	8,869	6,458	185	-	-		3,810	103,177
Kiowa	17,281	15,562	12,205	12,255	24	-	-		15,113	72,438
Pawnee	59,127	21,710	35,327	16,494	52	-	-		18,915	151,626
Pratt	58,679	38,472	19,270	17,711	377	1,122		12,500	33,533	181,663
Reno	89,693	13,495	51,240	22,829	1,253	-	15		13,118	191,642
Rice	111,254	14,194	50,816	15,130	931	-	24		8,190	200,539
Stafford	35,258	18,182	20,366	14,845	85	-	-		31,935	120,670
Total	**759,742**	**210,058**	**364,416**	**157,632**	**3,435**	**1,768**	**222**	**15,318**	**198,443**	**1,711,034**

Figure ES-1 shows the geographic distribution of the residues in the study area. Notice that, in general, greater quantities of residues are produced in the eastern counties of the region.

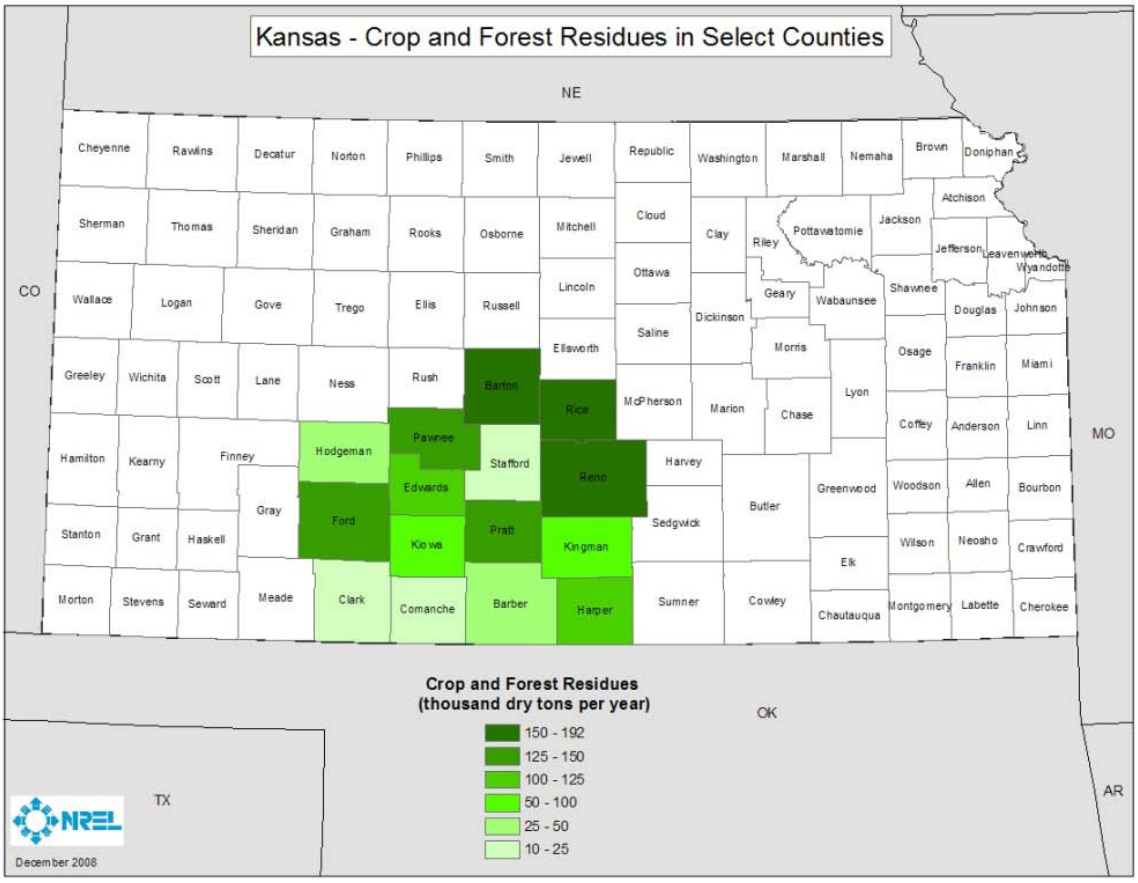


Figure ES-1. Biomass residue distribution

Looking in greater detail at the production of agricultural residues, we present in Table ES-2 the yields of biomass per acre of land harvested. The values for corn are only from irrigated acres. The table indicates that irrigated sorghum and irrigated corn will yield the greatest amount of biomass per acre. Thus, if one is interested in collecting agricultural residues, these two feedstocks should be considered as the top priority, as fewer acres will be needed to collect the most material.

Table ES-2. Yields of Biomass per Acre of Crop Land (bdt/acre/yr)

County	Wheat (bdt/acre)			Sorghum Residues (bdt/acre)			Corn (bdt/acre)
	Wheat Irrigated	Wheat Non-irrigated	Wheat Total	Sorghum Irrigated	Sorghum Non-irrigated	Sorghum Total	Corn Stover and Cobs
Barber	0.52	0.22	0.22			0.50	1.24
Barton	0.67	0.46	0.46	1.35	0.80	0.86	1.64
Clark	0.27	-	0.01	1.22	0.70	0.65	0.75
Comanche	0.44	0.05	0.06	1.23	0.37	0.55	1.23
Edwards	0.70	0.27	0.33	1.13	0.60	0.71	1.69
Ford	0.57	0.31	0.33	1.28	0.71	0.80	1.54
Harper	0.61	0.44	0.44			0.57	1.56
Hodgeman	0.64	0.17	0.21	1.09	0.64	0.69	1.15
Kingman	0.69	0.40	0.41	1.20	0.54	0.59	1.79
Kiowa	0.47	0.22	0.25	1.27	0.63	0.73	1.52
Pawnee	0.74	0.42	0.45	1.29	0.73	0.83	1.61
Pratt	0.58	0.39	0.40	1.25	0.64	0.70	1.61
Reno	0.68	0.37	0.38	1.17	0.67	0.71	1.52
Rice	0.57	0.75	0.75	1.07	0.63	0.85	2.05
Stafford	0.56	0.23	0.26	1.24	0.69	0.75	1.18
Average	**0.51**	**0.26**	**0.28**	**1.05**	**0.52**	**0.58**	**1.47**

Biomass Physical and Chemical Properties. Table ES-3 shows the results of lab tests for some of the feedstocks in the region. The column labeled SMEC pellets shows the results of tests performed on a 50-50 blend of wood and agricultural residues made by Show Me Energy Cooperative (SMEC) of Centerview, Missouri. These pellets have moderate Btu value, high percentage of ash, and high alkalis. Most pellet-burning appliances are designed to handle low-ash (< 1%) fuels and low-alkali fuels. Values higher than 0.4 pounds of alkali per million British thermal units (lb/Mbtu) are likely to cause slagging or clinker formation during the combustion process. Pellets made from wood and agricultural residues in Greensburg would exhibit similar characteristics if similar blend ratios are used. In general, the SMEC pellets are better suited for use in large-scale utility plants (mixed with coal) or in large industrial- or commercial-scale biomass combustors designed to handle high-ash, high-alkali fuels. Appendix B contains the detailed lab results of the analysis of these samples, and of samples of corn stover, corn cobs, and sorghum residue.

Potential end users of biomass pellets in the region would likely want a price concession on the cost of the product in order to offset the higher operations and maintenance costs associated with using a high-ash, high-alkali fuel.

Table ES-3. Biomass Physical and Chemical Properties

Value	Wheat Straw	Freshly Cut Cedar	Seasoned Cedar	SMEC Pellets
Btu content as received HHV (Btu/lb)	7,125	8,143	8,056	7,059
Btu content bone dry (Btu/lb)	7,709	8,827	8,976	7,680
Moisture content as received (%)	7.57	7.75	10.25	8.09
Percentage Ash (%)	7.83	1.63	0.88	9.04
Lb Alkali/Mbtu	1.3	0.08	0.05	1.44
Lb ash/Mbtu	10.99	2.00	1.09	12.81
Potassium in ash as K2O (%)	11.4	3.25	4.55	10.8

The values for cedar shown in Table ES-3 indicate that this material would make an excellent feedstock for a biomass system. A product made of only cedar, or mostly cedar, is going to have much better combustion properties than a 50-50 blend of agricultural residues and cedar. For this reason, entrepreneurs wishing to develop a plant in the region may want to use either 100% cedar or a small blend percentage of agricultural residues. Test batches of various blend percentages would need to be made in order to test for ash content and alkali values before any full-scale production begins. The size of any potential pellet enterprise may be limited by the quantity of cedar that can economically be collected in the region.

Biomass Cost. Biomass collection cost is one of the major factors influencing the final cost of pellets. One of the challenges of using agricultural residues for feedstock is that the resource is dispersed on the land and relatively expensive to collect. Remember, too, that biomass pellets are competing against fossil fuels–primarily natural gas and propane. In recent months, the wholesale price of natural gas has fallen from $14/Mbtu to less than $4/Mbtu.

Figure ES-2 shows the cost of biomass in $/Mbtu versus various costs to collect and deliver a ton of agricultural residues. Based on results of this and other studies referenced herein, we estimate that biomass collection costs will be in the range of $55-$60 per field-dried ton for agricultural residues. Note that at $60 per ton, the fuel cost alone is equivalent to $4.29/Mbtu. When pellet manufacturing costs (labor, energy, packaging, debt, transportation) are added to this, it is clear that pellets will have a difficult time competing with fossil fuels at today's prices.

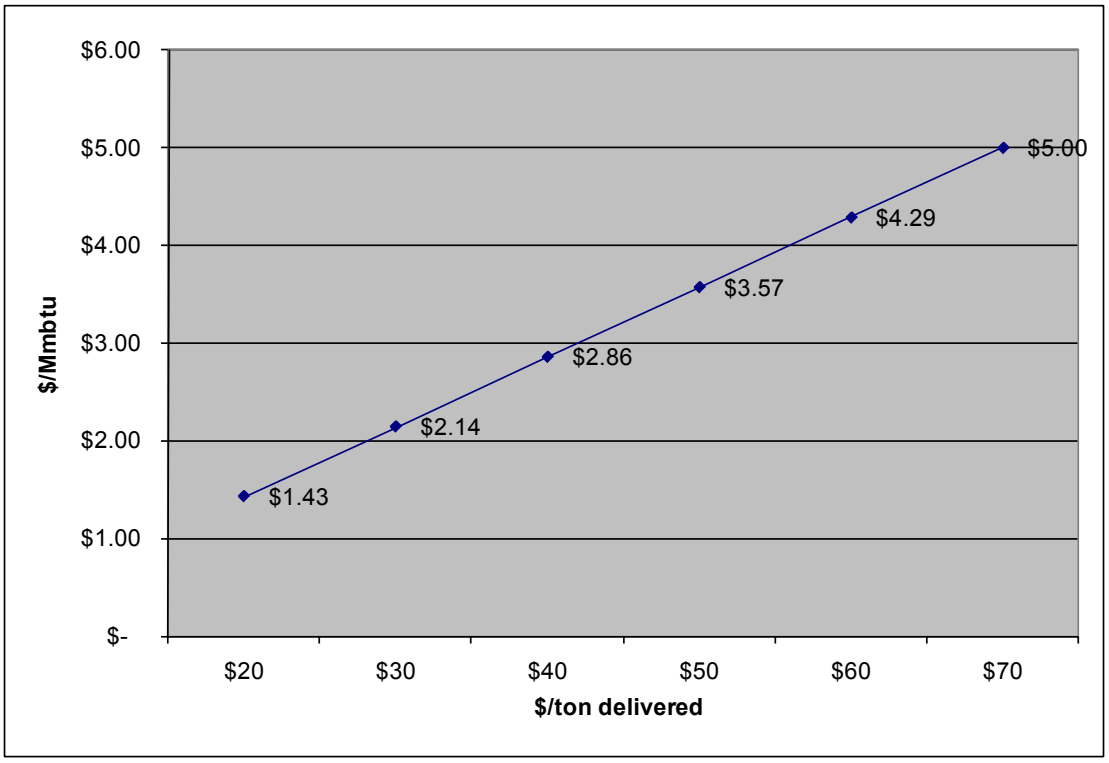


Figure ES-2. Fuel costs of agricultural residues ($/Mbtu versus $/delivered ton)

The delivered cost of cedar biomass is likely to be somewhat lower than that of agricultural residues. We estimate that cedar can be delivered to a regional pellet manufacturing plant for about $35/green ton. Assuming 8,800 Btu per dry pound and 40% moisture, this equates to

$3.31/Mbtu. Cedar is an important feedstock in the region, as it is likely to be the lowest cost resource; at the same time it has the best physical and chemical qualities of all the regional biomass sources.

Regional Demand for Thermal Energy and Competing Fuel Costs

Comparison of Fuel Prices. Table ES-4 shows the delivered costs of energy from various fuels used in the region. The delivered cost of energy takes into account appliance efficiency and thus represents the cost to deliver a therm of useful energy to the building space. The natural gas prices used in the table are based on statewide averages for Kansas for the months of April through December 2008. Although the natural gas prices are based on average values for the period, note that the most recent prices for November and December 2008 were considerably lower than the averages. So while the commercial cost per therm is listed as $1.57 in table ES-4, the value for December 2008 was $1.00 per therm, which would make the delivered cost of energy $12.00/Mbtu as compared to the $19.63 shown in Table ES-4.

Table ES-4. Delivered Cost of Thermal Energy for Various Fuels ($/Mbtu)

Source	Units	Cost to User ($)	Efficiency (%)	Btu/unit	$/Mbtu
Chipped Cedar	$/green ton	50.00	75	13,200,000	5.05
Wheat straw bales	$/ton	55.00	70	14,000,000	5.61
Natural gas (industrial)	$/therm	0.69	80	100,000	8.63
Wood/ag pellets ($130/ton)	$/ton	130.00	80	15,000,000	10.83
Wood/ag pellets ($160/ton)	$/ton	160.00	80	15,000,000	13.33
Hardwood pellets	$/ton	185.00	80	16,600,000	13.93
Natural gas (commercial)	$/therm	1.50	80	100,000	18.75
Fuel oil	$/gallon	2.17	85	135,000	18.91
Natural gas (residential)	$/therm	2.10	80	100,000	26.25
Propane	$/gallon	2.13	85	91,600	27.36
Electricity	$/kWh	0.10	100	3,413	29.30

When assessing the market for pellets, it is important to remember that fossil fuel prices fluctuate considerably, and while prices are low, end users may not be as interested in alternative fuels as they would be when prices are high. One of the selling points of biomass should be that biomass prices typically remain stable and seldom exhibit the wild price swings evident with fossil fuels.

Chipped cedar at $50 per ton has the lowest delivered cost, followed by straw bales. However, the use of these fuels will require additional on-site labor and higher up-front capital costs when compared with systems that burn pellets or other densified fuels. Notice that wood/ag pellets at $130 per ton are about $0.67 less per Mbtu than the cost of energy at the average industrial rate for gas in Kansas. It is difficult to compete with natural gas if your fuel is just slightly less expensive yet takes more labor and maintenance and requires an up-front purchase of a new appliance. Ag pellets at $130 per ton compare nicely, however, with hardwood pellets at $185 per ton, fuel oil at $2.17 per gallon, propane at $2.13 per gallon, and electrical resistance heat at $0.10 per kilowatt-hour (kWh). Ag pellets also compare well with commercial natural gas rates of $19.63/Mbtu. Ag pellets at $160 per ton compare favorably with fuel oil, commercial and residential gas, propane, and electricity. Note that it may be a challenge for a pellet plant to deliver wood/ag pellets to its customers at $130 per ton, even when using bulk shipments instead

of plastic bags. A cost of $160 per ton for bulk pellets delivered to a regional customer may be more likely.

Table ES-5 shows the average natural gas rates in Kansas by customer type. Data are shown through October 2008. It is likely that in the near term these rates will show a continued downward trend. The value for "electric power price" is the rate paid for gas used to generate electricity. The Energy Information Administration reports the data in terms of dollars per thousand cubic feet ($/Mcf). We have reported these values in $/Mbtu to be consistent with the other units used in this report.

Table ES-5. Average 2008 Monthly Natural Gas Prices in Kansas, by Customer Type ($/Mbtu)

Sector	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Average
Residential	15.29	17.14	22.41	23.81	24.90	21.82	18.73	12.71	10.41	18.58
Commercial	14.57	15.71	18.61	19.11	19.32	17.54	15.15	11.64	10.06	15.75
Industrial	9.30	9.64	10.09	11.09	10.11	8.35	6.95	7.84	9.25	9.18
Electric Power	10.22	10.98	11.65	10.85	8.97	6.67	4.50	4.88		8.59

Figure ES-3 shows historic wholesale prices of Kansas natural gas, adjusted to 2008 dollars. Prices have experienced significant volatility over the 36-year period. From the early1990s until about 2000, prices were around or below $4/Mbtu and relatively stable. Since the year 2000, prices had been on a steady upward trend until the fall of 2008. With the recent economic downturn, prices have fallen significantly. On January 22, 2009, the Henry Hub natural gas prices closed at $4.72/Mbtu. Although prices have fallen precipitously over the last few months, the long-term trend line is still upward, at least for now.

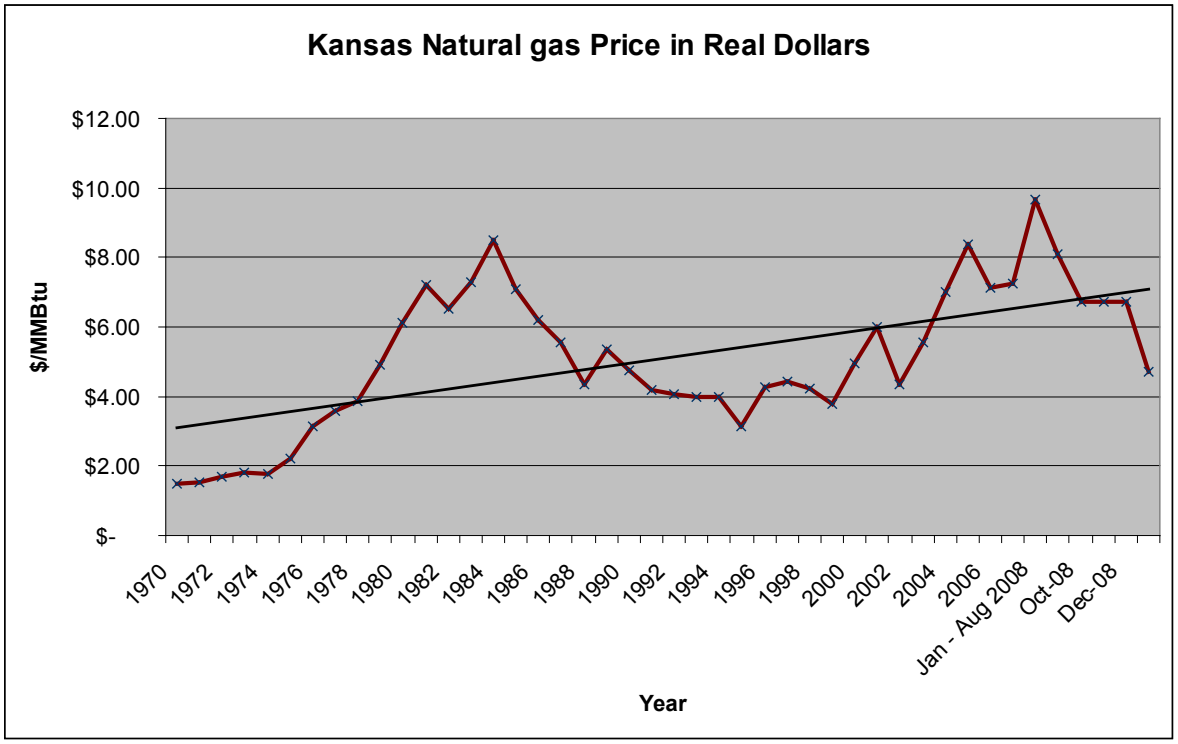


Figure ES-3. Industrial customer natural gas prices (1970-January 2009)

Regional Demand for Natural Gas. NREL contacted regional natural gas providers to request aggregate data on natural gas sales by zip code or town/city place name. NREL staff then aggregated these data to the county level. Table ES-6 shows the estimated regional demand for thermal energy based on natural gas consumption. These numbers do not account for customers heating with propane, fuel oil, or other sources such as electricity, corn, or wood pellets, or customers on well-head gas. Overall, nearly 235 million therms of natural gas are consumed each year by more than 225,000 customers in the study area. The largest county in terms of both consumption and users is Sedgwick, which contains the city of Wichita. Reno and Ford counties also consume significant quantities of natural gas. While it is clear that it is not possible for pellets to replace 100% of regional natural gas use, the annual consumption of natural gas in the region is equivalent to approximately 1.6 million tons of pellets, assuming 7,000 Btu/lb for the pellets. This is tied very closely to the potential supply in the region of 1.8 million bdt/yr.

Table ES-6. Regional Demand for Natural Gas by Customer Type

	RESIDENTIAL			COMMERCIAL			INDUSTRIAL			Total	
County	Therms	# of Users	Average Use	Therms	# of Users	Average Use	Therms	# of Users	Average Use	Therms	# of Users
Barber	1,040,442	1,481	702	391,788	256	1,532	0	0	0	1,432,230	1,737
Clark	576,868	777	743	181,722	133	1,366	233,991	7	33,427	992,581	917
Comanche	457,942	626	732	266,810	128	2,089	0	0	0	724,752	753
Edwards	691,173	911	758	500,976	188	2,660	142,831	16	8,927	1,334,980	1,116
Ford	6,609,854	10,616	623	4,433,399	1,071	4,139	14,841,118	189	78,524	25,884,371	11,876
Kingman	1,354,386	1,990	680	588,138	306	1,919	180,679	5	35,543	2,123,203	2,302
Kiowa	634,912	689	922	285,830	135	2,111	408,839	37	11,050	1,329,581	861
Pawnee	1,528,536	2,029	753	529,844	256	2,069	169,351	8	21,169	2,227,731	2,293
Prattt	2,386,993	3,201	746	1,498,291	487	3,074	234,771	18	13,043	4,120,055	3,706
Reno	13,864,507	20,655	671	4,683,720	1,907	2,457	23,068,579	27	854,392	41,616,806	22,588
Sedgwick	106,217,438	162,805	652	34,022,082	12,565	2,708	11,267,245	75	150,230	151,506,766	175,445
Stafford	1,032,418	1,348	766	398,222	257	1,549	84,910	9	9,434	1,515,550	1,615
Total	**136,395,468**	**207,128**		**47,780,823**	**17,690**		**50,632,314**	**391**		**234,808,605**	**225,209**

Adding the pellet potential across the commercial and industrial sectors yields 700,000 tons per year maximum potential. Assuming pellets can capture 5% of this market, we get a total of about 35,000 tons per year local potential in these sectors. This is not to suggest that the market in the area is limited to 35,000 tons. It may be possible to identify several larger customers that alone could consume more than 35,000 tons at a single facility. These large potential users should be contacted directly to discuss their possible interest in biomass pellets. It is also possible to develop markets outside of the local area, either by truck or rail.

Entrepreneurs interested in starting a pellet facility should be prepared to spend significant amounts of time educating potential end users and developing the market before constructing any facility. One of the biggest challenges associated with building a facility to make pellets in the region is that there are no existing customers beyond perhaps some residential or farm users of pellet or corn appliances. This is the proverbial "chicken and egg" problem—end users will only be willing to invest in conversion technologies to burn pellets if there is a reliable, affordable, high-quality product available, and the builders of a pellet mill must have a reliable, credit-worthy customer base to ensure that the product they make can be sold. Under present market conditions, there are few compelling reasons for potential end-users to be early adopter adapter.

Possible Local Commercial Customers. A successful biomass fuel production facility would need to develop off-take contracts with customers in order to obtain financing. Two industrial

plants in the area, Orion Ethanol in Pratt and National Gypsum in Medicine Lodge, may be potential customers. The Pratt ethanol plant is not operating at this writing but presumably could be reactivated when more favorable business conditions return. There are many other potential customers in Dodge City and Wichita that could be identified and contacted.

As an example of a potential customer, the National Gypsum drywall manufacturing plant in Medicine Lodge could utilize biomass fuel. The plant presently consumes about 900,000 Mbtu per year of natural gas in its dryers. Offsetting 75% of this load would require on the order of 45,000 tons of biomass pellets (or 50,000 tons of 25% moisture content cedar chips) per year. As of February 2009, National Gypsum is interested in exploring the economics of switching from gas to biomass.

National Gypsum currently purchases natural gas for the NYMEX price, plus about 45 cents for delivery. Biomass costs must compete with those of natural gas. National Gypsum's delivered cost of gas is presently about $5.00/Mbtu, although this price fluctuates daily. We do not believe that biomass pellets can be delivered to National Gypsum for $5per million Btu. If a ton of biomass pellets has 15 Mbtu, then the delivered cost would need to be $75 per ton to meet $5/Mbtu gas. The only biomass feedstock that can come close to meeting this cost at present is cedar chips.

It is interesting to consider emissions of carbon dioxide. Consumption of 675,000 Mbtu/yr of natural gas (75% of National Gypsum's estimated use) emits 39,500 tons of CO_2 per year. Since biomass is considered CO_2 neutral by the U.N. International Panel on Climate Change, conversion to biomass could potentially free up carbon credits for National Gypsum under a cap and trade system. Some of these credits may need to be given to the biomass supply company to offset the emissions of the biomass pellet operation (from field to customer). Alternatively, the price of natural gas would go up by about $1.20/Mbtu if CO_2 is taxed at $20 per ton. This would make biomass pellets more attractive to the plant.

Abengoa Ethanol Plant, Hugoton, Kansas. Abengoa is presently moving forward with plans to construct a 100 million gallon per year combination corn/cellulosic ethanol plant in Hugoton, Kansas. As of the writing of this report, Abengoa is in the process of conducting its environmental studies and developing its feedstock supply infrastructure. Abengoa has stated that the plant will require nearly 500,000 "as is" tons of biomass—primarily wheat straw and corn stover—as inputs for the cellulosic ethanol process, as well as to provide thermal energy for the plant. At this time, Abengoa has stated that it plans to collect feedstocks from within 50 miles of Hugoton, which would keep transportation costs as low as possible. At this time, we are unsure if Abengoa will need to go beyond this 50-mile radius and obtain feedstocks from closer to the Greensburg/Pratt areas. However, interested entrepreneurs should contact Abengoa to discuss the potential for supplying the ethanol plant with densified biomass feedstocks.

Summary of Local Market Potential. For any densified biomass product to be commercially viable, it must be at least as cost-competitive and somewhat as convenient as competing fuels. This includes wood pellets as well as fossil fuels. In most cases, pellets are truly a commodity product. A lower cost producer can ship farther and thus compete with smaller, higher production cost pellet mills, even in the smaller mill's own backyard. Agricultural residue pellets are generally lower in grade than wood pellets. If agricultural residue pellets are available

in the same market as wood pellets, they would have to sell at a lower price to compete with both wood pellets and natural gas. Biomass pellets are likely to compete very favorably with propane, fuel oil, commercial natural gas rates and electricity, but so will wood pellets. Any entrepreneur who seeks to develop a biomass pelletization facility in the Greensburg/Pratt region should be prepared to spend considerable time and effort on educating potential consumers and developing the market.

Densification Options

We evaluated three potential densified products that could be made from local biomass: pellets, briquettes, and bripells. All three options represent commercial technologies that would create viable market products, and all three can be used in commercial boiler systems to produce heat, power, or combined heat and power. We estimate that a 24,000-ton-per-year plant is the minimum size that should be built to take advantage of economies of scale, labor requirements, and infrastructure. It may be possible, however, to start with a smaller briquette or bripell production level, and scale up as the market develops.

Of the three products, pellets are associated with the most acceptance and consumer awareness, especially in the residential and small commercial sectors. However, the pellet market is still dominated by demand for premium, bagged pellets (less than 1% ash, high Btu) for the residential sector. Most pellet-burning appliances being sold to the residential market today are designed to handle low-ash fuels. Based on the feedstocks available in the Greensburg region, pellets made from a mixture of wood and agricultural residues will be high in alkalis, produce high ash, and contain medium Btu content (see the chemical analysis of the biomass sample pellets located in Appendix A). Without changes to pellet stove technology, there is not likely to be a high demand for this type of pellet from the residential sector. If pellets are the desired product, we suggest they be made either from 100% wood or perhaps a blend of 85%–90% wood with the remainder coming from agricultural residues. The exact blend could be determined through lab tests of various mixture percentages.

For the large commercial or industrial sectors, there are a number of boilers or furnaces on the market that are capable of handling higher ash pellets. Briquettes and bripells are also well-suited for commercial use. Appendix E contains a list of manufacturers of technologies that could burn any of these products in larger applications.

Table ES-7 shows the estimated costs of pellets, briquettes, and bripells. It must be stressed that these numbers are estimates only, and interested entrepreneurs are encouraged to develop their own detailed cost analyses before selecting one technology over another. The numbers below are sensitive to many factors, and changing one assumption can change any value. All of the numbers below were developed assuming a biomass feedstock cost of $65/bdt delivered to the plant.

Table ES-7. Summary of Manufacturing Costs

Product	Plant Capacity (tons/year)	Capital Costs ($)	Employees (FTEs)	Estimated Cost Bagged ($/ton)	Estimated Cost Bulk ($/ton)	Cost for 100% Cedar ($/Mbtu Bulk)	Cost for 50/50 Ag-Cedar Blend ($/Mbtu Bulk)
Pellets	24,000	5,500,000	15	159	135	8.42	8.98
Briquettes	25,000	4,700,000	6	143	123	7.66	8.17
Bripells	24,000	3,000,000	10	154	134	8.36	8.92

Conclusions

There is sufficient biomass located in the region to supply at least one plant creating pellets, briquettes, or bripells. Because cedar represents the highest quality feedstock in the region, the interested entrepreneur may wish to consider sizing a plant based on the quantity of cedar available. Agricultural residues can be added into the product mix at a later date as markets mature. We estimate that 12,500 bdt of cedar can be collected easily, although to get to a minimum sized plant (24,000 tons per year), additional cedar will need to be collected, or ag residues will need to be added. Due to the dry climatic conditions in the region, only agricultural residues from irrigated lands should be considered. Potential target feedstocks include corn stover, corn cobs, sorghum residue. and wheat straw.

There is also sufficient demand for thermal energy in the region. Given the current price of natural gas, it may be more difficult than it was a year ago to convince large commercial or industrial users to switch heating fuels. They could be reminded, however, that fossil fuel prices fluctuate considerably, and it is only a matter of time before prices begin to increase again. But while fossil fuel prices are low, considerable market conditioning and educational efforts will still be needed to persuade current natural gas customers to consider installing a biomass heating system. Biomass fuel will compete better with fuel oil or propane, as these two fuels are more expensive on a $/Mbtu basis.

A pellet, briquette, or bripell plant in the region will create six to 15 jobs, depending upon the technology selected.

Suggestions for Next Steps

This report has confirmed that there is a potential business opportunity in the region to develop some form of densified biomass business, be it pellets, bripells, or briquettes. The following actions are suggested as potential next steps for interested parties:

- Product Development
    - Make sample blends of various feedstock combinations (e.g., cedar/corn stover, cedar/sorghum) in various percentage mixtures
    - Send samples to the lab for chemical analysis, especially to asses ash percentages, Btu content, and alkali content
    - If possible, conduct test burns of products in candidate appliances to assess ash, feed handling, slagging, and odor.

- Feedstock Procurement
    - Identify producers interested in biomass supply options
    - Develop contract mechanisms for biomass supply
    - Assess potential for planting Conservation Reserve Program (CRP) land in switchgrass, mixed grass prairie, or other biomass for specific production of biomass for pellets or bricks. Some sample questions to answer would be:

        What is the best mix of plants for the local region?

        What are the yields and economics versus alternative CRP options?

        What is the best mix of plants in terms of energy content and use?
- Market Development
    - Perform additional market development efforts and educate potential end users about biomass energy
    - Seek state support to organize a local biomass heating workshop in the region
    - Contact large commercial energy users to analyze their actual energy usage and costs. For example, potential regional targets in Kansas could include National Gypsum in Medicine Lodge; the Robert J. Dole VA Medical Center in Wichita; the new Kiowa County Memorial Hospital in Greensburg; Pratt Community College in Pratt; agricultural processing plants in Dodge City; and any federal facilities
    - Continue to identify end use technologies that are commercially available and can be deployed at customer sites.
- Business Analysis
    - Conduct detailed pro forma analyses for bripells, briquettes, and pellets
    - Develop a business plan and conduct a detailed plant design.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Executive Services and Communications Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
November 2009	Technical Report	

4. TITLE AND SUBTITLE
Assessment of Biomass Pelletization Options for Greensburg, Kansas: Executive Summary

5a. CONTRACT NUMBER
DE-AC36-08-GO28308

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
S. Haase

5d. PROJECT NUMBER
NREL/TP-7A2-45843

5e. TASK NUMBER
IDKS1070

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

8. PERFORMING ORGANIZATION REPORT NUMBER
NREL/TP-7A2-45843

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)
NREL

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 Words)*
This executive summary provides an overview of a technical report on an assessment NREL conducted in Greensburg, Kansas, to identify potential opportunities to develop a biomass pelletization or briquetting plant in the region.

15. SUBJECT TERMS
National Renewable Energy Laboratory; NREL; DOE; U.S. Department of Energy; Greensburg; executive summary; TP-7A2-45843; technical report; technical assistance; Greensburg tornado; Kansas; tornado; tornado damage; EF-5 tornado; severe weather; green communities; green buildings; green community development; sustainable development; rebuilding green; energy efficiency; biomass; pelletization; briquetting; eastern red cedar

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
Unclassified	Unclassified	Unclassified	UL		19b. TELEPHONE NUMBER (*Include area code*)

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

D. 12 GREENSBURG, KANSAS, LONG TERM RECOVERY PLAN, LANDFILL GAS POTENTIAL

Philip Shepherd
National Renewable Energy Laboratory

Mr. Doyle Conrad of Greensburg Public Works indicated that they had looked at the potential of recovering landfill gas as an energy resource and concluded that this was impractical.

Greensburg has two landfills. The North Landfill (closed in 1996) covers 40 acres and is classified as a Construction and Demolition Landfill because demolition debris from a recent tornado was placed there even though the landfill had been closed. Construction and Demolition Landfills contain insufficient decomposable material to be considered a source of methane gas.

The South Landfill is an active municipal solid waste facility. However, it is not an acceptable source for landfill gas for several reasons:

- The landfill is much too small. The U.S. EPA recommends a minimum waste content of one million tons if gas recovery is to be considered. The South Landfill was described as a small "seven-acre hole" that will never hold anything close to one million tons.
- It would take more than 1000 years for a community with a population of 1200 to generate the suggested minimum one million tons of household waste needed for a viable landfill gas operation.
- Annual rainfall is very low (ca. 20 inches) and the landfill has no membrane liner to retain the small amount of water it will receive. Therefore, the waste cannot anaerobically decompose to methane in this arid climate.

(November 30, 2007)

D.13 Greensburg, Kansas, Downtown District Heating and Cooling Study

Chris Gaul, PE
National Renewable Energy Laboratory

The town of Greensburg, Kansas, was hit by an EF5 tornado on May 4, 2007, destroying most of the town (EF is the Enhanced Fujita scale for rating the strength of tornadoes in the U.S.). Various government and non-government organizations have undertaken to rebuild Greensburg "green." The Department of Energy (DOE) National Renewable Energy Laboratory (NREL), based in Golden, Colorado, is providing technical assistance to this effort. This paper explores installing a renewable energy district heating and cooling system serving the downtown business district.

Background

District energy systems supply heating and cooling from a central plant to buildings in a concentrated, defined area. Typical heating systems send steam or hot water in buried pipes to buildings and return cooler water to the plant. Air conditioning is provided by circulating cold water to buildings.

District energy systems are typically found in high-density downtown areas of larger cities. They arose in the 19th century as a practical solution to providing heat to dense central business districts (CBD) using coal-fired steam boilers. This eliminated the need for each building to have a coal supply, furnace or boiler, an operator, and ash disposal. As air conditioning came into vogue, it was a natural extension for district steam heat companies to provide cooling as well, through chilled water piped to buildings. CBDs in large cities such as New York and Chicago are served by district energy systems as well as in smaller cities such as Omaha, Nebraska and St. Paul, Minnesota. Beyond CBDs, district energy systems serve college campuses, medical centers, and large installations such as military bases.

District energy systems can use renewable resources or conventional (natural gas or oil for heating, or electricity for air conditioning) resources. For example, Boise, Idaho, has a district energy system that takes advantage of hot water geothermal resources for building heating. Several colleges in the northeast use biomass-based boilers for hot water in district systems.

Geothermal sources have also been used for cooling. The Arts and Sciences Hall at the University of Nebraska was constructed in 1936, it was the first air conditioned college building in America. It was cooled using cold artesian well water. At the time, air conditioning was common only in movie theaters. Free air conditioning in the muggy midwest during the depression was quite an achievement. As the campus grew, a district energy system was built. The artesian water source was inadequate and was replaced with electrically-powered air conditioning. As a modern-day example, Cornell University in Ithaca, New York uses the cold waters of Cayuga Lake to provide 20,000 tons of free cooling for its huge campus. The system reduces cooling energy use by 87%.

Before the tornado, downtown Greensburg consisted of 20 businesses ranging from 1,200 to 15,000 square feet, stretched 1,000 feet along South Main Street. Two buildings remained standing as of October 2007, both damaged. Planners anticipate that the downtown area could reach 300,000 square feet as businesses and dwellings are built over the next 15 years.

The south end of downtown will be anchored by a new city hall. On the north end, one block east of Main Street, is the historic Kiowa County Courthouse, which will be restored. These buildings are not included as part of the 300,000 square foot downtown build-out figure.

District Energy Concepts for Downtown Greensburg

Geothermal Water Cooling

The district energy cooling opportunity for downtown Greensburg is to use a geothermal source. The most intriguing geothermal resource would be to use the town's claim to fame, the Big Well, located at 311 South Sycamore Street, one block west of Main Street. This well is 109 feet deep and 32 feet in diameter. It holds 15 feet of standing water. The water temperature is 55ºF. This cool water was explored as a resource to cool buildings.

The simplest cooling scheme is to draw cold well water and pump it through an insulated supply pipe buried under Main Street. Individual buildings would connect to the system in manhole vaults or buried valves similar to drinking water systems. Air conditioning would be accomplished using conventional chilled water air conditioning coils. Chilled water coils are typically designed for 45ºF water and so they would have to be increased in size for 55ºF water. Warmed water from the building would flow to an underground return pipe. This pipe would not be insulated. At a convenient location at one end of Main Street, a well would be drilled to reinject the water back into the water table, or the Big Well might be used as a return well.

The district cooling system would not consume any water. It would merely borrow it briefly before returning it to the earth. In conversations with the Kansas Department of Health and Environment (KDHE) Bureau of Water in November 2007, KDHE confirmed that this water use is approved. Reinjecting air conditioning water is considered a Class V well. KDHE requires the injection be reported so it can be tracked in their well inventory. KDHE does not require a permit to drill the injection well. A permit is needed for the production well. Since no water would be consumed, KDHE did not foresee any problem issuing the production well permit.

Professional Engineering Consultants of Wichita built a similar system for a school in Garden City, Kansas. The system worked acceptably for a number of years and won energy-efficient design awards. After seven to eight years, the return well started having problems accepting water. Something had changed in the strata around the return well. Perhaps particles from the production well clogged the strata and reduced permeability. The Big Well's 32-foot diameter should be less prone to clogging compared to a small bore well. A dirt separator could also be added to remove fine particles that could clog strata or damage equipment.

In the downtown plan, the production well would be on the north end of Main Street. The return well would preferably be the Big Well. The advantages of using the Big Well include:

- It already exists in the right location, thus saving return well construction costs.
- Greensburg's most famous landmark would be used as part of Greensburg's green initiative.
- It is large in diameter, avoiding clogging problems.

Air conditioning requires not only cooling the air, but adjusting the humidity. The Greensburg climate is at the boundary between the humid midwest and dry high plains. Air conditioning is required to not only cool but dehumidify. Two hundred miles west of Greensburg relative humidity is low enough to use swamp (evaporative) coolers.

Greensburg summer design conditions are 96°F dry-bulb and 72°F wet-bulb. Dew point is 60°F, only five degrees above groundwater water temperature. A cooling system using 55°F groundwater would not effectively dehumidify air using conventional chilled water cooling coils. Additional HVAC equipment would be needed to remove moisture, such as a desiccant system. Desiccant systems are more energy efficient than refrigeration for moisture removal. They are used along the humid Gulf Coast in commercial applications but are not in general use in southwest Kansas. Construction cost estimate for a 1,000-foot cooling water distribution system along Main Street is $368,000 (Appendix A). This does not include connections to individual buildings. Each user would have to pay connection costs to the district cooling system.

The energy cost to pump well water is calculated as 25% of operating a refrigeration-based cooling system (Appendix B). Assuming 60,000 square feet of space in year one and growing to 300,000 square feet in year 15 (Appendix C), the system would generate enough cash flow to cover operating and maintenance expenses, and debt service. The project could pay for itself in a reasonable time frame.

Biobased Heating

Greensburg has 1,600 cooling degree days and 4,800 heating degree days. Heating is the dominant building comfort requirement. For district heating to be economically viable it must have a cost advantage over conventional (individual building) natural gas fueled heating systems.

The new Greensburg downtown will be built to modern codes and its buildings will consume less energy than former structures. Average annual natural gas use for all occupancies is projected at 20,000 BTU/square foot. For the 300,000 square foot assumption for building out downtown, natural gas use would be 60,000 therm/year (1 therm = 100,000 BTU). At $0.80/therm annual natural gas heating costs would be $48,000.

Kiowa County has no known hot geothermal sources. The local renewable fuel resources suitable for district heating include corn grain, corn stover, and corncobs.

Corn prices decreased in inflation-adjusted dollars from 1976 to 2004. Corn burning heating equipment made good sense with cheap corn and expensive fossil fuel. However, in the last two harvest years, corn prices have roughly doubled due to high demand for ethanol production. Corn is

not the bargain fuel it was a few years ago; at $3.50/bushel corn costs $0.87/therm and is more expensive than natural gas. Corn grain is better utilized for food or ethanol production instead of solid fuel.

Corn stover is the residue left on fields after grain is harvested. Stover can be gathered in bales typically weighing around 1,500 lb. Stover would have to be processed for use in a heating system. Stover bales cost an estimated $45/ton delivered; fuel cost would be $.38/therm.

Corncobs are superior to corn stover as solid fuel because they can be transported in bulk and handled by conveyors and augers. While no firm data is available, corncob fuel from an established distribution system is estimated to cost $35/ton delivered. Fuel cost would be $0.32/therm.

Corn crop residue in the form of stover or cobs could be burned in a special boiler to produce hot water that would be piped to buildings. The boilers burn clean with no smoke or odor once they are up to operating temperature.

The energy cost for corncob residue heat is 40% of gas-fired heating equipment ($0.32/therm compared to $0.80/therm). The maximum cash flow switching from natural gas to the lowest cost renewable fuel is: ($.80 natural gas therm - $0.32 corncob therm) X 60,000 therms/year = $28,800/year. Corncob fuel would have operating and maintenance costs not associated with natural gas estimated at $15,000/year. Assuming 60,000 square feet of space in year one and growing to 300,000 square feet in year 15 (Appendix D), the system would not generate enough cash flow to cover operating, and maintenance expense, even without debt service.

Geothermal Heat Pumps Heating and Cooling

Another way to use 55°F groundwater is to supply water-source geothermal heat pumps for heating and cooling. This arrangement would eliminate the need for individual building owners to drill wells in the constricted downtown area. If Greensburg's electric power was derived from wind or another renewable resource, the downtown could be entirely heated and cooled with renewable energy.

Piping

The key element of a district energy system is the buried pipes. These pipes have to be sized to handle the maximum predicted load. Wells can be added as needed but undersized piping is difficult to replace. They are installed similar to water mains, which are sized based on rough guesses of future requirements. But unlike water mains, district energy systems need to be competitive with stand-alone energy systems. Because stand-alone energy systems are available, the high uncertainty of rate of growth in a situation like the Greensburg downtown area make it difficult to justify investing in buried piping for district heating and cooling. If growth is slow, and system subscribers come on slowly, the cash flow will not support the repayment of financing for the piping.

A good time to install the underground pipes would be when the landscaped strip is being built along Main Street. When the sidewalks are torn up, piping can be installed on the business side of the landscaping. Taps could be installed to serve known buildings.

Conclusions

District heating using corncob residue is not recommended for Greensburg because operating costs offset energy savings. Even if lower operating costs were possible, the price difference between corn residue and natural gas is not sufficient to finance a biofueled boiler plant and district heating system. There is not enough cash flow to support a district heating plant built with borrowed money.

The greater cost differential between traditional cooling and groundwater-based cooling made district cooling initially attractive; however, the cost of piping drives the economics negative.

The conclusion is: district heating and cooling is not recommended for Greensburg. The costs for such systems would be better applied to individual buildings using quality low-energy building construction, high efficiency natural gas heating equipment, and SEER 14+ air conditioners. There would then be no risk of the city being saddled with underutilized infrastructure.

If piping and wells could be donated or helped financially, a district energy system based on 55°F water for direct cooling and heat pumps would definitely add to Greenburg's green town image.

(January 2008)

Attachment A

Cost Estimate

Project: Greensburg District Cooling System

Mechanical

Page : 1 of 1

Date: 12/15/2007

By: Chris Gaul

ITEM	QUANTITY		MATERIAL		LABOR				Equipment	Total	TOTAL
	No.	Unit	Per Unit	Total	Unit Hrs	Rate	Ext Hrs	Total			
Engineering`											$50,000
Irrigation well	1	LS	$27,700.00	$27,700.00	0.00	$60	0	$0.00			$27,700
Pump and gearhead	1	LS	$22,000.00	$22,000.00	0.00	$60	0	$0.00			$22,000
Power unit	1	LS	$10,000.00	$10,000.00	0.00	$60	0	$0.00			$10,000
Pipe - 8" PVC insulated	1500	LF	$32.00	$48,000.00	0.67	$60	1000.5	$60,030.00			$108,030
Pipe - 8" PVC	1500	LF	$14.80	$22,200.00	0.09	$60	138	$8,280.00			$30,480
Misc. Piping	1	LS	$10,000.00	$10,000.00				$10,000.00			$20,000
Trenching	1800	CY	$2.50	$4,500.00	0.08	$60	144	$8,640.00	$1.43	2,574	$15,714
Pipe Bedding	1500	LF	$3.83	$5,745.00							$5,745
Controls	1	LS									$30,000
Estimating Contigency											$64,000
Subcontractor Overhead & Profit - 20%	1	LS		$30,029.00				$17,390.00			$47,419
								Sheet Total=			$431,088

Attachment B

Greensburg District Cooling System

Energy Cost to Pump Well Water (assumed 25% of operating a refrigeration-based cooling system)

Downtown buildout 300,000 Blended Power Cost / kWH: $0.11

Occupancy	Area-%	Area-Ft.2	Ft.2/ton	Tons	GPM	Annual DX cooling kWH/Ft.2	Annual kWH DX cooling	Annual Ton-Hours (1 kWH/T-H)	Annual DX Cooling cost	Annual Well Water Cooling kWH (0.25 kWH/T-H)	Annual Water Well Cooling Cost
Restaurant	15%	45,000	250	180	540	6.0	270,000	270,000	$ 29,700	67,500	$ 7,425
Office	30%	90,000	350	257	771	4.3	387,000	387,000	$ 42,570	96,750	$ 10,643
Retail	35%	105,000	350	300	900	4.3	451,500	451,500	$ 49,665	112,875	$ 12,416
Apartment	20%	60,000	500	120	360	3.0	180,000	180,000	$ 19,800	45,000	$ 4,950
Totals	100%	300,000		857	2,571		1,288,500	1,288,500	$ 141,735	322,125	$ 35,434
								Avg$/Ft.2	$ 0.47		$ 0.12

Attachment C

Cashflow Analysis for District Cooling

Downtown build out cashflow analysis — 2007 dollars

Year	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Restaurant sq. ft.	45,000	42,750	40,500	38,250	36,000	33,750	31,500	29,250	27,000	24,750	22,500
Office sq. ft.	90,000	85,500	81,000	76,500	72,000	67,500	63,000	58,500	54,000	49,500	45,000
Retail sq. ft.	105,000	99,750	94,500	89,250	84,000	78,750	73,500	68,250	63,000	57,750	52,500
Apartment sq. ft.	60,000	57,000	54,000	51,000	48,000	45,000	42,000	39,000	36,000	33,000	30,000
	300,000	285,000	270,000	255,000	240,000	225,000	210,000	195,000	180,000	165,000	150,000
Conventional Air-conditioning Energy Cost @ $0.47/Ft.2	$ 141,000	$ 133,950	$ 126,900	$ 119,850	$ 112,800	$ 105,750	$ 98,700	$ 91,650	$ 84,600	$ 77,550	$ 70,500
Well Cooling Energy Cost @ $0.12/Ft.2	$ 36,000	$ 34,200	$ 32,400	$ 30,600	$ 28,800	$ 27,000	$ 25,200	$ 23,400	$ 21,600	$ 19,800	$ 18,000
Annual Energy Savings Well vs. Conventional	$ 105,000	$ 99,750	$ 94,500	$ 89,250	$ 84,000	$ 78,750	$ 73,500	$ 68,250	$ 63,000	$ 57,750	$ 52,500
Well Debt Service @ 6% Interest	(44,376)	(44,376)	(44,376)	(44,376)	(44,376)	(44,376)	(44,376)	(44,376)	(44,376)	(44,376)	(44,376)
Well O&M costs	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)
Annual Well Cashflow	48,624	43,374	38,124	32,874	27,624	22,374	17,124	11,874	6,624	1,374	(3,876)
Cumulative Cost Savings	$ 142,738	$ 94,114	$ 50,739	$ 12,615	$ (20,259)	$ (47,883)	$ (70,258)	$ (87,382)	$ (99,256)	$ (105,880)	$ (107,255)

Attachment D

Cashflow for Biobased (corncob) District Heating System

Year	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Restaurant sq. ft.	45,000	42,750	40,500	38,250	36,000	33,750	31,500	29,250	27,000	24,750	22,500	20,250	18,000	15,750
Office sq. ft.	90,000	85,500	81,000	76,500	72,000	67,500	63,000	58,500	54,000	49,500	45,000	40,500	36,000	31,500
Retail sq. ft.	105,000	99,750	94,500	89,250	84,000	78,750	73,500	68,250	63,000	57,750	52,500	47,250	42,000	36,750
Apartment sq. ft.	60,000	57,000	54,000	51,000	48,000	45,000	42,000	39,000	36,000	33,000	30,000	27,000	24,000	21,000
	300,000	285,000	270,000	255,000	240,000	225,000	210,000	195,000	180,000	165,000	150,000	135,000	120,000	105,000
Gas Heating Cost @ $0.80/therm	$ 48,000	$ 45,600	$ 43,200	$ 40,800	$ 38,400	$ 36,000	$ 33,600	$ 31,200	$ 28,800	$ 26,400	$ 24,000	$ 21,600	$ 19,200	$ 16,800
Biofuel Heating Cost @ $0.32/therm	$ 19,200	$ 18,240	$ 17,280	$ 16,320	$ 15,360	$ 14,400	$ 13,440	$ 12,480	$ 11,520	$ 10,560	$ 9,600	$ 8,640	$ 7,680	$ 6,720
Biofuel O&M cost	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000
Annual Savings	$ 13,800	$ 12,360	$ 10,920	$ 9,480	$ 8,040	$ 6,600	$ 5,160	$ 3,720	$ 2,280	$ 840	$ (600)	$ (2,040)	$ (3,480)	$ (4,920)
Total Savings	$ 46,560	$ 32,760	$ 20,400	$ 9,480	$ -	$ (8,040)	$ (14,640)	$ (19,800)	$ (23,520)	$ (25,800)	$ (26,640)	$ (26,040)	$ (24,000)	$ (20,520)

D.14 Greensburg Recovery Program – The Feasibility and Benefits of Fuel Cell Cogeneration

Trudy Forsyth
National Renewable Energy Laboratory

Thomas A. Wind
Wind Utility Consulting

Greensburg Recovery Program



THE FEASIBILITY AND BENEFITS OF FUEL CELL COGENERATION

UTC Power
A United Technologies Company

WP0001
17 March 2008

GREENSBURG RECOVERY PROGRAM

THE FEASIBILITY AND BENEFITS OF FUEL CELL COGENERATION

WHITE PAPER

Prepared for
National Renewable Energy Laboratory
Attn: Lynn Billman, Senior Project Leader II
1617 Cole Boulevard
Golden, CO 80401-3393

and

The City of Greensburg, Kansas

CONTACT: Rob Roche
TELEPHONE: (860) 727-2422
CELL: (860) 614-1351
FAX: (860) 998-9318
E-MAIL: robert.roche@utcpower.com

UTC Power
A United Technologies Company

1. PURPOSE

UTC Power is pleased to submit this white paper to the National Renewable Energy Laboratory (NREL), the City of Greensburg, and various other Greensburg Recovery Program stakeholders so that fuel cells may be considered for the rebuilding effort in concert with other energy technologies. We hope that this paper will provide useful information about the cogeneration capabilities of fuel cells and, specifically, the applicability, benefits, economics and environmental considerations of integrating this technology into the rebuilding and recovery of this community.

2. THE PURECELL® MODEL 400 FUEL CELL SYSTEM

The PureCell® Model 400 energy solution is a 400 kW phosphoric acid fuel cell (PAFC) slated for market introduction in the first half of 2009. This product is a next generation technology, drawing on the experience and success of the world's most versatile and proven fuel cell system, the PureCell® Model 200 solution. The PureCell® Model 200 fuel cell system has accrued over 8.5 million fleet hours on approximately 300 installed systems since 1992. The PureCell® Model 400 fuel cell system distinguishes itself from all other fuel cell products in the marketplace with its very high cogeneration system efficiency (about 85 percent), and its 10 year cell stack life (more than double the life of competing fuel cell technologies). It can be fueled by pipeline natural gas (2009) or anaerobic digester gas (ADG; available 2010). The electric-only system efficiency is 42 percent (LHV) at startup, with an average lifetime electrical efficiency of 40 percent (LHV).

The PureCell® Model 400 system product datasheet, provided as Attachment A, describes the performance and physical characteristics of this product in detail.

3. POTENTIAL APPLICATIONS

Fuel cell application economics are driven by the following considerations:

- *Favorable spark spread* – Spark spread is the price difference between the fuel cost (*e.g.*, natural gas) and electricity being displaced. The higher the electricity costs are relative to the cost of gas, the better the value proposition is for any type of cogeneration system.

- *Available federal or state incentives* – As of right now, the federal investment tax credit of $1,000/kW is set to expire on 31 December 2008. The fuel cell industry is working to have the deadline extended beyond this date. There are currently no state fuel cell incentives in Kansas.

- *Ability to baseload the power and thermal output of the fuel cell* – Usually, it is easier to baseload power and more difficult to baseload heat use at many types of buildings. The PureCell® system offers up to 1.7 MMBtu/hr of useful heat to customers for space heating, industrial processes or domestic hot water. If natural gas costs about $8/MMBtu and converts to heat at 80 percent, then this fuel cell heat is worth about $20/hr or about $140,000/year if fully utilized.

- *Value of energy reliability* – If the grid fails, then having on-site fuel cell power handling mission critical or life safety related electrical loads has financial value, though it is sometimes difficult for a specific dollar value to be assigned to this. The PureCell® system has delivered this type of assured power for many customers since 1992.

The optimal application of fuel cells in Greensburg involves two possible installation configurations:

a. Central plant

b. Dispersed concept.

3.1 CENTRAL PLANT

Recent NREL commissioned reports estimate a ~1.5 MW base electric load for the entire Greensburg community. The peak load is projected to be about 4.5 MW (summer months). Four 400-kW PureCell® systems would deliver 1.6 MW of power and could produce 6.8 MMBtu/hr of hot water. Since the current projections for thermal demand in residential Greensburg do not appear to call for sizable heat distribution, a large commercial or industrial entity with a requirement for large amounts of thermal energy might be attracted to the area by the promise of useable heat at a reasonable discount. The total economic value of the PureCell® central plant would be about $560,000 per year (assuming gas costs of $8/MMBtu, and an 80 percent conversion efficiency). At a plant life of 20 years, this projects to about $11.2 million (assuming no gas price escalation). Additionally, the central plant concept offers the possibility of supporting up to 1.6 MW of Greensburg town power loads if the grid fails. Such power security would offer great peace of mind to the town and its residents.

A PureCell® central plant is envisioned to employ at least one or two Greensburg citizens as UTC Power contractors. In this role, these contractors would be trained to operate and maintain the central plant.

3.2 DISPERSED CONCEPT

One or more fuel cells could be located at various sites that require power, heating, cooling and/or backup power. Each PureCell® system can make about 50 tons of chilled water for space cooling (air conditioning) through the use of absorption chiller technology. Recent data suggests the new high school (125,000 sq ft) and hospital (38,000 sq ft) electrical loads together could be supported by a single 400 kW fuel cell. As other large facilities emerge in the recovery buildout, they could be assessed for need and equipped with fuel cell cogeneration and backup power as well.

A typical system integration concept is shown in ***Figure 1***.

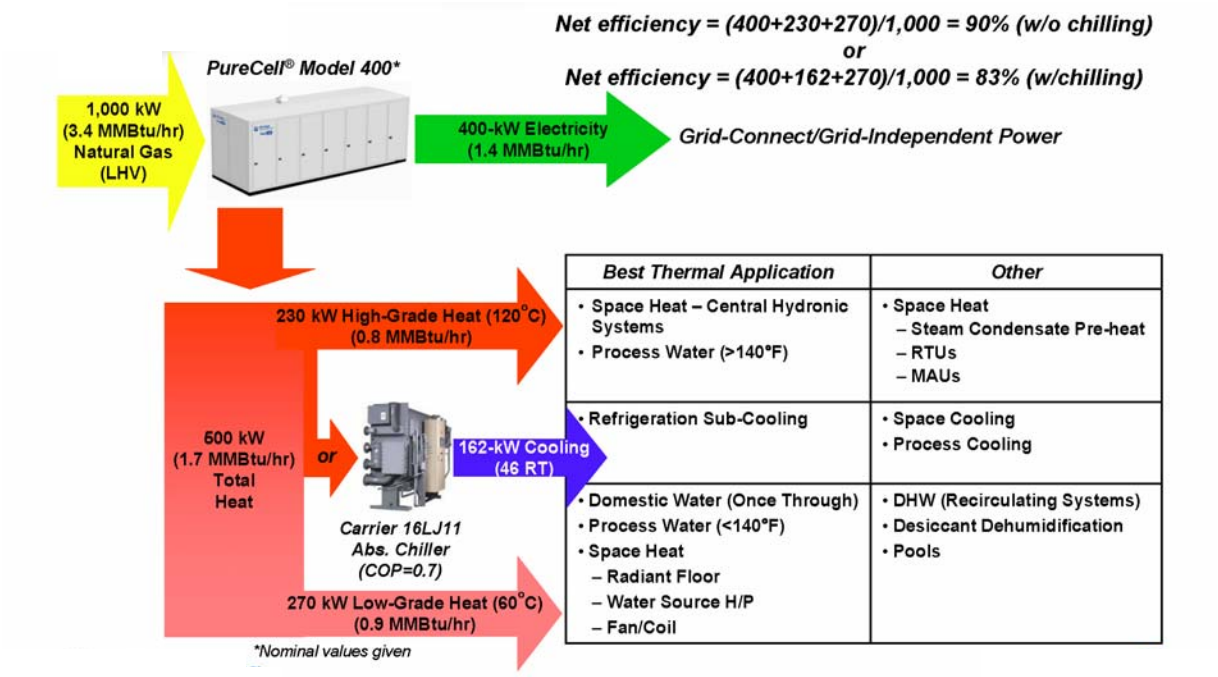


Figure 1. *Typical PureCell® Model 400 CHP System Installation*

4. FUEL CELL ECONOMICS IN GREENSBURG

The following assumptions were used to assess fuel cell economics in Greensburg.

- Input assumptions:
  - Each fuel cell installed cost = $3,000/kW or $1.2 million each
  - Annual service cost = $68,000 per fuel cell or about 2.0¢/kWh
  - Fuel cell uptime = 95 percent
  - Rated power output = 400 kW
  - Electric energy produced per year, per fuel cell = 3.33 million kWh/yr
  - Natural gas price = $8/MMBtu.
- Output:
  - Cost of power generation = 12.5¢/kWh (if 0 percent fuel cell waste heat is used)[1]
  - Cost of power generation = 7.5¢/kWh (if 100 percent fuel cell waste heat is used)[1]
  - Value of 100 percent waste heat use = $140,000/yr (about 4.0¢/kWh).

Fuel cell economics are compared to pre-tornado electricity costs in ***Figure 2***. The pre-tornado data was provided by Greensburg's Steve Hewitt via NREL.

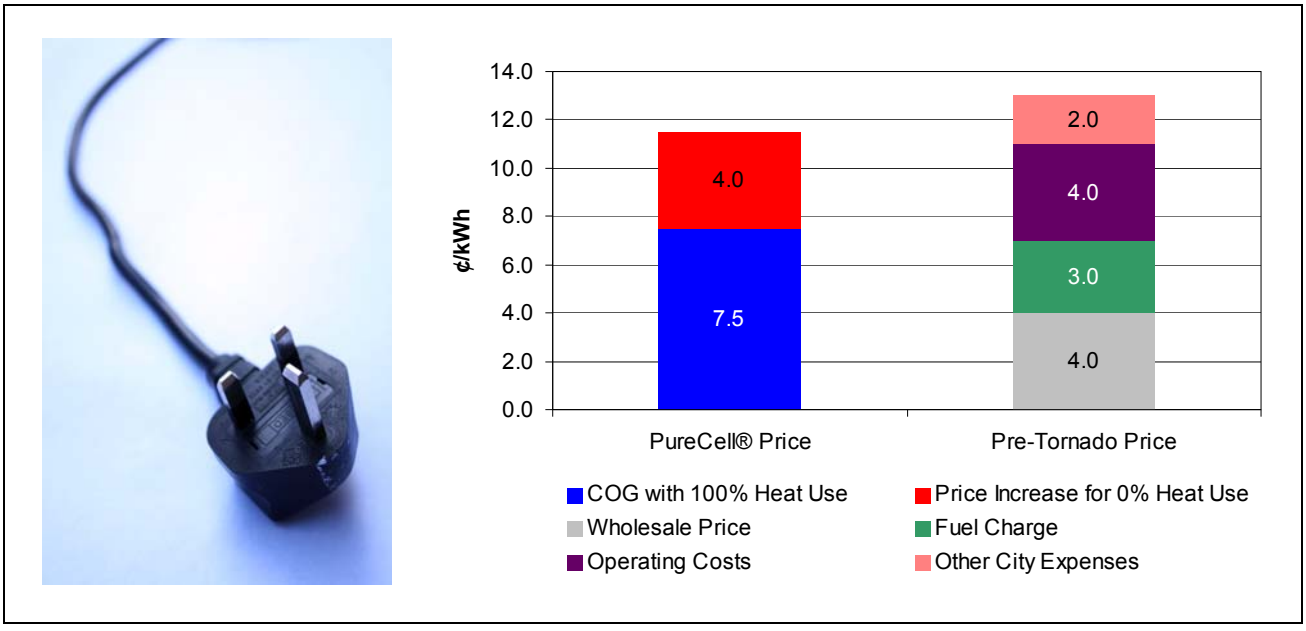


Figure 2. *Fuel Cell Economics Versus Pre-Tornado Electricity Costs*

[1] If Greensburg uses the dual electric mode capability of the PureCell® system and its ability to operate both grid connected or grid independent, then the cost of diesel generators will be avoided. UTC Power approximates this avoided cost as about 1¢/kWh (capital plus operating/service) and these values would be about 11.5¢/kWh and 6.5¢/kWh, respectively.

5. ENVIRONMENTAL CONSIDERATIONS

5.1 AIR EMISSIONS

The carbon dioxide generation potential of a 1.5-MW PureCell® system is compared to the Kansas grid, as well as solar and wind energy production, in ***Figure 3***. The chart shows that the carbon dioxide generation potential of a fuel cell project with 0 percent heat use is roughly equal to a wind project with a 41-percent capacity factor. However, if 100 percent of the fuel cell heat is used, then carbon dioxide generation is reduced significantly by about 62 percent.

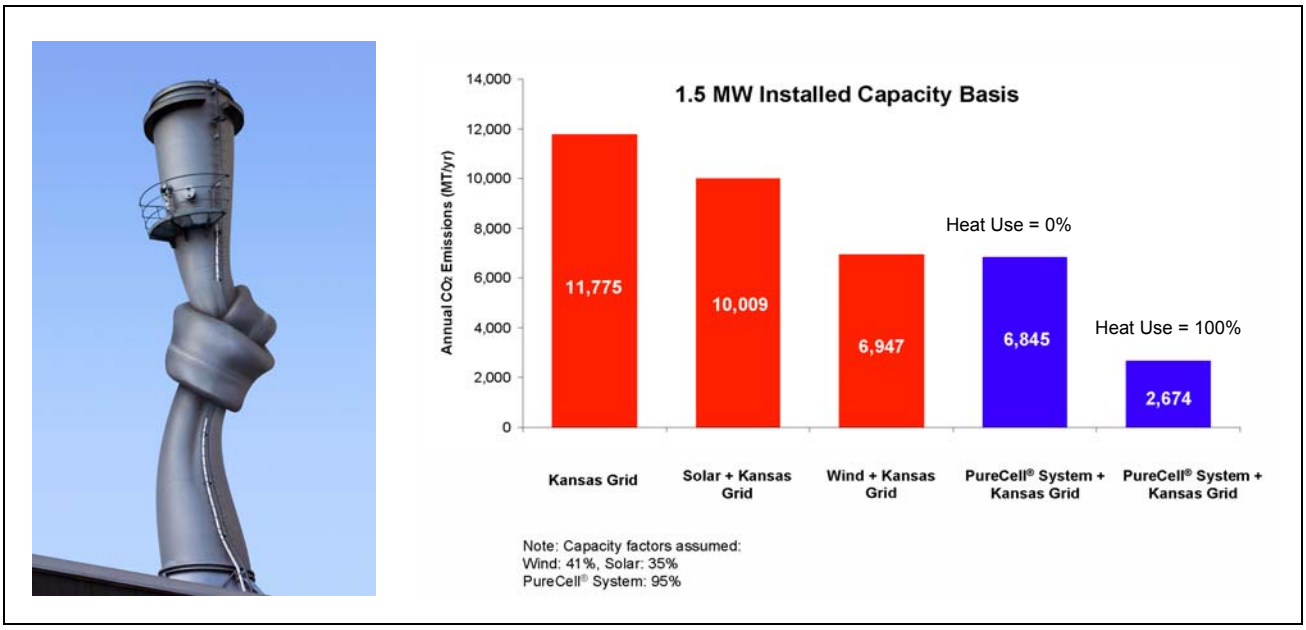


Figure 3. *Comparison of Carbon Dioxide Generation By Source*

Additionally, the PureCell® fuel cell solution avoids other conventional pollutants that cause health and environmental issues. The emissions advantages of the PureCell® system are illustrated in ***Figure 4***.

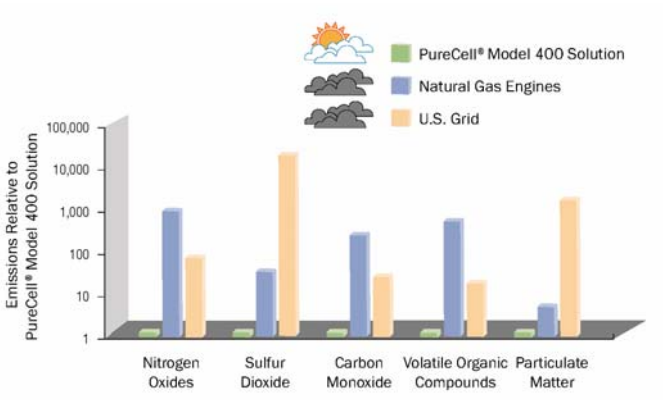


Figure 4. *Emissions Advantages of the PureCell® System*

5.2 WATER CONSERVATION

Utility scale power generation consumes large quantities of water. According to the U.S. Geological Survey (1995 data), the Kansas grid uses 556 gal/MWh of water. The PureCell® system uses very little water by comparison. If PureCell® systems are used to displace 1.5 MW of grid power, about 7 million gallons of water per year (relative to the Kansas grid) would be conserved. This comparison is depicted in ***Figure 5***.

A 1.5-MW PureCell® System Could Save Greensburg Roughly 7 Million Gallons of Water Annually

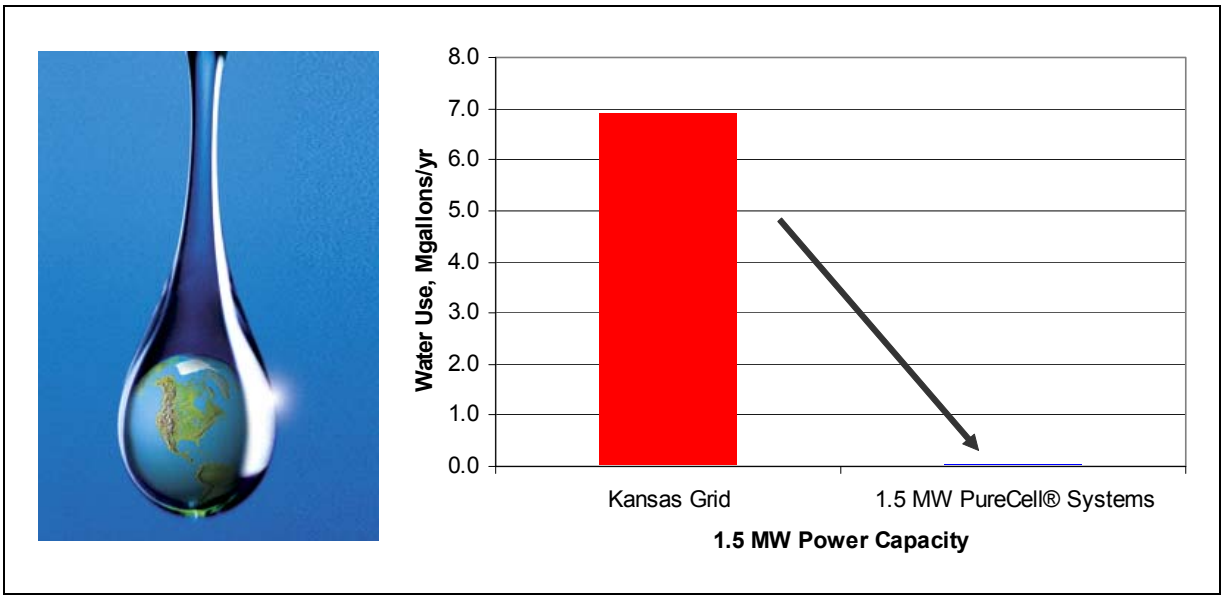


Figure 5. *Comparison of Water Use*

6. OTHER FUEL CONSIDERATIONS

The PureCell® system can operate on ADG fuel as stated previously. However, there is currently no source of ADG in Greensburg. If it looks like a source will emerge in the buildout of the community, then this fuel could be considered as a fuel source for an installed PureCell® system. The ADG source could be blended with pipeline natural gas to produce power while reducing fuel costs.

UTC Power has also delivered and operated a PureCell® Model 200 system fueled by hydrogen. If NREL is considering converting wind energy to hydrogen, then UTC Power would be pleased to discuss this fuel option in greater detail.

APPENDIX A — PURECELL® MODEL 400 SOLUTION DATASHEET

The technical datasheet for the PureCell® Model 400 is replicated on the following pages.

Model 400

MODEL 400
PureCell® System

Introducing a new generation of fuel cell technology: The PureCell® Model 400 Energy Solution.

UTC Power is a world leader in developing and producing fuel cells for on-site power, transportation, space and defense applications. We are committed to providing high quality solutions for the distributed energy market that increase energy productivity, energy reliability and operational savings for our customers. Building on our unmatched operational experience and a technology platform proven at more than 260 sites worldwide, UTC Power is pleased to offer an advanced fuel cell energy solution for the commercial marketplace.

The ultra clean and quiet PureCell® Model 400 fuel cell can provide up to 400 kW of assured electrical power, plus up to 1.7 million Btu/hour of heat, for combined heat and power applications. And with energy efficiencies more than double those of traditional power sources, the PureCell® Model 400 system is an energy solution that will not only help you conserve precious resources, it will save you money, shield you from operational interruption, and secure your place at the forefront of environmentally sustainable business practices.

Performance Characteristics

Power

Electric power	400 kW/471 kVA initial 400 kW lifetime average (10 yr) 360 kW initial (ADG)
Voltage/frequency	480VAC/60 Hz/3 phase§ 400VAC/50 or 60 Hz/3 phase

Efficiency

Electrical (LHV)	42% initial/40% nominal (5 yr)
Overall (LHV)	90%‡

Fuel

Supply	Natural gas or ADG*
Consumption (HHV)	1,054 kW (3.60 MMBtu/hr) initial 1,110 kW (3.79 MMBtu/hr) average
Pressure	1.0 to 3.5 kPA (4 to 14 in. water)**

Heat Recovery

Low grade (60°C/140°F supply)†	450 kW (1.537 MMBtu/hr) initial 500 kW (1.708 MMBtu/hr) nominal
High grade (121°C/250°F supply)†	200 kW (0.683 MMBtu/hr) initial 230 kW (0.785 MMBtu/hr) nominal

Other

Noise	< 65 dBA at 10m (33 ft) with no heat recovery < 60 dBA at 10m (33 ft) with full heat recovery
Overhaul interval	10 yr (major)

Emissions

NO_x	0.016 kg/MWh (0.035 lb/MWh)
CO	0.004 kg/MWh (0.008 lb/MWh)
CO_2	508 kg/MWh (1120 lb/MWh) average
SO_x	Negligible
Particulate matter/VOCs	Negligible

Water

Consumption	None (up to 30°C/86°F ambient)
Discharge	None (normal operating conditions)

energy
Reinvented

** All given characteristics are for a natural gas application, unless otherwise noted. Maximum allowable levels for natural gas components are documented separately in the PureCell® Model 400 System Installation Design Guide. ADG applications require an additional gas processing unit. ** Gauge pressure. † Available heat at rated power. Low-grade heat assumes a return temperature of 27°C (80°F); high-grade heat assumes a return temperature of 90°C (194°F). If high-grade heat is utilized, the remaining value will be available as low-grade heat. ‡ Overall efficiency as given assumes full thermal utilization. § Operating range from -29° to 45°C (-20° to 113°F) at up to 150m (429 ft).*

Model 400

MODEL 400
PureCell® System

Physical Characteristics

Power Module

Shipping Dimensions

Length:	27 ft. 6 in. (339 cm)
Width:	8 ft. 6 in. (111 cm)
Height:	10 ft (305 cm)
Weight:	60,000 lb (27,216 kg)

Cooling Module

Shipping Dimensions

Length:	15 ft. 11 in. (485 cm)
Width:	7 ft. 10 in. (239 cm)
Height:	6 ft. 7 in. (201 cm)
Weight:	3,190 lb (1,447 kg)

The manufacturer reserves the right to change or modify, without notice, the design or equipment specifications without incurring any obligation either with respect to equipment previously sold or in the process of construction. The manufacturer does not warrant the data on this document. Warranted specifications are documented separately.

UTC Power
A United Technologies Company

195 Governor's Highway . South Windsor, CT 06074 . Phone: (866) 900-POWER . Fax: (860) 727-2319 . www.utcpower.com

Copyright ® 2008 by UTC Power Corporation. All rights reserved.

DS0012A



UTC Power

A United Technologies Company

Appendix E: Alternative Transportation

Page

E.1 Options for Alternative Fuels and Vehicles in Greensburg, Kansas 488

E.1 Options for Alternative Fuels and Vehicles in Greensburg, Kansas

Gerry Harrow
National Renewable Energy Laboratory
(February 4, 2008)

Background

Not long ago, Greensburg, Kansas, was nearly wiped off the map. In May 2007, Greensburg was hit by a fierce tornado that either destroyed or severely damaged the city's homes, commercial areas, a hospital, and many vehicles. The population of this city, which is also the Kiowa County seat, was more than 1,400 before the tornado struck. By the end of 2008, the population could be only half that many—about 700 people—according to some estimates.

But Greensburg is a city that refuses to give up. Its leaders and many of its citizens are committed to rebuilding Greensburg to be a model of sustainability for other cities and towns in rural America. To assist the city, the National Renewable Energy Laboratory (NREL) is working with the U.S. Department of Energy (DOE) and other federal, state, and local agencies to help Greensburg define its vision for rebuilding as a "green" city.

As of December 1, 2007, 44 businesses had made a commitment to rebuild there, and six new businesses had expressed interest in locating there, as well. Before the tornado, many of Greensburg's businesses depended on fleets of vehicles to carry out their day-to-day operations. Since the storm, the state has provided them with a number of older replacement vehicles. But many vehicles—and especially newer ones—are still needed.

As the city rebuilds its fleets, a number of officials have expressed considerable interest in using alternative fuels. To successfully incorporate alternative fuels and alternative-fueled vehicles in the city's rebuilding plan, the following factors will be key:

- Private and public commitments to the use of alternative fuels
- Adequate numbers and availability of alternative-fueled vehicles and support systems, including sales, maintenance, and supplies of parts
- Sufficient alternative fuel supplies and fueling stations
- Competitive prices for both vehicles and fuels

Selecting a portfolio of the most appropriate alternative fuels and vehicles for the area is also important in ensuring the success of those technologies in Greensburg. An appropriate portfolio will help the city and its citizens reduce both greenhouse gas (GHG) emissions and the city's dependence on foreign oil. Biofuels can especially support the community if they are produced from locally grown crops and by using local, renewably generated power.

Biodiesel, electricity, ethanol, natural gas, and propane are all commercially available and could meet the majority of Greensburg's transportation needs. The following information about these technologies can also be found on DOE's Energy Efficiency and Renewable Energy Alternative Fuels and Advanced Vehicles Data Center (AFDC) Web site (see *www.eere.energy.gov/afdc/fuels/index.html*), and it is reprinted here. Readers can use the links to obtain more information.

Biodiesel (*www.eere.energy.gov/afdc/fuels/biodiesel.html*)

Biodiesel is a renewable alternative fuel produced from a wide range of vegetable oils and animal fats. Pure biodiesel is compatible with most diesel engines and is commonly blended with petroleum diesel. Blends like B5 (5% biodiesel, 95% diesel), currently being used by the Kansas Department of Transportation in Greensburg, are becoming increasingly common as fleets and drivers become more aware of the many benefits. Biodiesel blends up to B20 (20% biodiesel and 80% diesel) are becoming more widely available and can be implemented using current infrastructure.

Electricity (*www.eere.energy.gov/afdc/fuels/electricity.html*)

Greensburg is considering renewable electricity generation options using wind power. This renewable energy can be used to power electric vehicles directly from the power grid. Electric vehicles (EVs) store electricity in an energy storage device, such as a battery. The electricity powers the vehicle's wheels by means of an electric motor. Due to current battery technology and vehicle design limitations, EVs have limited energy storage capacity and driving range. Some EVs replenish the electricity with onboard chargers; others plug into a charger located outside the vehicle. There are currently no light-duty electric vehicles available from major auto manufacturers. Neighborhood electric vehicles (NEVs), on the other hand, are being manufactured by a variety of companies. These small vehicles are ideal for a city the size of Greensburg and are commonly used for municipal tasks, neighborhood commuting, light hauling, and delivery. Their use is limited to areas with 35 mph speed limits or for off-road service.

Ethanol (*www.eere.energy.gov/afdc/fuels/ethanol.html*)

Ethanol is a renewable transportation fuel primarily made today from starch crops, such as corn. It can also be made from sugar beets and cane or cellulosic materials, such as corn stover and wheat straw. Nearly one-third of U.S. gasoline used in conventional vehicles contains ethanol in a low-level blend to reduce air pollution. E85 (85% ethanol, 15% gasoline) is considered an alternative fuel and is used to fuel E85-capable flexible fuel vehicles (FFVs), which are available in a variety of models from U.S. and foreign automakers. FFVs are capable of operating on gasoline, E85, or a mixture of both using a single fueling system. Other than fueling capability and corrosion-resistant components, FFVs are similar to their conventional gasoline counterparts. Power, acceleration, payload, and cruise speed are comparable whether running on ethanol or gasoline. The only noticeable difference is that fuel economy is lower when FFVs run on ethanol because of its lower energy content. However, if priced correctly, E85 has an equivalent cost per mile.

Natural Gas *(www.eere.energy.gov/afdc/fuels/natural_gas.html)*
Natural gas is a domestically produced alternative fuel and is readily available to end users through the utility infrastructure. Most natural gas is extracted from gas and oil wells with much smaller amounts derived from supplemental sources such as synthetic gas, landfill gas and other biogas resources, and coal-derived gas. Dedicated natural gas vehicles (NGVs) are designed to run only on natural gas; bi-fuel NGVs have two separate fueling systems that enable the vehicle to use either natural gas or a conventional fuel (gasoline or diesel). Natural gas vehicles are fueled with compressed natural gas (CNG) or liquefied natural gas (LNG). The driving range of NGVs generally is less than that of comparable gasoline- and diesel-fueled vehicles because of the lower energy content of natural gas. NGV horsepower, acceleration, and cruise speed are comparable with those of an equivalent conventionally-fueled vehicle. Light-duty natural gas vehicles work much like gasoline-powered vehicles with spark-ignited engines. Some heavy-duty vehicles use spark-ignited natural gas systems, but other systems exist as well. High-pressure direct injection engines burn natural gas in a compression-ignition (diesel) cycle. Heavy-duty engines can also burn diesel and natural gas in a dual-fuel system. Several light-duty and heavy-duty natural gas vehicles are available from manufacturers or certified conversion companies. (Note that conversions must be performed by companies that have received approval from the Environmental Protection Agency). A CNG powered Honda Civic and a FuelMaker FMQ-2-36 CNG refueling station was recently donated to Greensburg. See also *www.fuelmaker.com/Products/NaturalGasRefueling/ProductSpecifications*.

Propane *(www.eere.energy.gov/afdc/fuels/propane.html)*
Propane, also known as liquefied petroleum gas (LPG), is used by many fleets. It is produced as a by-product of natural gas processing and crude oil refining. Propane has a high-energy density, high-octane rating, and excellent properties for spark-ignited internal combustion engines. Propane vehicles work much like gasoline-powered vehicles with spark-ignited engines. Depending on the system, a vapor mixture of propane and air or liquid propane is drawn or injected into the combustion chamber where it is burned to produce power, just like gasoline. The Southern Plains Co-op has a propane refueling station in Greensburg. As with CNG, there are several certified propane light- and heavy-duty conversions that are available.

Hybrids *(www.eere.energy.gov/afdc/vehicles/hybrid_electric.html)*
Hybrid electric vehicles (HEVs) typically combine the internal combustion engine of a conventional vehicle with the battery and electric motor of an electric vehicle. HEVs combine the benefits of high fuel economy and low emissions with the power, range, safety characteristics, and convenience of conventional diesel and gasoline fueled vehicles. Future offerings might also include plug-in hybrid electric vehicles that could take advantage of available public or private charging facilities. Hybrid electric vehicles are cost competitive with similar conventional vehicles. What cost premiums there are for HEVs can be offset by fuel cost savings and tax incentives. There are numerous original equipment manufacturers that offer light duty hybrid vehicles. Various manufacturers currently offer medium and heavy duty hybrid vehicles including delivery vehicles, buses, and refuse trucks.

Idle Reduction *(www.eere.energy.gov/afdc/vehicles/idle_reduction.html)*
Idle reduction (IR) technologies and practices are an important way to cut petroleum consumption and emissions. IR is typically used to describe technologies and practices that reduce the amount of time vehicles idle their engines. Reducing idle time saves fuel, engine wear, and money while reducing emissions and noise. A variety of technologies are employed to reduce this fuel use. Onboard equipment such as automatic engine stop-start controls and auxiliary power units can be used. Additional strategies are available for light- and medium-duty vehicles and school buses.

Public and Private Commitments to Alternative Fuels

In December 2007, NREL conducted extensive interviews with members of the Greensburg community. Both public and private fleets indicated support for alternative fuels—if they were cost competitive, operationally similar to conventional fuels, and readily available. The use of biofuels, such as E85 and biodiesel, was noted several times in the interviews as a way to support the local agricultural economy. Questions and concerns were raised about the relative merit of biofuels, and many of these inquiries were addressed during the interviews.

Vehicle Numbers and Availability

From the Greensburg fleet interviews, combined with data obtained from R.L. Polk & Co., we concluded that, before the tornado struck, there were approximately 4,000 vehicles within a 30-mile radius of Greensburg. The vehicles included 100 FFVs, 300 diesel on-road vehicles, and 3,600 gasoline-fueled vehicles. The current vehicle population is more difficult to ascertain, because a significant number of residents have not returned to Greensburg, damaged vehicles have not been permanently replaced, and fleet owners are trying to assess their future needs before acquiring new vehicles.

After the tornado, the Greensburg Chevrolet dealer relocated to a temporary facility and continues to sell and maintain FFVs. A Ford dealership approximately 30 miles away in Pratt also sells FFVs. There is currently no local support infrastructure to provide, maintain, and repair hybrid, electric, or natural-gas-fueled vehicles.

Fuel Supplies and Pricing

The three Greensburg fueling stations— Kwik Shop, Southern Plains Co-op, and Volz Oil—provide various blends of gasoline, diesel, and dyed diesel. Kiowa County and the Kansas Department of Transportation also maintain multiple fuel tanks for vehicle refueling. When the interviews were conducted, there were no E85 or biodiesel refueling stations, but all of the fuel providers indicated that their suppliers could provide them with both fuels. There were also no publicly available electric charging stations.

Changes are on the way, however. For example, a FuelMaker CNG refueling station was recently donated to the city and the Southern Plains Co-op plans to install a credit card reader at their propane refueling station. For an up-to-date listing of the Greensburg area's alternative fuel stations, see the AFDC's Alternative Fueling Station Locator at *http://afdcmap2.nrel.gov/locator*. Using the station locator, you can search the Greensburg area to find stations offering compressed natural gas, liquefied petroleum gas, E85, electricity,

biodiesel, hydrogen, and liquefied natural gas. The results are displayed in a map with details about each station.

Even when an alternative fuel is available, cost-competitive pricing is critical to its successful use. During the 2007 interviews, station owners indicated that the wholesale cost of biodiesel and ethanol was not competitive with that of conventional diesel and gasoline. A CNG/gasoline cost comparison supplied by Kansas Gas Service (Appendix D) indicates that CNG costs significantly less than unleaded gasoline, however, on a gasoline gallon-equivalent basis.

A successful approach to obtaining biodiesel and ethanol at a favorable price is to negotiate long-term contracts directly with local fuel producers. This approach reduces transportation charges, potentially eliminates fuel marketer fees, and provides support to local production facilities that purchase feedstocks, such as soybeans and corn.

There are two local producer options for ethanol in the area. The Gateway Ethanol plant in Pratt is in the initial startup phase and should be producing within a few months, if it is not already doing so. Noble Americas, representing Gateway, indicated that it would be interested in supplying E85 to facilities in Greensburg. Also, Kwik Shop has been purchasing E85 for one of its Wichita stations from Abengoa Bioenergy Corporation in Colwich, Kansas. Abengoa Bioenergy New Technologies currently has a grant from DOE to produce ethanol from cellulosic materials. This might provide both a short-term option for corn-based ethanol as well as a longer term option for cellulosic ethanol. Recently, Torsten Energy announced that it would be building a biodiesel plant in Greensburg. Several plants could be in production within three to four years. No additional local biodiesel producers have been identified.

The 2007 interviews also indicated that the approximate annual volume of transportation-related fuel being obtained at current Greensburg fueling sites amounts to 1.6 million gallons of gasoline; 300,000 gallons of on-road, clear diesel; and 115,000 gallons of off-road, dyed diesel. At the time of this report, the numbers from Volz Oil had not been confirmed.

Table 1. Estimated Vehicle Fuel Consumption in Greensburg (gallons per year)

	Gasoline	Diesel	E85	CNG	Propane
Municipal and Retail Locations	1,600,000	415,000	0	0	0

Fueling Locations

The economics of dispensing alternative fuels must be sustainable over the long term. Economic sustainability will be affected by the local vehicle population, the commitment of vehicle owners to use alternative fuels, and the cost of installing fueling equipment, such as tanks and dispensers.

As mentioned earlier, both diesel vehicles and FFVs are currently operating in the Greensburg area. In the 2007 interviews, most fleet owners indicated that B20 is operationally viable for

their diesel vehicles and that they could mandate its use if it were cost competitive with #2 diesel. However, private vehicle owners would be the primary purchasers of E85, and it could take some time and education to change their behaviors in this regard. The fleets that currently include FFVs, or are considering purchasing them, indicated that they would probably refuel with E85 when it is offered at competitive prices.

Station owners reported that they have received estimates of $60,000 to $70,000 to add E85 equipment. If the owner qualifies for it, Kansas currently offers a 40% tax credit for this. There is also a 30% federal tax incentive for increasing the alternative fuel infrastructure (see Appendix C for more on infrastructure tax incentives). All the fuel providers interviewed expressed interest in supporting alternative fuels and the associated infrastructure if the business case supports the investment and the fuel is available at a competitive price.

Calculations made using the NREL E85 Business Case model and estimated FFV populations suggest that adding an E85 capability to existing stations might be feasible (see Appendix B for specific calculations used in the Greensburg scenarios). Additional information, including assumptions and calculation methods used in the business case, can be found at *www.eere.energy.gov/afdc/fuels/ethanol_business.html*.

Further studies need to be conducted to better understand the business cases for all alternative fuels. If other sources of funding can be found to help build an alternative fuel infrastructure in Greensburg, the economic viability of this option will be enhanced.

Incentives for Alternative Fuels and Alternative-Fueled Vehicles

Numerous federal and state incentives promote the use of alternative fuels and the acquisition of alternative-fueled vehicles in Kansas, and many could be applicable in Greensburg. Incentives for alternative fuels usually fall into the following categories: fuel infrastructure credits, vehicle credits, fuel tax credits, and fuel production credits.

For example, if one of the stations in Greensburg added an E85 or B20 biodiesel dispenser that cost $70,000, it could be eligible for a 30% federal tax credit ($21,000) and a 40% Kansas state tax credit ($28,000), depending on its tax liability. This would result in an out-of-pocket cost for the dispenser of $21,000.

Appendix C of this report and the Incentives and Laws section of the AFDC site (*www.eere.energy.gov/afdc/incentives_laws.html*) describe various federal incentives for alternative fuels and vehicles as well as state incentives available in Kansas.

Recommendations

The Greensburg community faces many challenges, including projecting its future population to help determine transportation needs, vehicle replacements, and the viability of transportation-focused businesses. The city's size and makeup will have a direct effect on its successful implementation of alternative fuels and advanced-technology vehicles.

The following recommendations should increase the potential for the successful use of alternative transportation technologies in Greensburg. They are based on the information we collected during the December 2007 interviews and supplemented with historical data.

General Recommendations

1. Encourage major fleet operators in Greensburg to work with the business community to develop an optimum fuel supply infrastructure. If station owners can depend on a base level of fuel purchases from fleet operators, the business case becomes much more favorable despite the city's relatively small size.

2. Encourage the Chamber of Commerce to work with Greensburg Greentown and city and county leadership to establish a green transportation subcommittee that would be the primary group for developing and implementing transportation recommendations.

Public and Private Commitment to Alternative Fuels and Petroleum Reduction

1. Hold a joint meeting with key fleets and station owners to assess, solicit, and gain support for biofuels. With commitments from fleets located in Greensburg and the surrounding area, this group would work with local fueling businesses to build up the alternative fuel infrastructure.

2. Hold educational events to provide a forum for fleets and the public. Several participants expressed significant interest in alternative fuels during the 2007 interviews, and many of them asked questions related to biofuels and advanced-vehicle technologies. Educational events can serve as a platform for obtaining the community's support. In addition, consider holding training sessions with drivers in the fleets that commit to using alternative fuels and vehicles.

3. Develop fleet recognition and incentive programs for drivers. For example, hold a monthly drawing for a $20 gift card awarded randomly to a driver that has filled his or her vehicle with biofuel. For privately owned vehicles used in fleets, reimburse an additional $50 per month for a driver who uses an alternative fuel in his or her FFV rather than a conventionally fueled vehicle.

4. Discuss the possibility of using B20 in Greensburg with the Kansas Department of Transportation.

5. Consider adding idle-reduction technologies to vehicles, such as school buses, that spend a significant amount of time idling.

Vehicle Population and Availability

1. Consider implementing a purchasing policy for the City of Greensburg and Kiowa County that requires agencies to purchase alternative fuel and an advanced-technology vehicle, when they are locally available, for a vehicle application that is being added or replaced.

2. Conduct an in-depth analysis of vehicles that have to be replaced or added to municipal and private fleets. Determine the pricing differential for purchasing alternative fuel and advanced-technology vehicles. Solicit and establish a fund to help offset any incremental costs for alternative fuel or advanced-technology vehicles.

3. Explore the feasibility of purchasing neighborhood electric vehicles for city and county employees, such as building inspectors and meter readers, who use vehicles primarily in the city.

4. Conduct an analysis of the cost of installing public electric recharging stations throughout Greensburg. Based on the analysis and the projected population of electric vehicles, consider including recharging stations in the master plan to encourage businesses and residents to use electric vehicles for their in-town activities.

5. Complete the business case for adding a neighborhood electric vehicle dealership in Greensburg. If the volume of sales and service would support this type of dealership, solicit seed funding and work with the local dealership to get it started. Global Electric Motorcars, LLC, one of the electric car companies contacted for this analysis, reported that it would cost approximately $60,000 in initial vehicle inventory, parts, and fees to start a new dealership.

6. Explore the feasibility of locating a hybrid electric vehicle dealership in Greensburg. Contact dealerships in the area that currently offer hybrids and assess their interest .

7. Explore the availability of CNG and propane vehicles and options for refueling multiple vehicles at a donated CNG refueling station.

Fuel Supply and Pricing

1. Study E85 and biodiesel pricing structures from current suppliers. Determine local pricing strategies and their impact on fuel sales.

2. Continue to pursue alternative fuel supply options and contracts with local biofuel producers.

Fueling Locations

1. Solicit grants or donations to cover the initial cost of upgrading the existing fueling infrastructure to include biofuels. Station owners in Greensburg estimated that costs would be $70,000 per station for E85 or B20, not including any tax incentives. That amount includes the cost of a new tank, a dispenser, and other equipment needed to make the fuels available to the public. If all available federal and Kansas state alternative fuel infrastructure tax credits applied, the out-of-pocket costs and funding required would be approximately $21,000 per fuel per location.

2. Maximize the use of alternative fuels in local fleets whenever possible by purchasing new alternative-fueled vehicles and using E10 and B5 in conventional vehicles.

Challenges

The challenges that Greensburg faces in adopting green transportation technologies include:

- Predicting the future vehicle population
- Ensuring the availability of alternative fuels at competitive prices
- Covering the cost of replacing current or lost vehicles with alternative-fueled vehicles, which includes obtaining outside funding
- Developing the infrastructure required for alternative fuels and advanced vehicles

Potential Economic Development Opportunities

Opportunities in Greensburg for economic development associated with alternative fuels and vehicles include:

- Providing sales and services for electric vehicles
- Building an infrastructure for biodiesel
- Building an infrastructure for E85
- Providing maintenance and other support for CNG and Propane-fueled vehicles
- Providing sales, services, and support for hybrid electric vehicles
- Providing sales, installation, and other services for idle-reduction technologies

Attachment A

Stakeholder Fleets

Successful implementation of alternative fuels within an area is directly affected by local fleet support for those fuels. If the station owners can depend on a base level of fuel purchases from these fleets, the business case becomes much more favorable. To assess the support for alternative fuels in Greensburg, the stakeholder fleets were contacted and estimated vehicle numbers and fuel usage was obtained. It needs to be emphasized that these numbers are estimates based on the best information available at the time.

City of Greensburg

Contact: Pam Reeves, Treasurer
Vehicles: 10 light-duty gasoline
Two light-duty diesel
Two medium- and heavy-duty diesel trucks
Fuel Supplier: Volz Oil
Southern Plains Co-op

Kiowa County

Contacts: Kiowa County Commissioner, Gene West
Sheriff Department, Galan Marvel
Road and Bridge, Doyle Conrad
Fire Department, Chance Little, Jay Kane
Weed Department, Reed Foster
Emergency Services, Kendal Lothman
Vehicles: 21 light-duty gasoline
Four light-duty diesel
Eight medium- and heavy-duty diesel trucks
>20 off-road diesel equipment
Fuel Supplier: Volz Oil

John Deere Dealership

Contact: Kelly Estes, President
Mike Estes, Greensburg Store Manager/Sales
Vehicles: 18 private vehicles reimbursed by the company
75 diesel vehicles between four stores
Fuel Supplier: Volz Oil
Southern Plains Co-op

School System
Contact: Darin Headrick, School Superintendent
Vehicles: One FFV Chevrolet Impala, 30,000 miles per year
2 FFV Suburbans, 20,000 miles per year
Five passenger vans (will be replaced with six or seven FFV or hybrid Suburbans)
One motor coach (would consider idle reduction for this and other units)
One Kubota diesel 4-wheeler
Future - may look at a 66 passenger school bus
Fuel Supplier: Southern Plains Co-op

Iroquois Center for Human Development
Contact: Shelton Carpenter, Executive Director
Vehicles: 25 light-duty
Fuel Supplier: Volz Oil
Southern Plains Co-op

Hospital
Contact: Mary Sweet, Administrator
Vehicles: Two diesel ambulances (24,000 miles per year)
Maintenance ½ ton pickup (7,000 miles per year)
2001 Dodge Cargo van (not currently in use)
Fuel Supplier: Southern Plains Co-op

Southern Plains Co-op
Contact: Ron Gruber
Vehicles: Six gasoline pickups
Six tender trucks
Six applicator trucks
Two propane delivery trucks
Fuel Supplier: Southern Plains Co-op

Kansas Department of Transportation vehicles located in Greensburg
Contact: Gary Jarvis
Vehicles: Three diesel trucks
Two pickups
Multiple off-road vehicles (graders, loaders, and a backhoe)
Fuel Supplier: Volz Oil, Moeder or Hampel (depending on lowest bid)

Vehicle Providers
The local Chevrolet dealer, Ron Shank of Dwane Shank Motors, Inc., currently orders and stocks FFVs when the models are available in FFV versions. He does not make a concerted effort to stock used FFVs. General Motors (GM) is assisting him in building a "Green" dealership which includes energy efficiency improvements, solar, and wind generation. He is interested in electric vehicles and believes that, in certain applications, it is a good choice for Greensburg.

Lanterman Motors is a Ford dealership located approximately 30 miles away in Pratt. When contacted, they said that they currently sell a limited number of FFVs and do not sell or service the Ford Escape hybrid.

Schofield Honda, a dealership in Wichita approximately 90 miles away, donated a Honda GX and a FuelMaker CNG refueling station.

There are no local businesses that currently provide maintenance and service for alternative vehicle technologies such as electric, hybrid, natural gas, and propane. The GM dealer is not open to providing that service due to the retraining and equipment costs associated with supporting other OEM vehicles.

Infrastructure
The city currently has two publicly available fueling sites that were quickly rebuilt after the tornado: the Southern Plains Co-op and the Kwik Shop (a part of the Dillons chain and ultimately tied to Kroger). They both offer unleaded and diesel fuel. In addition to these two sites, many of the businesses and fleets purchase their fuel from Volz Oil.

Southern Plains Co-op	Three tanks (6,000 gallon red diesel, 6,000 gallon clear diesel, and 8,000 gallon unleaded), two dispensers, propane filling station
Kwik Shop	Three tanks (10,000 gallons unleaded, 10,000 gallons premium, and 10,000 gallons diesel), three dispensers
Volz Oil	No data available at this time

Kiowa County Road & Bridge department had four bulk refueling tanks before the tornado: two 500-gallon unleaded, one 8,000-gallon clear diesel, and one 8,000-gallon red diesel. They are currently using three 1,000-gallon tanks for red diesel, one 8,000-gallon tank for clear diesel and one 1,000-gallon tank for unleaded.

The state of Kansas fleet in Greensburg has a 2,000-gallon diesel tank that is filled with B5. The district office in Hutchinson sets the guidelines for fuel use including biodiesel mixtures.

There are no mentioned fire jurisdictions. The city controls what is within its boundaries and the county indicated that people could do whatever they wanted in the county.

According to NREL's Alternative Fuels Data Center in December 2007, within 90 miles of Greensburg there is no biodiesel available; five stations offer E85 (closest one is 24 miles away in Offerle, Kan.), one station offers CNG (64 miles away in Alva, Okla.), and 11 additional stations offer propane (closest one is 30 miles away in Pratt, Kan.).

Fuel Availability
There is an existing ethanol plant in Pratt, Kan. (30 miles) and one in Dodge City (60 miles). On December 3, 2007, there was an announcement that a biodiesel plant will be built in Greensburg. It appears that biodiesel from this facility will be available in approximately three years.

The co-op has access to biodiesel from Cenex, their fuel provider, and has considered offering it to their customers. Up until now, pricing, in addition to the infrastructure costs, has prevented them from offering B20. Pricing available to them on December 6, 2007 was $4.37 per gallon of pure biodiesel and $2.57 per gallon of #2 diesel. Nationwide at the end of November, 2007, E85 pricing was 18% lower than unleaded (EPIC data).

There is an abundance of natural gas in the area and propane was previously used in transportation and for powering irrigation wells. Both have been declining in use.

Idle Reduction
City, county and school vehicles that require significant idling could be up-fitted with idle reduction devices. Idle reduction devices can cost from $700 for a simple light-duty application to over $7,000 for certain heavy-duty vehicle applications.

Attachment B

Calculations using the NREL E85 Business Case model and estimated FFV populations indicate that the required gross margin to give a 10% expected rate of return would range from $0.13 per gallon for 93,000 gallons of E85 sold per year (assumes all vehicles fill up 100% of the time with E85 in Greensburg at one station) to $0.58 for 16,000 gallons of E85 sold per year (assumes 100% of the vehicles fill up 50% of the time with E85 at three stations in Greensburg).

The required gross margin for E85 would be significantly lower if outside funding would pay a portion of the out-of-pocket expenses associated with adding the necessary equipment to provide infrastructure. Gross margin is defined as the money the retailer needs to make on each gallon of E85 sold. For more detailed information on the E85 Business Case and its assumptions, go to *www.eere.energy.gov/afdc/fuels/ethanol_business.html*.

Attachment C

The following information is taken directly from DOE's EERE Alternative Fuels & Advanced Vehicles Data Center at *www.eere.energy.gov/afdc/progs/fed_summary.php/afdc/US/0*.

United States (Federal) Incentives and Laws

Alternative Fuel Infrastructure Tax Credit

Section 1342 of the Energy Policy Act of 2005 provides a tax credit equal to 30% of the of cost alternative refueling property, up to $30,000 for business property. Qualifying alternative fuels are natural gas, propane, hydrogen, E85, or biodiesel mixtures of B20 or more. Buyers of residential refueling equipment can receive a tax credit for $1,000. For non-tax-paying entities, the credit can be passed back to the equipment seller. The credit is effective on equipment put into service after December 31, 2005. It expires December 31, 2009 (hydrogen property credit expires in 2014).

This legislation also extends the Tax Deduction Timeline that was established by EPAct 1992, Section 179, and extended by the Working Families Tax Relief Act of 2004.

In May 2006, the Internal Revenue Service (IRS) published Form 8911, which provides a mechanism to claim the infrastructure tax credit. Owners who install qualified refueling property on multiple sites can utilize the credit for each property. The instructions define what is considered qualified property and the value of the credit. See IRS Form 8911 at *http://www.irs.gov/pub/irs-pdf/f8911.pdf* .

Alternative Motor Vehicle Credit

Section 1341 of the Energy Policy Act of 2005 provides a tax credit to buyers of new alternative fuel vehicles placed in service as an alternative fuel vehicle after January 1, 2006. The legislation provides for a tax credit equal to 50% of the incremental cost of the vehicle, plus an additional 30% of the incremental cost for vehicles with near-zero emissions (SULEV or Bin 2 for vehicles <14,001 lb GVWR). The IRS has issued two notices to establish rules for manufacturers and qualified vehicle buyers to claim the credit. The Current Tax Credits table at *www.eere.energy.gov/afdc/vehicles/hybrid_electric_tax_credits.html* has information on certified vehicles and available credits.

The credit is available on the purchase of light-, medium, and heavy-duty vehicles and fuel-cell, hybrid, and dedicated natural gas, propane, and hydrogen vehicles. Light-duty lean burn diesel vehicles are also eligible.

Vehicles are subject to the following incremental cost limitations:

- $5,000: 8,500 GVWR or lighter
- $10,000: 8,501 - 14,000 GVWR
- $25,000: 14,001 - 26,000 GVWR
- $40,000: 26,001 GVWR and heavier

For non-tax-paying entities, the credit can be passed back to the vehicle seller. The tax credit can be applied to vehicle purchases made after December 31, 2005. The credit expires December 31, 2010.

IRS Notice 2006-9 (*www.irs.gov/pub/irs-drop/n-06-09.pdf*), issued in January 2006, establishes procedures for manufacturers to certify to the IRS that a vehicle meets requirements to claim the credit and the amount of the credit for which the vehicle is eligible.

IRS Notice 2006-54 (*www.irs.gov/pub/irs-drop/n-06-54.pdf*), issued in June 2006, extends the Qualified Alternative Fuel Motor Vehicle (QAFMV) tax credit to vehicle conversions. This IRS guidance states that new or used vehicles, placed in service as alternative fuel vehicles after January 1, 2006, qualify for the tax credit when the conversion system manufacturer has received a certificate of conformity from the EPA or California Air Resources Board. This guidance also establishes that manufacturers (conversion system installers) must provide certification to the IRS that a vehicle is eligible for a tax credit. The IRS must then provide the manufacturer with acknowledgement that a vehicle qualifies for the credit. The credit is taken by the buyer of a vehicle, and IRS Form 8910 should be used to claim the credit. The credit cannot be sold or transferred but can be carried forward by the seller for use in later years.

This legislation replaces the Clean Fuel Vehicle Property Tax Deduction previously available to purchasers.

Hybrid Motor Vehicle Credit
Section 1341 of the Energy Policy Act of 2005 provides a tax credit for light-duty hybrid vehicles (<8,501 lb GVWR) based on their improved fuel economy and their life-time fuel savings potential. The IRS will certify vehicles for the credit and publish qualifying credit amounts as vehicles are certified. The Current Tax Credits table has the most recent information from the IRS.

The fuel economy portion of the credit is based on the following efficiency gains over model year 2002 baselines.

- 125%-149%: $400
- 150% -174%: $800
- 175%-199%: $1,200
- 200%-224%: $1,600
- 225%-249%: $2,000
- 250%+: $2,400

The conservation credit increases the fuel economy credit based on the following lifetime fuel savings:

- 1,200-1,799 gal: $250
- 1,800-2,399 gal: $500

- 2,400-2,999 gal: $750
- 3,000 gal+: $1,000

To qualify for the credits, the vehicles must meet at least Bin 5 standards if they are up to 6,000 lb GVWR, or Bin 8 standards if the vehicles are 6,001 lb-8,500 lb GVWR.

Heavy-duty hybrid vehicles are subject to the following incremental cost limitations:

- <14,001 GVWR: $7,500
- 14,001-26,000 GVWR: $15,000
- 26,001+ GVWR: $30,000

This tax credit replaces the tax deduction previously available to purchasers under the Clean Fuel Vehicle Property guidance. This tax credit expires December 31, 2010.

The IRS issued guidance to automobile manufacturers in January 2006. Specifically, this notice provides procedures for a vehicle manufacturer to certify to the Internal Revenue Service both that the vehicle meets certain requirements for the credit and information to calculate the amount of the credit allowable with respect to that vehicle. See Notice 2006-9 at *www.irs.gov/pub/irs-drop/n-06-09.pdf*.

Clean School Bus USA
Clean School Bus USA reduces operating costs and children's exposure to harmful diesel exhaust by limiting bus idling, implementing pollution reduction technology, improving route logistics, and switching to biodiesel. In fiscal year 2005, the program offered $7.5 million in cost-shared grants to help school districts upgrade their diesel fleets. The Energy Bill of 2005 utilizes this EPA program to grant up to 50% cost share (depending on the age and emissions of original bus) to replace school buses with ones that operate on alternative fuels or low-sulfur diesel, or up to 100% for retrofit projects. $55 million are authorized for both 2006 and 2007, and "such sums as necessary" for 2008-2010. More information is available on the Clean School Bus USA site at *www.epa.gov/cleanschoolbus/index.htm*.

Biodiesel and Ethanol (VEETC) Tax Credit
The American Jobs Creation Act of 2004 (Public Law 108-357) created tax incentives for biodiesel fuels and extended the tax credit for fuel ethanol. The biodiesel credit is available to blenders/retailers beginning in January 2005. It also established the Volumetric Ethanol Excise Tax Credit (VEETC), which provides ethanol blenders/retailers with $.51 per pure gallon of ethanol blended or $.0051 per percentage point of ethanol blended (i.e., E10 is eligible for $.051/gal; E85 is eligible for $.4335/gal). The incentive is available until 2010.

Section 1344 of the Energy Policy Act of 2005 extended the tax credit for biodiesel producers through 2008. The credits are $.51 per gallon of ethanol at 190 proof or greater, $1.00 per gallon of agri-biodiesel, and $.50 per gallon of waste-grease biodiesel. If the fuel is used in a mixture, the credit amounts to $.0051 per percentage point ethanol or $.01 per percentage point of agri-biodiesel used or $.0050 per percentage point of waste-grease biodiesel (i.e. E100 is eligible for $.51 per gallon).

For more information, read IRS Form 637 (*www.irs.gov/pub/irs-pdf/f637.pdf*) and IRS publication 510 (*www.irs.gov/pub/irs-pdf/p510.pdf*).

Non-Urbanized Area Formula Program

The Non-Urbanized Area Formula Program assists in the maintenance, development, improvement, and use of public transportation systems in rural and small urban areas; helps people in non-urbanized areas get transportation to health care, shops, school, employment, pubic services, and recreation; assists in the development and support of intercity bus transportation; and more. The program provides funding for capital, operating, and administrative purposes to state and local governments, non-profit organizations, and public transit operators. For more information, read the Federal Transit Administration's FY 2007 Budget Request at *www.irs.gov/pub/irs-pdf/p510.pdf* or call the Federal Transit Administration's Office of Resource Management and State Programs at (202) 366-2053.

Kansas Incentives and Laws

Last Updated May 2007

The following information is taken directly from DOE's EERE Alternative Fuels & Advanced Vehicles Data Center and can be accessed by going to *www.eere.energy.gov/afdc/incentives_laws.html* and clicking on the state of Kansas on the map.

Kansas is the proud home of the Kansas City Regional Clean Cities Coalition *(www.kcenergy.org/transportation.html*). Coordinator contact information is listed below.

Alternative Fuel Refueling Infrastructure Tax Credit

The state offers an income tax credit for alternative fuel refueling stations placed in service after January 1, 2005, and before January 1, 2009. The tax credit, worth up to 40% of the total amount, may not exceed $160,000. For any refueling station placed in service after January 1, 2009, the amount may not exceed $100,000. This tax credit should be deducted from the taxpayer's income tax liability for the taxable year in which the expenditures are made. In the event the credit is more than the taxpayer's tax liability for that year, the remaining credit may be carried over for up to three years after the year in which the expenditures were made.

Point of Contact

Jim Ploger
Director of Renewable Energy & Energy Efficiency
Kansas Energy Office
Phone (785) 271-3349
Fax (785) 271-3268
j.ploger@kcc.state.ks.us
http://www.kcc.state.ks.us/energy/

Renewable Fuel Retailer Incentive

Beginning January 1, 2009, a licensed retail motor fuel dealer may receive a quarterly incentive for selling and dispensing renewable fuels, including biodiesel. Qualified motor fuel

dealers are eligible for up to $0.065 for every gallon of renewable fuel sold and up to $0.03 for every gallon of biodiesel sold, if the required threshold percentage is met. The threshold percentage for the incentive payment will increase on an annual basis from 10% for renewable fuel and 2% for biodiesel in 2009 to 25% beginning on January 1, 2024. Funds will be allocated from the Kansas Retail Dealer Incentive Fund.

'Biodiesel' is defined as a renewable, biodegradable, mono alkyl ester combustible liquid fuel derived from vegetable oils or animal fats that meets the specifications adopted by rules and regulations of the Secretary of Agriculture pursuant to current law. The specification must meet the American Society for Testing and Materials (ASTM) specification D6751-07 for biodiesel fuel (B100) blend stock for distillate fuels, but may be more stringent regarding biodiesel quality and usability. 'Renewable fuels' are defined as combustible liquids derived from grain starch, oil seed, animal fat, or other biomass; or produced from biogas source, including any non-fossilized, decaying, organic matter which is capable of powering spark ignition machinery.

Point of Contact

Cindy Mongold
Public Service Administrator II
Kansas Department of Revenue
Phone (785) 296-7048
Fax (785) 296-4993
cindy_mongold@kdor.state.ks.us
www.ksrevenue.org

Alternative Fuel Vehicle (AFV) Tax Credit

The state offers an income tax credit worth up to 40% of the incremental or conversion cost for qualified AFVs placed into service after January 1, 2005, as outlined in the chart below. Qualified AFVs include vehicles that operate on a combustible liquid derived from grain starch, oil seed, animal fat, or other biomass, or produced from a biogas source.

GVWR	Credit
Less than 10,000 lbs.	Up to $2,400
10,000 to 26,000 lbs.	Up to $4,000
Over 26,000 lbs.	Up to $40,000

Alternatively, a tax credit in an amount not to exceed the lesser of $750 or 5% of the cost of the AFV is available to a taxpayer who purchases an original equipment manufacturer AFV. This credit is allowed only to the first individual to take title of the vehicle. For motor vehicles capable of operating on E85, the individual claiming the credit must provide evidence of purchasing at least 500 gallons of E85 between the time the vehicle was purchased and December 31 of the next calendar year. This tax credit should be deducted from the taxpayer's income tax liability for the taxable year in which the expenditures are made. In the event the credit is more than the taxpayer's tax liability for that year, the

remaining credit may be carried over for up to three years after the year in which the expenditures were made.

Point of Contact
Jim Ploger
Director of Renewable Energy & Energy Efficiency
Kansas Energy Office
Phone (785) 271-3349
Fax (785) 271-3268
j.ploger@kcc.state.ks.us
http://www.kcc.state.ks.us/energy/

Biodiesel Production Incentive

A biodiesel fuel production incentive is available in the amount of $.30 per gallon of biodiesel fuel sold by a qualified Kansas biodiesel fuel producer. The incentive is payable to producers from the Kansas Qualified Biodiesel Fuel Producer Incentive Fund. Funding will be made available for the production of biodiesel fuel beginning July 1, 2007.

Ethanol Production Incentive

The Kansas Qualified Agricultural Ethyl Alcohol Producer Fund enables qualified agricultural ethyl alcohol producers to apply for a production incentive with the Department of Revenue. If an ethyl alcohol producer who was in production prior to July 1, 2001, increases production capacity by an amount of 5,000,000 gallons over the producer's base sales, $0.075 may be collected for each gallon sold to an alcohol blender that is in excess of the producer's base sales (up to 15,000,000 gallons). Producers who start production on or after July 1, 2001, and who have sold at least 5,000,000 gallons to an alcohol blender may receive $0.075 for each gallon sold (up to 15,000,000 gallons).

Point of Contact
Patricia Platt
Public Service Administrator II
Kansas Department of Revenue
Phone (785) 291-3670
Fax (785) 296-2703
patricia_platt@kdor.state.ks.us

Regional Biofuels Promotion Plan

Kansas has joined Indiana, Iowa, Michigan, Minnesota, Ohio, South Dakota, and Wisconsin in adopting the Energy Security and Climate Stewardship Platform Plan (Platform), which establishes shared goals for the Midwest region, including increased biofuels production and use. Specifically, the Platform sets the following goals:

- Produce commercially available cellulosic ethanol and other low-carbon fuels in the region by 2012.
- Increase E85 availability at retail fueling stations in the region to 15% of stations by 2015, 20% by 2020, and 33% of all fueling stations in the region by 2025.

- Reduce the amount of fossil fuel that is used in the production of biofuels by 50% by 2025.
- By 2025, at least 50% of all transportation fuels consumed by the Midwest will be from regionally produced biofuels and other low-carbon transportation fuels.

The Platform also establishes a regional biofuels corridor program. The program directs state transportation, agriculture, and regulatory officials to develop a system of coordinated signage across the region for biofuels and advanced transportation fuels and to collaborate to create regional E85 corridors. The program requires standardized fuel product coding at fueling stations as well as increased education for retailers about converting existing fueling infrastructure to dispense E85. The state transportation, agriculture, and regulatory officials are required to report their corridor implementation plans to the Midwest Governors Association by April 1, 2008.

Idle Reduction Weight Exemption

Any vehicle or combination of vehicles equipped with idle-reduction technology may exceed the state's gross and axle weight limits by up to 400 pounds to compensate for the additional weight of the added idle reduction technology.

Point of Contact
Tom Whitaker
Executive Director
Kansas Motor Carriers Association
Phone (785) 267-1641
Fax (785) 266 -6551
tomw@kmca.org
www.kmca.org

E85 Tax Rate Reduction and Definition

Effective January 1, 2007, the motor vehicle fuel tax rate on E85 fuel is at least $0.17 per gallon, until July 1, 2020. On and after July 1, 2020, the tax on E85 fuel will be a minimum of $0.11 per gallon. E85 is defined as an alternative fuel that is a blend of denatured ethanol and hydrocarbon that typically contains 85% ethanol by volume, and must contain at least 70% ethanol by volume and complies with American Society for Testing and Materials (ASTM) specification D5798-99.

Biofuels Use

A 2% or higher blend of biodiesel must be purchased for use in state-owned diesel powered vehicles and equipment, where available, as long as the incremental price of biodiesel is not more than $0.10 per gallon as compared to the price of diesel fuel. Further, individuals operating state-owned motor vehicles must purchase fuel blends containing at least 10% ethanol, as long as these fuel blends are not $0.10 per gallon more than the current price per gallon of regular gasoline fuel.

Low-Speed Vehicle Access to Roadways

A low-speed vehicle is defined as any four-wheeled electric vehicle whose top speed is greater than 20 miles per hour (mph) but not greater than 25 mph and is manufactured in compliance with the national highway and traffic safety administration standards for low-speed vehicles in Title 49 of the Code of Federal Regulations Title 49, Part 571.500. Low-speed vehicles may only travel on roads with a posted speed limit of 40 mph or less and must be appropriately licensed.

Attachment D

Kansas Gas Service CNG/Gasoline Comparison

Month/Year	SSCPL Index $/Mcf	Marketer Margin* $/Mcf	KGS Delivery** $/Mcf	Gas Cost $/Mcf	CNG/gal $/GGE	Fed Tax $/GGE	Fed Cred $/GGE	State Tax $/GGE	Total $/GGE		Kansas Unleaded Avg***
Aug-2006	$6.2300	$ 0.5000	$ 0.7500	$ 7.4800	$ 0.8976	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.8106		$ 2.9800
Sep-2006	$5.7200	$ 0.5000	$ 0.7500	$ 6.9700	$ 0.8364	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.7494		$ 2.3900
Oct-2006	$3.4900	$ 0.5000	$ 0.7500	$ 4.7400	$ 0.5688	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.4818		$ 2.1700
Nov-2006	$6.3700	$ 0.5000	$ 0.7500	$ 7.6200	$ 0.9144	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.8274		$ 2.1900
Dec-2006	$6.7100	$ 0.5000	$ 0.7500	$ 7.9600	$ 0.9552	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.8682		$ 2.2200
Jan-2007	$5.5000	$ 0.5000	$ 0.7500	$ 6.7500	$ 0.8100	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.7230		$ 2.0200
Feb-2007	$7.0100	$ 0.5000	$ 0.7500	$ 8.2600	$ 0.9912	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.9042		$ 2.2000
Mar-2007	$6.6700	$ 0.5000	$ 0.7500	$ 7.9200	$ 0.9504	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.8634		$ 2.5100
Apr-2007	$6.0800	$ 0.5000	$ 0.7500	$ 7.3300	$ 0.8796	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.7926		$ 2.7600
May-2007	$6.6400	$ 0.5000	$ 0.7500	$ 7.8900	$ 0.9468	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.8598		$ 3.1900
Jun-2007	$6.9200	$ 0.5000	$ 0.7500	$ 8.1700	$ 0.9804	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.8934		$ 3.0200
Jul-2007	$6.1100	$ 0.5000	$ 0.7500	$ 7.3600	$ 0.8832	$ 0.1830	$ (0.5000)	$ 0.2300	$ 0.7962		$ 3.1000
								Avg	$ 0.7975		$ 2.5625
								Difference	**$ 1.7650**		

* Assumption for illustration only
** Does not include $38.50 monthly service charge
*** AAA

7/24/2007
JWWright

Appendix F: Green Building Codes and Standards

Page

F.1 Building Codes for Greensburg – Introductory Discussion 512

F.2 Greensburg Green Building Codes 528

F.3 Greensburg Green Building Program, Residential Recommendations 541

F.4 Recommendations for the Greensburg Green Building Program 550

F.5 NAHB Green Commitment to City of Greensburg, Kansas Memo 555

F.1 Building Codes for Greensburg – Introductory Discussion

Lynn Billman, John Holton, Alex Dane
National Renewable Energy Laboratory

National Renewable Energy Laboratory
Innovation for Our Energy Future

Building Codes for Greensburg – Introductory Discussion



City of Greensburg, KS

Lynn Billman
John Holton
Alex Dane

October 22, 2008

Topics

- Project Goal and Scope
- Building Codes Overview
- Green Building Programs Overview
- Energy Considerations
- What's Happening Today

Green Building Approaches

- Examples from Other Communities

Examples

- Greensburg Commitments
- Greensburg Suggestions
- Questions and Feedback
- Next Steps

Greensburg

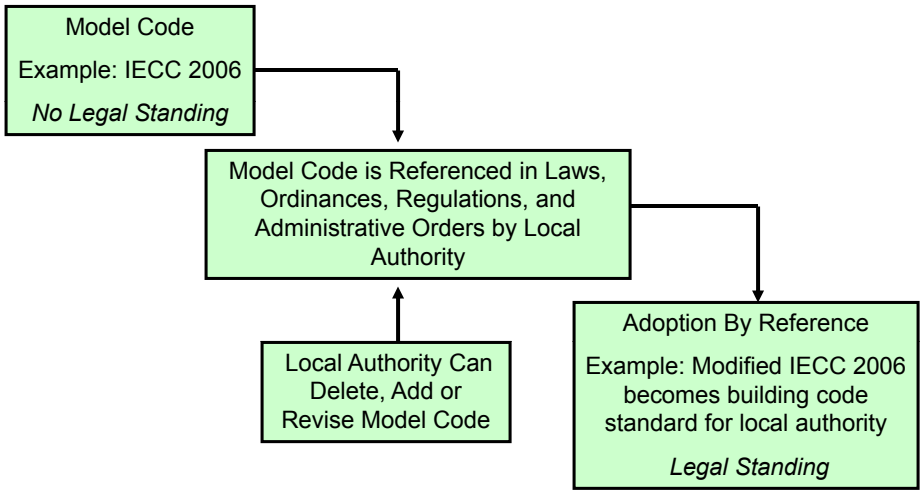
2

City Goals and NREL Project Scope

- Primary City Goal – Demonstrate a strong city position on sustainability through city policies affecting all buildings
  - Gordon Stull has confirmed "…the City can adopt a 'green code' if carefully and reasonably crafted."
- Secondary City Goals
  - Garner support from businesses and residents
  - Strike a balance between ideals and practicality
- Scope of NREL Project
  - Analyze options and make recommendations
  - Assist in discussions with stakeholders
  - Assist in training and education of city staff and stakeholders

3

Building Code Adoption Process



4

Building Codes (National and International)

- Written in a format and in sufficient detail to guide architects, builders, and city enforcement officials
- Traditionally focused on building safety and occupant health issues
- Established by lengthy, inclusive processes
  - American National Standards Institute (ANSI) develops standards for building components and materials, comprehensive building standards
  - International Code Council develops a family of model buildings codes (IRC, IBC, IECC, etc.)
  - American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) develops standards for mechanical systems and components, comprehensive energy, and building standards
- Green building codes just now being developed

5

Residential Model Building Codes

Current

- 2003 IRC (International Residential Code)
  - Very modest insulation requirements: walls R13, roof R26, windows R1.3
- 2003 IECC (International Energy Conservation Code)
  - Modest insulation requirements: walls, roof, windows
  - Includes prescriptive and performance path
  - Includes air sealing
  - Includes duct insulation and sealing
- 2006 IECC
  - Better insulation requirements: walls R13, roof R38, windows R2.5
  - Likely equates to 15% better than IECC 2003
  - Likely meets Energy Star level
  - Includes prescriptive and performance path
  - Includes air sealing
  - Includes duct insulation and sealing

6

Residential Model Building Codes (cont.)

In Development

- 2009 IECC
  - Similar to 2006 IECC
  - Only insulation increase is windows R2.9
- "30% Solution"
  - Suggested amendment to 2006 IECC
  - Not adopted by International Code Council
  - Good insulation values: walls R20, roof R49, windows R2.9
  - Likely equates to 30% better than 2003 IECC
  - Improves air sealing requirements
- ANSI/NAHB National Green Building Standard
  - Based on National Association of Home Builders (NAHB) Model Green Home Building Guidelines
  - Coverage parallels Leadership in Energy and Environmental Design (LEED), residential
  - Has four achievement levels, based on points
  - For energy efficiency, offers prescriptive or performance path
  - In addition, has a full compliment of "green" criteria: site, resources, water, indoor environmental quality, and operations and maintenance

7

Commercial Model Building Codes

Current

- ASHRAE Standard 90.1
  - Originally developed as an energy efficiency code in the 70s
  - Worst energy performing building you can legally build
  - At least 14% savings over 90.1 required for LEED minimum
  - Energy costs basis — no green requirements
  - Revised every three years

In Development

- ASHRAE Standard 189
  - Applicable to new commercial buildings and major renovation projects and will address
    - Energy efficiency
    - A building's impact on the atmosphere
    - Sustainable sites
    - Water use efficiency
    - Materials and resources
    - Indoor environmental quality
  - At least a year out

8

Green Building Programs

- Written to encourage new building practices
  - Offers builders the opportunity to go above and beyond the current building code
- Each program developed independently
- International, national, state, or local recognition based on specific criteria and certification levels
- Marketing benefits to owners, builders, and architects
- Significant competition (for fame) among the various programs

9

Examples

- U.S. Green Building Council: LEED
- NAHB: Green Building Program
- Environmental Protection Agency: Energy Star
- Department of Energy: Builder's Challenge
- Build It Green (non-profit in California): Green Points
- Built Green™ organizations in several states

10

Prescriptive vs Performance-based Codes (Energy Use)

- Current building codes are prescriptive
  - Prescribes the minimum construction details required
  - Example: Details minimums for R value for walls and roofs, U factor for windows, watts/sq ft for lighting, HVAC equipment efficiencies
- Green building programs are both prescriptive and performance-based
  - Focus on certification and ranking
  - Requires predicting energy performance of a design (or constructed building) and comparing to a baseline building design
  - Example: 30% energy (or energy cost) savings compared to IECC 2003
  - More flexibility in how to meet the requirement
  - Requires software tool to predict energy savings from building design details; e.g., Home Energy Rating System (HERS)

11

Home Energy Rating System (HERS)

- HERS index is an energy efficiency scoring system
  - Maintained by Residential Energy Services Network (RESNET) since 1981; trains and monitors raters, provides info, etc.
  - http://www.natresnet.org/ratings/default.htm
- A HERS index score used by some cities
- HERS Reference Home (based on the 2006 IECC) scores a HERS index of 100
- Net zero energy home scores a HERS index of 0
- Lower HERS index = more energy efficient

12

What's Happening Today

- Dynamic field
  - New green building codes being considered
  - New green building programs keep popping up
- Green building codes and green building programs converging
- Diverse examples
  - San Francisco, CA
  - Santa Monica, CA
  - Boulder, CO
  - Frisco, TX
  - Marin County, CA

13

San Francisco, CA

- Green building requirements for all new construction, enacted September 2008
- Requirements for low-rise residential include
  - 25 Green Points Rating
    - Run by Build It Green, a Californian non-profit
    - Organization created prescriptive rating system
    - A 25 point rating includes a 15% improvement over California Title 24 energy requirements
  - Required Green Point Rating rises over the next 4 years until a 75 Green Point Rating is achieved
- http://sfenvironment.org/

14

Santa Monica, CA

- Green building requirements for all new construction enacted in May, 2008
- Energy efficiency requirements
  - Building meets California's Title 24, 2005 Energy Efficiency Standards, or
  - Municipal code contains prescriptive requirements for energy-efficient building systems
- Landscape, water conservation, construction waste management, and material selection are prescriptive
- Santa Monica is an example of a city creating their own prescriptive requirements for a green building program
- Future of the program may include the incorporation of HERS rating
- http://greenbuildings.santa-monica.org/

15

Frisco, TX

- Rapidly growing suburb of Dallas
- Program enacted in May 2001, updated in 2007
- Required residential building code includes the following for all new construction
  - Minimum energy efficiency standard
    - Energy Star® designation for single-family residence, or
    - May be amended with a score of 83 or below on the HERS index
  - Every home must be tested
  - The minimum standard for indoor air quality of single-family residential structures shall be the ASHRAE Standard 62.2 as it stands or may be amended
  - Other prescriptive measures include: indoor air quality, energy efficiency, and water conservation
- http://www.ci.frisco.tx.us/Projects_Programs/Green_Building/index.aspx?id=155

16

Boulder, CO

- Green Points Program enacted 2008 (previous version 1997)
- Mandatory for all new residential construction
- Energy efficiency requirements include
  - A HERS index score better than the 2006 IECC
    - Up to 3,000 sq ft, 30% Percent = 70 HERS index score
    - 3,001 - 5,000 sq ft, 50 % = 60 HERS index score
    - Verification of HERS index score by RESNET accredited rater
- Prescriptive mandates for Green Point Certification
  - Demolition management
  - Construction waste recycling
- http://ci.boulder.co.us/index.php?option=com_content&task=view&id=208&Itemid=489

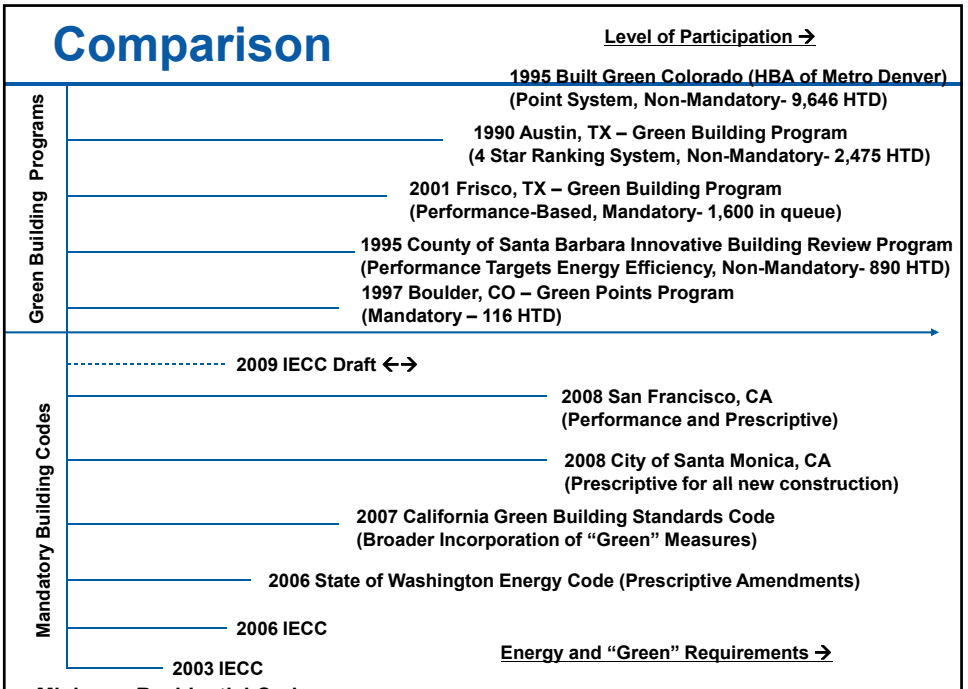
17

Marin County, CA

- County level green building implementation
- Prescriptive checklist for home builders
- County-wide residential green building rating system administers the program
- County service “BEST (Building Energy Efficient Structures Today)” provides free energy efficiency and green building consulting
- Energy efficiency requirements to exceed Title 24 by 15%
- http://www.marinsustainability.org

18

Comparison



Greensburg Community Master Plan — A Mixture of Directives

Residential Efficiency Target

The City should formally recommend that individual homeowners and/or residential developers use an integrated design approach to achieve at least 40 percent energy savings relative to current building code.

Commercial Efficiency Target

Commercial buildings include non-profit and non-city-owned public buildings. A formal policy recommendation made by the City for commercial building efficiencies should suggest that such projects utilize an integrated design approach to achieve at least 30 percent energy savings above current building code requirements.

40% EFFICIENCY RECOMMENDATIONS		
Insulation		
	Walls	R-21
	Roof	R-50
	Basement	R-10
Windows	Double-glazed, low-e, argon-filled	
	U-Value	0.28
	Solar Rating	0.37
Lighting		
	% Compact Fluorescents	80%
Heating		
	Efficiency Rating	90+%
Air Conditioning		
	Efficiency Rating	18
Appliances	Standard	
Water Heater	Tank - gas	
	Energy Factor	0.61
Ventilation	Supply	

* Source: NREL

ENERGY SAVINGS	
For a typical 2,000 sq.ft. home: With High Efficiency Upgrades	
Savings on Monthly Utility Bill 1	$76.58
Increase in Monthly Mortgage Payment 2	$34.25
Net Monthly Savings	$42.33

1 Evaluated relative to current Building Code - IECC 2003.
2 Based on a 30 year mortgage at 7% APR with an increase in loan value of $4,000 for the 30% option, $7,000 for the 40% option, and $13,000 for the 50% option.

* source: NREL

More from the Plan

SUSTAINABLE GUIDELINES

For the encouragement of sustainable and energy efficient re-construction in the residential sector, the following guidelines are recommended:

Energy Efficiency: design and construct homes to provide a Home Energy Rating System (HERS) score of 60 or lower (note: this represents a house with energy consumption 40% below that of a house built to the International Residential Code)

Indoor Air Quality: construct homes to meet the requirements of ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 62.2 " Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings" and use only power-vented sealed combustion appliances.

Durability: design and construct homes in accordance with the "Energy Star Indoor Air Package, version 2, Section I, Moisture Control" at www.energystar.gov.

Water Conservation: select high efficiency fixtures for sinks (kitchen and bath), showers and toilets. Use the criteria of LEED-H (LEED for Homes) Water Efficiency, WE, Credit 3.1. See www.usgbc.org.

Efficient Lighting: provide an Energy Star Advanced Lighting Package. See www.energystar.gov.

Position for future Solar Applications: orient one major roof slope to the south.

21

General Suggestions

- Use something already drafted
  - So you don't have to develop all the details
- Choose something likely to be a nationally accepted green building code
  - Nationally accepted means easier recognition and marketability
  - Less change and adjustment later

22

Preliminary Residential Suggestions

- ANSI/NAHB National Green Building Standard
  - Pros: Most complete, nationally recognized, consensus standard
    - A fully sustainable building standard
    - Offers flexibility of prescriptive or performance path
    - Offers several achievement levels
  - Cons: Somewhat complex to navigate
    - Requires significant documentation, certification, and testing
    - Requires builder action in all areas of the design: site, resources, energy, water, indoor air quality, and operations and maintenance

23

Preliminary Residential Suggestions (cont.)

- IECC 2006 with "30% Solution" modifications
  - Pros: Achieves good energy efficiency level (30% better then IECC 2003)
    - Offers flexibility of prescriptive or performance path
    - Based on nationally accepted code, IECC
    - Builder not required to address other sustainability criteria
  - Cons: Builder not required to address other sustainability criteria
    - 30% modifications have not currently been adopted by ICC

24

Preliminary Residential Suggestions (cont.)

- IECC 2006 with "30% Solution" for energy and ANSI/NAHB for other green criteria
  - Pros: Achieves the 30% improved energy performance and includes all green criteria
  - Cons: Not likely to ever be a nationally accepted consensus standard

25

Preliminary Commercial Suggestion

- ASHRAE Standard 189
  - Pros: Most complete, nationally recognized, consensus standard
    - Addresses all green aspects
    - Applicable to new commercial buildings and major renovation projects
    - Can be customized (i.e., leave out PV requirement)
  - Cons: Somewhat complex to navigate
    - Requires significant documentation, certification, and testing
    - Requires builder action in all areas of the design: site, resources, energy, water, indoor air quality, and operations and maintenance

26

Questions to Resolve

- How far towards full sustainability? Energy, water, other, all?
- Which code, program, or combination?
  - Greensburg-specific modifications?
- Incentives?
- Costs?
  - City will need a staff person or consultant with green building skills
  - Extra costs of green buildings
  - Formal certification costs
- Phasing?
  - Compliance levels
  - Implementation

27

Questions to Resolve (cont.)

- Stakeholder involvement?
  - Resident representatives
  - Business representatives/Chamber of Commerce
  - Locally active builders and architects
  - Planning commission
  - City staff
  - City Council (decision makers)

28

Reference

Fourteen Points to Consider when Developing a Green Building Program or Ordinance

1. Understand and assess the direction desired by the local council or board. Without strong political backing, gaining support for funding, staffing and other resources will prove more difficult.
2. Consider the pros and cons of a mandatory versus voluntary program and choose the one most appropriate for the jurisdiction. Consider the use of development agreements as an option to introduce green building features into the local process one step at a time.
3. Research local cities' and counties' green programs and ordinances for possible use as models.
4. Consider taking a "working group" approach consisting of a balanced mix of stakeholders including elected officials, governmental staff members, developers and builders, and the public at large.
5. Work with the Planning Commission and use its meetings as a platform for workshops and public participation.
6. Conduct a "sustainability workshop" to illustrate how green building is connected to a host of related issues and help garner support from special interest groups.
7. Select green building guidelines or standards that are appropriate for your jurisdiction and, when possible, are already used in your region.
8. Consult with legal counsel to ensure that proposed guidelines or standards do not conflict with other state or local regulations. In the case of an ordinance, be sure that it is legally defensible.
9. Consider the use of outside resources for green building plan check and inspection.
10. Keep compliance thresholds realistic and try not to address them until the end of the development process.
11. Keep the "triple-bottom line"—environment, economy and social equity—in mind to ensure a sense of fairness for all parties.
12. Determine how the program or ordinance will be staffed and funded.
13. Select a staff member to champion the development process.
14. Provide education about green building principles and your jurisdiction's program or ordinance to staff members, developers, builders and residents.

Bruck, Peter; Building Safety Journal, August 2007, pp. 22-23

29

Next Steps

- Choose best recommendation — Late November
- Meet with stakeholders for discussion — December/January
- Finalize recommendation — January
- Present to City Council — January

30

F.2 Greensburg Green Building Codes

Alex Dane, Lynn Billman, John Holton
National Renewable Energy Laboratory

National Renewable Energy Laboratory
Innovation for Our Energy Future

Greensburg Green Building Codes



Greensburg, KS
City Leadership

Alex Dane
Lynn Billman
John Holton

December 11, 2008

Outline

- Recommendations for Building Codes
- Recommendations for Phasing
- Recommendations for Incentives
  - Existing Federal and State Programs
  - Possible State Opportunities
  - Suggested Greensburg Incentives
  - Possible Greensburg Incentive Opportunities

Greensburg Green Building Standard

- **Recommendation**: Adopt "ANSI/NAHB National Green Building Standard (NGBS), Version 2.0"
  - NGBS is a nationally recognized consensus standard
- **Phase 1**: Energy Efficiency
  - 35% energy savings is set as the threshold level
  - Options and incentives proposed for energy savings above 35%
  - Use supporting sections of Chapter 6 and Chapter 9 (Indoor Air Quality) as mandatory requirements
  - Use Chapter 7 of the NGBS, and the supporting sections of Chapter 9
- **Phase 2**: Water Efficiency Requirements
  - Use Chapter 8 of the NGBS
- **Phase 3**: Entire "Greensburg Green Building Standard"
  - Use all Chapters of the NGBS

3

National Green Building Standard

- NGBSv2 was drafted and sent to the International Code Council (ICC), where it is known as ICC-700-2008: National Green Building Standard
- NGBS is now in the hands of the American National Standards Institute (ANSI) and ICC for approval
- Approval is estimated to occur in mid-January
- National Association of Home Builders (NAHB) has confirmed that it will certify the NGBS within a week of its approval by ANSI

4

National Green Building Standard

Comparison of Additional Costs as a Percentage of House Cost

Dallas production house cost of $172,700 is represented.

Rating System	Bronze/Certified	Silver	Gold	Emerald/ Platinum
GBG	1.0 – 1.4%	2.3 – 3.4%	4.7 – 6.4%	NA
NGBSv2	1.1 – 1.7%	2.8 – 3.1%	6.9 – 7.6%	16.3 – 16.9%
LEED-H	3.6 – 5.6%	5.1 – 7.4%	11.2 –13.5%	17.3 – 22.9%

Note: All 3 of these programs are in their infancy, so costs are likely to change as the programs develop.

5

Greensburg Green Building Standard

- Uses a Point System
  - Illustrates performance levels of the green building standard
  - Allows City to adjust levels of phasing
  - Allows City to appropriately incentivize certain levels of performance
  - Uses the point system from an identifiable program with benchmarked goals

6

Why 35% Energy Efficiency?

Table 3.2
Architecture 2030 Challenge Interim Code Equivalents

Code/Standard	Commercial	Residential
ASHRAE 90.1-2004	30% below	
ASHRAE 90.1-2007	25% below	
ASHRAE 189 (in progress)	0	
IECC 2006	30% below	30% below
California Title 24 2005		15-20% below
California Title 24 2008	10% below	
Oregon Energy Code	25% below	30% below
Washington Energy Code	25% below	25-30% below
RESNET HERS Index		65 or less
LEED NC 2.2/Home	New: EA credit #1: 6 pts Renovations: EA credit #1: 8 pts	HERS Index 65
LEED 2009 (in progress)	New: EA credit #1: 7 pts Renovation: EA credit #1: 9 pts	
GBI Standard	PATH A, 8.1.1.1: 150 pts	
EECC Option (prescriptive path)		EC: 154
NBI Option (prescriptive path)	New: core performance with enhanced measures	

Source: Architecture 2030

7

Proposed Phase 1: Residential Energy Efficiency Standard

- Compliance with Chapter 7 is mandatory (Bronze Level)
  - A minimum score of 70 points is required
  - This provides a 35% energy efficiency level
- Compliance with the following sections of Chapters 6 and 9 are mandatory and no points are given
  - Foundation drains, drip edges and flashing
  - Pollutant source control
  - Pollutant control
  - Moisture management
  - Innovative practices: kitchen make-up air
- Scoring as follows

	Required	Voluntary→		
	Bronze	Silver	Gold	Emerald
Ch. 7 Energy	70	70	100	120

8

Proposed Phase 2: Add Water Efficiency Standard

- Add requirements of Chapter 8
- Score as follows

	Mandatory	Voluntary→		
	Bronze	Silver	Gold	Emerald
Ch. 7 Energy	70	70	100	120
Ch. 8 Water	14	26	41	60
Total	84	96	141	180

9

Proposed Phase 3: Complete Greensburg Green Building Standard

- Add in the balance of the "ANSI/NAHB National Green Building Standard". This includes Chapters 4,5,6,10, and the remaining optional sections of Chapter 9

	Mandatory	Voluntary→		
	Bronze	Silver	Gold	Emerald
Ch. 5 Lot Design	39	66	93	119
Ch. 6 Resources	45	79	113	146
Ch. 7 Energy	70	70	100	120
Ch. 8 Water	14	26	41	60
Ch. 9 Indoor Env. Quality	36	65	100	140
Ch. 10 Ops. and Maint.	8	10	11	12
Additional	50	100	100	100
Total	262	416	558	597

10

Existing Federal and State Incentives

- For builders – *Federal Energy Efficient Home Tax Credit*
  - All new residential built to the Bronze Level (mandatory) for all phases, will provide at least a 35% energy efficiency level
- All builders are eligible for
  - $1000 tax credit for each home achieving better than 30% energy efficiency over 2003 IECC
- For the higher levels of performance (NGBS Gold and Emerald)
  - $2000 tax credit for each home achieving better than 50% energy efficiency over 2003 IECC

11

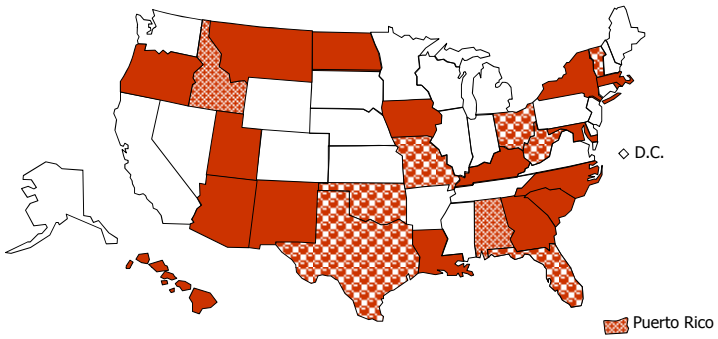
Existing Federal and State Incentives (cont.)

- For homeowners – *Federal Residential Energy Tax Credit*
  - A tax credit of 10% of the cost of building envelope improvements, up to a $500 limit; various details apply
- For low-income homeowners – *Kansas Energy Efficiency Program (KEEP)*
  - Kansas Housing Resources Corp. will provide 50% of the loan amount needed to make energy efficient improvements, at zero interest, up to $7,500; balance of the loan through Sunflower Bank; lowers interest rate to make energy efficiency improvements more affordable; weatherization grants also available
- For homeowners – *Federal Energy Efficient Mortgages*
  - The Federal Housing Administration (FHA) allows lenders to add up to 100% of energy efficiency improvements to an existing mortgage loan by insuring a loan of up to 5% of a home's appraised value, with certain restrictions

12

Kansas Tax Incentives Compared to Other States

State Income Tax Credits and Deductions for Renewables



DSIRE: www.dsireusa.org

September 2008

13

Opportunities for State Level Incentives

- Urge Kansas legislature to amend state income tax code per following examples
  - Idaho – Insulation Income Tax Deduction: 100% of material and labor
  - Missouri – Energy Efficiency Improvement Deduction: 100% of improvements, $2000 max
  - Oklahoma – Energy Efficient Residential Construction Tax Credit: $2,000 and $4,000 tax credits, depending on energy efficiency above IECC 2003
  - Oregon – Residential Tax Credit: Various tax credits for energy efficient appliances and HVAC, up to 25% of net purchase price
  - Arizona – Income Tax Subtraction: 5% of sales price of energy efficient home, $5,000 max

14

Recommended Greensburg Incentive Program

- Partial Waiver of Fees (permit, water meter, sewer, and street repair)
- Recognition Program for Builder and Owner
- Expedited Plan Review
  - Likely implementation when significant increase of applications occurs

15

Recommended Greensburg Incentive Program

- Partial Waiver of Fees
  - Current Greensburg residential development fees
    - $35 per required permit
    - $950 (1-in meter) or $1250 2’’(2-in meter) – new water meter
    - $100 sewer hook up
    - $350 street repair

16

Recommended Greensburg Incentive Program

- Recognition Program for Builders and Owners
  - Plaques for homes
  - Signs for builders
  - Publicity
  - Groundbreaking ceremonies

17

Proposed Phasing of Greensburg Incentives

	Mandatory/Code Bronze	Voluntary→ Silver	Gold	Emerald
Phase 1:	70	70	100	120
Phase 2:	84	96	141	180
Phase 3:	246	386	508	627

"Greensburg GreenHome" Bronze Recognition (Marketing and Public Recognition)

Expedited Plan Review Process

"Greensburg GreenHome" Silver Recognition (Marketing and Public Recognition)

Waive % of Development Fees

Expedited Plan Review Process

"Greensburg GreenHome" Gold Recognition (Marketing and Public Recognition)

Waive % of Development Fees

Expedited Plan Review Process

"Greensburg GreenHome" Emerald Recognition (Marketing and Public Recognition)

18

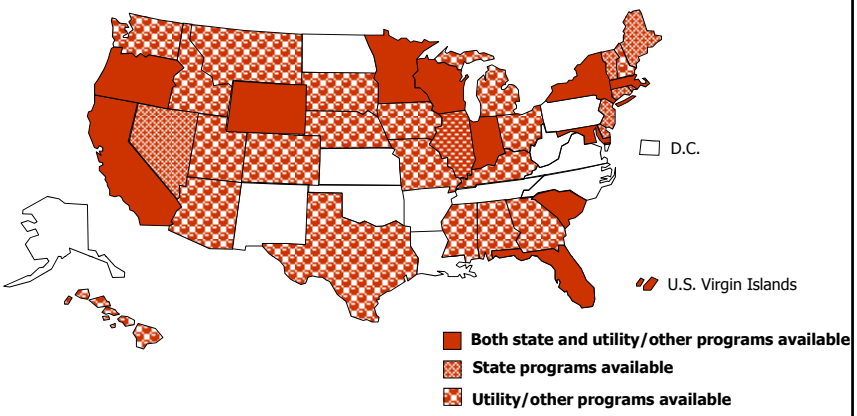
Possible Greensburg Incentive Programs

- Greensburg/Kansas Power Pool Rebate Program and Partnership
- Property Tax Reduction
- Energy Efficiency/Renewable Energy (EE/RE)Bond Issuance

19

Greensburg/Kansas Power Pool (KPP) Rebate Program

Rebate Programs for Renewable Energy Technologies



DSIRE: www.dsireusa.org

September 2008

20

Greensburg/KPP Rebate Program (cont.)

- Viable nation-wide practice
- Utilities require improvements to be Energy Star® rated
- Sample utility rebates nationwide

– Electric water heater	$50 - $100
– Heat pumps	$200 - $1000
– Room air conditioner	$50
– Clothes washers	$50 - $150
– Refrigerator	$30 - $200
– Dishwasher	$50
– High performance windows	$1/sq ft
– Insulation	$0.10 sq ft
– Programmable thermostat	$20 - $25 (KCP&L free)

21

Property Tax Reduction

- Property Tax Abatement Program – Certified residential buildings qualify for percentage reduction of property tax
  - Existing programs
    - Nevada
    - New York
    - Maryland
  - *Limitation* – Kansas programs would be subject to State amending its Constitution to allow for local property tax adjustments

22

Energy Efficiency/Renewable Energy Bond Issuance

- "Sustainable Energy Financing District"
  - Initial costs are covered by Municipal/District EE/RE Bond
  - Cities that have implemented include
    - Palm Desert, CA (Energy Independence Program)
    - Berkeley, CA (FIRST Initiative)
    - Boulder, CO
- Energy improvements funded through special tax district model
  - Homeowner payback is based on a 20-year model, with taxes transferred at time of sale
- Potential issues
  - Legal ability of Greensburg to form property tax districts
  - Existing usage is primary intended for financing PV systems

23

Commercial Building Code Phase I

- ASHRAE Advanced Energy Design Guides achieve 30% energy savings over ANSI/ASHRAE/IESNA Standard 90.1-1999
- Available today
  - Small Office Buildings
  - Small Retail Buildings
  - Small Warehouses and Self-Storage Buildings
  - K-12 School Buildings
- Recommend Greensburg Commercial Building Code Phase I — adopt "Climate Zone 4 Recommendations Table" for the appropriate type of building

24

F.3 Greensburg Green Building Program, Residential Recommendations

Alex Dane, Lynn Billman, John Holton
National Renewable Energy Laboratory

National Renewable Energy Laboratory
Innovation for Our Energy Future

Greensburg Green Building Program





Residential Recommendations
Greensburg, KS
City Leadership

Alex Dane
Lynn Billman
John Holton

February 11, 2009

NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC

Greensburg Green Building Program

- National Green Building Standard
- Partnerships with Kansas Building Industry Association (KBIA), National Association of Home Builders (NAHB), and Local Home Builders Assoications (HBAs)
- Partnership Specifics
- Incentives and Benefits for Greensburg
- Recommended Steps

National Green Building Standard

Recommendation: Utilize ICC-700 National Green Building Standard (NGBS) as the foundation for Greensburg's green building goals

- The NGBSv2 was drafted and sent to the International Code Council (ICC), where it is known as ICC-700-2008: **National Green Building Standard**
- The NGBS **is now approved** by the American National Standards Institute (ANSI) and ICC
- The NAHB has confirmed that it will certify the NGBS within a week of its approval by ANSI

KBIA, NAHB, and Local HBAs

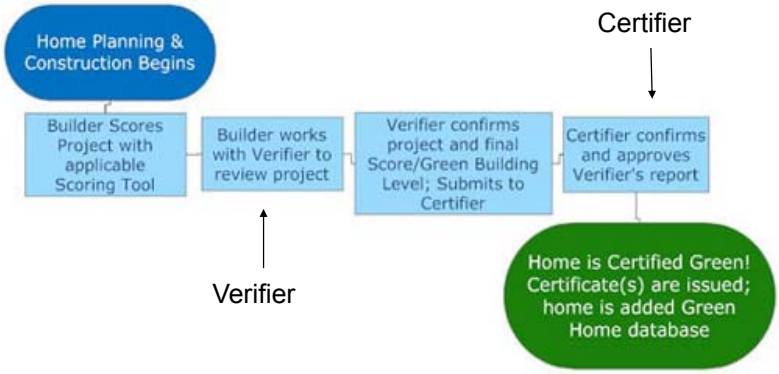
- These associations support the NGBS, but do not yet support it as a mandatory code
- These associations have indicated a strong interest in being partners for Greensburg in implementing a voluntary "pilot residential green building program"

Why Consider a Voluntary Program First Instead of Mandatory Codes?

- Partnership with KBIA ,NAHB, and HBAs could provide
  - Training
  - Education
  - Financial incentives
  - Extra media visibility
- A voluntary green building program gives builders a chance to understand green building techniques gradually

Partnership Specifics

NAHB "Green" Home Certification Process



From www.nahbgreen.org

Partnership Specifics

Verifier Qualifications

- 1 year of acceptable professional experience in home building and green building practices, *or*
- 12 hours of acceptable green training, *or*
- Designation by NAHB as a Certified Green Building Professional (CGBP), *or*
- Professional certification from Green Advantage (U.S. Green Building Council), *or*
- Green Building Certification from National Association of the Remodelers Industry (NARI)
- Leadership in Energy and Environmental Design (LEED) Accredited Professionals (APs) or Home Energy Rating Systems (HERS) raters can be verifiers

Partnership Specifics (cont.)

Certifier and Certification

- After the verification process has been completed, the verifier submits evidence that the points needed to achieve the certification level being sought have been verified per the program criteria
- The NAHB Research Center will review the documentation provided by the verifier and award the **Certified Green Home certificate**

Greensburg Pilot Program Support from KBIA and NAHB

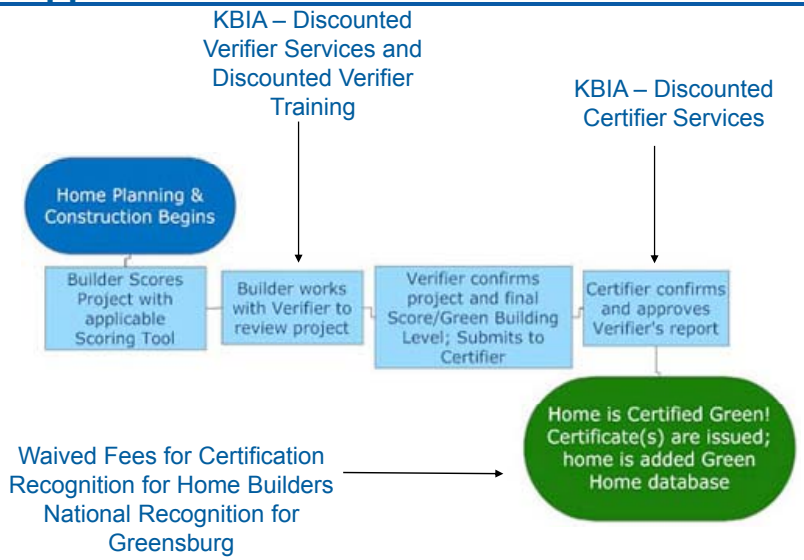
Costs of Verification and Certification

- Certifications
  - The fee to have a "green" home certified through the NAHB Research Center is $200 per home for NAHB members and $500 per home for non-members; does not include verification services
- Verifiers
  - Pay the annual $125 verifier listing fee set by the NAHB Research Center
  - Attend an annual continuing education seminar approved by the NGBP
  - Maintain appropriate records and be available for periodic audit of their verification process at least annually by the NAHB Research Center

Greensburg Pilot Program Support from KBIA and NAHB

- NAHB potentially can offer
  - National recognition of Greensburg
- KBIA potentially can offer
  - Discounted verifier training and verifier services
  - Discounted certifier services
  - Waived state-level fees for certification
  - Recognition for home builders
  - NGBS training and orientation for builders
  - Facilitated builder-to-builder discussions in the region

Greensburg Pilot Program with NAHB and KBIA Support



From www.nahbgreen.org

Incentives and Benefits for Greensburg

How Does Pilot Green Building Program Benefit Greensburg?

- Verification and certification is managed by a 3rd Party
- Develops state and national media exposure for ICC-700, local builders, and Greensburg
- Allows for a green building "learning curve" to occur among homebuilders (eases transition)
- Creates incentive to develop in Greensburg without discouraging growth with regulation
- Creates a receptive environment for shifts in building code
- Feasibility and affordability

Recommended Steps

- Greensburg Pilot Program Formal Agreement and Timeline Creation with KBIA
- Outreach to Builder Community with KBIA and HBA Support

Model Commercial Building Code

Current

- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 90.1 2007
  - Energy efficient design requirements for commercial buildings
  - Revised every 3 years
  - 2007 version is more stringent than the 2004 90.1 version
  - 2007 version is more stringent than IECC 2006

Recommended Commercial Building Code

- Adopt
  - American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 (2007 version)
- Voluntarily Utilize
  - ASHRAE advanced energy design guides (30% better than 90.1, 2004)
    - Small Office Buildings
    - Small Retail Buildings
    - Small Warehouses and Self-Storage Buildings
    - K-12 School Buildings

15

Future Commercial Building Codes

- In Development
  - ASHRAE 90.1, 2010
  - ASHRAE Standard 189 Green Building Standard for Commercial Buildings
    - Applicable to new commercial buildings and major renovation projects and will address
      - Energy efficiency
      - A building's impact on the atmosphere
      - Sustainable sites
      - Water use efficiency
      - Materials and resources

      Indoor environmental quality

16

F.4 Recommendations for the Greensburg Green Building Program

Alex Dane, John Holton, Lynn Billman
National Renewable Energy Laboratory

Recommendations for the Greensburg Green Building Program

Prepared by NREL Building Codes Team (Dane, Holton, Billman) 3/16/09

What is Green Building?

Green Building is a general name for incorporating the practice of sustainable construction and building techniques which result in an efficient, healthful and durable building system with reduced environmental impact. Many builders for years have constructed homes and commercial buildings that are energy efficient and long lasting. Thus, "green building" is nothing new. Over the past decade numerous rating systems, codes and assessment tools have been created by industry, government and professional associations to standard building best practices and create rating systems to award levels of achievement.

Why is Green Building Important?

Green building has a triple bottom line: environmental, social and economic. Green buildings require less energy to heat and cool, light and operate, resulting in lower utility bills for the owner or renter. The increase in water and energy efficiency along with higher levels of indoor air quality, improve the health of the occupants and the natural environment. Green building also has social ramifications; it encourages communities to think about their resource consumption and allows for a greater understanding of sustainable practices. Hundreds of communities have recognized the effort to build green as one of the chief priorities of their municipality, realizing the benefits financially, economically and socially. These communities and cities have risen to the top of the green movement and are nationally and internationally recognized for their building practices and commitment to improving quality of life and quality of environment.

Why is Green Building Important to Greensburg?

The reconstruction effort in Greensburg will be greatly enhanced with a commitment to green building in the residential and commercial sectors. By adopting a green building program for both commercial and residential construction Greensburg will garner more national legitimacy as one the greenest cities in the nation, if not the world. The City of Greensburg is already setting the example for its citizens, as the municipal buildings, schools and hospitals are built to a LEED-Platinum Level. Now, with national attention on energy efficiency and green building, it is the opportune moment for the City to commit itself to both residential and commercial green building. The Kansas Building Industry Association (KBIA) is posed to partner with Greensburg and local builders to implement a residential green building program. Commercial building standards for green construction are feasible and attainable for builders in the area as well.

How Does Greensburg Implement a Green Building Program?

For Greensburg to incorporate the concept of green across their community, it is necessary to address both residential and commercial construction. The commitment to green building lies in a combination of adjusting the City's building codes and forging partnerships to create incentives. Fortunately Greensburg does not have to re-invent the wheel. Industry recognized and approved building codes exist for both residential and commercial. The adoption of these codes

is significant in terms of the National agenda as well. Opportunities for funding energy efficiency efforts and building code revisions are found in the legislative language of the American Recovery and Reinvestment Act, also known as "The Stimulus Bill". There are opportunities for cities like Greensburg to apply for funding through the Energy Efficiency and Conservation Block Grant (EECBG) Program, which grants funding for a variety of energy related projects including green building code adoption. The following recommendations are made by the technical team from the National Renewable Energy Laboratory.

Adopt IECC 2006 for Residential and Commercial Construction

Greensburg's first step to strengthen its residential and commercial building code should be the adoption of the International Energy Conservation Code 2006 (IECC 2006). This is a feasible and attainable step, which will augment, but not replace, the International Residential and Building Code (IRC & IBC) currently in place. The IECC will be a credible benchmark for new residential and commercial construction in Greensburg. It is also the ground level energy efficiency goal of the National Green Building Standard.

Residential Green Building Program "Greensburg GreenHome"

The residential green building program should start with the adoption and mandatory enforcement of IECC 2006. To go above code, a green residential building program should also be created. With this in mind, the NREL technical team looked to market-driven solutions to further advance green building in Greensburg.

Partnership with KBIA

The solution developed is a complementary partnership with Kansas Building Industry Association. Presently, a memorandum of understanding is being developed to create a mutually beneficial relationship for both the City and KBIA to participate in a green building pilot program over the next two years. KBIA is an affiliate of the National Association of Home Builders (NAHB). KBIA serves as an advocate for Kansas' housing industry, and as a corporate channel through which builders contribute time, money and services to local community service projects and education initiatives. KBIA has recently endorsed the National Green Building Standard (ICC700-2008); a standard developed by a consensus process through the American National Standards Institute (ANSI) and adopted by the International Code Council (ICC). This guiding document is a credible source and provides national recognition for green building techniques and practices.

Greensburg GreenHome Pilot Program

The voluntary Greensburg GreenHome Pilot Program is a resource and support program for residential homebuilders in Greensburg. The verification and certification of the green building process and completed home will be managed by a third party. The third party services are subsidized by KBIA for builders in Greensburg. KBIA will also provide training and incentives for builders building to the National Green Building Standard in Greensburg. This is a beneficial relationship for the City and KBIA. The City benefits by having a green residential building

program incentivized by an association recognized statewide and composed of homebuilders. Builders in the area benefit by the KBIA provided training in green building techniques and NGBS. Finally, KBIA benefits from increased visibility and marketing for their green building program and endorsement of the NGBS by a Kansas community recognized for its sustainability achievements.

Benefits

- Simplifies verification and certification by using a third party
- Develops state and national media exposure for NGBS, local builders, and Greensburg
- Allows for a green building "learning curve" to occur among homebuilders (eases transition)
- Encourages growth with minimal regulation change right now, and incentives to go beyond the minimum
- Creates a receptive environment for shifts in building code
- Feasibility and Affordability

Commercial Green Building Program "Greensburg GreenBusiness"

Commercial building codes should be updated in Greensburg, and the adoption of IECC 2006 will satisfy this need. It is the current industry standard that the NREL technical team recommends for Greensburg. Along with this baseline code, Greensburg should recommend that architects voluntarily use ASHRAE Advanced Energy Design Guidelines. These easy-to-use workbooks guide engineers and architects to implement advanced techniques beyond the 60.1-2007 Standard to save 30% more energy. There are four specialized design guides:

- Small Office Buildings
- Small Retail Buildings
- Small Warehouse and Self Storage
- K-12 School Buildings

By adopting the IECC 2006 code Greensburg would be placing itself as one of the leaders in Kansas on model commercial energy codes. The voluntary utilization of the Advanced Energy Design Guidelines affords the builder the option to go above and beyond code. Commercial building owners and developers also have the option to build to a LEED certification level. This option carries with it the benefits of building above and beyond, including a greater incorporation of green techniques, and publicity and recognition by the City and the U.S.G.B.C.

Incentive System for the Greensburg Green Building Program

Both the residential GreenHome program and commercial GreenBusiness program should be incentivized by the City. Development fees and permitting cost have the potential to be raised across the City. Discounts on the new fee rate can be made at different levels corresponding with different levels of achievement. In the case of the Greensburg GreenHome program, for example,

different levels of development fees could be waived by the City for increased levels of performance from Bronze to Emerald. In the case of the commercial building codes, development fees could be waived for the incorporation of the Advanced Energy Design Guidelines. Public recognition and acknowledgment can also be powerful incentives.

Steps to Implementing the Greensburg Green Building Program

1. Review and approve terms of agreement in Memorandum of Understanding with KBIA
2. Approve Greensburg GreenHome and Greensburg GreenBusiness programs through City Council
3. Signing ceremony with KBIA – May 2 or 3?
4. Implementation of Greensburg GreenHome Building Program
    a. Discuss with KBIA
    b. KBIA provides orientation on the NGBS and GreenHome Program
    c. Schedule training for builders and green program verifiers
    d. Partnership with Greensburg Greentown for public outreach and citizen education
    e. Create press release and media materials
    f. KBIA and Greensburg Greentown produce package of information on Greensburg GreenHome for:
        i. Builders
        ii. Homeowners
        iii. Home Verifiers
        iv. City
5. Implementation of Greensburg GreenBusiness Program
    a. City engineers and building code officials review IECC 2006 and ASHRAE Advanced Energy Design Guidelines
    b. Based on consensus and ability to administer, officials make recommendation to city council to approve
    c. City council approves new commercial building code.
    d. Greensburg Greentown works to publicize new commercial codes.

F.5 NAHB Green Commitment to City of Greensburg, Kansas Memo

National Association of Home Builders

NAHB
NATIONAL ASSOCIATION OF HOME BUILDERS

ACROSS THE COUNTRY · HOME BUILDERS CARE

CONSTRUCTION CODES & STANDARDS

April 1, 2009

RE: NAHBGreen Commitment to City of Greensburg Kansas

Dear Interested Parties:

On behalf of the National Association of Home Builders (NAHB)—an organization of 200,000 members that will construct 80 percent of the new housing units projected for 2009, I am pleased to hear of the endorsement of a voluntary, green building program currently being considered by the City of Greensburg, Kansas. Based on the only American National Standards Institute-approved green building standard, the ICC-700 2008 National Green Building Standard, and utilizing the National Green Building Certification, the proposed program will do much to not only move Greensburg forward, but do so in an effective "green" direction.

NAHB's National Green Building Program, or NAHBGreen, is a set of resources and tools that allow any home, anywhere to go green. Through education, construction rigor and accurate home performance, NAHBGreen brings national, state and local home building industries together for America's green homeowners. Now, home builders and remodelers all over the country can take advantage of this voluntary, market-driven and cost-effective way to think green, build green and sell green—especially Greensburg's builders and remodelers.

To that end, NAHBGreen is committed to working through the state affiliate, the Kansas Building Industry Association, and NAHBGreen's numerous partners and services to assist in every way possible. This assistance includes exploring potential sponsors to defer the costs of certification and verification in the National Green Building Certification to the Greensburg program's builders, as well as promotional and technical assistance as appropriate.

We look forward to working with you during this process. If you have any questions, please do not hesitate to call my office at 1-800-368-5242 ext. 8547.

Thank you for your consideration, and much luck in your ongoing efforts.

Sincerely,
Carlos Martín, PhD
Assistant Staff Vice President

1201 15th Street, NW • Washington, DC 20005-2800
(202) 266-8309 • (800) 368-5242, ext. 8309 • Fax: (202) 266-8056
e-mail: etombari@nahb.com

Appendix G: Electricity Generation Policies and Ordinances

Page

G.1 Information for Greensburg City Council on Proposed Changes Regarding Utility Customer Owned Renewable Energy Generation 558

G.2 Proposed Interconnection Agreement for Greensburg (Draft)..... 567

G.3 Proposed Net Billing Tariff for Greensburg (Draft) 573

G.4 Proposed Small Wind Turbine Ordinance for Greensburg (Draft)..... 575

G.5 Small Wind Zoning Ordinance for Greensburg, Kansas: Issue Discussion 577

G.6 Proposed Solar Ordinance for Greensburg (Draft)..... 581

G.7 Selected Solar Access Information 583

G.8 Cooperation Agreement (Greensburg MOU)..... 603

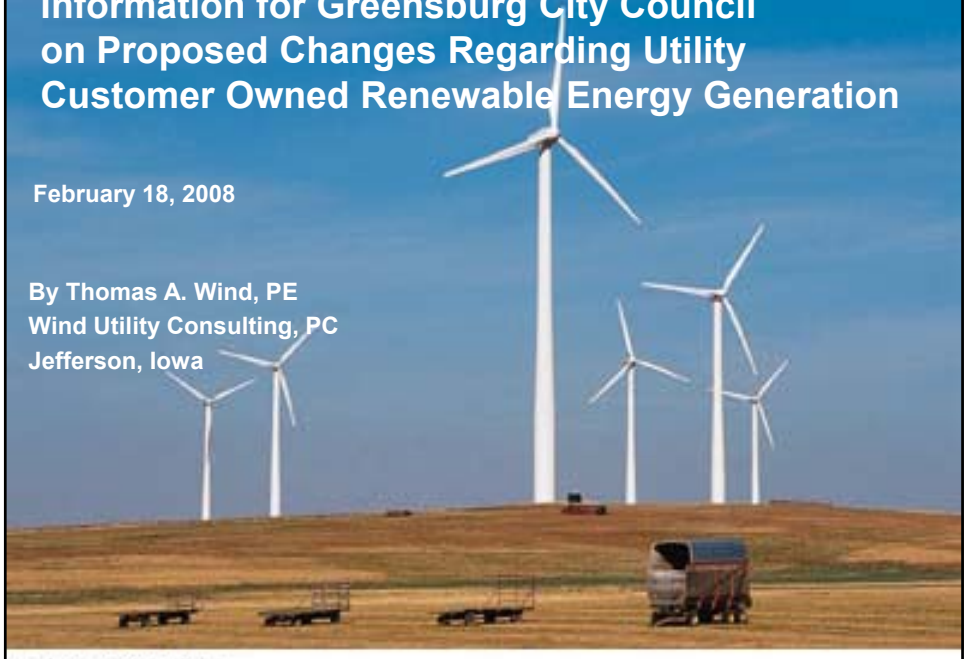
G.1 Presentation: Information for Greensburg City Council on Proposed Changes Regarding Utility Customer Owned Renewable Energy Generation

Thomas A. Wind
Wind Utility Consulting

Information for Greensburg City Council on Proposed Changes Regarding Utility Customer Owned Renewable Energy Generation

February 18, 2008

By Thomas A. Wind, PE
Wind Utility Consulting, PC
Jefferson, Iowa



© Layne Kennedy

Information for Greensburg City Council on Proposed Changes Regarding Utility Customer Owned Renewable Energy Generation

- Overview of current rules and regulations and changes that need to be made
- Permitting small wind turbines
- Interconnection Agreement for Renewable Energy Generators
- Net Billing policy
- New detailed wind speed maps

2



Changes Needed to Accommodate Customer Owned Renewable Energy Electric Generators

- Greensburg does not have regulations or ordinances regarding the siting, installation, electrical interconnection and operation of customer-owned renewable energy generators, such as wind turbines and electric solar photovoltaic ("PV") panels.
- Regulations are desirable to ensure that wind turbines and PV panel installations are safe and do not disturb city residents or cause electrical problems. Three changes are proposed:
  - 1) **Permitted Use for Small Wind Turbines** provides rules for the siting, installation, and safe operation of small wind turbines in the City
  - 2) **Interconnection Agreement** provides rules regarding the electrical connection of the generators to the electric system, whether they are on the utility or customer side of the meter.
  - 3) **Net Billing Options** provide an essential incentive needed to encourage customers to install wind turbines and solar PV panels. Without this incentive, few will be installed.

3



Permitted Use for Small Wind Turbines

- The proposed **Permitted Use Regulation for Small Wind Turbines** has the following main points:
  - Small wind turbines are defined as 100 kW or less
  - Towers must be set back from property lines by their fall down distance
  - There is no limit on tower height other than the setback requirement
  - Anchors or other equipment must be at least 10 feet from a property line
  - Noise is limited to 55 dBA at the closest inhabited dwelling
  - The owner must notify the City before installation and the wind turbine model must be approved by the City so as to prevent the installation of old used equipment that may be noisy or troublesome
  - The installation must be in compliance with building, electrical, and safety codes
  - The installation should prevent unauthorized climbing of the tower
  - Abandoned wind turbines must be removed

4



Permitted Use for Solar Energy Systems

- The NREL team is working on a proposed **Permitted Use for Solar Energy Systems.**
- This will cover rules for siting solar systems in the City.
- It will be presented at a future City Council meeting

5



Electrical Interconnection of Renewable Energy Generators

- The proposed **Interconnection Agreement for Connection of Distributed Generation** has the following main points:
  - Technical information, proposed location drawings, and electrical interconnection drawings for the installation must be provided to the City so that the City can ensure the installation will meet electrical standards
  - The generator and electrical interconnection must be inspected and approved by the City
  - A bidirectional electric meter will be installed by the City to record both kWh inflow and kWh outflows
  - Outflows to the City will be sold monthly to the City at the City's avoided cost, which will be calculated annually and is expected to be around 4¢ to 5¢ per kWh.
  - The customer can select a Net Billing option in lieu of selling the outflows monthly to the City
  - The City has the right to disconnect the generator if it is causing problems on the electric system

6

Net Billing Option for Renewable Energy Generators

- The proposed **Net Billing Procedures for Electric Conusmers Having Renewable Energy Generators** has the following main points:
  - Gives electric customers with wind turbines and PV panels the option of selecting a Buy and Sell arrangement or a Net Billing arrangement.
  - Under the Buy and Sell arrangement, the customers outflow is sold to the City every month at the City's avoided wholesale cost of energy (expected to be around 4¢ to 5¢ per kWh)
  - Under the Net Billing arrangement, the kWh outflow would be subtracted from the kWh inflow (netted out). If there was any excess outlfow at the end of the month, it would be carried forward to the next month's bill as a kWh credit and then be used to reduce inflows the next month.

7

What is Net Billing or Net Metering?

- The terms "Net Billing" and "Net Metering" are often used interchangeably, although there can be some technical differences.
- Net Billing is a billing option utilities provide to electric customers with electric generators, such as wind turbines or solar photovoltaic panels. The billing option allows the customer to bank excess electricity production with the utility for later use. This excess-banked power is then used when the wind turbine or solar panels are generating less than the customer's needs.
- Under Monthly net billing, the electric meters are read at the end of the month, and the customer would purchase the net amount of power needed during the month, if any. If a customer's wind turbine generates more than the customer uses over the month, the extra wind power flows back through the meter to the utility and is used by other nearby customers.
- Under Monthly net billing, the utility would pay the customer its avoided cost for the excess wind power on a monthly basis. The avoided cost is typically less than half of the retail rate charged by the utility. If the wind turbine generates fewer kWh than used by the customer during the month, then the customer would buy the extra power needed from the utility at the standard rate.

8



Why Does Net Billing Help Customers with Wind Turbines and Solar Panels?

- Without net billing, the customer would have to sell any excess power the wind turbine generates over the customer's own immediate needs (measured on an instantaneous basis) back to the utility at its relatively lower avoided cost.
- For example, with strong winds at night, a wind turbine might generate more power than a homeowner would need in the middle of the night. Without net billing, this excess power would be sold back to the utility at a relatively low avoided cost, which might be 5 ¢ per kWh for Greensburg. It could not "bank" these excess kWh for periods when the generator doesn't generate enough to meet the customer's needs. Without net billing, the customer ends up using less of the wind turbine's production, selling more back to the utility, and then buying more power from the utility at the higher retail rate. Net billing provides a necessary economic benefit to those customers installing a wind turbine, since the excess production can be banked with the utility for use later, rather than sold back to the utility at a low rate.
- The same situation can occur for solar panels if the homeowner is not home during the day to use all of the solar electricity.
- Small wind turbines and solar panels are almost always not cost-effective or attractive for most customers without net billing.
- Nearly all utilities consider net billing to be a cross subsidy to customers with wind turbines and solar panels.

9

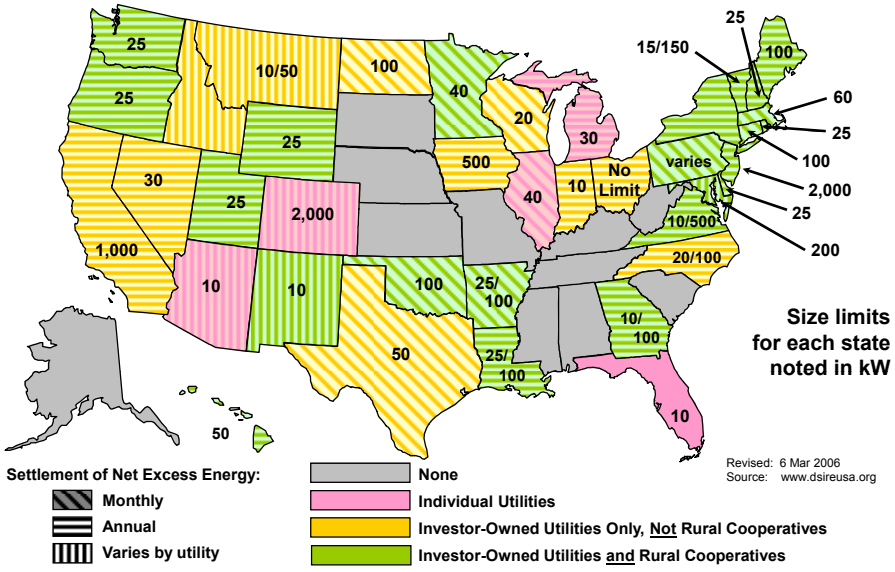


Monthly and Annual Net Billing

- The "netting" period used can be based on a monthly or annual settlement period.
- Under Monthly net billing, any excess production would be sold at the end of the normal monthly billing period. For example, if the customer's wind turbine generated 400 kWh and the customer used 600 kWh, then the customer would buy 200 kWh from the utility at the normal retail electric rate. Or if the wind turbine generated 700 kWh and the customer only used 600 kWh, then the utility would buy back the difference of 100 kWh from the customer at the low avoided cost.
- Under Annual net billing, any excess production would be sold at the end of the year. For example, if the customer's wind turbine generated more power than the customer needed during some of the windy winter and spring months, yet less than needed during the summer and fall, then the energy generated over the entire year would be compared to what the customer used over the entire year. Only if the annual total production was greater than the annual total usage, would the customer have to sell the extra production to the utility. Some states actually require the customer to give the excess production to the utility with no compensation.

10

39 States Have Net Metering Laws for Wind Turbines



This Graphic is from the Interstate Renewable Energy Council

Summary of Customer Savings With Net Billing

Comparision of Customer Savings Under Different Net Billing Options

	No Wind Turbine	Wind Turbine with No Net Billing	Wind Turbine with Monthly Net Billing	Wind Turbine with Net Billing With Perpetual Carryover
kWh Used by Home	10,000	10,000	10,000	10,000
Wind Turbine kWh Generated	0	10,000	10,000	10,000
Wind Turbine kWh Used	0	5,500	8,227	10,000
Wind Turbine kWh Sold	0	4,500	1,773	0
kWh Purchased from Utility	10,000	4,500	1,773	0
Cost of kWh Purchased	$ 1,344	$ 684	$ 357	$ 144
Billing Credit from Sales	$ -	$ 225	$ 89	$ -
Total Net Power Bill	$ 1,344	$ 459	$ 268	$ 144
Net Savings with Wind Turbine	Reference	$ 885	$ 1,076	$ 1,200
Net Savings per kWh Generated		8.8 ¢	10.8 ¢	12.0 ¢

The table above summarizes the power bill savings under the various scenarios presented previously. The bottom row showing the "Net Savings per kWh Generated" is a key indicator of the economic viability and attractiveness of a small wind turbine. In general, the initial savings will need to be around 12¢ per kWh generated for a small wind turbine. Therefore, without some form of net billing, small wind generation will not be viable in Greensburg.



Potential Utility Net Loss of Revenue for Greensburg with Net Billing

- In order to encourage electric customers to install wind turbines and solar photovoltaic panels, Greensburg should provide a net billing option.
- Estimates were made of the potential net loss of revenue if the City were to implement a net billing policy with a perpetual carryover. The primary assumptions for the analysis include:
  - Net billing where the utility always carries forward any excess wind or solar power and never buys it back
  - Estimated installations for three sizes of wind turbines and two sizes of solar panels
  - Turbines and solar panels sized such that there would be no excess kWh generated over the course of a year
  - Utility wholesale avoided power cost savings of 5¢ for every kWh not purchased from its wholesale provider
  - A retail rate of 12¢ per kWh for the first 4,000 kWh per month and 10.5¢ per kWh for the balance with no fuel adjustment clauses
- The table on the next page summarizes the potential lost revenue if net billing with perpetual carryover is provided.

13

Estimated Potential Annual Loss of Utility Net Revenue from Net Billing

Calculation of Estimated Potential Annual Loss of Utility Net Revenue

Wind Turbine Model	Average Annual kWh	Average Retail Rate, in ¢ per kWh	Net Lost Revenue per Unit Installed	Example Number of Units to be Installed	Total Annual Net Lost Revenue	Total Annual kWh Saved	% of kWh Needed by City in 2009
SkyStream 1.9 kW Turbine	4,000	12	$ 280	12	$ 3,360	48,000	0.4%
Endurance 4.25 kW Turbine	10,000	12	$ 700	6	$ 4,200	60,000	0.5%
Entegrity 50 kW Turbine	175,000	10.5	$ 18,375	4	$ 73,500	700,000	5.4%
Solar Photovoltaic - Residential	3,000	12	$ 360	5	$ 1,800	15,000	0.1%
Solar Photovoltaic - Commercial	10,000	11	$ 1,100	15	$ 16,500	150,000	1.2%
Totals				42	$ 99,360	973,000	7.6%

Notes:

The "**Average Annual kWh**" is a rough estimate of the average production from a typical wind turbine or solar panel installed by customers in the City.

The "**Net Lost Revenue per Unit Installed**" is the "Average Annual kWh" times the "Average Retail Rate" less the City's 5 ¢ per kWh estimated avoided wholesale power cost savings.

The projected gross kWh needed by the City in 2009 is 12,867,000 producing retail customer revenue of $1,447,000.

- This table suggests that the City might get about 8% of its annual energy needs from customer-owned renewable generators. This would result in an annual net loss of revenue of perhaps $100,000 per year, which is about 7% of the projected 2009 retail customer revenue of $1,447,000 with a net billing policy with perpetual carryover.

Observations From Net Billing Analysis

- The City could potentially get 8% of its energy needs from customer-owned wind turbines and solar panels if it adopts a net billing policy with perpetual carryover. Under this scenario, the City's utility net revenues could be reduced by about 7%, resulting in electric rates being a little higher (maybe up to 7%) than without net billing.
- To limit the potential revenue loss and resulting electric rate impact, the City should consider limiting the amount of wind generation a customer could install. For example, if the new school needs 1.5 million kWh annually, it could potentially install 8 Entegrity 50 kW wind turbines, or a larger wind turbine. This resulting loss of revenue from the school alone might be 10% of the City's electric utility revenues. Limiting net billing to 50 or 100 kW of wind or solar generation per customer would help prevent a major revenue shortfall and resulting rate increase. A customer could install more than 50 to 100 kW of generation, however, the benefits of net billing could be capped at the 50 to 100 kW level which would result in some of the excess generation being sold back to the utility at the lower avoided cost rate.
- In lieu of adopting a net billing policy, the City could have a relatively high buyback rate, such as 10¢ to 12¢ per kWh. This high buyback rate again might be limited to 50 to 100 kW of generation per customer to help prevent a major revenue shortfall.
- There was no consideration given to the value of any renewable energy credits from the customer-owned generation in this study. Perhaps this value might be shared with the utility in some way to offset any significant reduction in revenue due to net billing.
- Without any net billing policy or comparable incentive or subsidy, the economics of small wind turbines and solar panels are simply not attractive enough to entice customers to install them.



Conclusions From Net Billing Analysis

- The City must adopt a net billing policy if it wants its customers to install wind turbines or solar panels.
- The most attractive net billing policy for encouraging customer-owned wind generation would provide for a perpetual carryover period.
- In lieu of adopting a net billing policy, a high buyback rate in the 10 to 12 ¢ per kWh range could be adopted.
- The City should limit net billing to 50 or 100 kW of wind or solar generation per customer to help prevent a significant revenue shortfall and the resulting pressure on rates. This limit could be increased over time if the City wanted to encourage more customer-owned renewable energy.

Thomas A. Wind, PE
Wind Utility Consulting, PC
February 18, 2008

16

G.2 Proposed Interconnection Agreement for Greensburg (Draft)

Thomas A. Wind
Wind Utility Consulting

INTERCONNECTION AGREEMENT
FOR THE CONNECTION OF DISTRIBUTED GENERATION
TO THE GREENSBURG MUNICIPAL ELECTRIC SYSTEM

This Interconnection Agreement ("Agreement") is made and entered into this ____ day of _____, 20____, by the City of Greensburg, Kansas "Utility", a non profit electric utility organized under the laws of Kansas, and _____ ("DG Owner"), each hereinafter sometimes referred to individually as "Party" or both referred to collectively as the "Parties". In consideration of the mutual covenants set forth herein, the Parties agree as follows:

This agreement provides for the safe and orderly operation of the electrical facilities interconnecting the DG Owner's Generating Facility ("Facility") at the location and address of
(address)_____

_____
and the electrical distribution facility owned by the Utility.

This Agreement does not supersede any requirements of any by-laws, applicable tariffs, rates, rules and regulations in place between the DG Owner and the Utility.

1. **Intent of Parties:** It is the intent of DG Owner to interconnect an electric power generator to the Utility's electrical distribution system.

It is the intent of the Utility to operate the distribution system to maintain a high level of service to their customers and to maintain a high level of power quality.

It is the intent of both parties to operate the facilities in a way that ensures the safety of the public and their employees.

2. Inspection and Testing: Prior to parallel operation of the Facility, the Utility may inspect the Small Generating Facility for compliance with industry standards, the Utility's Tariffs, and the Rules and Regulations of the Kansas Corporation Commission. The Utility's inspection may include a witness test and the Utility may schedule appropriate metering replacement, if necessary. If the witness test is not satisfactory in the sole judgment of the Utility, the Utility has the right to disconnect the Facility. The DG Owner shall have no right to operate in parallel until a witness test has been performed, or previously waived in writing by the Utility. The Utility must complete the witness test

within ten (10) business days of receipt of a "Certificate of Completion" by the DG Owner.

3. Energy Purchases and Sales: All electricity generated in excess of the customer's needs will be sold to the utility at 150% of its monthly system average cost of energy. This buyback rate will be calculated monthly All electricity purchased by the DG Owner will be based on the standard tariff rates that would be applicable.

4. Net Billing Option: The DG Owner may utilize a net billing option for distributed generation totaling 100 kW or smaller. This option would be in lieu of selling excess generation to the utility on a monthly basis. This option allows the DG Owner to utilize a higher percentage of its generator's energy output by providing a carryover kWh credit to the next month for all excess generation received by the utility. Details of the net billing option are provided in a separate tariff sheet.

5. **Suspension of Interconnection:** It is intended that the interconnection should not compromise the Utility's protection or operational requirements. The operation of the DG Owner's System and the quality of electric energy supplied by the DG Owner shall meet the standards as specified by the Utility. If the operation of the DG Owner's system or quality of electric energy supplied (in the case of power export) does not meet the standards as specified, then the Utility will notify the DG Owner to take reasonable and expedient corrective action. The Utility shall have the right to disconnect the DG Owner's System, until compliance is reasonably demonstrated. Notwithstanding, the Utility may in its sole discretion disconnect the DG Owner's generating plant from the Distribution Facility without notice if the operating of the Generating Plant imposes a threat, in the Utility's sole judgment, to life or property.

6. **Maintenance Outages:** Maintenance outages will occasionally be required on the Utility's system. Compensation will not be made for unavailability of Utility's facilities due to outages.

7. **Access:** The Utility shall have access to the disconnect switch and metering equipment of the DG Facility at all times. The Utility shall provide reasonable notice to the DG Owner when possible prior to using its right of access.

8. **Liability and Indemnification**: DG Owner shall assume all liability for, and shall indemnify the Utility for any claims, losses, costs, and expenses of any kind or character to the extent that may result from DG Owner's negligence or other wrongful conduct in connection with the design, construction, or operation of DG Owner's facility.

9. **Term:** This Agreement shall be in full force and effect for an initial period of one (1) year from the date hereof, and shall remain in full force and effect each year thereafter, unless terminated by either party as set forth below.

10. **Termination:** This Agreement may be terminated by the DG Owner with thirty (30) days written notice to the Utility. In the event DG Owner terminates this Agreement, the

Utility shall have a reasonable amount of time to remove any facilities it may have. This Agreement may be terminated by the Utility for non-performance by the DG Owner under the terms of this Agreement, the Utility's Tariff, or for violation of any Commission rule. The DG Owner shall have thirty (30) days from the date that the Utility sends written notice to the DG Owner to remedy the item of non-performance. Upon expiration of the thirty (30) day remedy period and if the item of non-performance has not been corrected, the Utility may terminate this Agreement. Unless terminated early by the DG Owner or the Utility as described in this Article, this Agreement shall terminate when the Small Generation Facility is permanently removed from service or becomes inoperative for a period in excess of one year.

AGREED TO BY

DG Owner (Name)	Utility Representative
_____	_____
Title	Title
_____	_____
Date	Date
_____	_____

Distributed Generator Facility Information

Section 1. DG Owner Information

Name: _____
Mailing Address: _____
City: _____ State: _____ Zip Code: _____
Street address (if different than above): _____
Daytime Phone: _____ Evening Phone: _____
Utility Customer Account Number (from utility bill):_____

Section 2. Generating Facility Information

System Type (check one): Solar____ Wind____ Generator Size (kW AC):_____
Inverter Manufacturer:

_____

Inverter Model: _____
Inverter Serial Number: _____
Inverter Power Rating: _____
Inverter Location: _____
If over 5 kW: Disconnect Type (check one): Meter Removal ___ Separate Disconnect ____
Location of disconnect_____

Section 3. Installation Information

Electrician Name: _____
Mailing Address: _____
City: _____ State: _____ Zip Code: _____
Daytime Phone #:_____ Installation date: _____
A simple diagram must be attached showing the proposed location and electrical connection.

Section 4. Certifications

The generating facility's inverter meets the requirements of IEEE 929, "Recommended Practice for Utility Interface of Photovoltaic (PV) Systems" and Underwriters Laboratories (UL) 1741, "Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems;"
Signed (Equipment Vendor):_____ Date: _____
Name (Printed) _____ Company: _____
The generating facility has been installed in compliance with all applicable requirements of the National Electrical Code and local building codes.
Signed (Electrician): _____ Date: _____
Name (Printed) _____ Company: _____
The system has been installed to my satisfaction and I have been given system warranty information and an operation manual and have been instructed in the operation of the system.
Signed (Owner): _____ Date: _____

Section 5. City Inspection and Approval

1. Application Approved: _____ Date: _____
2. System Inspection by : _____Inspection Date: _____

Distributed Generator Proposed Location Sketch

Draw a simple sketch showing the proposed location of the generator and all associated equipment with respect to the DG owner's property lines and buildings

Distributed Generator Proposed Electrical Connection Sketch

Draw a simple one line electrical diagram showing how the proposed generator will be electrically connected to the DG owner's home or business.

G.3 Proposed Net Billing Tariff for Greensburg (Draft)

Thomas A. Wind
Wind Utility Consulting

NET BILLING PROCEDURES
FOR ELECTRICITY CONSUMERS
HAVING RENEWABLE ENERGY GENERATORS

Electricity consumers may install electric Renewable Energy Generators ("REGs"), such as wind turbines and solar photovoltaic panels, and interconnect them to the electric system. If the REGs are connected on the consumer's side of the City's electric meter, the city will install and provide, at no additional cost to the REG facility, a dual register meter capable of measuring kWh inflow (received by the REG facility) and kWh outflow (received by the City) and recording both quantities separately. The City will add $1.00 (one dollar) to the monthly minimum meter charge to help cover the extra cost of the dual register meter and higher administrative billing costs.

REGs shall select one of two billing procedure options.

OPTION 1: BUY AND SELL ARRANGEMENT

The first option is to utilize a Buy and Sell arrangement. Under a Buy and Sell arrangement, all kWh recorded by the inflow meter will be billed to the customer under the City's standard electric rates applicable for that consumer class. For REGs with a nameplate size of 200 kW or smaller, all kWh recorded by the outflow meter will be sold monthly to the City at 150% of the City's monthly system average cost of energy per kWh. For REGs with a nameplate size larger than 200 kW, all kWh recorded by the outflow meter will be sold monthly to the City at 100% of the City's monthly system average cost of energy per kWh.

OPTION 2: NET BILLING ARRANGEMENT

The second option is to utilize a Net Billing arrangement. Under a Net Billing arrangement, the amount of kWh billed to the consumer for the month will be the total energy inflow less the total energy outflow and will be based on the City's standard electric rates applicable to that consumer class. Any outflow kWh balances shall be carried forward to the next billing month and be subtracted from the next month's inflow kWh readings. The energy outflows from one meter shall not cover inflows on another meter nor shall it be converted to cash. Any energy outflow balance after the REG terminates service shall become property of the City. The consumer's monthly bill shall include applicable monthly service charges and any excess facilities charges.

If a consumer's Renewable Energy Generator or Generators have total nameplate generating capacity larger than 100 kW, then the amount of kWh outflow that is subtracted from the kWh inflow for net billing purposes is reduced proportionately and the balance is sold monthly to the City at its avoided cost rate. For example, if a customer has a 250 kW wind turbine which creates an outflow of 30,000 kWh for the month, then the amount of kWh outflow that is credited toward the consumer's inflow for net billing purposes is 12,000 kWh for that month (100 kW cap / Actual Nameplate kW) x Outflow, or (100 / 250) x 30,000 = 12,000 kWh). The remaining 18,000 kWh not credited for net billing purposes is sold back to the City that month at its monthly system average cost of energy per kWh.

G.4 Proposed Small Wind Turbine Ordinance for Greensburg (Draft)

Thomas A. Wind
Wind Utility Consulting

Permitted Use Regulation for Small Wind Turbines

Section 1 Purpose: It is the purpose of this regulation to promote the safe, effective and efficient use of small wind energy systems installed to reduce the on-site consumption of utility supplied electricity.

Section 2 Findings: The City of Greensburg finds that wind energy is an abundant, renewable, and nonpolluting energy resource and that its conversion to electricity will reduce our dependence on nonrenewable energy resources and decrease the air and water pollution that results from the use of conventional energy sources. We find that it is necessary to standardize and streamline the proper issuance of building permits for small wind energy systems so that this clean, renewable energy resource can be utilized in a cost-effective and timely manner.

Section 3 Definitions:

Small Wind Energy System: A wind energy conversion system consisting of a wind turbine, a tower, and associated control or conversion electronics, which has a rated capacity of not more than 100 kW and which is intended to primarily reduce on-site consumption of utility power.

Tower Height: The height above grade of the fixed portion of the tower, excluding the wind turbine itself.

Total Height: The height above grade of the tower and the tip of the blade when it is at its highest point.

Section 4 Permitted Use: Small wind energy systems shall be a permitted use in all zoning classifications where structures of any sort are allowed; subject to certain requirements as set forth below:

4.1 Tower Height: There is no limitation on tower height, except as imposed by FAA regulations.

4.2 Set-back: A wind tower for a small wind system shall be set back a distance equal to its total height from:

(a) any public road right of way;
(b) any overhead utility lines;
(c) all property lines.

No part of the wind system structure, including guy wire anchors, may extend closer than ten (10) feet to the property boundaries of the installation site.

4.3 Noise: Small wind energy systems shall not exceed 55 dBA, as measured at the closest neighboring inhabited dwelling. The level, however, may be exceeded during short-term events such as severe wind storms.

4.4 Approved Wind Turbines: Small wind turbines must have been approved under the Emerging Technologies program of the California Energy Commission or any other small wind certification program recognized by the American Wind Energy Association. The City of Greensburg must approve the specific model of wind turbine before it is installed.

4.5 Compliance with International Building Code: Building permit applications for small wind energy systems shall be accompanied by standard drawings of the wind turbine structure, including the tower, base, and footings. Applications for wind energy systems larger than 50 kW shall have installation drawings prepared and stamped by a professional engineer licensed by the State of Kansas.

4.6 Compliance with Federal Aviation Administration (FAA) Regulations: Small wind energy systems must comply with applicable FAA regulations, including any necessary approvals for installations close to airports.

4.7 Compliance with National Electric Code: Building permit applications for small wind energy systems shall be accompanied by a line drawing of the electrical components in sufficient detail to allow for a determination that the manner of installation conforms to the National Electrical Code. This information is frequently supplied by the manufacturer.

4.8 Utility Notification: No small wind energy system shall be installed until evidence has been given that the electric utility has been informed of the customer's intent to install an interconnected customer-owned generator. Off-grid systems shall be exempt from this requirement.

4.9 Abandonment: Any wind energy system that is not operated for a continuous period of twelve (12) months shall be considered abandoned, and the owners of such system shall remove all structures within ninety (90) days of receipt of notice from the City notifying the owner of such abandonment. If such facility is not removed within said ninety (90) days, the City may remove all structures at the owner’s expense.

4.10 Climbing apparatus: Any climbing apparatus must be located at least 12 feet above the ground, and the tower must be designed to prevent climbing within the first 12 feet. Alternatively, access to the tower must be restricted to authorized personnel so as to prevent unauthorized persons from climbing the tower.

4.11 Lighting: Tower structure lighting is prohibited unless required by another code or regulation.

G.5 Small Wind Zoning Ordinance for Greensburg, Kansas: Issue Discussion

A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
National Renewable Energy Laboratory
Innovation for Our Energy Future

Small Wind Zoning Ordinance for Greensburg, Kansas: Issue Discussion

June 19, 2008

The development of this discussion paper was prompted by the request from the Greensburg, Kansas Planning & Zoning Commission for more information about the wind ordinance which DOE/NREL drafted for the City of Greensburg.

In response to this request, the team of individuals who contributed to this discussion was broadened. The following discussion reflects the views of two staff members of DOE/NREL's National Wind Technology Center (NWTC), two wind energy consultants, and the DOE/NREL project leader for Greensburg technical assistance (Lynn Billman). These four wind experts have a combined 90 years of experience in small and community wind turbines and project development, both from a research point of view and from a real-world project implementation point of view. They include: Jim Green and Trudy Forsyth (NREL); Tom Wind (Wind Utility Consulting); and Dale Osborn (Distributed Generation Systems, primary author).

In considering the deployment of wind turbines of any size, there are four major issues that should be evaluated relative to appropriate installation; (i) safety, (ii) visual impacts, (iii) sound emissions and (iv) economics. Greensburg Kansas is currently considering an ordinance that would prescribe the allowable siting of wind turbines within city limits. The purpose of this short document is to inform the community leaders of the above issues prior to making their decisions on the ordinance.

Dimensions are important in all these considerations. We understand that residential lots in Greensburg are typically 100 ft x 140 ft (one quarter acre). Many different turbines are available for the residential market. Greensburg residents are familiar with two such turbines installed at the BTI Equipment John Deere dealership. The Endurance is 4.2 kilowatts (kw), 115 feet high at the tip, and has guy wires that extend out about 75 feet from the base of the turbine in all directions. The Skystream is 1.9 kw, 53.5 feet high at the blade tip and is on a free-standing monopole tower.

Safety: Towers of all kinds create a concern, although statistically very small, of the possibility of falling on neighbors' property such that damage to the property or even life might occur. Wind turbines are large pieces of equipment on typically tall towers, and are no exception to these concerns. Consequently, most developers of wind projects self impose setbacks from property boundaries such that if the tower, however unlikely, should fall, the fall area remains within the boundaries of the owner's property. Customarily, such setbacks also apply to proximity of overhead utility lines.

It has been correctly stated that insurance is available to mitigate these safety risks. However, we believe that such setbacks are prudent, and that if decisions on setbacks are considered in siting ordinances, safety is first and foremost on the list of considerations. Unfortunately, with turbine

heights ranging from 60 to 120 feet and lot dimensions of 100 ft x 140 ft, strict safety considerations could preclude the installation of 1.9-kw to 4.2-kw wind turbines on such residential lots.

Visual Impacts: Wind turbines, even small ones, can be considered attractive, or can be a visual concern for neighbors. That view is solely determined by the eye of the beholder. To provide reasonable performance, the hub height of the small turbine should be sixty feet above the height of dwellings and surrounding trees. To achieve that height, it is expected that the tower height would be about one hundred feet tall. It has been said that "A man's home is his castle." Our experience has shown that a one hundred foot tower with a rotating turbine atop, looming over a neighbor's backyard, may cause conflict between neighbors that may be very difficult to resolve after the turbine is installed. While the City of Greensburg is committed to the goal of sustainability, City leaders should be aware of potential conflicts between neighbors over visual issues.

Sound Emissions: Most communities defer to local noise ordinances when considering small wind siting ordinances. Customarily these ordinances specify sound emissions at the property boundaries, not at the neighboring residence. Most of the small wind turbines studied by the NWTC produced low amounts of sound in comparison to background noise. With reasonable setbacks, sound emissions should create a very limited impact on neighbors, if any. We recommend reference to a City sound ordinance which would apply to any residential wind turbines. This study provides additional information on the acoustics of wind turbines: "Acoustic Tests of Small Wind Turbines," Migliore, P.; van Dam, J.; and Huskey, A.; October 2003, NREL/CP-500-34662.

Economics: While it is not the responsibility of the city to create ordinances focused on economics of renewable technologies, we believe that the citizens should be fully informed about the economics of small wind before making purchase decisions. In the case of Greensburg, there may be a significant part of the population for which economics are a secondary consideration to the goal of sustainability. For others, the economics may be a critical component of that decision. It is estimated by the NWTC experts that the cost of energy from small wind in a residential setting would be near $0.25 per kilowatt hour. The primary reason for the high cost is the relatively poor performance of small turbines in a residential setting, due to disruption of the wind from buildings and trees. Preliminary data from a study, released May 2008, indicate that turbines within a residential area produce only 20% of the energy of the same turbine in a properly sited reference location nearby. (See www.warwickwindtrials.org.uk). It will likely take many years for the citizen to recover the cost of the turbine, depending on the utility rates. The Greensburg community wind project team has presented to the city leaders that the deployment of utility-scale turbines for the community could result in a retail electricity cost of about $0.12 /kwh.

Summary: We are very sympathetic to the desire of individuals in Greensburg to own and operate their own individual wind turbines. The City can certainly decide to adopt a different wind turbine ordinance that would make it easier for individuals to install residential wind turbines. However, our role is to communicate our concerns about safety, possible visual and noise conflicts between neighbors, and the likely economics of a residential wind system.

Therefore, after further review, we retain our support for the key points in the siting ordinance recommended previously:

a. A setback from utilities and property boundaries equivalent to the tip height of the turbine
b. Sound emissions requirements consistent with the noise ordinance.

Whatever the City decides, the following ideas may be of interest:

- Make educational information, such as that referenced in this discussion paper, broadly available to individuals interested in residential wind systems. In addition, DOE has available a consumer guide on small wind available at http://www.eere.energy.gov/windandhydro/windpoweringamerica/filter_detail.asp?itemid=311 . Further information can be found at: http://www1.eere.energy.gov/windandhydro/wind_consumer_faqs.html
  The booklet, and copies of the two studies referenced here, will be made available at the GreenTown office in Greensburg.
- A special use permit might be considered which would require written consent of neighbors to the planned wind turbine. Also, we are aware of one city trying the approach of installing two meters, and letting the neighbor have the extra wind-generated electricity.
- Develop a way that individuals could make financial contributions to the City-owned wind project, and receive public recognition for their support.

G.6 Proposed Solar Ordinance for Greensburg (Draft)

Thomas A. Wind
Wind Utility Consulting

Permitted Use Regulation for Solar Energy Systems

Section 1 Purpose: It is the purpose of this regulation to promote the safe, effective and efficient use of solar energy systems installed to reduce the on-site consumption of natural gas and/or utility-supplied electricity.

Section 2 Findings: The City of Greensburg finds that solar energy is an abundant, renewable, and nonpolluting energy resource and that its conversion to electricity will reduce our dependence on nonrenewable energy resources and decrease the air and water pollution that results from the use of conventional energy sources. We find that it is necessary to standardize and streamline the proper issuance of building permits for solar energy systems so that this clean, renewable energy resource can be utilized in a cost-effective and timely manner.

Section 3 Definitions:

3.1 Good Practice: Good practice is defined as adhering to established procedures and guidelines for the design, installation and maintenance of solar systems to ensure safe and effective operation.

3.2 Solar Access: The availability of (or access to) unobstructed, direct sunlight.

3.3 Solar Energy System: An active or passive solar conversion system which is intended to reduce the on-site consumption of natural gas and/or utility power by residential, commercial or government buildings.

> **3.3.1 Active Solar Electric System:** A system consisting of solar collectors and associated power-processing and safety equipment which generates electricity and which may be capable of either grid-connected or independent operation.
>
> **3.3.2 Active Solar Thermal System:** A system consisting of solar collectors and associated equipment which utilizes air or a suitable fluid to harvest the sun's energy for on-site heating purposes.
>
> **3.3.3 Passive Solar Thermal System:** A structure, such as a residence or commercial building, which utilizes glazing, overhangs, ventilation and other techniques, along with natural features such as trees and plantings to heat, cool, or otherwise control a building's environment.

Section 4 Permitted Use: Solar energy systems shall be a permitted use in all zoning classifications where structures of any sort are allowed; subject to certain requirements as set forth below:

4.1 Solar Access: This section is under development.

4.2 Set-backs: A passive solar, solar thermal or solar electric system shall be set back from any public road or right of way, and all property lines. No part of the solar system structure, including guy wires and anchors, may extend closer than ten (10) feet to the property boundaries of the installation site.

4.3 Noise: Ancillary equipment, such as the inverter, for solar energy systems shall not exceed 55 dBA, as measured at the closest neighboring inhabited dwelling.

4.4 Approved Active Solar System Components: All components in an active solar system must be UL-listed. The city of Greensburg must approve an active solar system design before it is installed.

4.5 Good Practice: Permit applications must demonstrate that good practice is being followed in the design and installation of a solar system.

4.6 Compliance with International Building Code: Permit applications for all solar systems will demonstrate compliance with the International Building Code, where applicable.

4.7 Compliance with Local Codes and Standards: Solar energy systems must comply with all local codes and standards.

4.8 Compliance with National Electric Code: Permit applications for active solar systems shall be accompanied by a line drawing of the electrical components in sufficient detail to allow for a determination that the manner of installation conforms to the National Electrical Code. This information is frequently supplied by the manufacturer or system installer.

4.8 Utility Notification: No active solar-electric energy system shall be installed until evidence has been given that the electric utility has been informed of the customer's intent to install an interconnected customer-owned generator. Off-grid systems shall be exempt from this requirement.

4.9 Abandonment: Any active solar energy system that is not operated for a continuous period of twelve (12) months shall be considered abandoned, and the owners of such system shall remove all structures within ninety (90) days of receipt of notice from the city notifying the owner of such abandonment. If such facility is not removed within said ninety (90) days, the city may remove all structures at the owner’s expense.

G.7 Selected Solar Access Information

John Thornton, P.E.
Consultant

a. 2005 Oregon Solar Access Guidelines

b. U.S. DOE State Solar Access Guidelines

c. Solar Access Guide

d. California's Solar Access Laws

e. Chapter 8 Solar Access

f. Protection of Solar Access

G.7.a 2005 Oregon Solar Access Guidelines

Disclaimer:

The following excerpt from the 2005 Oregon Revised Statutes is included on this site to assist in your research on an issue. Please be aware that there are likely to be other statutes and rules, both federal and state, that may apply based on a specific event or fact situation. Also, most court-made law will not appear in a statute.

Even if the statute on its face looks like it covers the situation, it may not. We urge you to consult your city attorney about your city's specific situation.

SOLAR ACCESS ORDINANCES

227.190 Solar access ordinances; purpose; standards. (1) City councils may adopt and implement solar access ordinances. The ordinances shall provide and protect to the extent feasible solar access to the south face of buildings during solar heating hours, taking into account latitude, topography, microclimate, existing development, existing vegetation and planned uses and densities. The city council shall consider for inclusion in any solar access ordinance, but not be limited to, standards for:

(a) The orientation of new streets, lots and parcels;

(b) The placement, height, bulk and orientation of new buildings;

(c) The type and placement of new trees on public street rights of way and other public property; and

(d) Planned uses and densities to conserve energy, facilitate the use of solar energy, or both.

(2) The State Department of Energy shall actively encourage and assist city councils' efforts to protect and provide for solar access.

(3) As used in this section, "solar heating hours" means those hours between three hours before and three hours after the sun is at its highest point above the horizon on December 21. [1981 c.722 §5]

227.195 Effect of land use regulations and comprehensive plans. Solar access ordinances shall not be in conflict with acknowledged comprehensive plans and land use regulations. [1981 c.722 §6]

G.7.b U.S. Department of Energy Solar Access Guideline

U.S. Department of Energy - Energy Efficiency and Renewable Energy

A Consumer's Guide to Energy Efficiency and Renewable Energy

Community Solar Access

Solar access is the availability of (or access to) unobstructed, direct sunlight. Your access to sunlight becomes important if you use solar energy for space heating (and cooling), water heating, electricity, and/or daylighting.

Solar access issues emerged in the United States initially as a means by which landowners could attempt to protect their "access," or use, of solar radiation from present or future impairment. For example, a laundry with solar water heater collectors on its roof could legally alter any nearby structural development that could cast a shadow on the collectors and negatively affect system performance.

Early efforts to protect solar access took the view that every landowner's right to natural sunlight deserved protection. It was later realized that broad solar access substantially benefited the entire community in many ways. Energy/cost savings, comfort, construction cost savings, enhanced market value, future solar energy utilization potential, and aesthetics were all improved.

Several communities in the United States have developed solar access planning guidelines and/or ordinances. Data gathering, policy determination and development, and integrating new and/or existing statutes with solar access are necessary steps in the process. Zoning is a common mechanism used to protect solar access.

Solar Landscaping

It's important to encourage compatibility between landscaping, shading, and solar access goals. Studies by the Lawrence Berkeley National Laboratory estimate a 25%–50% reduction in annual cooling energy consumption through well-designed landscape design. Additional benefits of energy-efficient landscaping include aesthetics, environmental quality, noise buffering, privacy, and spatial definition.

Solar Building Design

With optimum orientation, it is much easier to design buildings to incorporate solar features, such as passive space heating and cooling and daylighting. Many solar design strategies are highly cost-effective when incorporated into the initial building design. This typically reduces costs for initial capital investment in the building heating and cooling equipment, and ongoing operating costs.

The City of San Jose, California, for example, precisely describes what constitutes a solar access dwelling unit. There, the amount of shade on the dwelling unit defines its level of solar access. According to the City of San Jose, shading from a structure and/or vegetation must not exceed specific amounts.

Solar Energy Systems

Unobstructed access to the sun is necessary for the optimum performance of active and passive solar energy systems. There is generally no guarantee a solar system will always have unobstructed access to the sun. Every day, decisions about the built environment and landscape effect the future shading of existing or potential sites.

Solar access protection is clearly advantageous for the following systems in the associated locations:

- Rooftop: solar water heater and space heating collectors and photovoltaic arrays
- Walls: passive solar systems such as Trombe walls, attached solar greenhouses, and direct gain systems
- Lot (south-facing): ground-mounted or detached active collector systems.

Data Gathering

A number of communities throughout the country have created solar access policies and regulations according to unique local situations. If a community wishes to develop a plan for protecting solar access, they must take a number of steps to achieve its goal.

If there are no local solar access laws, private citizens requiring access to sunlight may have to bear the cost of private solar access agreements through such devices as easements or restrictive covenants.

Legislative Barriers

Zoning ordinances and building codes can create problems for solar access. Most pertain to the following:

- Height
- Setback from the property line
- Exterior design restrictions
- Yard projection
- Lot orientation
- Lot coverage requirements.

The most important solar access regulation for subdivision development is a predominantly east-west street orientation. This promotes optimal building orientation for solar access.

Related Information

- Building Codes, Covenants, and Regulations for Solar Energy Systems
- Solar Radiation Basics

Learn More

State & Local Resources

- Status of State Energy Codes
  DOE Building Energy Codes Program
- State Chapters
  Solar Energy Industries Association

Related Links

- American Solar Energy Society

Reading List

- Starrs, T.; Nelson, L.; Zalcman, F. *Bringing Solar Energy to the Planned Community* (PDF 1 MB). U.S. Department of Energy.

- Zalcman, F. et al. (2000). "Overcoming Private Land Use Restrictions on Solar Energy Systems," *Solar 2000: Proceedings of the Annual American Solar Energy Society Conference*, Madison, Wisconsin, June 16-21, 2000; pp. 169-178.
- Huddy, P. (1999). "The Power of Community as a Basis for Advancing Solar Energy Use—The Tucson Experience." *Solar 99, Proceedings of the American Solar Energy Society Annual Conference and 24th National Passive Solar Conference*. Portland, ME, June 12-16, 1999. 766 pp.
- Ravetto, A. et al. (1997). "Site Planning and Solar Access," *Proceedings of the 22nd National Passive Solar Conference*. Washington, DC, April 25-30, 1997. 381 pp.

Content Last Updated: September 12, 2005
http://www.eere.energy.gov/consumer/renewable_energy/solar/index.cfm/mytopic=50013?print#end#end

G.7.c Solar Access Guide

City of Boulder Building Services Center

Solar Access

In response to the diminishing supply and increasing cost of conventional energy resources, the City of Boulder enacted an ordinance to protect the use of solar energy. The ordinance guarantees access to sunlight for homeowners and renters in the city. This is done by setting limits on the amount of permitted shading by new construction and requiring that new buildings be sited to provide good solar access.

The degree of solar access protection is defined by either a 12 foot or 25 foot hypothetical "solar fence" on the property lines of the protected buildings. The ordinance is designed to protect access for a four hour period on December 21st. Under most circumstances, new structures will not be allowed to shade adjacent lots to a greater extent than the applicable solar fence.

There are three Solar Access Areas in the City of Boulder. Following is a list of zoning districts and which solar access area they fall into:

Solar Access Area I
Lots are protected by a 12 foot "solar fence" as mentioned above. These lots are in RR-1, RR-2, RE, RL-1 and MH zoning districts.

Solar Access Area II
Lots are protected by a 25 foot "solar fence". These lots are in RL-2, RM, MU-1, MU-3, RMX, RH, and I zoning districts.

Solar Access Area III
All other zoning districts are in Solar AccessAreaIII and are protected through the solar permit process

A solar access permit is available to those who have installed or who plan to install a solar energy system and need more protection than is provided automatically in Solar Access Areas I and II. The permit application must include detailed information describing the solar energy system, existing structures and vegetation on adjacent properties and the location and dimensions of the solar easement requested. Solar access permits do not affect vegetation which exists at the time of permit application submittal. Solar access permit application forms are available from the City Department of Planning and Community Development. The Board of Zoning Adjustment will review applications and award permits.

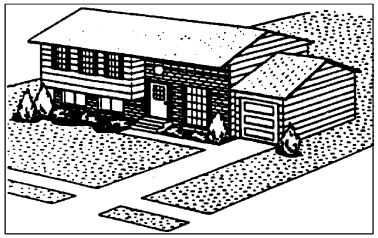
Members of the City of Boulder planning staff are available to answer questions regarding solar access and will be responsible for assuring that all plans are in compliance with the ordinance.

Compliance

When applying for a building permit, an adjusted shadow analysis must be submitted to Inspection Services. Identifying the height and orientation of the proposed building and the slope of the land, the shadow that it will cast on the 21st of December between 10 a.m. and 2 p.m. can be approximated. Complete the following steps and submit the results with the building permit application:

1. *Draw the proposed site plan.* The solar access site plan should be drawn to a scale of measurement (preferably 1:10) and show existing improvements, and the proposed building or addition, property lines, and a north arrow.

2. *Determine the height of the shadow casting portion of the roof.* Label the height of corners and peaks of the proposed roof structure on the site plan.



House to be analyzed below

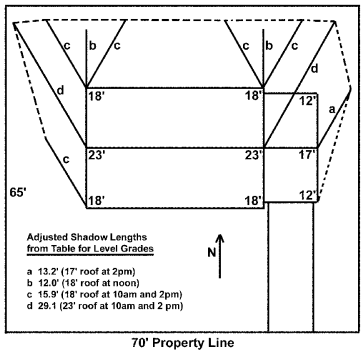


Figure 1. Simplified Shadow Analysis for House in Solar Access Area 1 (Illustration only—not to scale)

Table 1. Adjusted Solar Shadow Lengths for Level Grades

Solar Access Area I				*Solar Access Area II*			
Bldg Ht	Length of Shadow 10am	Noon	2pm	Bldg Ht	Length of Shadow 10am	Noon	2pm
13'	2.6'	2.0'	2.6'	26'	2.6'	2.0'	2.6'
14'	5.3'	4.0'	5.3'	27'	5.3'	4.0'	5.3'
15'	7.9'	6.0'	7.9'	28'	7.9'	6.0'	7.9'
16'	10.6'	8.0'	10.6'	29'	10.6'	8.0'	10.6'
17'	13.2'	10.0'	13.2'	30'	13.2'	10.0'	13.2'
18'	15.9'	12.0'	15.9'	31'	15.9'	12.0'	15.9'
19'	18.5'	14.0'	18.5'	32'	18.5'	14.0'	18.5'
20'	21.2'	16.0'	21.2'	33'	21.2'	16.0'	21.2'
21'	23.8'	18.0'	23.8'	34'	23.8'	18.0'	23.8'
22'	26.5'	20.0'	26.5'	35'	26.5'	20.0'	26.5'
23'	29.1'	22.0'	29.1'	36'	29.1'	22.0'	29.1'
24'	31.8'	24.0'	31.8'	37'	31.8'	24.0'	31.8'
25'	34.4'	26.0'	34.4'	38'	34.4'	26.0'	34.4'
26'	37.0'	28.0'	37.0'	39'	37.0'	28.0'	37.0'
27'	39.7'	30.0'	39.7'	40'	39.7'	30.0'	39.7'
28'	42.3'	32.0'	42.3'	41'	42.3'	32.0'	42.3'
29'	45.0'	33.9'	45.0'	42'	45.0'	33.9'	45.0'
30'	47.6'	35.9'	47.6'	43'	47.6'	35.9'	47.6'
31'	50.3'	37.9'	50.3'	44'	50.3'	37.9'	50.3'
32'	52.9'	39.9'	52.9'	45'	52.9'	39.9'	52.9'
33'	55.6'	41.9'	55.6'	46'	55.6'	41.9'	55.6'
34'	58.2'	43.9'	58.2'	47'	58.2'	43.9'	58.2'
35'	60.9'	45.9'	60.9'	48'	60.9'	45.9'	60.9'
				49'	63.5'	47.9'	63.5'
				50'	66.2'	49.9'	66.2'
				51'	68.8'	51.9'	68.8'
				52'	71.5'	53.9'	71.5'
				53'	74.1'	55.9'	74.1'
				54'	76.7'	57.9'	76.7'
				55'	79.4'	59.9'	79.4'

3. *Draw the approximate shadow cast by the proposed structure.* If your building is on a level lot and if the adjacent property to the north, east and west is part of the same solar access area, use Table 1 to check that your building's shadow is in compliance with the ordinance. Use the shadow pattern illustrated in Figure 1 as an example. Noon shadow lengths are projected directly north. Draw the 10:00 a.m. and 2:00 p.m. shadows at 30 degrees west of north and 30 degrees east of north. After the shadow lines have been drawn, connect the outer band of points to determine the four hour shadow pattern.

Note: If your proposed structure is not located on a level lot, please contact the Planning Department for information on adjusting actual shadow lengths for changes in grade.

4. *If the shadow cast is entirely within your property lines, the proposed building or addition is in compliance.*

5. *If the adjusted shadows cast by the proposed structure do not fall within your property lines, redesign your project or prepare a shadow analysis based on the actual shadows cast by the proposed structure.* An actual shadow analysis illustrates the true impact of all proposed shading on adjacent properties, and is required to demonstrate that the portion of the shadow which exceeds the solar fence falls within an exempt area. An actual analysis is also required as part of an application for an administrative or a board level solar exception. Apply shadow lengths listed in Table 2 to prepare an actual solar analysis.

Table 2. Actual Shadow Lengths On December 21 Solar Shadow Analysis Table for Level Grades

Bldg. Ht.	Length of Shadow 10 am	Noon	2 pm
10'	26.5'	20.0'	26.5'
11'	29.1'	22.0'	29.1'
12'	31.8'	24.0'	31.8'
13'	34.4'	26.0'	34.4'
14'	37.0'	28.0'	37.0'
15'	39.7'	30.0'	39.7'
16'	42.3'	32.0'	42.3'
17'	45.0'	34.0'	45.0'
18'	47.6'	36.0'	47.6'
19'	50.3'	38.0'	50.3'
20'	52.9'	40.0'	52.9'
21'	55.6'	42.0'	55.6'
22'	58.2'	44.0'	58.2'
23'	60.9'	46.0'	60.9'
24'	63.5'	48.0'	63.5'
25'	66.2'	50.0'	66.2'
26'	68.8'	52.0'	68.8'
27'	71.5'	54.0'	71.5'
28'	74.1'	56.0'	74.1'
29'	76.7'	58.0'	76.7'
30'	79.4'	60.0'	79.4'
31'	82.0'	62.0'	82.0'
32'	84.7'	64.0'	84.7'
33'	87.3'	66.0'	87.3'
34'	89.9'	68.0'	89.9'
35'	92.6'	71.0'	92.6'
36'	95.3'	72.0'	95.3'
37'	97.9'	74.0'	97.9'
38'	100.6'	76.0'	100.6'
39'	103.2'	78.0'	103.2'
40'	105.9'	80.0'	105.9'
41'	108.5'	82.0'	108.5'
42'	111.1'	84.0'	111.1'
43'	113.8'	86.0'	113.8'
44'	116.4'	88.0'	116.4'
45'	119.1'	90.0'	119.1'
46'	121.7'	92.0'	121.7'
47'	124.4'	94.0'	124.4'
48'	127.0'	96.0'	127.0'
49'	129.7'	98.0'	129.7'
50'	132.3'	100.0'	132.3'
51'	135.0'	102.0'	135.0'
52'	137.6'	104.0'	137.6'
53'	140.3'	106.0'	140.3'
54'	142.9'	108.0'	142.9'
55'	145.6'	110.0'	145.6'

Solar Exemptions

In certain circumstances, if the proposed structure shades an adjacent lot more than shades cast by the solar fence, the structure may still be in compliance. Compliance may be demonstrated through completion of an actual shadow analysis.

1. If an adjacent property is already shaded by existing buildings, mountains or other permanent objects (not including vegetation such as trees), you can build anything which does not add to those existing shadows.
2. If the proposed building or addition would shade part of an adjacent property which is outside the building envelope, the building or addition is exempt from the provisions of the solar ordinance.
3. A minimal amount of shading, as outlined in the solar ordinance, may qualify for an exemption and is not prohibited.

Solar Exception

If your plans actual shadows shade the building envelope of an adjacent property greater than the shadow cast by the solar fence, your options are to redesign your project or apply for a solar exception. Administrative exceptions can be considered if the owners of impacted lots have no objection, and the application complies with the criteria for exception found in section 9-9-17(f) Boulder Revised Code 1981.

A public hearing before the Board of Zoning Adjustment will be required when either the affected property owner objects to the increased shading or staff finds the proposal does not meet the criteria for a solar exception. Applications for an administrative exception or an exception from the Board of Zoning Adjustment are available from the Planning Department.

Solar Siting in New Construction

The ordinance sets standards for the siting of new development. It requires that all units in new developments which will not incorporate solar features include to the maximum extent possible:

1. long axis within 30 degrees of east-west;
2. roofs which are physically and structurally capable of supporting at least 75 square feet of solar collectors per dwelling unit; and
3. unimpeded solar access through the provisions of this ordinance or through private covenants.

Non-residential buildings have similar requirements for siting. Figure 2 is an example of a small project where 100% of the units are sited in accordance with the provisions of this ordinance.

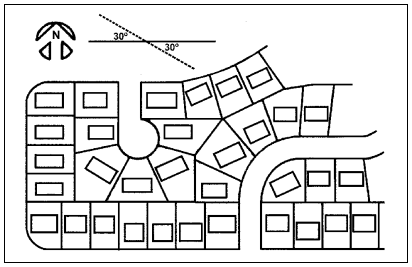


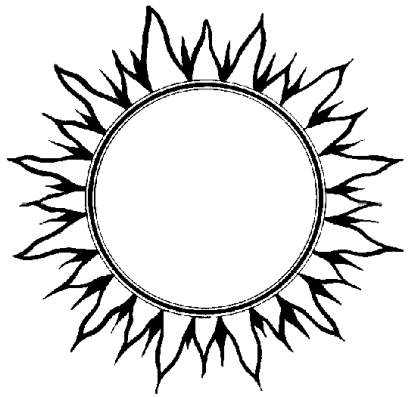
Figure 2. Typical Subdivision Site Plan

The planning staff or the Planning Board may waive the solar siting requirement for reasons of topography or lot configuration; substantial planning and design expenditures incurred before ordinance passage; or reduction in other aspects of energy efficient site planning. The incorporation of solar energy systems or other renewable energy sources may also be viable alternatives to the solar siting requirements.

If you have any questions or would like more information about the requirements of the solar access ordinance, please contact the City of Boulder Planning and Development Services Department at 303-441-1880. Also, the complete ordinance is available on the City website at: www.boulderplandevelop.net

Printed on Recycled Paper

Solar Access Guide



or Solar Shadow Analysis

City of Boulder
Building Services Center
Box 791, 1739 Broadway, Third Floor
P.O. Boulder, CO 80306
Website www.boulderplandevelop.net
Phone 303-441-1880 • Fax 303-441-3241

Revised Aug. 2006, 815.pdf

G.7.d. California's Solar Access Laws

Kurt Newick, Andy Black
http://www.gosolarnow.com/pdf%20files/CASolarAccessLaws.pdf

California's Solar Access Laws

By Kurt Newick & Andy Black

California has several laws designed to encourage solar access and prevent restrictions on solar energy systems. These laws address municipal restrictions, residential landscaping, and homeowner association restrictions.

- Solar Rights Act amended in 2004 by AB 2473 (Civil code section 714, Health and Safety Code section 17959.1, Government code section 65850.5): Prohibits local governments from restricting the installation of a solar energy system based on aesthetics.
- Solar Rights Act amended in 2003 by AB 1407 (Civil Code section 714): Requires that public entities do not place unreasonable restrictions on the procurement of solar energy systems when applying for state-sponsored grants and loans.
- Solar Shade Control Act of 1979 (Public Resources Code sections 25980-25986): addresses shade from neighboring vegetation.
- Solar Rights Act of 1978 (Civil Code section 714): Homeowner associations must not place unreasonable restrictions on homeowners wishing to install solar energy systems.
- Solar Easement Law (Civil code sections 801 & 801.5): Provides the opportunity to protect future solar access via a negotiated easement with neighboring property owners.
- Many cities and counties have local solar access laws and guidelines. For regional specific information on these and financial incentives, including tax credits, that make solar power more affordable, go to www.dsireusa.org.

Solar Rights Act amended by AB 2473

This law became effective on 1/1/2005. It is the intent of this law that "local agencies not adopt ordinances that create unreasonable barriers to the installation of solar energy systems, including, but not limited to, design review for aesthetic purposes." Local authorities shall approve applications through permit issuance and can only restrict solar installations based on health and safety reasons. It is thus intended to encourage installations by removing obstacles and minimizing permitting costs. Additional key changes limit aesthetic solar restrictions to those that cost less than $2,000 and limits a building official's review of solar installations to only those items that relate to specific health and safety requirements or local, state and federal law.

Solar Rights Act modified by AB 1407

This law prohibits public entities from receiving state grant funding or loans for solar energy systems if it places unreasonable restrictions on their installations. This law specifically

applies to cities, counties and other public entities and thus does not directly affect private parties.

Solar Shade Control Act of 1979

This act prohibits shading of solar collectors that result from tree growth occurring after a solar collector is installed. It applies to solar systems for electric generation, water heating and space heating or cooling.

It states that no plant may be placed or allowed to grown such that it shades a collector more than 10% from 10 am to 2 pm. It does not apply to plants already in place or replacement of plants that die after the installation of the solar collectors. It does require trees already in place, but not yet shading the system, to be trimmed and maintained so that they do not impact the system.

The solar collectors are required to meet building setback requirements, or a minimum of 5 feet from the property line and 10 feet from the ground. Further setback is required if the collector is lower than 10 feet.

A city or county may adopt an ordinance exempting its jurisdiction from the provisions of the act. Alternatively, some cities have passed ordinances that are more favorable to solar. In some cases, they require existing vegetation to be cleared to allow good solar access in at least some suitable place on a property.

Solar Rights Act of 1978

This law relates to homeowner associations. This code states that Community Covenants and Restrictions (CC&Rs) that prohibit or unreasonably restrict the installation or use of solar energy systems are void and unenforceable. It does provide for reasonable restrictions that don't significantly (more than 20%) increase the cost or reduce the output of a solar system from the original design.

Reasonable restrictions include 1) that the owner of the system take responsibility for roof maintenance, repair and replacement and 2) that the installers indemnify the association for any damage caused by the installation, maintenance, or use of the solar energy system.

Any homeowner covered by CC&Rs who has a roof immediately above his or her living space can use the roof for a solar system. A strategy to get maximum flexibility and output from the final "compromise" design is to propose a system designed to optimize solar production, at minimum cost, not considering other factors. Then, through the necessary negotiation stages to adjust for aesthetics, a final design might be achieved that isn't far from the owners original intention.

There may be significant costs associated with taking on responsibility for the roof maintenance that should be discussed and negotiated before project advancement. It may be possible to have a portion of association dues for roofing held separately.

Solar Easement Law

A solar easement can be written up and attached to the deed of neighboring properties to legally protect your right to receive future sunlight. Such an easement can be used to address concerns regarding neighboring structural changes. New developments may be required to include a solar access easement (a deed restriction to protect solar access within a development). Local building codes regarding building height restrictions, building set back requirements relative to property lines and solar orientation relative to neighboring properties may reduce the need for an easement.

To view these California laws see: www.leginfo.ca.gov/calaw.html

California Municipalities with specific Solar Access Laws/Guidelines

- Los Angeles - Zoning Code
- Marin County - Energy Conservation
- Sacramento - Zoning and Subdivision Regulations
- San Diego County - Solar Access Regulations
- San Jose - Solar Access Design Guidelines
- Santa Cruz - Solar Access Ordinance
- Santa Cruz County - Solar Access Protection
- Sebastopol - Solar Access

FOR MORE INFORMATION
DSIRE Database Summary of California Solar benefits – scroll down to end for Solar Access laws:
http://www.dsireusa.org/library/includes/statesearch.cfm?State=CA&back=fintab&CurrentPageID=7&Search=TableState

Energy Efficiency and Renewable Energy:
http://www.eere.energy.gov/consumerinfo/factsheets/ja1.html
Includes reference material, example solar access ordinances, bibliography including web resources.

American Planning Association 1313 East 60th Street Chicago, IL 60637(312) 955-9100 http://www.planning.org/

© 2005 by Kurt Newick & Andy Black

G.7.e Chapter 8 Solar

Code of Ordinances, Title 10, Land Use Ordinances, Chapter 08, Solar Access, Village of Prairie du Sac, Wisconsin, pp.10-8-1 to 10-8-5, 2008

CHAPTER 8

Solar Access

§ 10-8-1 Statement of Finding and Purpose
§ 10-8-2 Definitions
§ 10-8-3 Permit Application and Notice
§ 10-8-4 Hearing
§ 10-8-5 Grant of Permit
§ 10-8-6 Appeals
§ 10-8-7 Record of Permit
§ 10-8-8 Rights of Permit Holder
§ 10-8-9 Waiver of Rights
§ 10-8-10 Termination of Permits
§ 10-8-11 Preservation of Rights

SEC. 10-8-1 STATEMENT OF FINDINGS AND PURPOSE.

(a) The Village Board finds that:
  (1) Diminishing supplies of nonrenewable energy resources threaten the physical and economic well being of the residents of this community who presently rely on such resources to maintain their homes, industries, businesses and institutions;
  (2) Solar energy systems hold great promise for the future energy needs of this community because they use a renewable energy resource; because they require less capital, land, water and other resources needed for central-station generation of electricity; and because they do not pollute the community's water and air; and
  (3) The successful use of solar energy systems for such purposes as supplying space heating, water heating or the production of electricity is dependent upon sufficient access to direct sunlight.

(b) This chapter is adopted under authority contained in sec. 66.032, Wis. Stats., for the purpose of protecting the health, safety, and general welfare of the community by:
  (1) Promoting the use of solar energy systems;
  (2) Protecting access to sunlight for solar energy systems; and
  (3) Assuring that potentially conflicting interests of individual property owners are accommodated to the greatest extent possible compatible with the overall goal of this ordinance.

SEC. 10-8-2 DEFINITIONS.

(a) In this Chapter "AGENCY" means the Village of Prairie du Sac Zoning Inspector.
(b) "APPLICANT" means an owner applying for a permit under this chapter.
(c) "APPLICATION" means an application for a permit under this chapter.

(d) "COLLECTOR SURFACE" means any part of a solar collector that absorbs solar energy for use in the collector's energy transformation process. "Collector surface" does not include frames, support and mounting hardware.

(e) "COLLECTOR USE PERIOD" means 9:00 a.m. to 3:00 p.m. standard time daily.

(f) "IMPERMISSIBLE INTERFERENCE" means a blockage of solar energy from a collector surface or a proposed collector surface for which a permit has been granted under this chapter [section] during a collector use period, if such blockage is by any structure or vegetation on property an owner of which was notified under Section 10-8-3(f). 'impermissible interference" does not include:

(1) Blockage by a narrow protrusion, vegetation, or other object which never obstructs more than 5% of the solar energy which would strike a solar collector during the collector use period on any given day;

(2) Blockage by any structure constructed, under construction or for which a building permit has been applied for before the date the last notice is mailed or delivered under Section 10-8-3(f).

(3) Blockage by any vegetation planted before the date the last notice is mailed or delivered under Section 10-8-3 (f).

(4) Blockage by any structure or vegetation which obstructs less solar energy from a solar collector during the collector use period than would be obstructed by a 6 foot high wall located along the northern boundaries of the property to the south of the solar collector.

(g) "OWNER" means at least one owner, as defined under Sec. 66.021(1)(a), Wis. Stats., of a property or the personal representative of at least one owner.

(h) "PERMIT" means a solar access permit issued under this Chapter.

(i) "SOLAR COLLECTOR" means a device, structure or part of a device or structure a substantial purpose of which is to transform solar energy into thermal, mechanical, chemical or electrical energy.

(j) "SOLAR ENERGY" means direct radiant energy received from the sun.

SEC. 10-8-3 PERMIT APPLICATION AND NOTICE.

(a) PERMIT JURISDICTION. Any owner who has installed or intends to install a solar collector may apply to the Village Board for a permit. A permit may affect any land located within the territorial limits of the Village or which is subject to an extraterritorial zoning ordinance unless the extraterritorial land is subject to a zoning ordinance adopted by a county or town.

(b) APPLICATION. An application for a permit under this Chapter may be obtained from the Village Administrator and shall be completed by the applicant.

(c) INFORMAL PRE-APPLICATION MEETING. Prior to the filing of an application, the applicant shall meet with the Plan Commission to discuss the application and the permit process.

(d) APPLICATION FEE. The completed permit application shall be submitted to the Village Administrator with an application fee as stated in the Schedule of Fees.

(e) REVIEW OF APPLICATION. The Plan Commission shall review the application to determine if it is satisfactorily completed. The Plan Commission shall notify the applicant of this

determination within thirty (30) days after the application has been filed and the application fee received. If the Plan Commission determines that the application is satisfactorily completed, the Village shall provide notice forms and receipt forms to the applicant for service and signing under Subsection (f).

(f) SERVICE OF NOTICE. If an applicant is notified that an application has been satisfactorily completed, the applicant shall deliver by certified mail or by hand the notice, supplied by the Village, to the owner of any property which the applicant proposes to be restricted by the permit. The applicant shall submit to the Village Administrator a copy of a signed receipt for every notice- delivered under this subsection.

(g) CONTENT OF NOTICE. The information on the notice form shall include:

(1) The name and address of the applicant, and the address of the land upon which the solar collector is or will be located.

(2) That an application has been filed by the applicant.

(3) That the permit, if granted, may affect the rights of the notified owner to develop his or her property and to plant vegetation.

(4) That any person who received a notice may request a hearing under Section 10-8-4 within thirty (30) days after receipt of the notice.

(5) he procedure for filing a hearing request and telephone number, address and office hours of the agency.

SEC. 10-8-4 HEARING.

Within thirty (30) days after receipt of the notice under Section 10-8-3(f), any person who has received a notice, or anyone acting on that person's behalf, may file a request for a hearing on the granting of a permit or the Village Board may determine that a hearing is necessary even if no such request is filed. If a request is filed or if the Village Board determines that a hearing is necessary, the Village Board shall conduct a hearing on the application within 90 days after the last notice is delivered. At least thirty (30) days prior to the hearing date, the Village Board shall notify the applicant, any person who has requested a hearing under this section, all owners notified under Section 10-8-3(f), and any other person filing a request of the time and place of the hearing. Prior to the hearing, the Plan Commission shall submit an advisory recommendation to the Village Board.

SEC. 10-8-5 GRANT OF PERMIT.

(a) DETERMINATION. The Village Board shall grant a permit if the Board determines that:

(1) The granting of a permit will not unreasonably interfere with the orderly land use and development plans of the Village;

(2) No person has demonstrated that she or he has present plans to build a structure that would create an impermissible interference by showing that she or he has applied for a building permit prior to receipt of a notice under Sec. 10-8-3(f), has expended at least Five Hundred ($500.00) Dollars on planning or designing such a structure, or by submitting any other credible evidence that she or he has made substantial progress toward planning or constructing a structure that would create an impermissible interference; and

(3) The benefits to the applicant and the public will exceed any burdens.

(4) No person has demonstrated that the granting of a permit would cause an undue hardship in using his or her property in a manner consistent with existing zoning regulations and neighboring property uses.

(b) CONDITIONS.

(1) The Village Board may grant a permit subject to any condition or exemption the Village Board deems necessary to minimize the possibility that the future development of nearby property will create an impermissible interference or to minimize any other burden on any person affected by granting the permit. Such conditions or exemptions may include but are not limited to restrictions on the location of the collector and requirements for the compensation of persons affected by the granting of the permit.

(2) As a condition of receiving a permit, the permit holder shall be responsible for the cost of trimming [pre-existing] vegetation on property affected by the permit to prevent an impermissible interference. The permit holder shall give consideration to the desires of the property owner in trimming such vegetation and shall not unnecessarily remove vegetation which does not or will not in a reasonable period of time create an impermissible interference.

SEC. 10-8-6 APPEALS.

Any person aggrieved by a decision under this chapter may appeal the decision by making a written request to the Village Board within ten (10) days of the decision. The decision shall be reviewed by the Zoning Board of Appeals.

SEC. 10-8-7 RECORD OF PERMIT.

If the Village Board grants a permit:

(a) The Village Board shall specify the property restricted by the permit and shall prepare notice of the granting of the permit. The notice shall include the legal description pursuant to sec. 706.05(2)(c), Wis. Stats., for the property upon which the solar collector is or will be located and for any property restricted by the permit, and shall indicate that the property may not be developed and vegetation may not be planted on the property so as to create an impermissible interference with the solar collector which is the subject of the permit unless the permit affecting the property is terminated or unless a waiver agreement affecting the property is recorded under Section 10-8-9.

(b) The applicant shall record with the register of deeds of the county in which the property is located the notice under Subsection (a) for each property specified under Subsection (a) and for the property upon which the solar collector is or will be located.

(c) The Village Board shall note the location of any solar collector which is the subject of a permit on a map showing the location of all solar collectors for which permits have been granted and shall identify on the map all properties which are subject to restrictions resulting from the granting of a permit.

SEC. 10-8-8 RIGHTS OF PERMIT HOLDER.

The holder of a permit granted under this Chapter is entitled to access to sunlight for the solar collector subject to any conditions or exemptions in the permit and may seek damages for any loss caused by an impermissible interference or an injunction to prevent an impermissible interference as provided under sec. 66.032(7), Wis. Stats.

SEC. 10-8-9 WAIVER OF RIGHTS.

A permit holder by written agreement may waive all or part of any right protected by a permit. The permit holder shall record a copy of the agreement with the register of deeds. A copy of the agreement shall also be filed with the Village Board.

SEC. 10-8-10 TERMINATION OF PERMITS.

(a) Any rights protected by a permit under this Chapter shall terminate if the Village Board determines that the solar collector which is the subject of the permit is:
  (1) Permanently removed or is not used for two (2) consecutive years, excluding time spent on repairs or improvements, or
  (2) Not installed and functioning within two (2) years after the date of issuance of the permit.

(b) The Village Board shall give the permit holder written notice and an opportunity for a hearing on a proposed termination under Subsection (a).

(c) If the Village Board terminates a permit, the Village Board shall record a notice of termination with the register of deeds. The Village Board may charge the permit holder for the cost of recording.

(d) The Village Board shall modify the map of solar collectors prepared under Section 10-8-7(c) to reflect the termination of a permit.

SEC. 10-8-11 PRESERVATION OF RIGHTS.

The transfer of title to any property shall not change the rights and duties provided by a permit granted under this Chapter.

G.7.f Protection of Solar Access

Topic:
COURTS; EASEMENTS; LAND USE; MUNICIPALITIES; REAL PROPERTY; SOLAR ENERGY; ZONING;
Location:
EASEMENTS; ENERGY, SOLAR;

OLR RESEARCH REPORT

August 27, 2007 2007-R-0498

PROTECTION OF SOLAR ACCESS

By: Kevin E. McCarthy, Principal Analyst

You asked what protections a homeowner who installs a photovoltaic or other solar energy system has against a neighbor who blocks sunlight from reaching the system.

SUMMARY

In the 19th century the legislature enacted legislation that supersedes easements protecting solar access arising from common law. The state Supreme Court has construed this law to severely limit the scope of such easement. However, it appears that the homeowner could enter into agreements with his or her neighbors to obtain an easement to preserve solar access for the system. If the neighbor violated the easement, for example by enlarging the size of his building or allowing vegetation to grow to block sunlight from reaching the system, the homeowner could seek relief from the courts.

In addition, the homeowner may have some protection under zoning law. Standard provisions of municipal zoning ordinances, such as limits on the height of buildings, can limit the ability of the owner of an adjoining property from modifying his property in a way that blocks sunlight from reaching the solar system. We found one municipality that specifically protects solar access, albeit in a minor way, through zoning. Several other municipalities have land use provisions that encourage the preservation of solar access.

COMMON LAW

Under the English doctrine of "ancient lights" if a landowner and his ancestors had received sunlight across an adjoining property for a specified period of time, the landowner was entitled to continue to receive this benefit. He could prevent his neighbor from obstructing his access to light. Under these circumstances, the landowner was said to have an easement by prescription to "light and air" over his neighbor's property. English common law also allowed for the creation of an easement to light and air by implication. Such an easement was one created by law based on the reasonable expectations of the purchaser of a piece of property regarding the benefits (such as light and air) from the adjoining property.

These provisions were part of American common law into the 19th century (cf. *Bushnell v. Proprietors of Ore Bed*, 31 Conn. 158 (1862)). However, the Connecticut legislature eliminated easements to light and air by prescription in 1875 and the state Supreme Court subsequently severely limited the scope of easements by implication. The 1875 act (CGS § 47-25) bars the acquisition, by adverse occupation (prescription), of the right to keep any light so as to prevent the owner of an adjoining property from building or maintaining a building on his property. In *Robinson v. Clapp,* 65 Conn. 365, appeal after remand 67 Conn. 528 (1896), the Court held that a landowner has an easement to light and air by implication only under very restrictive conditions. It held that the doctrine of implied easements to light and air should only be applied when:

1. the actions of the offending property owner exclude, rather than merely diminish, light from entering the aggrieved owner's property; and

2. the easement is clearly necessary for the reasonable enjoyment of the affected property, as distinct from being merely a convenience for its owner.

The Court held that in the absence of a statute, easement, or contract to the contrary, a landowner may block the view previously enjoyed by an adjoining landowner by erecting a building or other structure. This is true even if the structure was built for the express purpose of shutting out the light and air from the adjoining property.

Unlike most states, Connecticut law does not explicitly provide for easements between property owners to preserve solar access, but neither does it preclude such easements. We have found one zoning ordinance (Windsor) that encourages such easements. If a homeowner with a solar system had an easement with a neighbor and the neighbor violated it, for example by enlarging the size of his building or allowing vegetation to

grow to block sunlight from reaching the system, the homeowner could seek relief from the courts. This relief could take the form of an injunction or damages for the diminution of the solar system's value.

Information about solar easement laws in other states is available at http: //www. dsireusa. org/library/includes/type. cfm?EE=0&RE=1.

STATUTORY PROVISIONS

CGS § 8-2 allows, but does not require, zoning ordinances to encourage the use of solar and other forms of renewable energy. Standard provisions of zoning ordinances, such as limits on building heights, minimum distances between buildings and lot lines, and lot coverage limits, may provide some protection to a homeowner who owns a solar energy system. Exceeding these limits requires a variance granted by the zoning board of appeals (ZBA). If the ZBA grants a variance, the owner of adjoining properties can appeal the decision to the courts without demonstrating that they are aggrieved (CGS § 8-8). If a homeowner believes a neighbor has violated the zoning ordinance, he or she can seek enforcement from the municipal zoning enforcement officer and ultimately the courts.

We have found one municipality that has an enforceable zoning provision that specifically applies to solar access. Griswold prohibits the erection of satellite TV dishes in locations that would block solar access of an adjoining property. In addition, zoning and subdivision regulations in several other municipalities have provisions that encourage the preservation of solar access. For example, Bolton's zoning regulations require applicants for the development of any building intended for human occupancy to demonstrate that their site designs seeks to maximize solar access. This can be done through design techniques including building orientation, street and lot layout, vegetation, and the protection of solar access within a development. Similarly, Cromwell encourages the preservation of solar access in site designs and discourages the erection of buildings that would shade the buildable parts of adjoining lots on the shortest day of the year.

KM: ts

G.8 Cooperation Agreement (Greensburg MOU)

COOPERATION AGREEMENT

This Agreement is made and entered in this __the day of _____ , 2009, by and between **THE CITY OF GREENSBURG, KANSAS,** ("City") and KANSAS BUILDING INDUSTRY ASSOCIATION, ("KBIA").

RECITALS

1. The City is a city duly authorized and existing in accordance with the laws of the State of Kansas.

2. The City experienced a devastating tornado on May 4, 2007, causing the destruction of a significant portion of the private dwellings, business and commercial properties, and government buildings and infrastructure.

3. In response to the tornado destruction, the City has entered into efforts to develop a longer-term plan for the rebuilding process and it is the desire of the City and the community that the rebuilding of the City is done in a manner which is environmentally friendly, technology advanced, and sustainable.

4. The City desires to have residential buildings built with environmentally friendly techniques, using advanced technologies sustainability and energy efficiency. The City desires to formalize this effort into a city-wide voluntary program.

5. Kansas Building Industry Association (KBIA) is an affiliate of the National Association of Home Builders ("NAHB"). KBIA serves as an advocate for Kansas' housing industry, and as a corporate channel through which builders contribute time, money and services to local community service projects and education initiatives.

6. KIBA endorses the National Green Building Standard (ICC700-2008); a standard developed by a consensus process through the American National Standards Institute (ANSI) and approved by the International Code Council (ICC). This guiding document is a credible source and national recognition for providing green building techniques and practices.

7. The National Renewable Energy Laboratory (NREL) of the U.S. Department of Energy (DOE) has provided consultation services on energy efficient construction to owners and builders for residential construction projects in Greensburg throughout the rebuilding process from August 2007 to this date.

8. KBIA supports the National Green Building Program developed and administered by NAHB. The program is a formal approach that clearly outlines steps and procedures for a residential home to be certified by NAHB as "Green".

9. The City desires to enter into an agreement with KBIA and KBIA desires to enter an agreement with Greensburg that outlines their respective rights and responsibilities regarding a cooperative effort between them and whereby KBIA will assist the City in its formal green building program.

10. The parties desire to place their agreement in this regard in writing as to avoid future disputes and difficulties.

NOW, THEREFORE, in consideration of the recitals and the mutual terms, convents, conditions and promises herein contained, the parties hereto do agree as follows:

1. The City of Greensburg shall initiate a voluntary green residential building program (Greensburg GreenHome) in partnership with KBIA.

2. The parties will enter into partnership for a time period of two years.

3. The basis of the Greensburg – KBIA partnership "Greensburg GreenHome" shall be the application of the ICC 700-2008 National Green Building Standard, and the NAHB building verification and certification process (National Green Building Program) to residential construction projects in Greensburg.

4. KBIA will jointly host, with the City of Greensburg, and NREL, an orientation program to introduce all interested parties to the Greensburg – NAHB "Green Initiative", at no cost to participants.

5. KBIA will offer training for the Certified Green Professional designation from NAHB. This is a 2-day Green Building for Building Professionals Course and a one-day Business Management course.

6. KBIA will host Verifier Training for anyone interested in becoming certified as a Verifier and waive state and local fees for this training if they perform verification services in Greensburg.

7. KBIA will waive the state and local association fees for any home built in Greensburg that achieves an NAHB green built certification.

8. KBIA will work with verifiers to provide discounts on verification services for green built homes in Greensburg.

9. KBIA will provide state association awards as incentives for homes built in Greensburg that achieves "GreenHome" certification.

10. KBIA will publicize the green building program and green built homes in Greensburg.

11. Communication between the City and KBIA shall be conducted between office of KBIA and the City Administrator on the part of the City.

12. KBIA and Greensburg Greentown 501 (c3) will work together to develop materials for publication and press. KBIA and Greensburg Greentown are also encouraged to work together and share resources related to community outreach and public engagement concerning the Greensburg GreenHome Program.

13. This Agreement contains the entire agreement between the parties and may not be modified except by written agreement signed by both parties. This Agreement may not be assigned by either party with the consent of the other party in writing.

14. The Agreement shall exist for two years or until mutually extended or mutually terminated or terminated by either party upon written notice to the other end, upon such notice, the Agreement and all efforts of the parties, pursuant to the Agreement shall cease.

Appendix H: Educational and Outreach Materials

Page

H.1 Rebuilding After Disaster—Going Green from the Ground Up 608

H.2 Greensburg, Kansas—A Better, Greener Place to Live 633

H.3 From Tragedy to Triumph—Rebuilding Green Homes after Disaster..... 642

H.4 From Tragedy to Triumph—Rebuilding Green Buildings after Disaster . 647

H.5 From Tragedy to Triumph—Rebuilding with Renewable Energy after Disaster 652

H.6 From Tragedy to Triumph—Resources for Rebuilding Green after Disaster 657

H.7 Rebuilding It Better—BTI-Greensburg John Deere Dealership 662

H.8 Greensburg Kansas: Building a Model Green Community, How Would You Rebuild a Town Green? 667

H.1 Rebuilding After Disaster—Going Green from the Ground Up

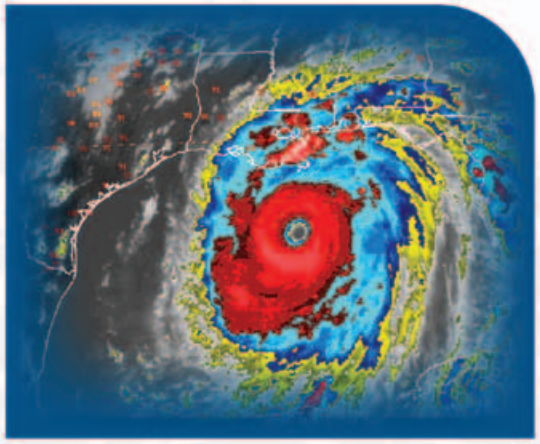
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy





Rebuilding After Disaster:

Going Green from the Ground Up









About This Guide

If you're a leader in a community that has met with disaster and must be rebuilt, this guide is for you. It's intended to show how communities—big or small—can incorporate green principles and technologies like energy efficiency and renewable energy into their rebuilding plans. The information in this guide is based on the real-life experiences of two U.S. Department of Energy (DOE) teams. One team worked with city leaders in New Orleans, Louisiana, after hurricanes Katrina and Rita in 2005, and the other assisted community leaders in Greensburg, Kansas, after a devastating tornado in 2007. Although the two communities are quite different, the teams learned common lessons and found that the reasons for going green from the ground up are compelling.

Table of Contents

Out of Crisis, Opportunity 1

Why Go Green from the Ground Up? 2

Green Choices, Community Benefits 3

Crafting a Green Recovery Plan. 5

- Step 1: Identify and Bring Stakeholders Together. 5
- Step 2: Choose Your Leaders 7
- Step 3: Visualize and Capture the Vision . 9
- Step 4: Get the Lay of the Land 9
- Step 5: Set Your Goals 10
- Step 6: Find the Funds 15
- Step 7: Write the Plan 17

For More Information 18

Cover photo credits: (top to bottom) Lynn Billman/PIX 16677, NREL; © iStockphoto.com/file#3662528; Jeff Weber, © University Corporation for Atmospheric Research (UCAR); Lynn Billman/PIX 16660, NREL; Galen Buller/PIX 16676; and Lynn Billman/PIX 16709, NREL.

Key Distinctions

In this guide, we focus on topics related to disaster recovery as distinct from disaster response, with the two concepts defined as follows:



© iStockphoto.com/file#1515437

Response: Immediate action, in which core emergency services and first responders—firefighters, police officers, and emergency medical technicians—mobilize in the disaster area. Specialist rescue teams (e.g., divers) or Hazmat crews may be called in. Response focuses on rescuing people, pets, and livestock; treating injuries; dealing with any loss of life; setting up emergency shelters; restoring electricity and natural gas services; supplying clean water; and clearing streets and neighborhoods of dangerous debris.

Recovery: Ongoing action with the goal of restoring the area to its pre-disaster state or better. Recovery involves rebuilding destroyed property, putting residents back to work or creating new jobs, repairing essential infrastructure, bringing all community services back online, and attracting new industries.



Galen Buller, Ingalls, Kansas/PIX 16675

Out of Crisis, Opportunity



Galen Buller, Ingalls, Kansas/PIX 16666

Every year, communities just like yours are devastated by tornadoes, floods, hurricanes, and other natural disasters. If disaster does strike your community, the initial response will focus on immediate needs. After those are met, and some of the shock wears off, the community can begin to recover. And although discouragement and despair are natural responses to a disaster, human beings are also resilient. The residents of your community are likely to want to return quickly to the way things were. There's great comfort in familiarity, and its pull is strong.

[America has always] found the capacity to not only endure, but to prosper—to discover great opportunity in the midst of great crisis.

—President Barack Obama

But as you begin to make plans for recovery, you might want to take a step back. Try to see past the devastation for a moment. Reframe that shattered glass as a clean, new window of opportunity. You can choose to make this catastrophe into an opportunity. . . not just to return to the status quo, but to grow and change. Instead of reflexively reinstating the choices of the past, why not rebuild today to better position your community for tomorrow?

One way to do this is by rebuilding your community as a model of sustainability. This means reducing energy use, using energy more efficiently, incorporating more renewable energy, and much more. That's what Greensburg did. It's also happening in parts of New Orleans.

And it's what this guide is all about. The pages that follow explain how we're using green terminology and outline the benefits of rebuilding sustainably. Next, we present a step-by-step process for green disaster recovery (or simply "green recovery"). The guide includes suggestions based on the lessons learned in Greensburg and New Orleans along with concrete examples from both communities. Because this guide is intended as an introduction to green recovery, it includes a number of other resources for you and your community to explore. For more details about any of the federal, state, and local organizations, programs, and associations mentioned in the text, please visit the Web sites listed in the For More Information section starting on page 18.

What Happened in Greensburg and New Orleans

On May 4, 2007, Greensburg was a declining but close-knit farming community with a population of about 1,400 in Kiowa County in south-central Kansas. That night, an EF-5 tornado—the highest level on the standard meteorological scale used to estimate wind strength—plowed through the town. With winds estimated at more than 200 mph, the tornado killed ten people and destroyed or severely damaged 90% of the community.

Hurricane Katrina struck the New Orleans area in the early morning on August 29, 2005. The storm surge breached the city's levees in multiple places, leaving 80% of the city submerged, tens of thousands of victims clinging to rooftops, and hundreds of thousands scattered to shelters around the country. Three weeks later, Hurricane Rita reflooded much of the area. The devastation to the Gulf Coast by these two hurricanes has been called the greatest disaster in our nation's history. More than 1,800 people are believed to have lost their lives, and damages have exceeded $81 billion (NOLA.com 2008).

Why Go Green from the Ground Up?

First, let's clarify what we mean by green. It's easy to get hung up on defining terms that may mean different things to different people, and you don't want your recovery efforts to stall because you can't arrive at a common definition. Even seasoned experts disagree on common explanations of all the elements embodied in the word "green". Actually, that's part of the beauty of the term . . . it encompasses so many choices. In this guide, we're aiming for simplicity and aligning with today's common parlance. So we're using the terms "green" and "going green" to encompass energy efficiency (using less energy to supply the same level of energy service) and renewable energy (energy produced from the sun, the wind, and the water, among many other sources). The terms also embody principles of sustainability, by which we mean simply that new development meets needs of today without compromising those of tomorrow. Resource conservation, recycling, and reuse, along with best practices for community and building design and construction that minimize negative environmental impacts, are the final pieces of the green picture.

In this guide, we focus primarily on energy considerations within a larger green and sustainable framework.



Catherine Hart, Greensburg GreenTown/PIX 16671



Catherine Hart, Greensburg GreenTown/PIX 16670

In rebuilding the Kiowa County, Kansas, courthouse—originally constructed in 1914—the community decided to salvage the original white trim along with several ornate doors from the stately and historic building.

Why Consider Energy At All?

Because it's an integral part of our daily lives, whether we think about it or we don't. Of the energy used in the United States today, residential buildings account for 21%; commercial and public buildings for 18%; industry for 32%; and transportation for 29%. According to the Energy Information Administration (EIA 2008), this energy comes from coal (22%), natural gas (19%), domestic crude oil (12%), imported petroleum (27%), various other imports (6%), and nuclear power (8%).

Natural gas and crude oil prices are volatile and subject to fluctuations outside our nation's control. That volatility leads to greater uncertainty in forecasting energy costs, which, in turn, can make lenders or investors reluctant to support new projects. Or, lenders may charge higher interest rates on loans for projects to cover what they perceive as higher risks.

The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired, in value.

—Theodore Roosevelt

Rallying Greensburg Around Green Recovery

Inevitably, questions borne of despair follow incredible devastation. Should we even rebuild here? Will enough people come back? Will we ever even have a town, a city, again? In Greensburg, just days after the storm, community leaders and members came together and decided that their town was worth rebuilding. And they had some novel ideas about how to do it.

Maybe, they said, we can rebuild to use the wind that almost destroyed us to generate electricity. Rebuild to consume less energy and water and more local food. Rebuild to give our children the best and greenest school in Kansas.

These green messages resonated with local and state leaders alike, and excitement began to build about rebuilding Greensburg to truly embody its name. One by one, the townspeople embraced the green initiative.

Rebuilding as a model green community became the cornerstone of the town's new master plan and the economic development vision of the townspeople.

Today, the headline on the City of Greensburg Web site says it all:

Greensburg:
Better, Stronger, Greener!



Lynn Billman, NREL/PIX 16650

The county courthouse renovation in Greensburg captures much of the structure's original design and beauty but incorporates new energy efficiency strategies including daylighting (using the existing window openings) and high-performance lighting and controls. The building also uses pipes beneath the ground to capture geothermal energy, lowering the cost of heating and cooling.

Green Choices, Community Benefits

Making green choices during disaster recovery has a number of benefits:

Lower energy bills. The large-scale rebuilding effort following a disaster is an ideal time to require or encourage high energy efficiency standards for all new and remodeled buildings. Constructing energy-efficient buildings from the ground up is much cheaper than retrofitting or upgrading down the road.

> *Our choices at all levels—individual, community, corporate and government—affect nature. And they affect us.*
>
> *—David Suzuki*

Cleaner energy sources. If the disaster affected your local utility, this might be the perfect time to change the electricity mix to incorporate more renewable energy sources such as wind and solar. You might be able to negotiate a new type of power purchase agreement with the local utility, or you might build your own generation facilities to bring more renewables online.

A cleaner environment. Using energy produced from renewable sources softens your impact on the planet. Clean, renewable energy reduces the carbon emissions that contribute to global warming and significantly lowers emissions of other regulated pollutants (like sulfur dioxide and oxides of nitrogen). In addition, generating electricity from renewables can save large amounts of water—an increasingly precious commodity.

More robust economic development. When you make the commitment to greener choices in all sectors of your community, economic opportunities can follow. Green recovery can set a new focal point for economic development, place emphasis on new green-collar jobs, and improve your community's image, which in turn, can attract businesses and residents.

A renewed sense of hope. Joining other communities that are embracing different ways of building, greener community master plans, and new renewable energy sources can help create a vision of hope for your citizens and business owners. Most importantly, coming together to go green will help you recapture the values and sense of common identity that gave your community cohesiveness before the disaster.

Green communities are easier than ever to achieve. Great strides have been made in ways to reduce the amount of energy used in homes and businesses. More and more communities are successfully generating electricity from the sun and the wind. Alternative transportation technologies are accelerating in the marketplace, and hybrid electric vehicles are now readily available in most vehicle categories. Interest in alternative fuels like biodiesel and other biofuels is high. Once-abstract concepts have progressed to concrete, real-world options that are available now.



Photo courtesy of the City of Greensburg/PIX 16667

Vehicles fueled with alternatives to petroleum are on the road today, and automakers continue to pioneer new offerings each year.



Invenergy LLC / PIX16042



Warren Gretz / PIX10598

The wind and solar power technologies that are readily available on today's market can make a significant contribution to your community's energy needs.

Crafting a Green Recovery Plan

So how do you get started? If your community already has a master development plan, an energy plan, or an energy policy, you have a head start. You can begin the green rebuilding efforts by revisiting and updating your existing plan. You're likely to find that some green projects are now possible simply because you must rebuild. If your community doesn't have any sort of master plan, take this opportunity to create one. The goal should be to develop a single, unified plan that avoids redundancy and overlap.

Success always comes when preparation meets opportunity.

—Henry Hartman

A suggested framework for getting there—seven sequential steps—follows. As you move through the steps and consider the associated issues and examples, make a commitment to writing everything down and being as specific as possible. Aim for quantifiable goals wherever you can, but if you get stuck, set qualitative goals and move forward. The planning process should propel progress, not stymie it.

Step 1: Identify and Bring Stakeholders Together

A *stakeholder* is anyone who has an interest in your community. Stakeholders can include everyone from city leaders (either elected or appointed)—through planning and zoning commissions, economic development councils, chambers of commerce, and public building owners—to major business owners, affected and interested homeowners, education leaders and students, and nonprofits.

Depending on the size of your community, stakeholder lists can be long. But each will bring unique perspectives and diverse ideas to the table, leading to robust brainstorming sessions. Including as many stakeholders as possible from the outset—when you hold your first planning meeting—will build community buy-in for the final plan. It also ensures that representatives of various community sectors have the opportunity to air concerns that can be addressed in the planning process.



Lynn Billman, NREL

Gaining buy-in from stakeholders is an important part of any green recovery initiative.

qualitative**: adj. of, relating to, or involving quality or kind* **quantitative: adj. of, relating to, or involving the measurement of quantity or amount.*

—Merriam Webster Unabridged Dictionary

At this stage of your planning, the importance of a **green champion**—someone who is passionate about the green cause—cannot be overstated. An ideal champion will be recognized and respected both in the community and within city government. Your champion must be willing to make the time to offer ideas and information, suggest opportunities, and work to inspire others to see the possibilities. The champion will also need to establish good communications and actively involve other stakeholders as much as possible.

A Few Words About Resistance

You may meet with some resistance among those individuals and business owners who want to rebuild right now. Greensburg officials recognized that the need to reestablish revenue was urgent and real, and they wondered whether they should insist on developing a new community plan before approving any construction permits. To help them decide, they visited New Orleans and other Gulf Coast cities and saw for themselves the real-life examples of the benefits of a good plan. They came home newly energized and spoke eloquently to their business leaders about the importance of waiting just a few more months so the community could "get it right." City and business leaders then negotiated a commitment for a tight deadline from a planning firm, worked tirelessly with that firm, and developed an award-winning community plan in a remarkably short time.

If you meet with reluctance in your community, showcase Greensburg as a shining example of getting it right.

Resistance can also stem from fear of the unknown, and the antidote is to make the unknown known. This brings us to the next key point that applies to your stakeholders—the importance of education and communication.



Lynn Billman, NREL/PIX 16668

The RnE²EW vehicle is designed to take renewable energy technologies on the road. The vehicle is equipped with solar panels and a wind turbine, which produce the power needed to run everything that requires energy during an educational event like this one in Greensburg.

Educate, Communicate, Educate and Communicate Some More

The more your stakeholders know about the topics at hand, your proposed plans, and how these relate to their place in your community, the more comfortable they'll be with new ideas and changing attitudes and behaviors. Winning community support for your green recovery plans will require you to pay deliberate attention to education and

> *Learn everything you can, anytime you can, from anyone you can—there will always come a time when you will be grateful you did.*
>
> *—Sarah Caldwell*



The World Wide Web offers a wealth of educational resources about energy efficiency and renewable energy. And most of the information, like the U.S. Department of Energy Web sites illustrated here, is free.

communication. Involving all your stakeholders will naturally enhance communication, but use your imagination and creativity to go a bit further.

Keep all your stakeholders up to date through communication venues like the city Web site, flyers distributed in public buildings and stores, articles in local newspapers, spots on local radio, regular and special public meetings, and announcements and reminders at group meetings to work on other topics. Greensburg communicated through all these venues at one time or another.

Your education efforts can be as simple as a printed fact sheet or as elaborate as a day-long seminar. To keep costs down, homebuilders' associations or professional green-building advocacy groups may be able to offer low-cost training in areas that apply to green recovery. Your residents and businesses may be interested in, for example:

- How much money they can save by reducing energy use in buildings
- What features make a building green or energy efficient
- How to improve insulation or windows during major repairs
- How to use alternative energy sources such as ground-source heat pumps (to capture and distribute geothermal energy), solar panels, solar hot water systems, and small wind turbines.

Local architects, engineers, contractors, and suppliers might find topics like these useful:

- Green building strategies, including integrated design
- Tax incentives for green building practices
- Continuing education courses for design professionals
- Green materials, local products, and regional suppliers.

Encourage your stakeholders to learn all they can about the experiences of others. The links in For More Information are a good place to start. So are Web searches for topics such as sustainable communities, green master planning, and green development—use your imagination!

Finally, take full advantage of the major role K-12 schools and students can play in educating stakeholders and changing attitudes and behaviors. When young people learn about clean energy, they're likely to bring that knowledge home wrapped in enthusiasm that will inspire their parents and grandparents. In Greensburg, the words of a teenager at a town meeting are thought to have been a tipping point toward green recovery: "Before the tornado, I was planning on going to college and never coming back to Greensburg. But now I want to come back. I want to help make this a model for other communities. I want to live here."



Lynn Billman, NREL/PIX 16292

Remember to include young people in your educational efforts. They have proven to be a powerful force for change.

Curricula are readily available to strengthen or start K-12 coursework on energy. Promote the development of classes or majors in energy or sustainability at your local university or four-year college, or certification classes for installers and maintenance workers at your community college. Such programs are expanding rapidly around the country. And if the local college already has expertise in sustainability, renewable energy, or efficient building construction, call on those experts to offer information and seminars.

Step 2: Choose Your Leaders

At the kickoff meeting with all your stakeholders, select a small group of local leaders from diverse parts of the community. These individuals should be able to see the big picture, and their job will be to lead the overall planning. Leaders often emerge naturally based on the strengths and preferences

of the people in the room. Or positions of authority may already have been established. Either way, encourage openness and freedom of expression to make it work.

Problems can become opportunities when the right people come together.

—Robert South

Depending on your community's unique rebuilding requirements, you'll almost certainly want to break the broader leadership team into smaller working groups. Each group will have an assigned area of responsibility. This helps carve the task at hand, which will seem overwhelming, into manageable pieces. Using the working group approach also gives each aspect of green recovery the attention it deserves.

When you're rebuilding to go green from the ground up, establishing an Energy Working Group will be particularly important. Why? Because energy and efficiency choices are an intrinsic part of the rebuilding process. When you rebuild, you'll be creating structures that should stand for 40 years or longer. Power plants last for several decades, and contracts for supplying electricity often extend for many years. As you plan for green recovery, you'll be making decisions that affect, for example:

- Land use planning
- Building restoration, repair, and reconstruction, including building codes for all types of buildings (residential, business, public, and nonprofit, among others)
- Fleet and personal vehicle replacements
- Reconstruction of fueling stations
- Reconstruction of the electricity distribution system
- City ordinances that govern distributed electricity.

Energy considerations are part of virtually every project a community takes on after a disaster.

What a Quantitative Energy-Use Baseline Looks Like

Electricity

Electricity used in Greensburg is created largely from coal-based sources.

Conversion factors: In Greensburg, the utility fuel mixes are typically 1/10 wind and 9/10 coal-fired. Therefore, 1,000 kilowatt-hours (kWh) = 594.6 pounds (lb) of CO_2 emissions.

2006 electricity usage:
9,800,000 kWh = 5,827,080 lb of CO_2

Natural Gas

In Greensburg, natural gas is the primary source for heating.

Conversion factors: 1 therm of natural gas produces 11.64 lb of CO_2.

2006 natural gas usage: 650,000 therms = 7,566,000 lb of CO_2

Transportation

Most vehicles in Greensburg are powered by fossil fuel, primarily gasoline and diesel, which are major greenhouse gas contributors. Most drivers travel alone to work or school. As the amount of driving increases, so does the amount of greenhouse gases emitted. For the purposes of this exercise, estimated figures and national averages were used:

Estimated number of vehicles in Greensburg in 2006: 577

Average annual miles driven (national average): 15,000

Average fuel efficiency (national average): 20.7 mpg

Gallons of gas driven:
(15,000 x 577) / 20.7 = 418,116 gal

Conversion factor: Every gallon of gasoline burned releases 20 lb of CO_2.

2006 transportation impact:
8,360,000 lb of CO_2

Source: Adapted from City of Greensburg, Kansas + BNIM (2008), p. 95

© University Corporation for Atmospheric Research (UCAR)

Step 3: Visualize and Capture the Vision

A vision excites and energizes the stakeholders and makes them believe that all things are possible, so spend some time here. Brainstorm ideas and come to consensus on what you want to achieve. Building on that common identity while adopting a new community framework can be the spark that energizes a discouraged community. When enthusiasm lags, return to the vision. It will help you remember why you're doing this in the first place.

The vision is also where you can begin making the connection between the broader goal of rebuilding sustainably and the more specific objectives that feed into that goal. Greensburg's *Vision Plan Draft* is an excellent example (City of Greensburg 2007). The 12-page working draft is broken into five topic areas: Energy, Built Environment, Water, Economic Development, and Community. In each topic area, the stakeholders identified specific targets. Under Energy, for example, they envisioned the following:

- Increase efficiency of all end uses to reduce energy demand
- Meet all energy needs through renewable generation sources
- Reduce citywide carbon dioxide (CO_2) emissions.

The stakeholders then used this draft as they worked with the planning professionals to prepare their *Greensburg Comprehensive Sustainable Plan* (City of Greensburg, Kansas + BNIM 2008).

Step 4: Get the Lay of the Land

To see where you want to go, you have to understand where you are. You'll need to assess the current situation in your community, often called "establishing a baseline." In disaster recovery, this step can have several components. For example, consider what Greensburg called the built environment: Evaluate what, if any, damaged materials can be salvaged and reused. Determine how much land is actually available for rebuilding or redevelopment. Decide whether to completely rebuild portions of your infrastructure.



Daniel Wallach, Greensburg GreenTown/PIX 16669

After the tornado, Greensburg residents regretted missing the opportunity to recycle lumber and other usable materials from the tornado debris.

> *We are all faced with a series of great opportunities brilliantly disguised as impossible situations.*
>
> *—Charles R. Swindoll*

You'll also need to know how your community once used energy. Although your Energy Working Group might find this challenging, best estimates will work. You might ask your utility companies for help. Individual use is not publicly available information, but companies are often willing to supply averages for typical residences or composite figures for a business district. Ask your major industries and the largest public energy users (such as schools, hospitals, and industries) for their energy use and costs, and enlist their support for your Energy Working Group. Ask major fleet owners about the number of various types of vehicles they had before the disaster and what fuel they used, and see if they can estimate how many miles per year each drove. This step can be time consuming, so consider soliciting local high school or college students to help gather these data.

Or, to establish a more formal, quantitative baseline, you may want to enlist an energy analyst. After the tornado, the U.S. Department of Energy contacted Greensburg's leaders to offer assistance. DOE opened an office in Greensburg and assembled a team of experts from its National Renewable Energy Laboratory (NREL). The team helped to determine Greensburg's previous energy use baseline in quantitative terms (see sidebar for an example).

Working from your baseline, you can see what you want to do differently. In terms of energy, now's the time to learn what renewable resources are available to you. You can find extensive—and often free—data on renewable resources, such as wind, solar, geothermal, and biomass on the Web. Here are three examples of the types of information available free of charge (see For More Information for specifics):

- 3TIER, a company that provides renewable energy assessment and forecast information, has developed an online assessment tool—called FirstLook—for wind and solar resources. With a couple of mouse clicks, you can identify potential locations for wind and solar installations, along with free preliminary wind and solar data about the sites. You can also purchase a FullView Site Analysis if the free information reveals promising sites in your area.
- NREL and the Environmental Protection Agency (EPA) developed a free Biomass Power Assessment Tool to enable access to county-level biomass resource data. After you select a site and define a geographic radius or boundary, the tool reports on the estimated annual amount of biomass available from crop residues, forest waste, wood waste, landfills, and wastewater treatment plants, among other sources.
- DOE and NREL's Alternative Fuels & Advanced Vehicles Data Center hosts a free interactive map of alternative fueling stations.

Step 5: Set Your Goals

> *If you don't know where you are going, you'll end up someplace else.*
>
> *—Yogi Berra*

Though lighthearted, Berra's quote contains an important nugget of truth. Setting goals is at the heart of the community's green recovery plan. Goals keep you on track. They keep you moving toward where you want to be, not someplace else. If you can, try to set quantitative goals. (For energy, this would be easier if you were able to quantify your energy use in Step 4.) But if that isn't possible, set qualitative



Lynn Billman, NREL/PIX 16660

The Sun Chips City Business Incubator in Greensburg is designed to offer affordable spaces for businesses getting back on their feet, as well as for new retail ventures. This building received a major funding boost from actor Leonardo DiCaprio, a well-known sustainability advocate.

goals instead. Either type of goal will help bring your community together in its understanding of energy—past, present, and future. The important thing is to set achievable goals that will allow you to move forward and experience a sense of accomplishment as a community.

You might find the following simple framework useful as you think about energy. Ask your Energy Working Group to consider how the community can:

- Reduce energy use in homes, businesses, and industrial processes
- Use more renewable energy in homes and businesses
- Decrease fossil fuel use in vehicles.

Reducing Energy Use

Simply reducing the amount of energy you use is the easiest and most cost-effective way to become more sustainable, so it makes sense to focus on this first. With buildings using 39% of the energy consumed in the United States today, green buildings can have a huge impact. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has published guidelines for reducing energy use by as much as 30% in warehouses, small retail buildings, small office buildings, and K-12 schools.

Compared to conventional buildings, a green building minimizes use of energy, water, materials, and land. Depending on construction choices, green buildings can sometimes cost no more to build than conventional buildings. If up-front costs do prove to be higher, they are offset over time by lower energy bills. When built properly, green buildings can use 30% to 50% less energy than their traditional counterparts. And once people move in, they'll be more comfortable because they will have better control over features such as lighting and temperature.

The key to minimizing construction costs for green buildings—whether they be public buildings, schools, homes, commercial buildings, or industrial plants—is using an *integrated design or whole-building approach*. Because all design team members participate in such a design process from the outset, all disciplines can weigh in on how design decisions will affect energy use. For example, incorporating *daylighting* (a term for illuminating the interior of a building by natural means like windows or skylights), high-performance energy-efficient windows, and good insulation strategies can reduce the size of the chiller plant, which can save a significant amount of money. During an integrated design process, architects and homebuilders routinely use energy-modeling computer programs like EnergyPlus and the Building Life-Cycle Cost Program to help predict energy usage.

Ask your Energy Working Group to work with local homeowners associations, homebuilders, business owners, and bankers to encourage energy efficiency in new construction. You might also want to consider adopting a voluntary green home building program or mandatory green building codes. The National Association of Home Builders (NAHB)

Sun Chips City Business Incubator Green Features

Located on the roof of the incubator, crystalline photovoltaic solar panels convert the sun's energy to electricity, providing about 10% of the building's total energy needs.

Most of the incubator is illuminated by natural daylight through strategic window placement, light shelves, and skylights. This allows artificial lighting to be turned off, saving both energy and money.

Water from the incubator's sinks and showers—called gray water—is collected and reused to flush toilets.

Rainwater is collected and used to supplement the gray water system.

A specialized heat pump system extracts both heat and cooling from the ground through a series of vertical well shafts.

Rain gardens and other mechanisms for storm water collection allow water to naturally return to underground reservoirs.

The walls of the incubator have very high structural capacity and feature state-of-the-art protection against high winds.



Mason Earles/PIX 16644

Eight of the 16 townhomes in the Prairie Pointe affordable housing development have been awarded the LEED platinum for homes rating—the first ever in Kansas.

has instituted a nationally accepted green building standard and program that can serve as a model for local efforts. And DOE's Builders Challenge Program offers benefits to homebuilders who build for exceptional energy efficiency.

The U.S. Green Building Council (USGBC) has been instrumental in encouraging the design of green buildings through its Leadership in Energy and Environmental Design (LEED™) Program. LEED "points" come from a wide variety of categories, so if you're pursuing LEED certification, be specific with your architect about how much energy you want to save and which certification level you want. The USGBC also recently launched a LEED for Homes rating system. Much like the system for commercial buildings, LEED for Homes assigns points to green attributes, such as recycled materials, low water use, and energy-efficient design, among others. Extensive educational materials about USGBC programs are readily available.

Public buildings serve as the "face" of your community, setting standards and expectations through their usability and aesthetic appeal. Although it's disheartening to see your city hall, public library, school, or hospital destroyed by disaster, it's also another opportunity to show leadership by setting high energy efficiency goals or green standards for your new public buildings. In Greensburg, DOE helped the town develop and pass a resolution proclaiming that all large city buildings would be built to LEED Platinum certification standards.

In New Orleans, **schools** were at the head of the class during rebuilding. Launched in 2007, the Quick Start Initiative put five schools—one in each New Orleans City Council District—on a fast track for construction while master planning continued. In each council district, a cross-section of neighborhood groups furnished input on site selection. The design and planning of these schools helped direct the building standards of the broader School Facilities Master Plan. At the same time, the Quick Start Initiative put students into clean, modern classroom space sooner rather than later. The master plan, which includes the goal of reducing energy consumption by 30% in all new public school construction in the city, was approved in November 2008 by the Louisiana Board of Elementary and Secondary Education and the Orleans Parish School Board. As you look to rebuild your own schools, consider taking a page from the New Orleans textbook.



Joe Ryan, NREL/PIX 16673

When construction on the 210,000-square-foot L.B. Landry High School in New Orleans is complete, energy costs for the building—which features a solar hot water system—are expected to be 30% lower than those of the school it replaced. The city is aiming at the 30% reduction target in all new public school construction.

Homes that must be rebuilt represent a valuable opportunity to save energy in your community. Homeowners can usually recoup the slightly higher monthly mortgage payments in significantly lower energy bills (see table). In fact, for more than 30 years, the expectation of energy savings has enabled homeowners to qualify for larger loans through "energy efficient mortgages." The savings are validated by a standardized computer system that predicts energy savings and are certified by an energy rater, such as the Residential Energy Services Network (RESNET) or a similar system from DOE called the EnergySmart Home Scale.

And homes that weren't a total loss can go green too. Although retrofitting and repairs are not as cost effective as new construction, seize every green

renovation opportunity by, for example, improving levels or types of insulation, putting in energy-efficient windows, and installing efficient heating and air-conditioning equipment and appliances. Be sure to look for ENERGY STAR labeling on all equipment and appliance purchases.

Particularly in these challenging economic times, **businesses—offices, retail stores, warehouses, and so on—**are an integral part of a successful green recovery. Your business owners can choose to rebuild in ways that will garner important benefits, both now and into the future:

- Building energy efficiency into a new structure saves money over the life of the building in terms of reduced energy use and lower operations and maintenance costs.
- Communities tend to view green businesses as socially responsible "good neighbors," a positive perception that can boost business.
- Your businesses may be able to create green-collar jobs, which not only improves the economic health of your community, but feeds into a stronger national economy as well.
- Going green may open opportunities to expand business into new areas and introduce new products.

In Greensburg, for example, the owner of the local John Deere dealership, BTI Equipment Inc., built a new dealership designed to LEED Platinum standards, using 42% less energy than required by code, and generating electricity with an Endurance 4-kilowatt wind turbine. John Deere's corporate division is now urging all its dealers to build to these standards, and the company has become a member of the Commercial Building Energy Alliance, a partnership among DOE, NREL, and key leaders in retail and other businesses that identifies opportunities for and promotes energy efficiency. Based on the Greensburg model, John Deere has redirected its business plan to promote energy-efficient, green dealerships throughout North America.



Lynn Billman, NREL/PIX 16661

The new BTI John Deere dealership opened for business in January 2009. An important part of Greensburg's economy, the building features tubular skylights for daylighting, radiant floor heating, an energy-efficient wall and roof system with plenty of insulation, a waste oil boiler, recycled steel support beams, and native landscaping.

And because of BTI's positive experience in Greensburg, the company launched BTI Wind LLC in late 2008 and early 2009. BTI Wind is the North American distributor for Canada-based Endurance Wind Turbines, and the new company's business lines include sales, installation, and maintenance. BTI Wind set up a network of 136 distributors in 32 states and 4 provinces, adding more than 100 new direct jobs and training the existing sales force in this new green technology. The company hopes to quadruple its business in the next two years.

High Energy Efficiency Saves Money Every Month (2006 US$)[a]

Cost and Savings	Base Efficiency (30%)[b]	High Efficiency (40%)	Premium Efficiency (50%)
Estimated Incremental First Cost	$4,000	$7,000	$13,000
Savings on Monthly Utility Bill[c]	$60.25	$76.58	$96.83
Increase in Monthly Mortgage Payment[d]	$17.58	$34.25	$58.83
Net Monthly Savings	$42.67	$42.33	$38.00

[a]For a typical 2,000-square-foot home built in Greensburg, Kansas, using national average costs.
[b]Percent of increased efficiency over International Energy Conservation Code (IECC) 2003.
[c]Evaluated relative to typical energy code (IECC 2003).
[d]Based on a 30-year mortgage at 7% APR with an increase in loan value of $4,000 for the base option; $7,000 for the high option; and $13,000 for the premium option.

Local industries are likely to use significant amounts of energy, not just in the buildings that house their operations, but in the industrial processes themselves. Many leaders in manufacturing industries have adopted best business practices and new technologies to reduce their energy costs, including combined heat and power systems. Encourage your plant managers and owners to seize the opportunity for improvements instead of rebuilding their businesses just as they were. DOE has excellent programs for energy audits, best practices in energy management, and new energy-saving technologies for small and large industrial plants.

Increasing Renewable Energy Use in Your Community

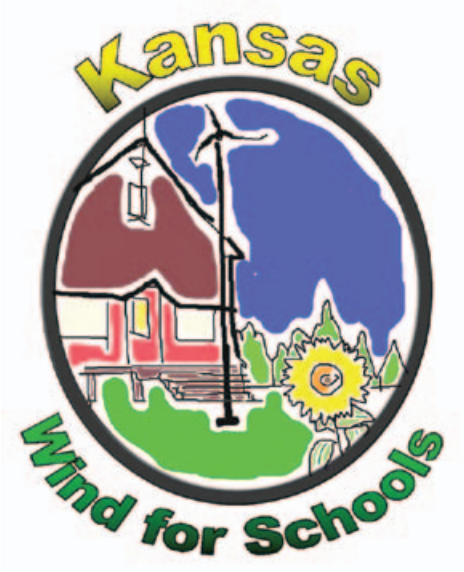
Your community is probably served by one or more utilities or rural electric cooperatives. Encourage leaders at these utilities and cooperatives to be partners in your new energy plan. They can help you understand how you can increase the amount of renewable resources in the electricity choices available to your community. Energy efficiency and renewable energy may help reduce loads on municipal systems, reducing or helping stabilize costs. You might need to enter into a short-term energy agreement while you consider longer term options. A disaster offers the opportunity to reexamine old relationships and forge new ones.

Municipal utilities can renegotiate electricity supply contracts, improve the generation mix to include more renewables, or purchase renewable energy credits (RECs) for the community. RECs are tradable environmental commodities in the United States. Although the particulars vary from state to state, RECs generally prove that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource.

New renewable energy sources, ranging from a single wind turbine to a field of solar panels, could be brought online to augment your electricity supply. The financial viability of such "distributed energy" projects will depend on your community's proximity to transmission lines, the utility with which you establish a power purchase agreement, and financial incentives available in your location from the local utility or from state and federal government agencies.

Major energy users in your community, or individual homeowners and businesses, might be good candidates for installing a solar or wind system. For individual homes, buildings, or collections of buildings, other renewable energy systems or technologies—such as ground-source heat pumps or burners and boilers that use wood pellets or other biomass sources—might prove cost effective. "District" heating and cooling systems use one heating and cooling plant (renewable or conventional) for several buildings. Such systems have been saving energy and money for decades in areas like college campuses and downtown districts. DOE has a Wind for Schools Program that can help schools install a small wind turbine under its Wind Powering America Program.

You may already have regulations in place to allow solar panels and wind turbines in your community. These regulations might include a solar and/or wind ordinance that describes how individuals can safely install such systems; an interconnection agreement that describes how these systems can be safely connected to the utility grid; and a net metering or net



The Kansas Wind for Schools program aims to help rural school districts install 1.9-kilowatt wind turbines for educational use and to encourage incorporation of renewable energy education into the K-12 science curriculum. The program goal is to install five turbines per year at rural schools throughout Kansas. In 2007 and 2008, five schools installed turbines.

billing policy that describes how the independent power generator will be reimbursed for the electricity produced. If you don't have these documents in place, look for examples that have been successfully adopted in other cities. Or, if you established such guidelines years ago, consider reviewing newer examples and updating your guidelines. The renewable energy field is expanding rapidly, and policy innovations occur every year.

Diminishing the Use of Fossil Fuels

As you make your rebuilding plans, look for ways to reduce driving in your community. Increase the appeal of walking and biking by, for example, relocating key community functions or adding trails or bike lanes. Encourage residents to use public transportation more often through incentives, or consider adding public transportation if your community didn't have it before the disaster. Electric trolleys and shuttle buses are on the market today, and in some cases, such vehicles can even add to the "character" of your community.

Encourage residents and fleet owners to replace damaged and destroyed vehicles with vehicles that use lower amounts of fossil fuels—like gasoline/electric hybrids, small electric vehicles for short distances, and flex-fuel vehicles that run on either gasoline or E-85 (a mixture of 85% ethanol and 15% gasoline). Many vehicle models on today's market are flex-fuel ready, and sometimes drivers don't even know that they own one. Compressed natural gas is another environmentally friendly alternative fuel choice, typically for fleet vehicles that are refueled at a central location.

Designate a community leader or group to work with entities in the community that own fleets and fuel supply companies. Combining purchasing power can influence both the price of vehicles and what alternative fuels local suppliers are willing to provide.

Step 6: Find the Funds

Financing is another area that will benefit from a strong working group. Your Financial Working Group will need to take time to investigate both the disaster-related and the green financial opportunities in your location and situation. Funding may be available from a variety of sources, including payouts from insurance companies and grants and loans from federal or state agencies. At the federal level, for example, the U.S. Department of Housing and Urban Development (HUD), the Federal Emergency Management Agency (FEMA), the U.S. Small Business Administration (SBA), and the U.S. Department of Agriculture (USDA) often make funds available after a disaster.

Small communities served by the USDA—typically 50,000 or fewer residents—have additional opportunities. The USDA's regular grant and loan programs will often cover the cost of energy-efficient features. For projects that can wait a year or so, the agency has competitive grant and loan programs specifically designed to fund energy efficiency and renewable energy projects.

When you work with disaster-assistance agencies at any level, be vocal about your wishes to rebuild differently to save energy, use lower amounts of fossil fuels, or become greener. Agency rules differ greatly. One agency might have to adhere to rigid rules about reimbursements. Another might have some flexibility. If the officials you're dealing with aren't tapped into the benefits of energy planning and energy choices, this is your opportunity to educate them. Knowing what you want and being insistent about it may open some doors.

If opportunity doesn't knock, build a door.
—Milton Berle

In Greensburg, the DOE/NREL team helped not only to develop renewable energy and energy-efficient business strategies, but also to assemble financing and ownership options for producing or procuring renewable energy technologies.

Going Green from the Top Down

With today's increased focus on all things green at our highest levels of leadership, opportunities abound for projects that save energy, use renewable energy, or promote green or sustainable development. When President Obama signed the American Recovery and Reinvestment Act (ARRA) into law on February 17, 2009, for example, financing mechanisms for energy efficiency and renewable energy

expanded significantly (EERE Network News 2009; Recovery.gov 2009). Some of these funds are available for a limited time, generally through state offices. ARRA and other federal financing options include:

- Energy-Efficient Community Development Block Grants
- Clean Renewable Energy Bonds (CREBs)
- State assistance on building codes (BCAP 2009)
- New Market Tax Credits (U.S. Department of the Treasury 2009).



www.whitehouse.gov/PIX 16672

President Barack Obama signs ARRA—which includes diverse and robust investments for green projects of all types—at the Denver Museum of Nature and Science in February 2009. Before signing the bill into law, he toured the museum's installation of 465 rooftop solar panels.

Tax incentives, both credits and deductions, are available to promote energy efficiency and renewable energy not only at the federal level, but also in almost every state. The Database of State Incentives for Renewables & Efficiency (DSIRE) maintains a reliable, up-to-date list of financial incentives.

Utility companies also offer such incentives, and energy service companies can be important partners in your green recovery. These companies typically supply the up-front capital for energy-saving improvements, often on retrofits or repairs but sometimes on new construction. They take the financial savings from lower energy costs until they are paid back—then it's your turn to reap the benefits. Some companies have begun applying the same concepts to energy-producing projects, such as fronting the costs for a wind turbine or photovoltaic system.

Financial Help on Many Fronts

Nonprofits, volunteer organizations, and other individuals and organizations are likely to donate money, materials, and helping hands. Some organizations may be interested in donating or discounting professional services. Or they may provide volunteers for planning, project design, cost estimating, or project implementation or construction. You might want to approach, for example:

- Local universities, colleges, and community colleges
- Nonprofit builders like Habitat for Humanity, Mennonite Housing, and others
- Nonprofit faith-based organizations; service organizations (such as the Rotary, Lions Clubs, Boy Scouts, and Girl Scouts, among others); and homeowners associations

Tax Incentives and Programs Encourage Green Jobs

In 2008 the Louisiana Legislature passed one of the most aggressive solar and wind tax credits in the country. As a result of this 50% tax credit, the Louisiana Community and Technical College System developed a solar installer training course to increase the number of certified solar installers in the state. This program has succeeded in training dozens of solar installers, ensuring quality installations. Also, in response to the rebuilding needs in New Orleans and a program to help low-income homeowners make their homes more energy efficient, the local utility, Entergy New Orleans, worked with Delgado Community College to develop courses to train home energy auditors, helping to develop a local green economy.

- Professional trade organizations
- Personal or corporate foundations
- State and national nongovernmental advocacy organizations for renewable energy, energy efficiency, and green or sustainable development.

To accomplish great things, we must not only act, but also dream; not only plan, but also believe.

—Anatole France

Step 7: Write the Plan

By now, you should have enough information to write a draft green recovery plan. This step can seem a bit daunting, but if you've been writing everything down along the way, your plan should come together relatively easily. Assign a single individual to pull all the information into a draft. Encourage the writer not to agonize over every word; the draft will be distributed to stakeholders for review and comment, and moving forward is more important than grammatical perfection. As the saying goes, "A good plan today is better than a perfect plan tomorrow." This is particularly applicable to green disaster recovery.

When you distribute the draft to your stakeholders, set a firm deadline for comments and stick to it. You want to strike a balance between making sure that everyone has input and respecting the urgency of the recovery process. You may need to go through several iterations of your planning document until you either reach consensus or strike compromises that everyone can support. And once you have a plan, you might want to take a few moments and simply acknowledge the achievement. Your community has pulled together and crafted a good plan on which its future rests, and that sense of accomplishment can propel you through the plan's implementation. When you hit the inevitable bump in the road as you move forward, your community can draw renewed strength from that sense of shared accomplishment.

After a disaster, your city, your town, or your community will never be the same . . . but it can be better. Although your challenges are daunting, your opportunities are even greater. By rebuilding a greener, more sustainable community, you can inspire others—of your generation and the next, in big and small cities both near and far—to do the same. If large cities like New Orleans and small towns like Greensburg can lift themselves out of devastation and take bold steps toward a greener future, your community can too.

All of us, and the planet that sustains us, will be better for it.

A Grassroots Nonprofit Helps with the Greening of Greensburg

Recognizing early on that Greensburg's small city staff would need some help during the green rebuilding process, a sustainability advocate from nearby Stafford County, Daniel Wallach, and his wife, Catherine Hart, founded Greensburg GreenTown. Interested local citizens immediately stepped forward to serve on the nonprofit's board of directors and then worked closely with city and county officials, business owners, and fellow residents to incorporate sustainable principles into the rebuilding process. Wallach says "This team effort is the true secret to Greensburg's success—the fact that so many community leaders were encouraging folks with a common vision and direction."

And because of its nonprofit status, GreenTown has been able to accept donations of green building materials, alternative vehicles, and other items with tax benefits to the donors.

Today, Greensburg GreenTown serves as an educational resource for the community and as a living example of how this type of nonprofit model can help other communities.

For More Information

Disaster Response Resources

International Association of Emergency Managers (IAEM): www.iaem.com

U.S. Department of Energy (Model Guidelines for Incorporating Energy Efficiency and Renewable Energy into State Energy Emergency Plan[s]): apps1.eere.energy.gov/state_energy_program/pdfs/emerg_plan_guide.pdf

U.S. Department of Homeland Security (DHS) Preparedness & Response: www.dhs.gov/xprepresp

U.S. Federal Response Plan: www.disasters.org/emgold/frp.htm



DOE and NREL Resources

Alternative Fuels & Advanced Vehicles Data Center: www.afdc.energy.gov/afdc

Alternative Fueling Station Resources: www.afdc.energy.gov/afdc/stations/find_station.php

Biomass Power Assessment Tool: rpm.nrel.gov/fbase/biopower/launch

Builders Challenge: www.buildings.energy.gov/challenge/builders.html

Builders Challenge EnergySmart Home Scale (E-Scale): www.buildings.energy.gov/challenge/energysmart.html



Courtesy of BNIM

Building America Program: www.buildings.energy.gov/building_america/publications.html

Building Technology Program Information Resources: www.buildings.energy.gov/information_resources.html

Buildings Database: http://eere.buildinggreen.com

EERE Network News: apps1.eere.energy.gov/news

Energy Education: www1.eere.energy.gov/education

EnergyPlus Energy Simulation Software: apps1.eere.energy.gov/buildings/energyplus

Federal Energy Management Program (FEMP)

Building Life-Cycle Cost (BLCC) Programs: www.femp.gov/information/download_blcc.html

Energy Cost Calculators: www.femp.energy.gov/procurement/eep_eccalculators.html

Industrial Technologies Program: www.industry.energy.gov

K-12 Energy Lesson Plans & Activities: apps1.eere.energy.gov/education/lessonplans

Save Energy Now®: www.industry.energy.gov/saveenergynow

Wind Powering America: www.windpoweringamerica.gov/schools.asp

Greensburg Resources

City of Greensburg Web site: www.greensburgks.org

Greensburg Sustainable Building Database: http://greensburg.buildinggreen.com

Greensburg GreenTown: www.greensburggreentown.org



Courtesy of BNIM/PIX 16674

Greensburg City Hall will house the city's administrative offices and council chambers and serve as a gathering space for town meetings and municipal court sessions. Built to incorporate solar panels and geothermal technology, it will be the first LEED Platinum-certified city hall building in America. Building materials will include recycled wood and reclaimed brick left behind by the tornado. It will also have a green roof with vegetation growing on the east end of the roof. This project is on track for completion in July 2009.

New Orleans Resources

BuildingGreen:
www.buildinggreen.com/press/new-orleans.cfm

Global Green USA:
www.globalgreen.org/neworleans

School Facilities Master Plan for Orleans Parish:
www.sfmpop.org

Other Resources

3TIER FirstLook:
http://firstlook.3tiergroup.com

Alternative Energy News Public Transportation:
www.alternative-energy-news.info/technology/transportation/public-transit

American Council on Renewable Energy (ACORE):
www.acore.org

American Solar Energy Society (ASES):
www.ases.org

American Wind Energy Association (AWEA):
www.awea.org

ASHRAE Advanced Energy Design Guides (free download):
www.ashrae.org/publications/page/1604

Database of State Incentives for Renewables & Efficiency (DSIRE):
www.dsireusa.org

Disaster Relief Agencies:
www.disastercenter.com/agency.htm

Edison Electric Institute:
www.eei.org

ENERGY STAR:
www.energystar.gov

Federal Emergency Management Agency (FEMA)
www.fema.gov

Geothermal Energy Association (GEA):
www.geo-energy.org

Green Communities:
www.greencommunitiesonline.org and
www.epa.gov/greenkit/index.htm

International Biofuels Association (IBA):
www.internationalbiofuels.org

Interstate Renewable Energy Council (IREC):
www.irecusa.org

National Association of Energy Service Companies:
www.naesco.org

National Association of Homebuilders (NAHB) National Green Building Program:
www.nahbgreen.org

Residential Energy Services Network:
www.natresnet.org

Southern California Edison Renewable & Alternative Power (RAP) program:
www.sce.com/EnergyProcurement/renewables

Solar Electric Power Association (SEPA):
www.solarelectricpower.org

U.S. Department of Agriculture (USDA):
www.usda.gov and
www.rurdev.usda.gov/rbs/energy.htm

U.S. Department of Housing and Urban Development (HUD):
www.hud.gov

U.S. Green Building Council (USGBC):
www.usgbc.org

U.S. Small Business Administration (SBA):
www.sba.gov

References

Building Codes Assistance Project (BCAP; 2009). Congressional Stimulus Compromise Retains State Energy Assistance Grants. www.bcap-energy.org/node/346. Accessed March 22, 2009.

City of Greensburg, Kansas (2007). Vision Plan Draft. www.greensburgks.org/recovery-planning/071212-VisionDocument-compressed.pdf. Accessed March 22, 2009.

City of Greensburg, Kansas + BNIM (2008). Greensburg Sustainable Comprehensive Plan. www.greensburgks.org/recovery-planning/Greensburg%20Comprehensive%20Master%20Plan%2001-16-08%20DRAFT.pdf/view. Accessed March 22, 2009.

EERE Network News (February 18, 2009). apps1.eere.energy.gov/news/archive.cfm/pubDate=%7Bd%20%272009-02-18%27%7D. Accessed March 22, 2009.

EIA (2008). Annual Energy Review 2007. Washington, DC: EIA.

IECC (2003). International Energy Conservation Code. (Washington, DC: International Code Council).

NOLA.com (2008). Katrina: The Storm We Always Feared. www.nola.com/katrina. Accessed March 8, 2009.

Raiji, A. (2002). Big & Green: Toward Sustainable Architecture in the 21st Century. (New York: Princeton Architectural Press).

Recovery.gov (2009). Web site. www.recovery.gov. Accessed March 22, 2009.

U.S. Department of the Treasury (2009). New Market Tax Credits. www.cdfifund.gov/what_we_do/programs_id.asp?programID=5. Accessed March 22, 2009.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

For Additional Information, Please Contact:
Energy Efficiency and Renewable Energy
Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy; NREL is operated by the Alliance for Sustainable Energy, LLC.

This document is one in a series of documents outlining the options for and benefits of rebuilding green after a disaster. The series draws on lessons learned by teams from the U.S. Department of Energy and its National Renewable Energy Laboratory as they helped the townspeople of Greensburg, Kansas, rebuild green after a devastating tornado. To see the other documents in this series, visit www.buildings.energy.gov/greensburg/.

DOE/GO-102009-2828 • Revised October 2009

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.

H.2 Greensburg, Kansas—A Better, Greener Place to Live



Greensburg, Kansas

A Better, Greener Place to Live

"The biggest success story in Greensburg, to me, has been the resiliency and determination of our citizens to make a difference in their world. We're new pioneers in the sustainability movement."

— Greensburg Mayor Bob Dixson



Courtesy of BNIM/PIX 16658

There's No Place Like Home

Greensburg, Kansas is Midwestern farm country. Its 900 residents are hard-working people who love their home and their way of life. They simply will not give up when it comes to making their community a better place to live.

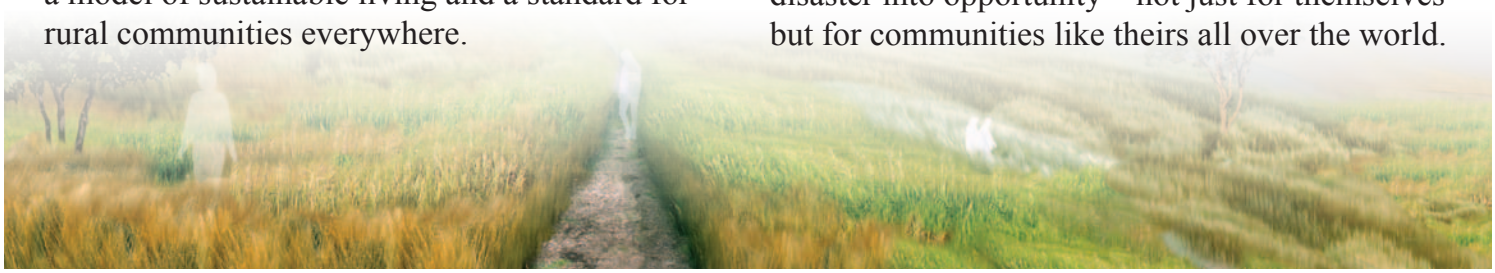
After the town was nearly wiped out by a massive tornado in May 2007, citizens saw the opportunity to make Greensburg something even better than it had been before. Living close to the land, they knew the value of solar and wind power and using water efficiently. When they rebuilt, they took those values to heart in a new way. The result: Greensburg is a truly green burg. It is a model of sustainable living and a standard for rural communities everywhere.

Blessed with a unique opportunity to create a strong community devoted to family, fostering business, [and] working together for future generations.

— Greensburg's Community Vision Statement

A Vision for the Future

Within months of the tornado, Greensburg residents came together to create a new vision for the future. They wanted to do more than rebuild. They turned disaster into opportunity—not just for themselves but for communities like theirs all over the world.



Courtesy of BNIM /PIX 16658

Buildings Tell a Story

Buildings are obvious evidence of Greensburg's commitment to sustainability. The 95-year-old Kiowa County Courthouse (Greensburg is the Kiowa County seat), one of the few structures left after the tornado, is being renovated with sustainable features designed to earn it a LEED Gold certification—an especially admirable goal, because the facility is being modified rather than replaced. The Leadership in Energy and Environmental Design (LEED) Green Building Rating System recognizes performance in five key areas of human and environmental health. Its top three ratings are Silver, Gold, and Platinum (highest).

Greensburg residents have taken sustainability to heart and home. Owners of more than half the new homes built after the tornado volunteered to have their homes rated for energy savings. On average, these homes should use 40% less energy than standard homes built to code. Businesses such as banks, car dealerships, and funeral homes, along with churches and a lodge have rebuilt to save energy and water, and to use environmentally friendly materials. Some of Greensburg's new buildings are showcased in this publication. If you'd like to learn more about these buildings, visit the Greensburg Greentown Buildings Database at www.greensburg.buildinggreen.com .



John Charlton, Kansas Geological Survey (KGS)/PIX 16659



Lynn Billman, NREL/PIX 16650

Greensburg residents developed a Sustainable Comprehensive Master Plan for the town's next 20 years, and the plan was adopted by the City Council. As the plan itself states, "A truly sustainable community is one that balances the economic, ecological, and social impacts of development." This balance is visible in the community's goals as stated in the master plan—goals that clearly represent solid Midwestern values.

- Be progressive while remaining unassuming
- Open doors to newcomers while maintaining traditional cultural heritage
- Provide opportunities for young people—education, jobs, a future back home
- Value the natural environment, balanced with growth and economic development
- Build a variety of durable, healthy, energy-efficient houses and buildings
- Look to renewable sources of energy, such as Greensburg's plentiful wind
- Treat each drop of water as a precious resource
- Remain affordable.

Rebuilding with Energy

As the residents of Greensburg focused their energies on rebuilding, they also kept energy efficiency, renewable energy, and other sustainability goals squarely in mind. Others might call this a goal of becoming a "net zero energy community," or reducing a community's "carbon footprint," but to Greensburg, it's just seemed like the right way to live.

The City Council passed a resolution requiring all new city buildings larger than 4,000 square feet to meet U.S. Green Building Council LEED Platinum certification and reduce energy consumption by 42% as compared to standard buildings.

The city, which operates as a municipal utility, helped to develop, and will directly benefit from, a new 12-megawatt wind energy system expected to be installed near Greensburg. This system is projected to meet the pre-tornado electricity needs of the community. The city has entered into a power purchase agreement with a "green" power provider that has promised "100% renewable electricity, 100% of the time" from their wind, hydro, and other renewable energy electricity generation sources. With these accomplishments, Greensburg does become a true net-zero-energy community. That is, an energy-efficient community that generates as much electricity from renewable energy as it uses. This means the town will not use electricity generated from fossil fuels, such as coal.

Greensburg is the first city in the world to adopt these kinds of resolutions. It sets a new standard, not just for its own citizens, but for other rural and urban communities as well. Greensburg could not have envisioned or realized its vision without contributions and support from many organizations. Along with state agencies, innovative commercial firms, and nonprofit organizations, the U.S. Department of Energy and other federal agencies, including the U.S. Department of Agriculture and the Federal Emergency Management Agency, have been extensively involved with the rebuilding effort.

Why such a commitment? Sustainable communities such as Greensburg, with energy-efficient homes and buildings, and electricity and fuels from renewable energy sources have many advantages for our nation. They have a higher regard for human health, are easier on the natural environment, are well-poised for economic growth and job creation, and through energy security, contribute to our nation's security. And, simply put, they are better places to live.

Clean, Green Medical Care

"Good building practices make sense," says Mary Sweet, Administrator of the Kiowa County Memorial Hospital, noting that infections will be easier to control in the new building. The facility combines all medical services in a single, highly energy-efficient structure—striving to be the first critical access hospital in the United States to meet LEED Platinum standards.

The whole building has high "R-value" insulation, and features a dual ventilation system that prevents the exchange of air between the emergency and isolation rooms and the rest of the hospital, and seamless floors and countertops that make cleaning easier and more thorough.

An onsite wind turbine helps to power the facility, a rain filtration and storage system supplies recycled (gray) water to irrigate the property and flush the building's toilets, and daylighting (natural light) illuminates 75% of the interior, reducing the use of electric lights.

"We're a rural health clinic," Sweet explained. "We provide basic lab work, X-rays, basic nursing, and ambulance service. We don't do surgery or deliver babies." But there is room to grow along with Greensburg. "There are ways we could take the clinic space and make it into surgical space. And the area of patient rooms is designed to allow us to add on."



Health Facilities Group & Mid-Kansas Engineering Consultants



Courtesy of BNIM/PIX 16653

High-Performance School

"We had wonderful things before the tornado," says Darin Headrick, Superintendent of Schools for the City of Greensburg, "We had a nice community, good kids, and good schools to attend." In 2007, the year of the tornado, the high school received the Governor's Award as one of the top 5% of the state's schools.

With a brand new school, all of Greensburg students will learn in a high-performance building worthy of their own high academic performance. The new two-story, 120,000-square-foot facility consolidates grades K-12 in a single campus designed to be the state's first LEED Platinum School. It includes state-of-the-art classrooms, a library, an interactive learning center, science labs, two gyms, a cafeteria and kitchen, art and music areas, courtyards, two playgrounds, a football stadium, and track and field facilities.

This new school replaces the total square footage of all the previous school buildings, combining all grade levels in a single facility. It will serve up to about 375 students (the school currently is serving about 220 students), allowing for the town's future growth.

Key green features include the extensive use of day-lighting (natural light) to ensure that artificial lighting is seldom necessary in most rooms. Heating and cooling are handled by geothermal heat pumps that take advantage of the difference between the earth's and the air's temperatures. The pumps circulate water from below the earth's surface to warm interior air in winter and cool it in summer. The building is also highly insulated.

An onsite wind turbine meets part of the facility's electricity needs. Rainwater is transported through the roof lines, stored in cisterns, and used to irrigate the grounds.

When completed, the school will be a great improvement over the one permanent campus structure, known as the "caf-a-gym-atorium" and the temporary classrooms the students have been in since the 2007–2008 school year.

"Before the tornado, if you asked most of the high school kids about their plans for the future, they'd say the same thing: 'I'm going to go away to college and never come back.' Now, they say, 'I'm going to go to college and then come back.' They see things here that they can impact."

— School Superintendent Darin Headrick

Children Today, Greensburg's Leaders Tomorrow

If anything can forecast the lasting success of Greensburg's bold vision, it's the way the town's young people envision their own futures. The town's enthusiasm for going green has definitely inspired young people. Under the sponsorship of Greensburg GreenTown, a local nonprofit organization pivotal to the town's rebuilding, Greensburg's high school students established a Green Club.

Alexsis Fleener, a high school junior, is a member of the club as well as the youth representative on the Greensburg GreenTown Board of Directors. The green rebuilding program has "definitely" had an impact on her career and future plans. "My interest in environmental issues will not end with high school. I want to be in community planning and architecture," she said. "My friends with the Green Club want to bring that to their careers too. We'd all love to come back to Greensburg."



Courtesy of BNIM



Courtesy of BNIM

"Ultimately, sustainability relies on the ability to bring new, high-quality jobs to town."

— Greensburg Master Plan

Seeing Green for the Long Term

"We'd like to see Greensburg become the ecotourism capital of the world," says Mayor Bob Dixson. "Companies can bring their customers here to see sustainable building products and all kinds of eco-friendly businesses. We want to be a living laboratory."

Greensburg also hopes to attract companies that can draw on the resources of the prairie for a variety of green purposes, from research to entrepreneurial manufacturing.

One of the first new, green firms in town was BTI Wind Energy, which represents Canada's Endurance Corporation, a manufacturer of wind turbines in the United States.

A Green Place to Grow

The two-story SunChips Business Incubator provides temporary, low-cost office space for as many as 10 small businesses rebounding from the tornado or starting from scratch. Like all structures owned by the City of Greensburg, the facility is built to LEED Platinum standards.

High-performance building materials provide maximum insulation and protection from high winds. Solar photovoltaic panels on the roof convert sunlight directly to electricity that meets about 10% of the building's electricity requirements. A geothermal heating and cooling system taps into the earth's temperature (warmer than outdoor air in winter and cooler in summer) to heat and cool the building.

Natural light provides most of the internal lighting, which minimizes the need for artificial lights. Water from sinks and showers is recycled and used to flush toilets. The recycled water (gray water) is supplemented by rainwater, which is collected and stored as it falls on the building.


Artist rendering of completed business incubator. Courtesy of BNIM


City of Greensburg: www.greensburgks.org/PIX 16660

A New and Better Way

Mike Estes of BTI-Greensburg, which owns and operates the local John Deere Dealership and Service Shop, says he had "only minimal interest in green building" before the 2007 tornado. "But when you have a chance to build back from scratch, you look for a new and better way."

The dealership was one of the first businesses to rebuild. It is housed in a new, metal structure that covers 27,000 square feet and was designed to achieve LEED Platinum standards.

"No agricultural dealership has ever done anything like this—to our knowledge," says Estes, whose family has owned BTI for four generations. Going green presented some challenges and involved some extra cost, "but we'll see payback for pretty much everything we put in here."

BTI's focus on green attracted the attention of John Deere, and the corporation now uses the Greensburg facility as a standard for its dealerships. Estes says, "John Deere has a 'Greensburg' model that somebody can look at so they can replicate what they can use."

The Greensburg dealership's green features include highly insulated wall and roof systems, a highly energy-efficient heating and cooling system, and a network of skylights and mirrored reflectors that direct natural light where it is needed and reduce electricity use for lighting. Two onsite wind turbines provide electricity that offsets nearly 10% of the building's total electricity needs.



Lynn Billman, NREL/PIX 16661



Lynn Billman, NREL/PIX 16651



Mike Estes and his brother established the company as a subsidiary of BTI-Greensburg, which owns the local John Deere dealership. In 2008, BTI purchased wind turbines from Endurance for its Greensburg facility and was so impressed with the quality and potential of the products that the Estes brothers chose to get into the green industry themselves.



Courtesy of BNIM

New businesses. New alternatives. New options for young people. Greensburg's future continues to unfold, providing an ongoing example of what is possible when the people of a community come together with common purpose. In the words of Mayor Dixson, "We've been blessed with opportunity here, and we have a tremendous obligation to offer hope to the world."

Creating a Green Showcase

> *"Green businesses, more than any other, rely on their reputation and integrity. Being connected to a community that has the same reputation they're looking to establish gives them a jump start."*
>
> *— Daniel Wallach, Greensburg GreenTown*

Greensburg GreenTown is a nonprofit organization deeply involved in Greensburg's new green vision and dedicated to making the town a center for ecotourism, a showcase for the latest in green technology, and a drawing card for new green businesses.

Daniel Wallach, executive director, saw the potential for green rebuilding after the disastrous tornado struck the town, several miles from his own home. He established Greensburg GreenTown soon afterward and has been a leader in the town's redevelopment effort ever since.

Among the organization's many projects is the building of as many as 12 "eco homes," each with a unique design and story. All will be open to visitors for tours and overnight stays, supporting the city's strong interest in ecotourism.

One of the first eco homes is built around a silo-shaped core, a testament to the local silo that remained standing after virtually every other structure in town was leveled by the 2007 storm.



City of Greensburg; www.greensburgks.org/PIX 16662

First in Green Lighting

One of the town's first completed green projects illuminates the downtown sidewalks and streets every night. Greensburg is the first city in the United States to use light-emitting diode (LED) lamps for 100% of its street lighting.

By replacing the old sodium vapor lights—all 303 of them—with LED fixtures, Greensburg improved outdoor lighting energy efficiency by 40% and reduced the cost of related energy and maintenance by an estimated 70%. As an added bonus, the new lamps reduce nighttime light pollution by focusing light where it is needed: on the ground rather than in the night sky.



Lynn Billman, NREL/PIX 16665/PIX 16664

For Additional Information

Greensburg GreenTown
204 West Florida
Greensburg , KS 67054
620-723-2790 or 620-549-3752
www.greensburggreentown.org

The Official Web Site of Greensburg, Kansas
www.greensburgks.org

This document is one in a series of documents outlining the options for and benefits of rebuilding green after a disaster. The series draws on lessons learned by teams from the U.S. Department of Energy and its National Renewable Energy Laboratory as they helped the townspeople of Greensburg, Kansas, rebuild green after a devastating tornado. To see the other documents in this series, visit www.buildings.energy.gov/greensburg/.

Greensburg would like to acknowledge and thank the U.S. Department of Energy and its National Renewable Energy Laboratory for the assistance provided to produce this brochure.

For Additional Information, Please Contact:
Energy Efficiency and Renewable Energy Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

Prepared by the National Renewable Energy Laboratory (NREL)
NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

DOE/GO-102009-2765 • Revised October 2009

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste

Green Where They Live

"Many Prairie Pointe residents have a better living situation now than before the storm."

— Laura Stoltenberg, Director of the Kiowa County Housing Authority

The people of Greensburg are green where it counts the most: at home. As with business and government structures, housing in the community is being built with the greatest possible attention to sustainability. The Prairie Pointe Townhomes complex is a case in point.

Completed in 2008, Prairie Pointe provides affordable housing (residents' incomes may be no higher than 60% of the Kiowa County median income) in three structures with a total of 16 rental units. One building contains eight apartments; each of the remaining buildings has four units each. Eight of the 16 units received the first residential LEED platinum rating in Kansas. A single structure was submitted for rating to limit the cost of the process; all units were built to the same specifications.

Laura Stoltenberg, Director of the Kiowa County Housing Authority and Manager of Prairie Pointe, said that many Prairie Pointe residents have a better living situation now than before the storm. Rental property was limited in the past, she explained, and consisted mostly of older homes that were not energy efficient.



Mason Earles/PIX 16644

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

GREENSBURG GreenTown

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

H.3 From Tragedy to Triumph—Rebuilding Green Homes after Disaster

From Tragedy to Triumph—Rebuilding Green Homes after Disaster



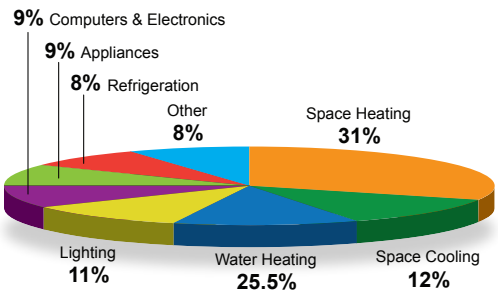
Decker Homes, NREL / PIX15617

This home in Ohio uses a roof-integrated solar electric system to offset energy consumption.

About Green Homes

A green home can save you thousands in utility bills and make your home a healthier and more comfortable place to live. Green homes save money with energy-saving features such as effective insulation, high-performance windows, tight construction, and efficient heating and cooling equipment and appliances. Green homes are healthier because they perform better and use green products, protecting homeowners against cold, heat, drafts, moisture, indoor pollutants, and noise. Green homes also protect homeowners against future utility rate increases for gas and electricity.

Green homes encourage the use of renewable energy, which can reduce your home's impact on the environment because it is the cleanest form of energy around. A variety of renewable technologies are available, including small wind energy systems, geothermal heating and cooling, and solar energy systems used to produce electricity and heat water. The most common form of renewable energy used by homeowners is solar energy, which is often financed with a home mortgage. In areas with frequent storms or after a natural disaster, renewable energy can provide emergency power if batteries are integrated into the system.



How We Use Energy in Our Homes
Source: 2007 Buildings Energy Data Book

Green Benefits to Homeowners

- Lowers utility bills
- Provides tax credits to homeowners
- Improves a home's energy performance
- Healthier and more comfortable home.

Green Benefits to the Community

- Stimulates local economies
- Restores neighborhood pride
- Promotes cleaner environment.

Renewable Energy Benefits

- Generates electricity from the sun or wind
- Heats and cools your home quietly and naturally

Rebuilding your home after a natural disaster such as a flood, hurricane, or tornado can be daunting. You can turn a tragedy into an opportunity to create a healthier, more comfortable, and more energy-efficient home by rebuilding your next home "green."

- Grants tax credits to homeowners
- Offers protection against rising utility bills
- Supplies reliable power after natural disasters
- Protects the environment.

continued >

Rebuilding Green in Greensburg

After a tornado devastated their town in May 2007, the citizens of Greensburg, Kansas, turned disaster into opportunity by rebuilding as a model "green" community. New homes will use 40% to 50% less energy than current building code. Renovated homes will use 25% less energy than current building code. Greensburg's green housing projects include:



Mason Earles/PIX 16644

Eight of the 16 units at the Prairie Pointe Townhome complex (above) are estimated to use about 50% less energy than code.



Lynn Billman, NREL/PIX 16643

Mennonite Homes is building green homes in Greensburg, Kansas, with features such as energy-saving light bulbs, a 90% efficiency furnace, a tankless hot water heater, and efficient insulation in the walls and attic.



Stephanie Peterson/PIX 16645

The Waters family of Greensburg, Kansas, built this green home after their town was destroyed by a tornado in 2007.

Prairie Pointe Townhomes—a 32-unit complex awarded the first residential LEED (Leadership in Energy and Environmental Design) Platinum rating in Kansas.

Mennonite Homes—Mennonite Housing Rehabilitation Services, a local nonprofit group, built 10 affordable energy-efficient homes in Greensburg and plans to build 40 more that will use 50% less energy than standard homes.

Waters Home—The Waters family rebuilt their home in Greensburg using these green strategies:

- Wall and roof insulation with an R-Value greater than 25
- A ground-source heat pump for heating and cooling
- Shading east/west windows with trees and shrubs to keep the sun's heat out in the summer and reduce cooling loads
- Light colors for surfaces and finishes to reflect sunlight deeper into the interior
- High performance windows and doors
- ENERGY STAR® computer equipment and appliances.

The home achieved a home energy rating score (HERS) of 47 in 2008, which means the home is more than 50% more efficient than a conventional home of similar size and type.

For more information about Greensburg, contact:
(620) 549-3752 or (620) 723-2790
info@greensburggreentown.org
204 West Florida
Greensburg, KS 67054

To see case studies of these and other Greensburg buildings, visit:
http://greensburg.buildinggreen.com

continued >

Green Home Checklist

Green construction methods can be integrated into buildings at any stage, but the most significant benefits result from using green methods in the earliest stages of a building project. Below is a checklist of green home features you can discuss with your builder.

Energy Efficiency

✓ **South orientation**—Build your home facing south to optimize its solar gain in winter and reduce heating loads. This also optimizes the efficiency of any renewable energy systems for producing electricity or heating water.

✓ **Efficient insulation**—Capitalize on one of the easiest, most cost-effective ways to save energy by using efficient insulation for foundations, walls, and roofs. Usually, the higher the R-Value of the insulation, the better it performs.

✓ **Seal openings and cracks**—To prevent infiltration of hot air in summer and loss of warm air in winter, properly seal openings and cracks to reduce cooling and heating costs.

✓ **Energy-efficient windows and doors**—Look for windows and doors with an ENERGY STAR® rating. Consider installing double-paned windows with a "low-e" glazing to hold in heat in winter and keep heat out in summer. Usually, the lower the U-Value, the better the performance.

✓ **Energy-efficient heating and cooling system**—Choose a high efficiency system with a cooling efficiency rating of SEER 13 (seasonal energy efficiency ratio) or higher. ENERGY STAR® SEER is 14.

✓ **Daylighting/passive solar gain**—Use natural light to offset electricity loads on weekends and to heat concrete, tile, or brick floors to reduce heating loads in winter. Proper window overhangs will block the summer sun and reduce cooling loads.

✓ **Efficient water heating**—Choose the most energy efficient water heating system you can, such as a tankless water heater, or consider installing solar water heating.

✓ **Lighting technologies**—Select lights that not only save energy, but also last much longer than traditional incandescent light bulbs, such as the compact fluorescent lights (CFLs) that have been easily available for some time. New technologies that use light-emitting diodes (LEDs) may also be an option. LED lamps illuminate at equivalent light levels to CFLs and can use less energy. An LED bulb can last for as many as 60,000 hours and a CFL for 10,000, compared to the incandescent's 1,500.

✓ **Programmable thermostat**—Install a thermostat that automatically turns itself down when you're at work and at night to save energy.

✓ **Appliances**—Install ENERGY STAR® appliances.

Water Efficiency

✓ **Water-efficient fixtures and appliances**—Reduce water and energy consumption (using less hot water also means using less energy) by installing low-flow sink and shower fixtures, toilets, and water-efficient dish and clothes washers.

✓ **Native landscaping**—Reduce water consumption by choosing plants indigenous to your area and use drip irrigation when possible.

Renewable Energy

✓ **Solar electricity**—Consider installing a small solar electric (photovoltaic) system on the roof to offset electrical loads. Invest in energy efficiency first to reduce system size and cost.

✓ **Wind electricity**—Small quiet wind energy systems are available for powering homes.

✓ **Geothermal heating and cooling**—The earth's natural temperature can be used to heat and cool your home using geothermal wells and a ground-source heat pump.

Air Quality

✓ **Nontoxic products**—Use products that don't contain toxic chemicals, such as paints and adhesives with low volatile organic compounds (VOCs) and formaldehyde-free insulation.

✓ **Ventilation**—Ventilate your home well for a good supply of fresh air. A ventilation system will control the amount of incoming fresh air to the home.

✓ **Heating and cooling system**—Purchase a system with high-efficiency filtration for interior and incoming air.

Sustainable Building Materials and Construction

✓ **Recycled materials**—Select recycled materials such as carpet, countertops, paint, and tile. Select insulation with recycled-content such as cellulose insulation.

✓ **Sustainably harvested or reclaimed wood**—Purchase wood certified by the Forest Stewardship Council. Some builders use reclaimed hardwood floors and siding or cork and bamboo flooring as alternatives.

✓ **Recycled construction waste**—Try to recycle at least 50% of the wood, cardboard, and concrete from new home projects.

continued >

Incentives for Energy Efficiency and Renewable Energy

Numerous financial incentives, such as federal and state tax credits and utility rebates, are available to help homeowners make their homes more energy efficient and to offset the cost of a renewable energy system. Many utility companies also offer net metering for grid-connected renewable energy systems, which gives homeowners credit for excess energy produced by their systems. The *American Recovery and Reinvestment Act*, signed into law on February 17, 2009, contains provisions that will financially benefit homeowners.

For more information, visit the Database of State Incentives for Renewables and Efficiency at: *www.dsireusa.org.*



Pete Beverly, NREL / PIX14163

This green home in Colorado produces as much energy as it consumes over a one-year period with the aid of a solar electric system. An illustration of this home's green features is provided by the National Renewable Energy Laboratory online at: *www.nrel.gov/buildings/zero_energy.html*

Green Building Resources

Energy Savers

Basic information about energy efficiency and renewable energy from the U.S. Department of Energy (DOE)

www.energysavers.gov

ENERGY STAR®

This program of DOE and the U.S. Environmental Protection Agency helps homeowners save energy and money through energy-efficient products and practices

www.energystar.gov

Green Home Building Guidelines

Guidelines for building green homes from the National Association of Homebuilders

www.nahbgreen.org/Guidelines/nahbguidelines.aspx

Residential Remodeling Guidelines

Information about remodeling an existing home to make it green

www.greenhomeguide.org/documents/regreen_guidelines.pdf

Renewable Energy Resources

Own Your Power! A Consumer Guide to Solar Electricity for the Home

Offers homeowners information about solar energy systems, financial incentives, and warranties and insurance along with tips for success

www.nrel.gov/docs/fy09osti/43844.pdf

Small Wind Electrical Systems

A consumer's guide containing information about small wind energy systems for rural areas, including maintenance and zoning issues

www.windpoweringamerica.gov/pdfs/small_wind/small_wind_guide.pdf

Geoexchange

A Web site from the Geothermal Heat Pump Consortium that presents information about geothermal heating and cooling

www.geoexchange.org

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INF (1-877-337-3463)
eere.energy.gov/informationcenter

Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy; NREL is operated by the Alliance for Sustainable Energy, LLC.

This document is one in a series of documents outlining the options for and benefits of rebuilding green after a disaster. The series draws on lessons learned by teams from the U.S. Department of Energy and its National Renewable Energy Laboratory as they helped the townspeople of Greensburg, Kansas, rebuild green after a devastating tornado. To see the other documents in this series, visit www.buildings.energy.gov/greensburg/.

DOE/GO-102009-2766 • Revised October 2009

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.

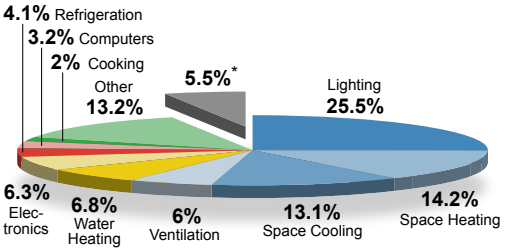
H.4 From Tragedy to Triumph—Rebuilding Green Buildings after Disaster

From Tragedy to Triumph—Rebuilding Green Buildings after Disaster

About Green Buildings

Green buildings save thousands in utility bills while making the indoor environment healthier and more comfortable for occupants. According to the U.S. Green Building Council, green commercial and public buildings on average use up to 50% less energy, emit up to 40% less CO_2, consume 40% less water, and produce 70% less solid waste. Green commercial buildings encourage the use of energy efficiency features such as effective insulation, high-performance windows, tight construction, and energy-efficient lighting, office equipment, and heating and cooling systems. Green buildings are healthier because they perform better and protect occupants against cold, heat, drafts, moisture, indoor pollutants, and noise.

Green buildings encourage the use of renewable energy to reduce a building's impact on the environment. A variety of renewable technologies are available, including small wind energy systems, geothermal heating and cooling, and solar energy systems. The most common form of renewable energy used on commercial and public buildings is solar energy. In areas with frequent storms or after a natural disaster, renewable energy can provide emergency power if batteries are integrated into the system.



How Commercial Buildings Use Energy

Source: EIA. * 5.5% is adjustment for variance in data. Energy use varies by building type. "Other" includes ATM machines, medical equipment, etc.



Courtesy of BTI-Greensburg/PIX 16647

The BTI-Greensburg John Deere Dealership is up and running now and being put to the test. To ensure the systems operate as planned, the Estes brothers are undergoing a commissioning process where everything is examined: lighting systems, mechanical systems, materials used, plumbing, and more. This continuous evaluation is critical to keep an efficient, sustainable building running smoothly.

Green Benefits to Building Owners

- Provides building owners with tax credits
- Increases building value
- Better building energy performance
- Lowers utility bills for tenants
- Less tenant turnover (tenant ratio increases)
- Green buildings rent for more on average (rent ratio increases).

Green Benefits to the Community

- Stimulates local economies
- Restores community pride
- Promotes cleaner environment.

Rebuilding a business and community after a natural disaster such as a flood, hurricane, or tornado can be daunting. Turn a tragedy into an opportunity to create a healthier, more comfortable, and more energy-efficient business or public office by rebuilding "green."

Renewable Energy Benefits

- Generates electricity from the sun or wind
- Heats and cools quietly and naturally
- Grants tax credits to building owners
- Offers protection against rising utility bills
- Supplies reliable power after natural disasters
- Protects the environment.

continued >

Rebuilding Green in Greensburg

After a tornado devastated their town in May 2007, the citizens of Greensburg, Kansas, turned disaster into opportunity by rebuilding as a model "green" community. As of September 2009 there were four LEED (Leadership in Energy and Environmental Design) Platinum certified buildings and several others attempting LEED Platinum or Gold certification. LEED Platinum buildings use much less energy than similar conventional buildings.



Lynn Billman, NREL/PIX 16646

The Dillons grocery store in Greensburg, Kansas, hopes to set a new energy efficiency standard for rural grocery stores.



Courtesy of City of Greensburg/PIX 16648

Greensburg's new City Hall will include solar panels and geothermal technology, and will be built out of reclaimed brick and recycled wood and materials.



Courtesy of Studio 804/PIX 16649

The 5.4.7. Arts Center in Greensburg, named after the May 4, 2007, tornado that destroyed most of town, is the first LEED Platinum building in Kansas.

Dillons Grocery Store

Completed in February 2009, the new Dillons is a hybrid between a grocery store and a gas station. The building includes a number of unique green building features such as an insulated concrete wall system, skylighting, LED lighting, and high efficiency refrigeration and HVAC equipment.

BTI-Greensburg John Deere

The John Deere farming equipment dealership in Greensburg is designed to LEED Platinum. Based on the lessons learned in Greensburg, additional John Deere dealerships are being built to maximize energy efficiency, and the company has redirected its business plan to promote energy efficient, green dealerships throughout North America. The Greensburg building includes green features such as a well-insulated roof and walls, insulated high bay doors, skylights, light tubes, energy efficient lights and equipment, wind turbines, and recycled waste oil used for heating water.

Green Public Buildings

The City of Greensburg passed a resolution that all new city-owned buildings would be LEED Platinum, including their City Hall and Business Incubator buildings. The resolution has inspired other public and commercial buildings to strive for building designs that will reach LEED Platinum or Gold, including, the Kiowa County Memorial Hospital and the Kiowa County Courthouse.

Greensburg School Complex

This K-12 school is setting a new standard for sustainable building practices. Not only is the school campus designed to LEED Platinum standards, but the school is expanding its curricula on energy and green technologies to include "hands-on" educational experiences for the students. The high school students in Greensburg have enthusiastically

continued >

supported the community's goals, and formed a "Green Club." Some sustainable features planned for the new school include:

- An optimized building envelope and outdoor classrooms to reduce heating, cooling, and lighting energy loads
- Ground source/geothermal heating and cooling systems
- Natural lighting and ventilation
- Indoor water control systems
- Electricity from an onsite wind turbine (tentative).

Contact Information

For more information about Greensburg, contact: (620) 549-3752 or (620) 723-2790
info@greensburggreentown.org
204 West Florida
Greensburg, KS 67054

To see case studies about Greensburg buildings, visit:
http://greensburg.buildinggreen.com

Green Building Checklist

Green construction methods can be integrated into buildings at any stage, but the most significant benefits result from using green methods in the earliest stages of a building project. Below is a checklist of basic green building features to discuss with your builder and architect.

Energy Efficiency

✓ **South and north orientation**—Build facing due south to optimize solar heat gain as well as the efficiency of any renewable energy systems for producing electricity or heating water. Reducing east and west wall areas maximizes the energy efficiency of buildings with large cooling loads.

✓ **Daylighting**—Install large windows that allow sunlight to reach about 75% of the interior to reduce the need for artificial lights. For small buildings with high heating loads, the extra sunlight can be used to heat concrete, tile, or brick flooring, which in turn can help heat the interior. Proper window overhangs will block the summer sun and reduce cooling loads. For large buildings with high cooling loads, large north windows will maximize daylight without increasing heat gain.

✓ **Efficient insulation**—Capitalize on one of the easiest, most cost-effective ways to save energy by using efficient insulation for foundations, walls, and roofs. Usually, the higher the R-Value of the insulation, the better it performs.

✓ **Energy-efficient windows and doors**—Look for windows and doors with an ENERGY STAR® rating. Consider installing double-paned windows with a "low-e" glazing to hold in heat in winter and cool air in summer. Usually, the lower the U-Value, the better the performance.

✓ **Efficient water heating**—Choose the most energy efficient water heating system you can, such as a tankless water heater, or consider installing solar water heating.

✓ **Energy-efficient heating and cooling system**— Choose a 90% or greater efficiency furnace, a cooling system with an efficiency rating of SEER 14 (seasonal energy efficiency ratio) or higher (ENERGY STAR® is SEER 14), or a ground-source heat pump.

✓ **Programmable thermostat**—Install a thermostat that automatically turns itself down at night to save energy.

✓ **Lighting technologies**—Select lights that not only save energy, but also last much longer than traditional incandescent light bulbs, such as the compact fluorescent lights (CFLs) that have been easily available for some time. New technologies that use light-emitting diodes (LEDs) may also be an option. LED lamps illuminate at equivalent light levels to CFLs and can use less energy. An LED bulb can last for as many as 60,000 hours and a CFL for 10,000, compared to the incandescent's 1,500.

✓ **Occupancy sensors**—Install sensors that turn off lights in unoccupied rooms such as conference rooms and bathrooms.

✓ **Appliances and Equipment**—Install ENERGY STAR® appliances and office equipment to save energy.

Water Efficiency

✓ **Water-efficient fixtures and appliances**—Reduce water and energy consumption (using less hot water also means using less energy) by installing low-flow sink and shower fixtures, toilets, and water-efficient dish and clothes washers.

✓ **Native landscaping**—Reduce water consumption by choosing plants indigenous to your area and use drip irrigation when possible.

Renewable Energy

✓ **Solar electricity**—Consider installing a small solar electric system on the roof to offset electrical loads.

✓ **Wind electricity**—Small quiet wind energy systems are available for buildings in areas with sufficient open space.

✓ **Geothermal heating and cooling**—The earth's natural temperature can be used to heat and cool your building using geothermal wells and a ground-source heat pump.

Air Quality

✓ **Nontoxic products**—Use low volatile organic compound (VOC) paints and adhesives, and formaldehyde-free insulation.

✓ **Ventilation**—Ventilate your building appropriately for a good supply of fresh air, without wasting energy on heating and cooling.

Sustainable Building Materials and Construction

✓ **Recycled materials**—Select recycled or recycled-content materials such as carpet, countertops, paint, tile, and insulation.

continued >

- ✓ **Sustainably harvested or reclaimed wood**—Purchase wood certified by the Forestry Stewardship Council, reclaimed hardwood floors and siding, or use cork and bamboo flooring as alternatives.
- ✓ **Recycled construction waste**—Try to recycle at least 50% of the wood, cardboard, and concrete from the project.

Incentives for Energy Efficiency and Renewable Energy

Numerous financial incentives are available to help building owners make their buildings more energy efficient and to offset the cost of a renewable energy system. Among the incentives available are federal and state tax credits and utility rebates. Many utility companies also offer net metering for grid-connected systems, which gives building owners credit for excess energy produced by their systems. And the *American Recovery and Reinvestment Act*, signed into law on February 17, 2009, contains provisions that will financially benefit businesses.

For more information about financial incentives, visit the Database of State Incentives for Renewables and Efficiency at *www.dsireusa.org.*

Commercial Building Energy Alliances

Partner members of these U.S. Department of Energy (DOE) alliances help guide research and encourage industry to move toward energy-efficient design and strategies in commercial buildings

www.buildings.energy.gov/commercial_initiative/alliances.html

Retailer Energy Alliance

www.buildings.energy.gov/retailer/

Hospital Energy Alliance

www.buildings.energy.gov/hospital/

Commercial Real Estate Energy Alliance

www.buildings.energy.gov/real_estate/

Green Building Resources

Energy Savers

Basic information about energy efficiency and renewable energy from DOE

www.energysavers.gov

ENERGY STAR®

This program of DOE and the U.S. Environmental Protection Agency helps building owners save energy and money through energy-efficient products and practices

www.energystar.gov

Commercial Buildings Energy Efficiency Practices

Guidelines from DOE for each step of the design and building process

www.buildings.energy.gov/commercial/index.html

High-Performance Buildings Database

Information from DOE about more than 100 high-performance buildings

http://eere.buildinggreen.com/

Green Building Case Studies

A database of green commercial buildings from the U.S. Green Building Council (USGBC)

www.usgbc.org/LEED/Project/CertifiedProjectList.aspxb

AIA Top Ten Green Buildings

The American Institute of Architects (AIA) gives awards to the top ten green buildings

www.aiatopten.org/hpb/index.cfm

Green Schools Resources

EnergySmart Schools

Guidelines for building green schools from DOE

www.buildings.energy.gov/energysmartschools/

Green Schools Guide

Guidelines for building green schools from USGBC

http://www.buildgreenschools.org/

Renewable Energy Resources

Own Your Power! A Consumer Guide to Solar Electricity for the Home

Information about solar energy systems, financial incentives, and warranties and insurance along with tips for success

www.nrel.gov/docs/fy09osti/43844.pdf

Small Wind Electric Systems

A consumer's guide that provides information about small wind energy systems for rural areas, including maintenance and zoning issues

www.windpoweringamerica.gov/pdfs/small_wind/small_wind_guide.pdf

Geoexchange

A Web site from the Geothermal Heat Pump Consortium that presents information about geothermal heating and cooling

www.geoexchange.org

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INF (1-877-337-3463)
eere.energy.gov/informationcenter

Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy; NREL is operated by the Alliance for Sustainable Energy, LLC.

This document is one in a series of documents outlining the options for and benefits of rebuilding green after a disaster. The series draws on lessons learned by teams from the U.S. Department of Energy and its National Renewable Energy Laboratory as they helped the townspeople of Greensburg, Kansas, rebuild green after a devastating tornado. To see the other documents in this series, visit www.buildings.energy.gov/greensburg/.

DOE/GO-102009-2767 • October 2009

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.

H.5 From Tragedy to Triumph—Rebuilding with Renewable Energy after Disaster

From Tragedy to Triumph—Rebuilding with Renewable Energy after Disaster

Renewable energy is generated from sources that are "green" and naturally replenished such as sunlight, wind, and geothermal heat. This energy can power, heat, and cool buildings, and can replace traditional sources of fuel (e.g., coal and natural gas) used by utilities. Most utilities are using wind power, but other types are coming to the forefront. Every day, more individuals, businesses, and communities decide to "go green" with renewable energy.



Pat Corkery / PIX15442

The Science & Technology Facility at the National Renewable Energy Laboratory in Golden, Colorado, incorporates a number of advanced energy efficiency and green building concepts. For example, the architecture makes good use of natural light wherever possible, and an automated system dims unnecessary artificial lighting to reduce electricity use.

Renewable Energy Benefits

- Generates electricity from the sun or wind
- Heats and cools quietly and naturally
- Grants tax credits to building owners
- Offers protection against rising utility bills
- Supplies reliable power after natural disasters
- Protects the environment.

Energy Efficiency First

Lower energy demand means renewable energy systems can be smaller and less expensive. Consider these basic energy efficiency strategies:

- Use efficient insulation for foundations, walls, and roofs
- Look for ENERGY STAR® doors and windows and double-paned windows with "low-e" glazing
- Seal openings and cracks to reduce cooling and heating costs

Rebuilding a community, a business, or a home after a natural disaster such as a flood, hurricane, or tornado can be daunting. Tragedy can be turned into opportunity by rebuilding with renewable energy and creating healthier and more energy-efficient communities.

- Choose high-efficiency heating, cooling, and air-conditioning (HVAC) equipment
- Use daylighting (natural light), compact fluorescent lights (CFLs), and ENERGY STAR® appliances and office equipment to reduce electricity use.

Types of Renewable Energy

Solar

Solar power technologies take advantage of a large, clean, free renewable energy source—the sun. Solar technologies are scalable—they're suitable for very small to very large applications. There are several types of solar technologies:

Solar photovoltaics (PV) convert sunlight directly to electricity and can be installed on individual rooftops or as large "fields" of solar arrays by a utility company.

Concentrating solar power (CSP) systems concentrate the sun's heat to drive a generator that produces electricity. Most CSP systems are installed by utility companies and may consist of a field of dishes, engines, parabolic troughs, or central power towers.

Solar heating technologies use collectors that absorb the sun's heat for water or space heating.

Solar lighting technologies include "clerestory" windows, skylights, and solar tubes that bring sunlight into a building where light is most needed.

Passive solar heating and daylighting strategies are integrated into designs so buildings work with the sun to operate more efficiently.

continued >

Rebuilding Green in Greensburg

After a tornado devastated their town in May 2007, the citizens of Greensburg, Kansas, turned disaster into opportunity by rebuilding as a model "green" community. Their master plan includes goals for making residential and commercial buildings more energy efficient and developing community- and small-scale renewable energy projects.



Lynn Billman, NREL/PIX 16651

The John Deere dealership in Greensburg, Kansas, owned by BTI Equipment, uses two wind turbines to produce electricity for the building and burns waste oil for heating.



Lynn Billman, NREL/PIX 16650

The Kiowa County Courthouse in Greensburg has a geothermal heating and cooling system that uses an energy efficient ground-source heat pump to circulate air that's naturally warmed and cooled in 32 deep underground wells. This is an excellent example of green historical restoration.



Lynn Billman, NREL/PIX 16652

Greensburg's new SunChips Business Incubator building offers affordable office space for small start-up businesses. Among other green features, the solar PV panels on the roof capture the sun's energy and convert it to electricity, meeting approximately 10% of the building's total energy needs.

Community-Scale Renewable Energy Projects

The City of Greensburg, which doubles as a municipal utility, is developing large-scale renewable energy resources. One project is the Greensburg Wind Farm, a joint effort of the City of Greensburg, the Kansas Power Pool, and John Deere Renewable Energy, that will consist of ten 1.25-MW wind turbines. The wind farm is expected to be operational in 2010 and will generate enough energy to power every home, business, and municipal facility in Greensburg. Excess electricity will be sold back to the local utility.

Financing for the project was supported by Native Energy Inc., which will be the exclusive marketer of Renewable Energy Certificates (RECs) from the wind farm. RECs, also called green tags, green certificates, or tradable renewable certificates, capture the environmental attributes—typically in terms of avoided emissions—of the power produced from renewable energy. They are sold separately from the electricity that runs through the grid. Usually, 1 REC represents proof that 1 megawatt-hour of electricity has been generated from an eligible renewable energy resource. Native Energy will purchase about two-thirds of the wind farm's expected RECs over 20 years.

The city is also working with surrounding counties to explore options for using agricultural wastes to produce energy.

Small-Scale Renewable Energy Projects

Greensburg completed a study outlining the opportunities for solar PV to generate electricity on individual homes and businesses. The city also has adopted an interconnection agreement and net-metering policy that will give home and business owners credit from the local utility for excess power produced by their systems. In such distributed systems, buildings both receive and send electricity to the grid through an interconnection agreement.

continued >



U.S. Environmental Protection Agency / PIX14837

At the EPA's Robert S. Kerr Environmental Research Center in Ada, Oklahoma, a retrofit to upgrade the building's mechanical system and incorporate renewable energy reduced the lab's annual energy consumption by 45%. The retrofit implemented a geothermal ground-source heat pump among other energy efficient systems. Because of these upgrades and "green tag" purchases from wind power, the Ada Lab became EPA's first zero emissions facility.

And net-metering policies allow the owner of a distributed system to get the most value for the electricity sent back to the grid.

Contact Information

For more information about Greensburg, contact:
(620) 549-3752 or (620) 723-2790
info@greensburggreentown.org
204 West Florida
Greensburg, KS 67054

To see case studies about Greensburg buildings, visit:
http://greensburg.buildinggreen.com

Wind

In certain areas, the wind is another resource for producing renewable energy. Wind turbines convert the wind's kinetic energy into mechanical power, which is sent to a generator that converts the mechanical power into electricity. Wind energy can also be used for specific needs such as pumping water.

Single small turbines, rated in the 5–50 kilowatt (kW) range, can power homes, ranches, or remote buildings (zoning restrictions may apply, so check with your local zoning authority).

Turbines in the 5–100-kW range may benefit commercial buildings in appropriate locations.

Utility-scale turbines from 100 kW to several megawatts (MW) are grouped together into wind farms, often 100 MW or more in total capacity, which supply power to the electrical grid in bulk.

Geothermal

Geothermal energy is heat that resides deep within the rock and fluid of the earth's crust. This energy can be harnessed to produce electricity or direct heat, or for heating and cooling buildings.

Electrical power plants use steam from geothermal reservoirs to rotate turbines that activate generators for producing electricity.

Small-scale geothermal power plants—under 5 MW— have the potential for widespread community application where geothermal resources are abundant, possibly as "distributed energy" resources (a variety of small, modular, power-generating technologies that can be combined to improve the operation of the electrical grid).

Ground-source heat pumps typically comprise a ground heat exchanger (a system of pipes called a loop, which is buried in the shallow ground near the building), a heat pump unit, and a series of ducts through which air is delivered. A fluid—usually water or a mixture of antifreeze and water—circulates through the pipes to absorb or relinquish heat. In the winter, the heat pump removes heat from the exchanger and pumps it through the ducts. The process is reversed in the summer, when the pump moves heat from the indoor air into the heat exchanger.

Biomass

When most people think of using biomass, ethanol from corn and biodiesel from soybean oil spring to mind. Other types of biomass have the potential to contribute to our energy mix as well. Dedicated energy crops such as fast-growing trees and grasses can be grown sustainably on land that is unsuitable for food crops. Forestry or agricultural residues, such as wheat straw and the stalks, leaves, and husks of the corn plant, called "stover," are all biomass. Even the organic components of municipal and industrial wastes are usable for energy production.

Biomass is used to make **liquid fuels for transportation**, as in the cases of ethanol and biodiesel.

Most of us are familiar with **consuming biomass to generate heat**. Firewood and other biomass such as corn cobs can be burned to heat buildings. Biomass can also be "pelletized" to burn more cleanly and efficiently than firewood in heating stoves.

Utilities and major industries **consume biomass directly or convert it to a gaseous fuel to generate electricity**. Many coal-fired power plants today add biomass to their coal-burning process. This practice, called co-firing, reduces emissions while producing electricity. And industries such as pulp and paper and forest products often use biomass to co-generate heat and electricity.

continued >

Some of these uses for biomass have been commercialized for a long time; other uses are in development and are not yet commercial. For example, the first pilot-scale ethanol plants that use biomass other than corn are just being constructed.

Financing Renewable Energy

Financial Incentives

Numerous financial incentives, such as federal and state tax credits and utility rebates, are available to help offset the cost of a renewable energy system. Many utility companies also offer net metering for grid-connected renewable energy systems, so consumers can get credit for power they produce but don't need. And the *American Recovery and Reinvestment Act*, signed into law on February 17, 2009, contains provisions that will financially benefit individuals, businesses, organizations, and the renewable energy industry as a whole.

For more information about financial incentives, visit the Database of State Incentives for Renewables and Efficiency at *www.dsireusa.org*.

Power Purchase Agreements

A power purchase agreement (PPA) is a financing mechanism created to help businesses, industrial concerns, schools and universities, and all levels of government go green with no up-front capital cost. Through these long-term contracts (about 15 years or more) a renewable energy company (PPA partner) finances, owns, and maintains the renewable energy system. The buyer agrees to purchase the electricity generated by the system from the PPA partner, which has assumed all the risks and responsibilities of ownership. At the end of the PPA term, the buyer can choose to purchase the system or extend the agreement. A PPA with predetermined electricity rates over the term of the contract helps to stabilize operating costs that were once highly variable.

Energy Efficiency and Renewable Energy Resources

Energy Savers

Basic information about energy efficiency and renewable energy from the U.S. Department of Energy (DOE)

www.energysavers.gov

ENERGY STAR®

This program of DOE and the U.S. Environmental Protection Agency (EPA) has information about energy efficiency for home and business owners as well as commercial and industrial building energy managers and operators

http://www.energystar.gov/

Own Your Power! A Consumer Guide to Solar Electricity for the Home

Information about solar energy systems, financial incentives, and warranties and insurance along with tips for success

www.nrel.gov/docs/fy09osti/43844.pdf

A Homebuilder's Guide to Going Solar

This guide helps builders assess the benefits of installing solar equipment or making houses "solar ready" to both their businesses and customers

www.solar.energy.gov/pdfs/44792.pdf

Small Wind Electric Systems: A U.S. Consumer's Guide

A consumer's guide containing information about small wind energy systems for rural areas, including maintenance and zoning issues

www.windpoweringamerica.gov/pdfs/small_wind/small_wind_guide.pdf

Geoexchange

A Web site from the Geothermal Heat Pump Consortium that presents information about geothermal heating and cooling

www.geoexchange.org

Exploring Ways to Use Biomass Energy

A DOE Web site that explains the different ways to use biomass

www.energysavers.gov/renewable_energy/biomass/index.cfm/mytopic=50001

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INF (1-877-337-3463)
eere.energy.gov/informationcenter

Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy; NREL is operated by the Alliance for Sustainable Energy, LLC.

This document is one in a series of documents outlining the options for and benefits of rebuilding green after a disaster. The series draws on lessons learned by teams from the U.S. Department of Energy and its National Renewable Energy Laboratory as they helped the townspeople of Greensburg, Kansas, rebuild green after a devastating tornado. To see the other documents in this series, visit www.buildings.energy.gov/greensburg/.

DOE/GO-102009-2768 • October 2009

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.

H.6 From Tragedy to Triumph—Resources for Rebuilding Green after Disaster

From Tragedy to Triumph—Resources for Rebuilding Green after Disaster

These resources offer builders and architects information about building healthier, more comfortable, and more energy-efficient homes, businesses, and public buildings.

Financial Incentives

Numerous financial incentives, such as federal and state tax credits and utility rebates, are available to help offset the cost of a renewable energy system. Many utility companies also offer net metering for renewable energy systems that are connected to the grid. And the *American Recovery and Reinvestment Act*, signed into law on February 17, 2009, contains provisions that will financially benefit individuals, businesses, organizations, and the renewable energy industry as a whole.

For more information about financial incentives, visit the Database of State Incentives for Renewables and Efficiency at *www.dsireusa.org*.

Commercial Building Energy Alliances

Partner members of these U.S. Department of Energy (DOE) alliances help guide research and encourage industry to move toward energy-efficient design and strategies in commercial buildings

www.buildings.energy.gov/commercial_initiative/alliances.html

Retailer Energy Alliance

www.buildings.energy.gov/retailer/



Bill Timmerman, NREL/PIX 14963

The National Renewable Energy Laboratory's Science & Technology facility is designed to encompass advanced energy efficiency and "green building" concepts in systems such as lighting and HVAC.

Rebuilding a business or home after a natural disaster such as a flood, hurricane, or tornado can be daunting. These resources can help you turn tragedy into opportunity by rebuilding with energy efficiency and renewable energy to create healthier buildings and homes.

Hospital Energy Alliance

www.buildings.energy.gov/hospital/

Commercial Real Estate Energy Alliance

www.buildings.energy.gov/real_estate/

Energy Efficiency Resources

Energy Savers

Basic information about energy efficiency and renewable energy from DOE

www.energysavers.gov

ENERGY STAR®

This program of DOE and the U.S. Environmental Protection Agency (EPA) helps building owners save energy and money through energy-efficient products and practices

www.energystar.gov

Commercial Buildings Energy Efficiency Practices

Guidelines from DOE for each step of the design and building process

www.buildings.energy.gov/commercial/index.html

continued >

EnergySmart Schools

Guidelines for building green schools from DOE

www.buildings.energy.gov/energysmartschools

Green Guides and Case Studies

Green Building

Provides general information about green buildings along with case studies from EPA

www.epa.gov/greenbuilding/

Green Building Case Studies

A database of green commercial buildings from the U.S. Green Building Council (USGBC)

www.usgbc.org/LEED/Project/CertifiedProjectList.aspx

Green Home Building Guidelines

Guidelines for building green homes from the National Association of Homebuilders (NAHB)

www.nahbgreen.org/Guidelines/nahbguidelines.aspx

Green Schools Guide

Guidelines for building green schools from USGBC

www.buildgreenschools.org/

Greensburg Sustainable Buildings Database

Case studies of green commercial buildings and homes in Greensburg, Kansas

http://greensburg.buildinggreen.com

High-Performance Buildings Database

Information from DOE about more than 100 high-performance buildings

http://eere.buildinggreen.com/

Remodeling Green Guidelines

A publication about remodeling an existing home to make it green

www.greenhomeguide.org/documents/regreen_guidelines.pdf

Top Ten Green Buildings

The American Institute of Architects gives annual awards for the top ten green buildings.

www.aiatopten.org/hpb/

Renewable Energy Resources

A Homebuilder's Guide to Going Solar

This publication helps builders assess the benefits of installing solar equipment or making houses "solar ready" to both their businesses and customers.

www.solar.energy.gov/pdfs/44792.pdf

Own Your Power! A Consumer Guide to Solar Electricity for the Home

Information about solar energy systems, financial incentives, and warranties and insurance along with tips for success

www.nrel.gov/docs/fy09osti/43844.pdf

Small Wind Electric Systems

A consumer's guide with information about small wind energy systems for rural areas, including maintenance and zoning issues

www.windpoweringamerica.gov/pdfs/small_wind/small_wind_guide.pdf

Geoexchange

A Web site from the Geothermal Heat Pump Consortium that presents information about geothermal heating and cooling

www.geoexchange.org



Ed Hancock/PIX 11668

The atrium at the Adam Joseph Lewis Center for Environmental Studies in Oberlin, Ohio, features low-e glaze windows that hold in heat during winter and keep heat out in the summer.

continued >



Cheryl Unger, NREL/PIX 15625

This ENERGY STAR® home in Colorado uses at least 15% less energy than a typical home built to code and features a solar PV system.

Organizations and Associations

Alliance to Save Energy

Information about energy efficiency, including building green schools and commercial buildings

www.ase.org

American Architectural Manufacturers Association

Includes information and news about building green in its green building section

www.aamanet.org/general.asp?sect=1&id=315

American Council for an Energy Efficient Economy (ACEEE)

ACEEE has energy efficiency information for both residential

www.aceee.org/Consumer/index.htm

and commercial buildings

www.aceee.org/buildings/commercial.htm

American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Information about the latest standards for green buildings

www.ashrae.org

American Solar Energy Society

Information about using solar for green homes

www.ases.org

American Wind Energy Association

Information on wind energy projects and technology and policy development

www.awea.org

BuildingGreen.com

Information about green buildings including books on green products

www.buildinggreen.com/

Build It Green

A nonprofit organization dedicated to energy and resource efficient building in California

www.builditgreen.org

Common Fire Foundation

A nonprofit organization dedicated to teaching others about green building

www.commonfire.org/

Cool Roof Rating Council

Provides an independent rating system for cool roofs used in green buildings

www.coolroofs.org

Energy & Environmental Building Alliance

Offers educational classes and information about green buildings

www.eeba.org

Green Building Resource Center

Free design advice and information about environmentally friendly products and strategies

www.globalgreen.org/gbrc

Green Concepts

Information about environmentally friendly products and green building

www.greenconcepts.com

Geothermal Energy Association

Geothermal resource maps and listing of U.S. geothermal plants by state

www.geo-energy.org

Home Ventilating Institute

Information about ventilation systems for home and businesses

www.hvi.org

Indoor Air Quality Association

A nonprofit organization dedicated to improving indoor air quality

www.iaqa.org

National Association of Home Builders (NAHB)

NAHB Green *www.nahbgreen.org* and the NAHB Research Center *www.nahbrc.org* provide resources and information to builders about green homes and products.

continued >



Courtesy of BNIM/PIX 16653

The new high school in Greensburg, Kansas, is being built using green strategies such as the use of daylighting in the gymnasium to offset artificial lighting loads.

National Resources Defense Council

Information for builders about how green homes and commercial buildings can boost the bottom line

www.nrdc.org/buildinggreen

National Roofing Contractors Association

Trade association for the roofing industry that has an online "Energy Wise" roof calculator

www.nrca.net

New Homes Directory

A national directory of new green homes and communities

www.newhomesdirectory.com/green

National Recycling Coalition, Inc.

Provides waste reduction information for builders

www.nrc-recycle.org

North American Insulation Manufacturers Association

Information about various types of insulation, including fiber glass, rock wool, and slag wool insulation products. Builders can search for green products

www.naima.org

Sustainable Buildings Alliance

International organization dedicated to sustainable development and green buildings

www.sballiance.org/

Sustainable Buildings Industry Council

Provides educational classes and resources for passive solar design

www.SBICouncil.org

U.S. Green Building Council (USGBC)

USGBC has information about green commercial and residential buildings as well as the LEED (Leadership in Energy and Environmental Design) rating system for commercial buildings *www.usgbc.org/*. They also have a blog about green buildings

http://blog.epa.gov/blog/category/greenbuilding

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INF (1-877-337-3463)
eere.energy.gov/informationcenter

Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy; NREL is operated by the Alliance for Sustainable Energy, LLC.

This document is one in a series of documents outlining the options for and benefits of rebuilding green after a disaster. The series draws on lessons learned by teams from the U.S. Department of Energy and its National Renewable Energy Laboratory as they helped the townspeople of Greensburg, Kansas, rebuild green after a devastating tornado. To see the other documents in this series, visit www.buildings.energy.gov/greensburg/.

DOE/GO-102009-2769 • October 2009

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.

H.7 Rebuilding It Better—BTI-Greensburg John Deere Dealership

U.S. DEPARTMENT OF ENERGY

Energy Efficiency & Renewable Energy

Rebuilding It Better

BTI-Greensburg John Deere Dealership

BTI GREENSBURG, KANSAS

The GREENER Dealer



On May 4th, 2007, brothers Kelly and Mike Estes saw their BTI-Greensburg John Deere Dealership ruined by an EF-5 tornado. They were not alone in their loss—95% of the town was destroyed that day. So they were overwhelmed the next morning when more than 100 customers and friends arrived to help them salvage what they could.

To support the community that helped them so much, Kelly, Mike, and their family committed to rebuilding their business in a better, greener way. They wanted the new 28,000 ft² prefabricated metal building to house the world's greenest farm machinery business, attain a LEED® Platinum rating, and use the least energy possible. And they did all they could to reach these goals.

> **Going green was important to us to be sure we're being good citizens of Greensburg and helping the environment.**
>
> *– Kelly Estes*

Green Goals

All of Greensburg, Kansas, is working toward becoming a model green community. The residents saw this tragedy as an opportunity to improve where they live. With the help of the U.S. Department of Energy and the National Renewable Energy Laboratory, Greensburg residents are building sustainable, energy-efficient homes, businesses, and government buildings.

The Estes brothers and the John Deere Company support this effort. In fact, the BTI-Greensburg building is the new "John Deere Place" design–a model for dealers who are building and remodeling across North America. The John Deere Company would like to see these energy-saving and environmentally-friendly features incorporated into future dealerships.

LEED® Platinum

The new building is designed to meet the requirements of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Platinum designation–the highest designation possible. No other metal prefabricated building has achieved LEED status–let alone LEED platinum.

Energy Conservation

Kelly and Mike set a goal of saving 42% in energy costs and looked for every opportunity to improve BTI-Greensburg's efficiency. Experts at the National Renewable Energy Laboratory, with the U.S. Department of Energy's support, worked with BTI-Greensburg as part of their research to reduce retail building energy use by half. They helped identify, through modeling and life-cycle analysis, the most cost-effective energy efficiency strategies.



The BTI-Greensburg John Deere Dealership features tubular daylighting devices that bring natural light into the showroom. This reduces electricity use, provides a better environment for employees and customers, and saves BTI-Greensburg money.



The insulated garage door and skylights at the BTI-Greensburg service center make this large, open area very energy efficient.

Natural Lighting

Daylighting, using natural instead of electric lighting, is critical in reducing energy use. A good daylighting design brings in diffused light to minimize glare and heat. Daylighting also provides a natural sense of well-being to employees and customers.

The BTI-Greensburg building features:

- 23 skylights in the service shop, parts department, and wash bay.
- 12 tubular daylighting devices in the retail space.
- High-efficiency lights and luminaire fixtures.

To further minimize electricity use, sensors detect occupancy and turn off unneeded lights. The lighting controls also automatically balance electric lighting with daylighting for maximum savings.

Improved Insulation

Insulation is key to keeping any building at the right temperature and minimizing heating and cooling costs. Insulation is measured in R-values–the higher the R-value, the better the insulation. BTI-Greensburg exceeded standard levels in all areas by using:

- R-16 highly insulated wall panels, typically used in refrigerated warehouses: 2 times better than building code.
- R-14 insulated panels in the garage doors: 20 times better than standard practice.
- R-38 insulation in the roof: 2 times better than standard.
- R-3.8 under the slab floor to minimize heat loss.



The ground breaking on February 4th, 2008, was the first step toward a new, green BTI-Greensburg building.

Efficient Heating, Ventilation, and Air Conditioning

The BTI-Greensburg building features a highly efficient radiant heating system in the concrete slab floor. The water for it is heated by recycled oil from BTI's normal operations, which reduces the need for natural gas.

A high-efficiency 16 SEER variable-air volume system provides heating, cooling, and outdoor air. Additionally, motion detectors and individual controls help minimize the use of the heating and cooling systems.

Power From the Wind

To help power the dealership, BTI installed two wind turbines (5 kW and 1.8 kW) to offset about 8% of the building's electricity use. Impressed by the 5 kW Endurance model chosen for the site, other family members are now involved in a new venture, BTI Wind Energy. It has become the North American distributor for Endurance, and has created more than 100 new green jobs at dealerships throughout the United States.

Sustainable Features

To earn a LEED Platinum rating, the Estes family followed other sustainable practices in addition to energy efficiency.

Sustainable Site

- Minimize site disturbance and control erosion.
- Reduce transportation impact by promoting the use of bicycles and fuel-efficient vehicles.
- Maximize the use of native landscaping and open space.
- Manage storm water runoff by using pervious hard surfaces such as recycled crushed concrete.
- Limit the site's heat island effect through white roofing and reflective paving.

Water Efficiency

- Plant drought-tolerant landscaping.
- Irrigate with runoff and rain water that are naturally filtered and stored in a holding pond.
- Aerate the holding pond with a wind-powered system.
- Use waterless urinals and low-flow fixtures.

Materials and Resources

- Manage and recycle construction waste.
- Have a workplace recycling plan.
- Used recycled local and regional steel and certified woods to build the structure.

Indoor Environmental Air Quality

- Control tobacco smoke.
- Ensure thermal comfort with personal heating and cooling controls.
- Use highly efficient filters and fresh air to improve indoor air quality.
- Use adhesives, woods, carpet, and paint with low volatile organic compounds.
- Provide daylit spaces and access to views.

Design Team

Owners:
The Estes Family

Builder:
Hastco Construction

Architect:
Landmark Architects

Mechanical, Electrical, and Plumbing:
Professional Engineering Consultants

Site Design:
BNIM Architects and John Deere Landscapes

Floor Plan/Layout Design:
John Deere Place

LEED Consultant:
BNIM Architects

Research Assistance:
National Renewable Energy Laboratory

Commissioning:
Midwest Engineering, Inc.

One of the new wind turbines is visible from the entrance of the BTI-Greensburg John Deere Dealership.



Great Results

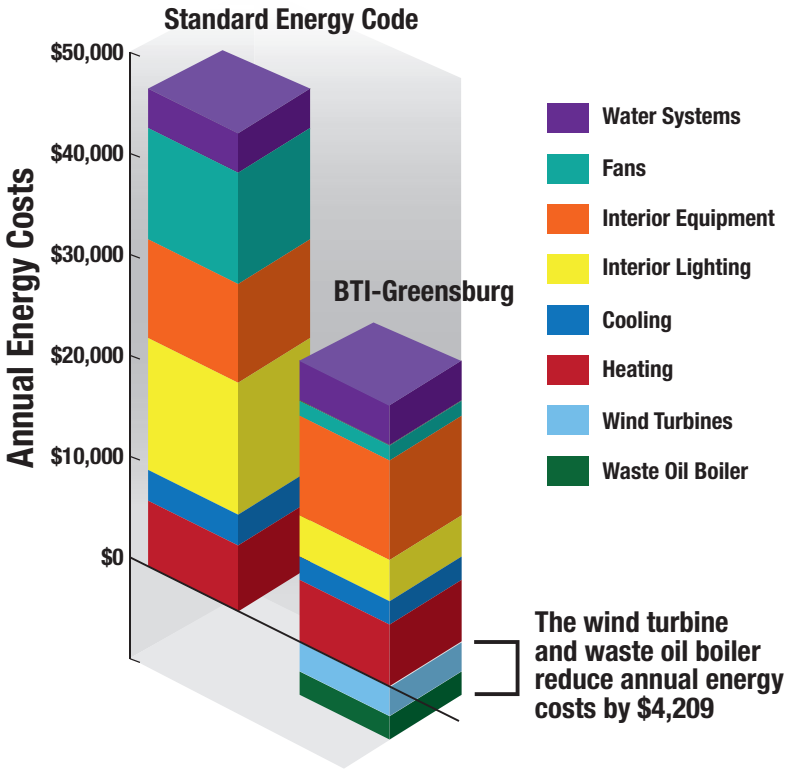
The BTI-Greensburg John Deere Dealership is up and running now and being put to the test. To ensure the systems operate as planned, the Estes brothers are undergoing a commissioning process where everything is examined: lighting systems, mechanical systems, materials used, plumbing, and more. This continuous evaluation is critical to keep an efficient, sustainable building running smoothly.

Mike and Kelly are delighted with their building. It is a healthier and more comfortable environment for customers and employees, and BTI-Greensburg is expecting significantly decreased energy bills. "We're really pleased with how it all turned out," states Mike Estes.

The Estes are proud to contribute to the community that helped them during a crisis. They provide an excellent example of what can be done to improve the quality and efficiency of commercial buildings. This is something that will not only benefit Greensburg, but our nation as a whole.

> **We're proud of what we accomplished and that BTI-Greensburg is going to be a model for future John Deere Dealerships.**
>
> *– Mike Estes*

Annual Energy Cost Savings



Energy modeling indicates that annual energy costs for a building similar to BTI-Greensburg built to standard code, the Standard Energy Code column, would be about $47,000. The right-hand column represents the expected annual energy costs for the BTI-Greensburg facility. The wind turbines and waste oil boiler reduce the total amount of purchased energy, so BTI-Greensburg is expected to spend approximately $24,000 per year on energy costs—a reduction of about 50%.

For more information:

BTI-Greensburg | 15479 US 54, Greensburg, KS, 67054 | (620) 723-3331 | www.btiequip.com

Greensburg Sustainable Building Database | greensburg.buildinggreen.com

Greensburg GreenTown | www.greensburggreentown.org

Department of Energy, Building Technologies Program | www.eere.energy.gov/buildings

National Renewable Energy Laboratory | www.nrel.gov

The U.S. Department of Energy and the National Renewable Energy Laboratory have provided technical expertise and support to the residents of Greensburg as they rebuild their homes, businesses, and government buildings.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

Prepared by the National Renewable Energy Laboratory (NREL)
NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

DOE/GO-102009-2832
Revised May 2009

H.8 Greensburg Kansas: Building a Model Green Community, *How Would You Rebuild a Town Green?*

Case Study Database

The Greensburg High Performance Buildings Database highlights building case studies that include design details and energy information for the town's new commercial and residential green buildings. The database provides a standardized format for displaying performance information as well as a system for collecting data on topics including energy, materials, indoor environmental quality, and land use.


GREENSBURG GreenTown

In Depth Case Studies

BTI-Greensburg John Deere Dealership, Greensburg Kansas (BTI-Greensburg John Deere)

Overview

- Location: Greensburg, KS
- Building type(s): Retail
- New construction
- 27,000 sq. feet (2,510 sq. meters)
- Project scope: a single building
- Rural setting
- Completed November 2008
  The dealership is currently under construction as of August 2008.
- Rating: USGBC LEED-NC 2.2—Level: Goal of Platinum with 38% Energy Cost Savings

BTI-Greensburg is rebuilding a new John Deere Dealership and Service shop in Greensburg, Kansas. 95% of the town was destroyed in a tornado in May of 2007. The metal building is attempting to achieve LEED® Platinum and 38% energy cost savings. Completion is expected in late 2008.

Environmental Aspects

BTI-Greensburg, the local John Deere dealership, is designed to meet the requirements of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) Platinum designation while saving greater than 38% in energy costs, and will be used as the model for future John Deere dealerships.

Stay Tuned…

Greensburg is in the early stages of rebuilding, and the Greensburg High Performance Buildings Database will continue to grow as the town does. If you are constructing a green, energy-efficient building in Greensburg, we'd love to hear about it. Visit greensburg.buildinggreen.com and click "submit a project."

To see the Greensburg case studies, visit:
greensburg.buildinggreen.com

For Additional Information, Please Contact:

Energy Efficiency and Renewable Energy Information Center 1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

Prepared by NREL, a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

For more information about Greensburg, contact
(620) 549-3752 or (620) 723-2790
info@greensburggreentown.org
204 West Florida
Greensburg, KS 67054

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

GREENSBURG GreenTown™

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

DOE/GO-102009-2829 • April 2009

Cover photo courtesy of Lynn Billman, NREL

Printed with a renewable source ink on paper containing at least 50% wastepaper, including 10% postconsumer waste.

How would you rebuild a town – *green*?



Greensburg, Kansas: Building a Model Green Community

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Why Greensburg?

On May 4th, 2007, an EF-5 tornado tore through Greensburg, Kansas, destroying or damaging 95% of the town's homes and businesses. With the help of many partners, including the U.S. Department of Energy and the National Renewable Energy Laboratory, Greensburg is rebuilding as a model green community for rural America.

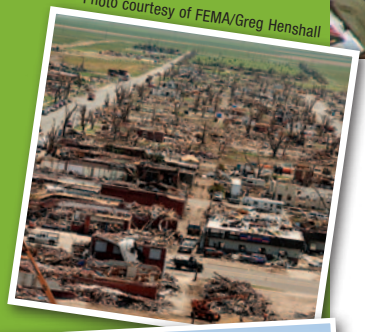


Photo courtesy of FEMA/Greg Henshall



Photo courtesy of FEMA/John Shea

Before the tornado, Greensburg was a typical Midwestern farming town of about 1,400 people. After the tornado, Greensburg recognized the opportunity to remake their devastated town in ways that could attract new residents of all ages. Because Greensburg is a small town with limited financial resources, they wanted this new green community to be affordable.

What they lack in financial resources, Greensburg residents more than make up for in resourcefulness and ingenuity. The town has gathered a diverse group of experts and enthusiasts to help make their vision of a green community a reality.

To expedite the process, residents formed Greensburg GreenTown™, a grassroots, community-based nonprofit organization established to provide resources and support as Greensburg rebuilds. For more information, visit:

www.greensburggreentown.org



Photo courtesy of BNIM Architects

Residents of Greensburg are turning a disaster into an opportunity, both for their town and for other rural American communities.

Greensburg's Green Goals

Greensburg's city leaders and residents are working to create a community that is:

- **Economically, environmentally, and culturally sustainable**
- **Walkable and mixed-use**
- **Supporting families, fostering business, and working together to spur economic growth**
- **A model for other rural towns**

How Greensburg Is Achieving Its Goals

Build an Effective Team

Combine residents' passion and knowledge of place with resources and technical expertise from industry and government partners

Put Efficiency First!

Reduce energy use by building high-performance homes, businesses, and public buildings, and renovating to high efficiency standards

100% Renewable, 100% of the Time

Use renewable energy to generate electricity, primarily community-scale wind and distributed-scale wind or solar photovoltaics with hydropower and biofuels when needed

Rethink Local Transportation

Reduce gasoline and diesel use through alternative transportation and careful community planning

Make it Easy and Cost-Effective

Encourage residents and businesses to go green by offering incentives, technical assistance, information, training, fundraising, and other support

Set Specific Energy Goals

LEED® Platinum Buildings

Greensburg is serious about energy efficiency. It is the only city in the country that requires all city-owned buildings to meet the U.S. Green Building Council's LEED Platinum standards. In addition, city buildings will earn the maximum number of LEED energy efficiency points, resulting in a 42% energy savings compared with buildings built to current code. Many of Greensburg's commercial and institutional buildings are following suit.

Greensburg's Master Plan

The Greensburg Master Plan includes other ambitious energy goals:

- New homes to use 40% to 50% less energy than current code
- Renovated homes to use 25% less energy than before
- Electricity to come from renewable resources such as wind and solar
- Transportation system to minimize fossil fuel consumption through careful planning and alternative transportation options



Photo courtesy of NREL/Lynn Billman