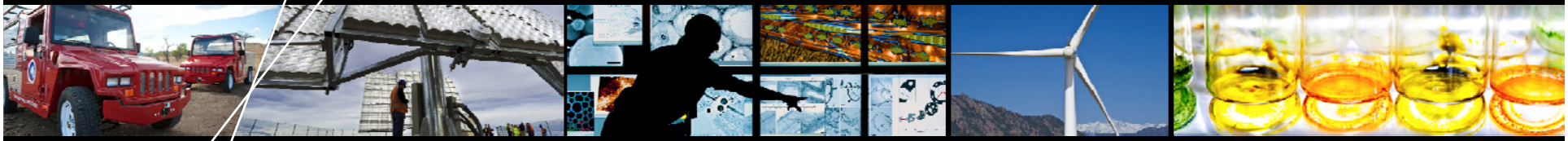
Renewable Energy Options for New Buildings and Major Renovations



NASA Net Zero Workshop

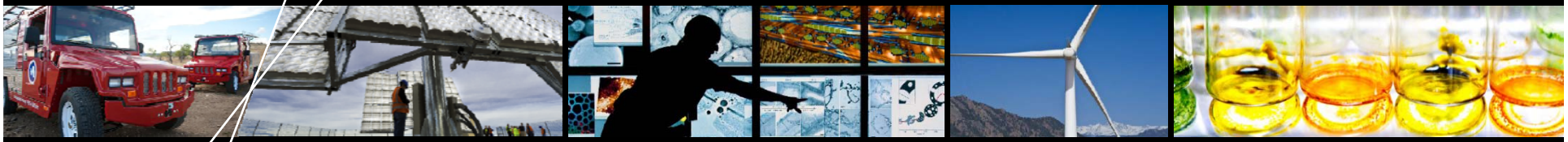
Andy Walker PhD PE

June 6, 2012

Motives to Consider Renewable Energy

- **Cost-effective: least cost alternative in many cases**
- **Hedge against future rate increases**
- **Zero environmental emissions on site**
- **Employs local trades rather than exporting jobs to import energy into a community**
- **Avoids fuel delivery and handling risks**
- **No fuel cost fluctuations**
- **Energy Security: no fuel supply interruptions**
- **Reliability: redundant power supplies**
- **Compliance; Mitigation**
  - Statutes (EPAct 2005; EISA 2007; NDAA 2010)
  - Executive Orders (13423; 13514)

NREL
NATIONAL RENEWABLE ENERGY LABORATORY



Renewable Energy Policy

What is the Federal Definition of Renewable Energy?

Electric energy generated from:

- Solar
- Wind
- Biomass
- Landfill gas
- Ocean (including tidal, wave, current, and thermal)
- Geothermal
- Municipal solid waste
- New hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project

EPAct 2005

Renewable Energy Technologies

Photovoltaics

PIX 1870

Wind Power

PIX 8727

Solar Water Heating

PIX 1050

Solar Vent Air Preheat

PIX 12132

Concentrating Solar

PIX 18700

Biomass Heat/Power

PIX 11913

Daylighting

PIX 17041

Ground Source Heat

PIX 07096

Landfill Gas

PIX 3626

Legislation

PIX 5690

PIX 11977

EPAct 2005

- **Not less than 5% of Electricity consumed by the Federal government must come from renewable energy in fiscal years 2010-2012**
- **Not less than 7.5% in fiscal year 2013 and thereafter**
- **Renewable Energy projects provide bonuses if energy is:**
  - produced on Federal lands and used at a Federal facility; or
  - produced on Native American land and used at a Federal facility

EISA 2007

- 30% solar hot water in new buildings
- 0% fossil fuels by 2030 in new buildings
- 40 year analysis period for RE
- Facilitates ESPC for RE

Executive Orders

PIX 18991

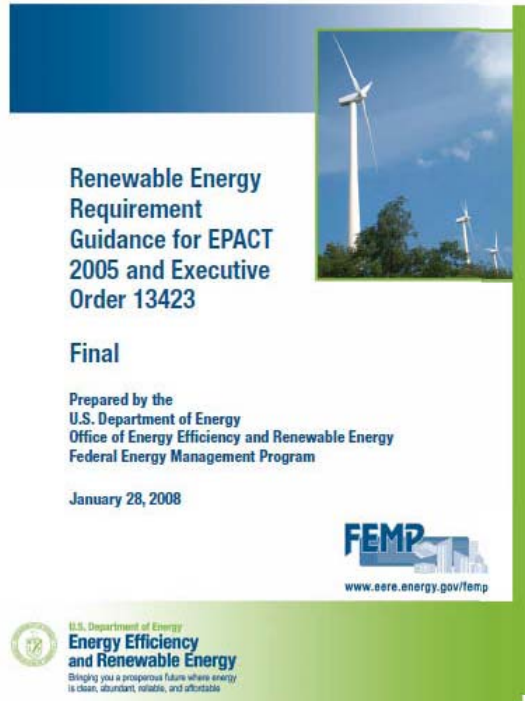
Executive Order. 13423

- ½ of RE goal must be “new”
- Thermal counts in ½ new requirement

Executive Order 13514

- GHG accounting and sustainability plans

Guidance Available from FEMP



- **Guide to Integrating Renewable Energy in Federal Construction**
  - http://www1.eere.energy.gov/femp/reconstructionguide/
- **Renewable Energy Requirement Guidance for EPACT 2005 and Executive Order 12423**
  - www1.eere.energy.gov/femp/pdfs/epact05_fedrenewenergyguid.pdf
- For on-site projects, agency must retain or replace RECs to show use
- Simply hosting a renewable project without RECs does not help meet Federal goals
- Excludes system mix energy and energy used to meet state RPS requirements
- Rules are stricter for GHG accounting than for EPACT 05 accounting

Energy Efficiency

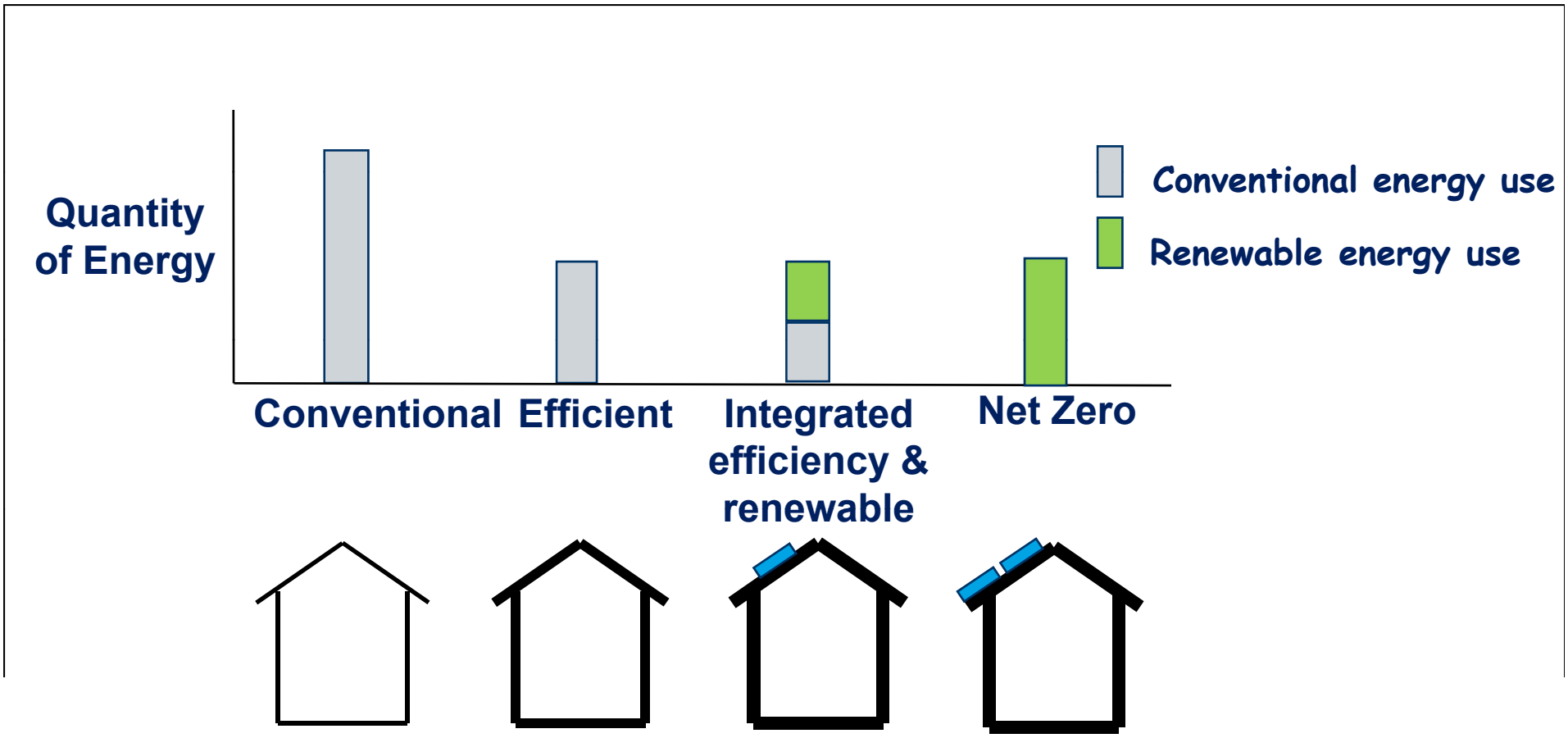
Clip Art

Renewable Energy

Clip Art

Any questions?

EE + RE = 0



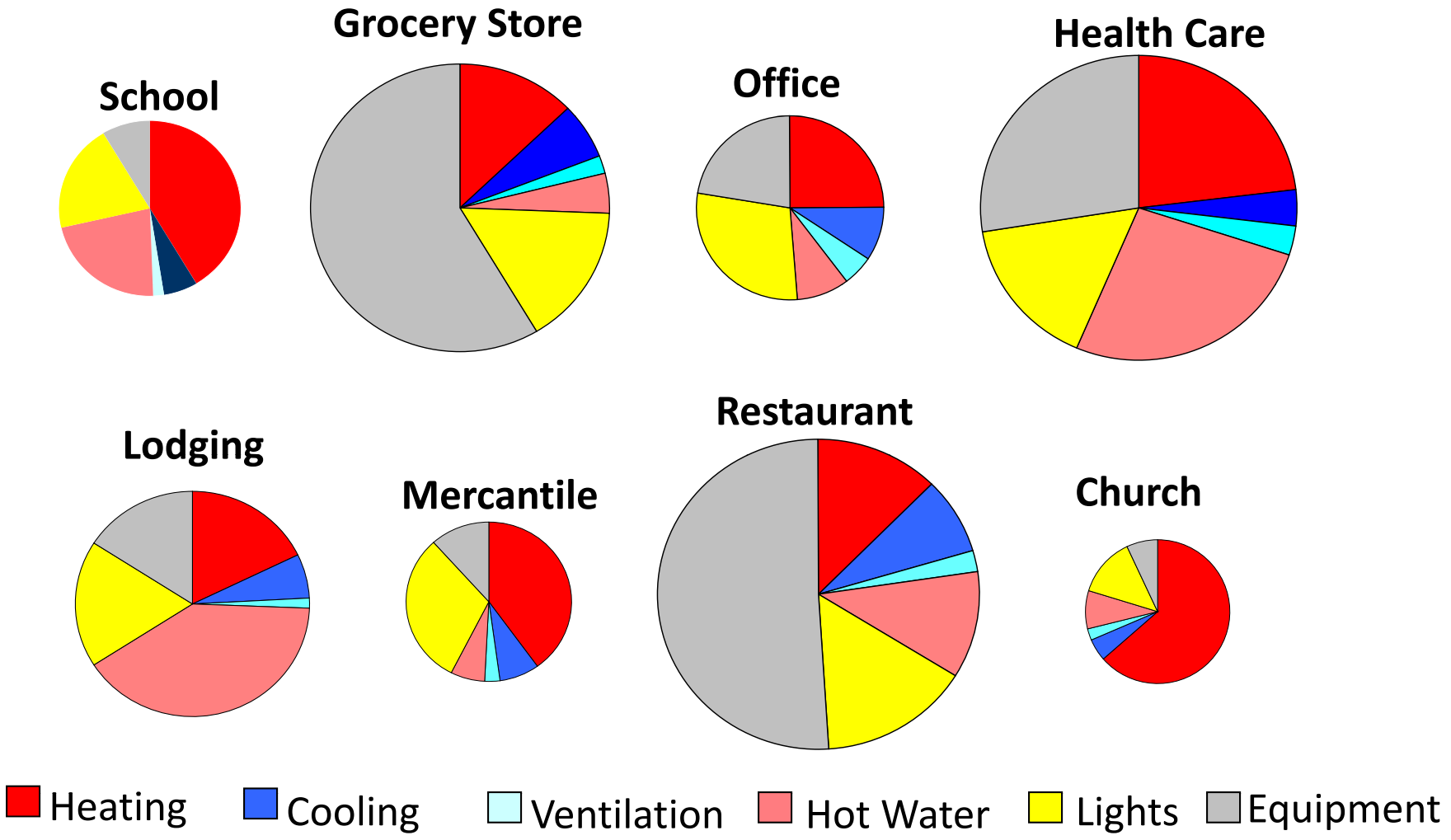
Strive for 40-70% energy reduction

$1 spent on EE lighting = $6 of PV (an NPS project)

$1 spent on EE refrigeration = $2 of PV (an NPS project)

$1 spent on EE = $2 spent on RE (EIA Press Release Aug 2011)

Building Energy Use



NREL
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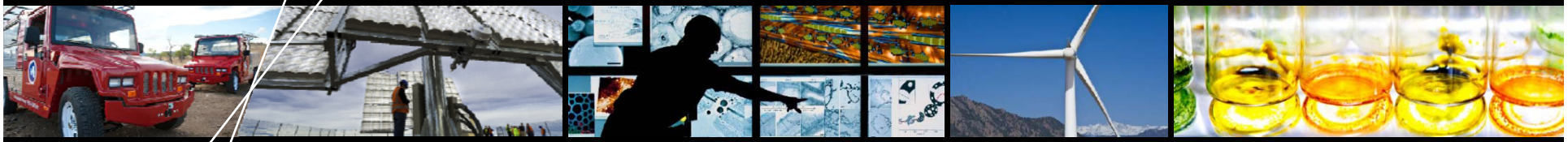


Photovoltaics

Photovoltaics (PV)

Pix 18481

- **Photovoltaic cells directly transform solar energy to an electrical energy**
- **DC converted to AC by inverter**
- **Solid-state electronics, no-moving parts**

Flat Plate PV Systems

Arizona Public Service, Prescott, AZ

Pix 13739

Dangling Rope Marina, Glen Canyon
National Recreation Area, UT

Pix 7990

Alamosa PV System, Alamosa, CO

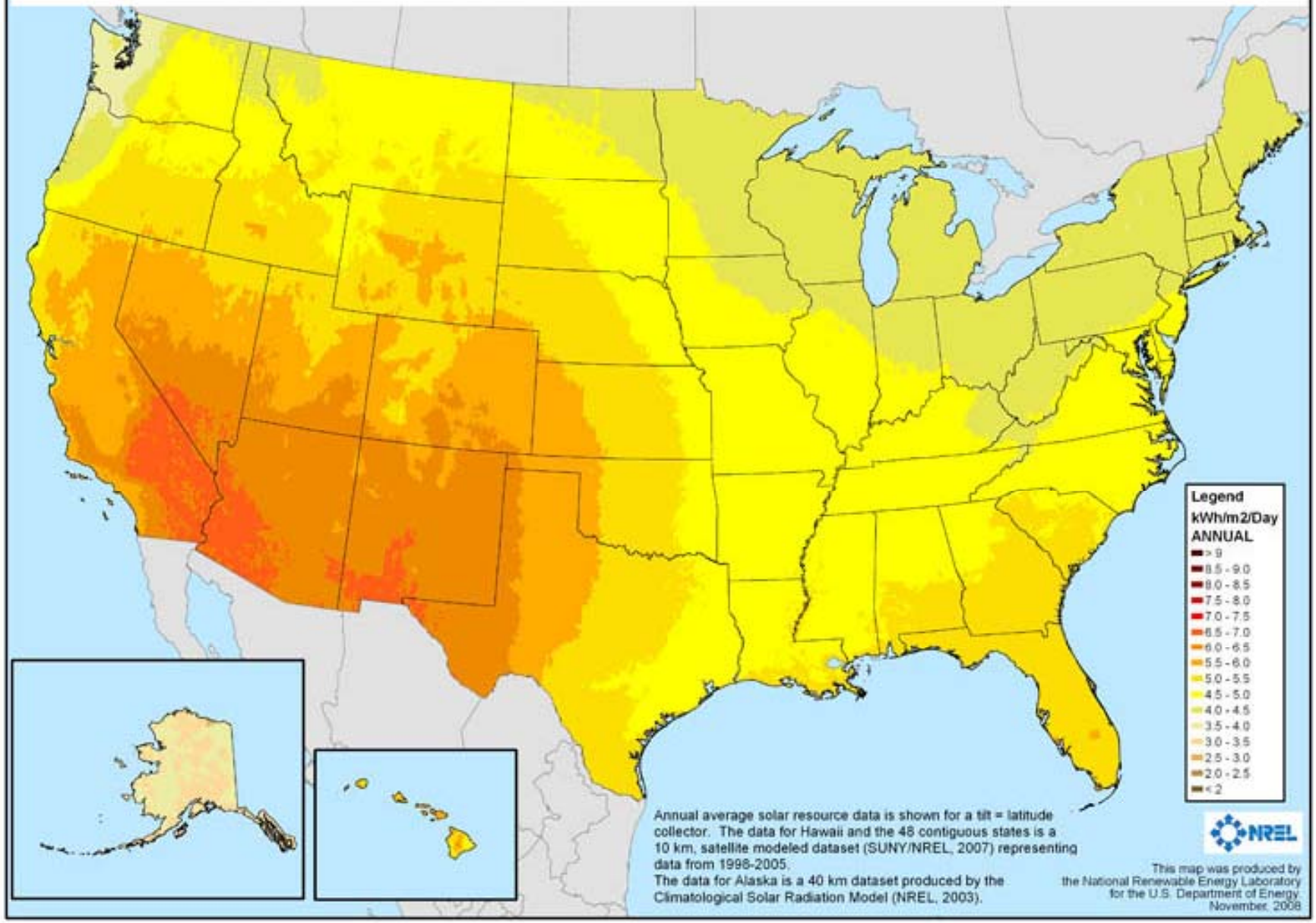
Pix 15558

5 – 10 acres per MW for PV systems

Land can be left as is or graded

Photovoltaic Solar Resource:
Flat Plate Tilted South at Latitude

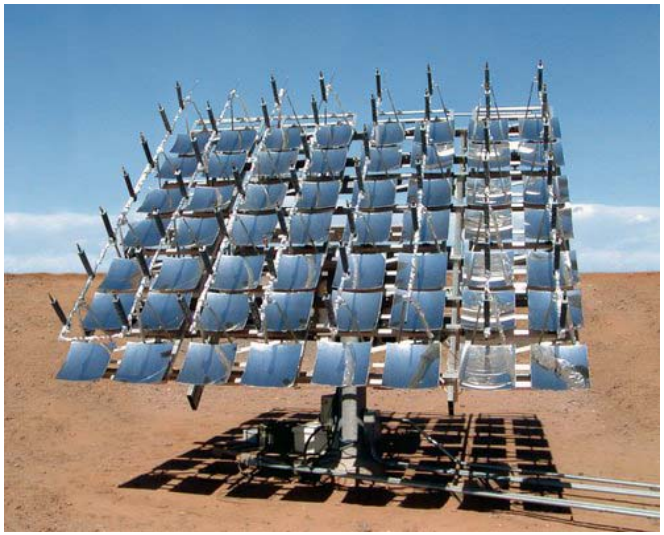
Annual



Concentrating PV Systems

Reflective

Pix 13739



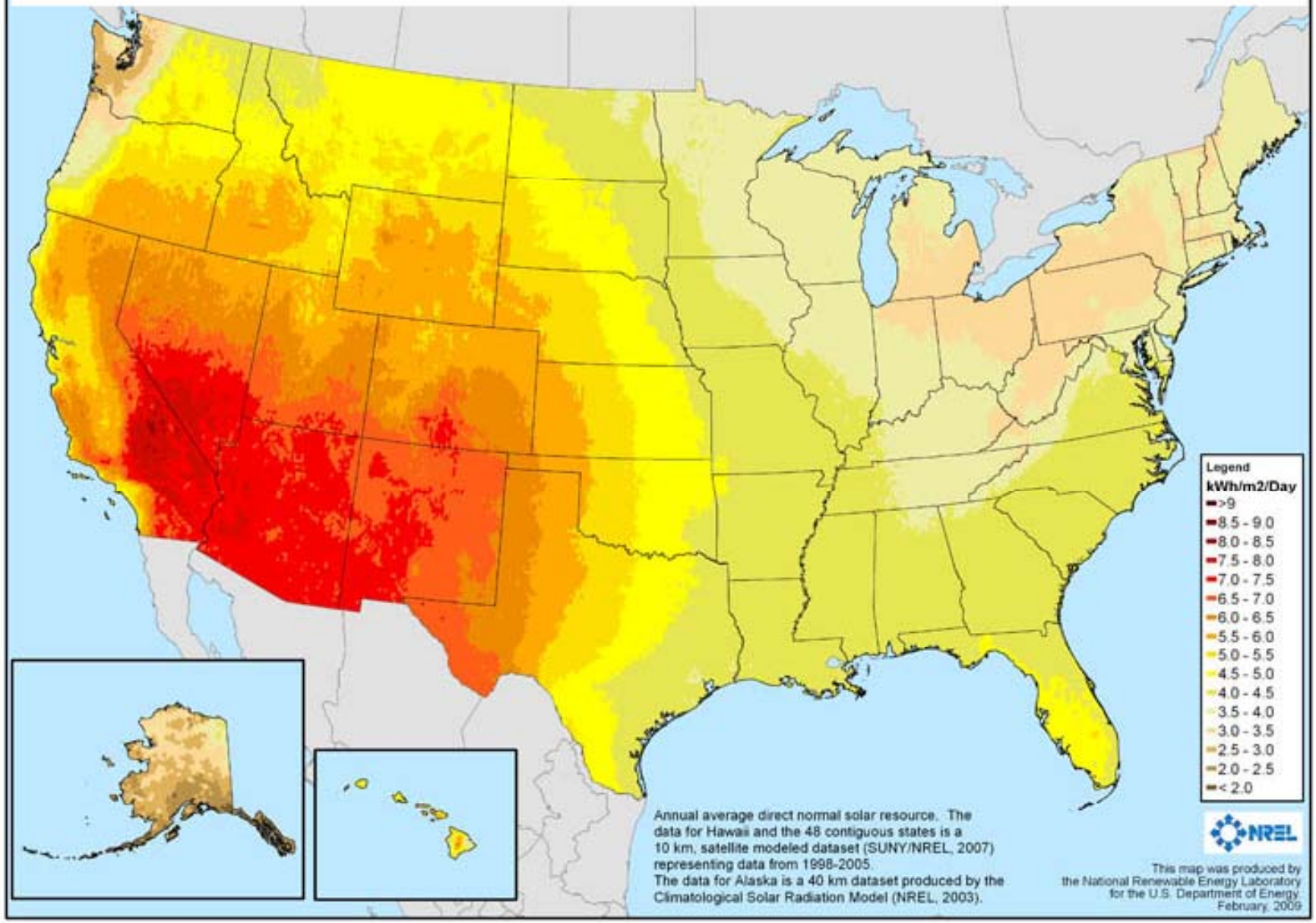
Pix 13740

Refractive

Pix 19119

Concentrating Solar Resource: Direct Normal

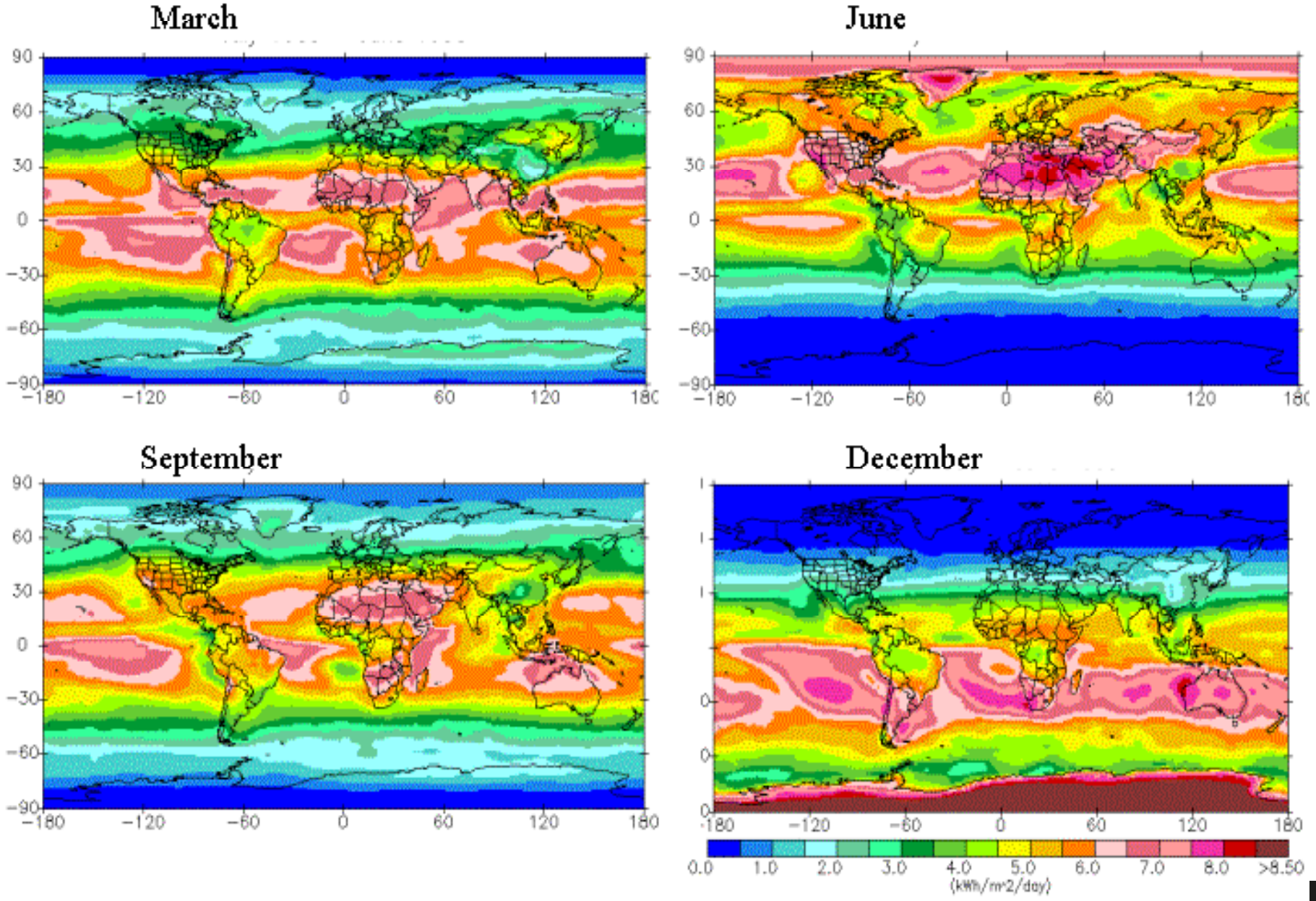
Annual

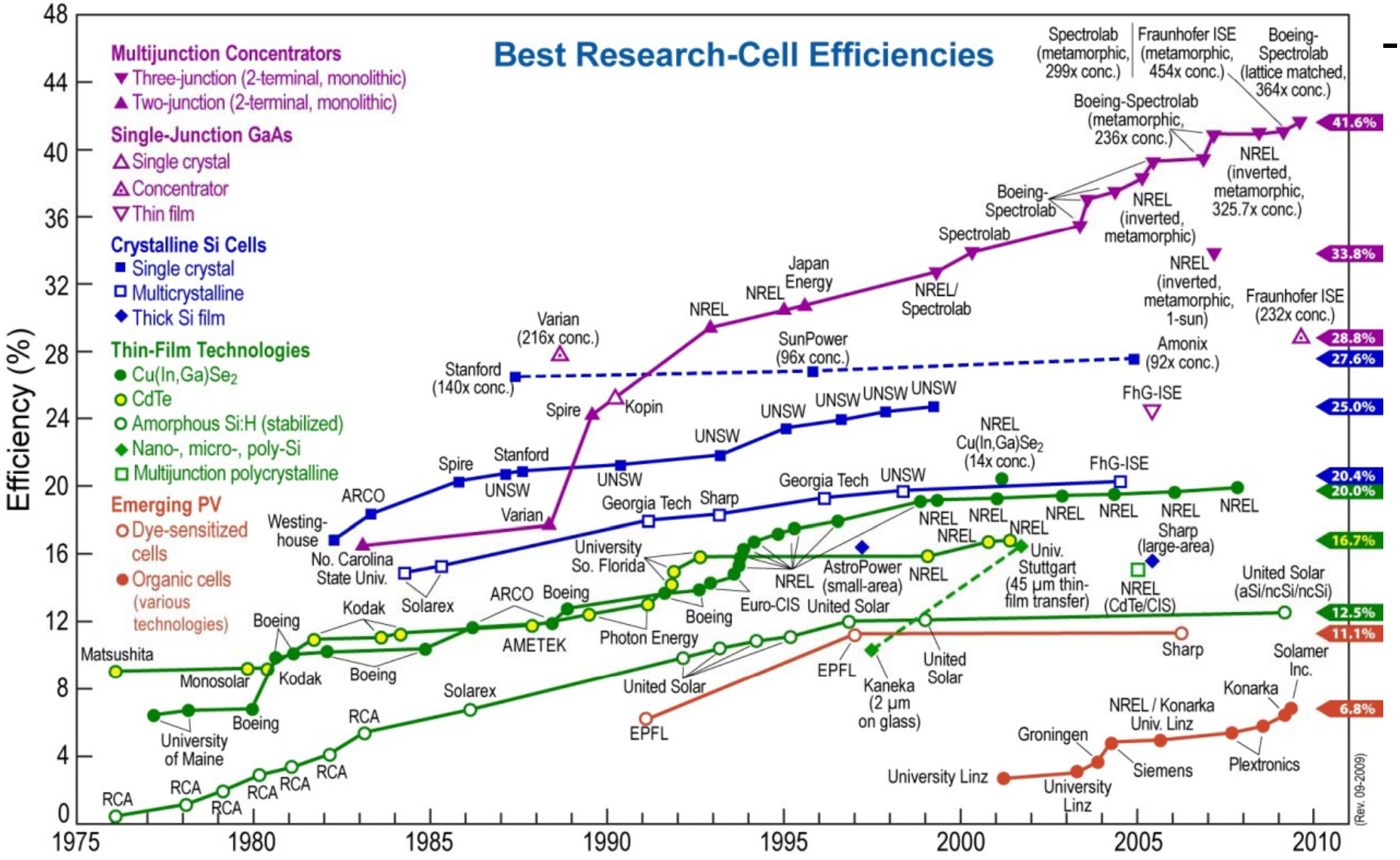


Annual average direct normal solar resource. The data for Hawaii and the 48 contiguous states is a 10 km, satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.
The data for Alaska is a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

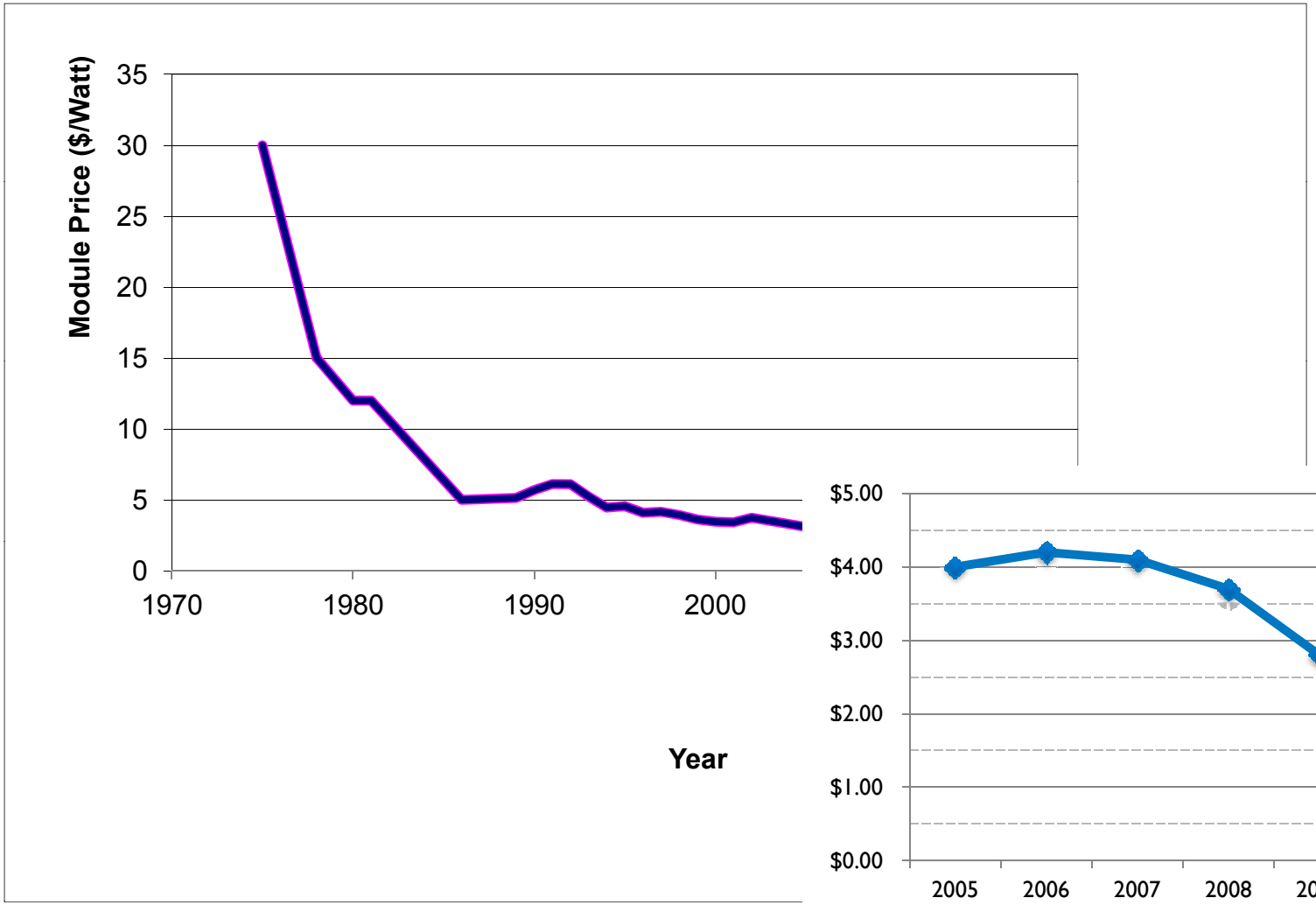
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy. February, 2009

Seasonal Solar Resource

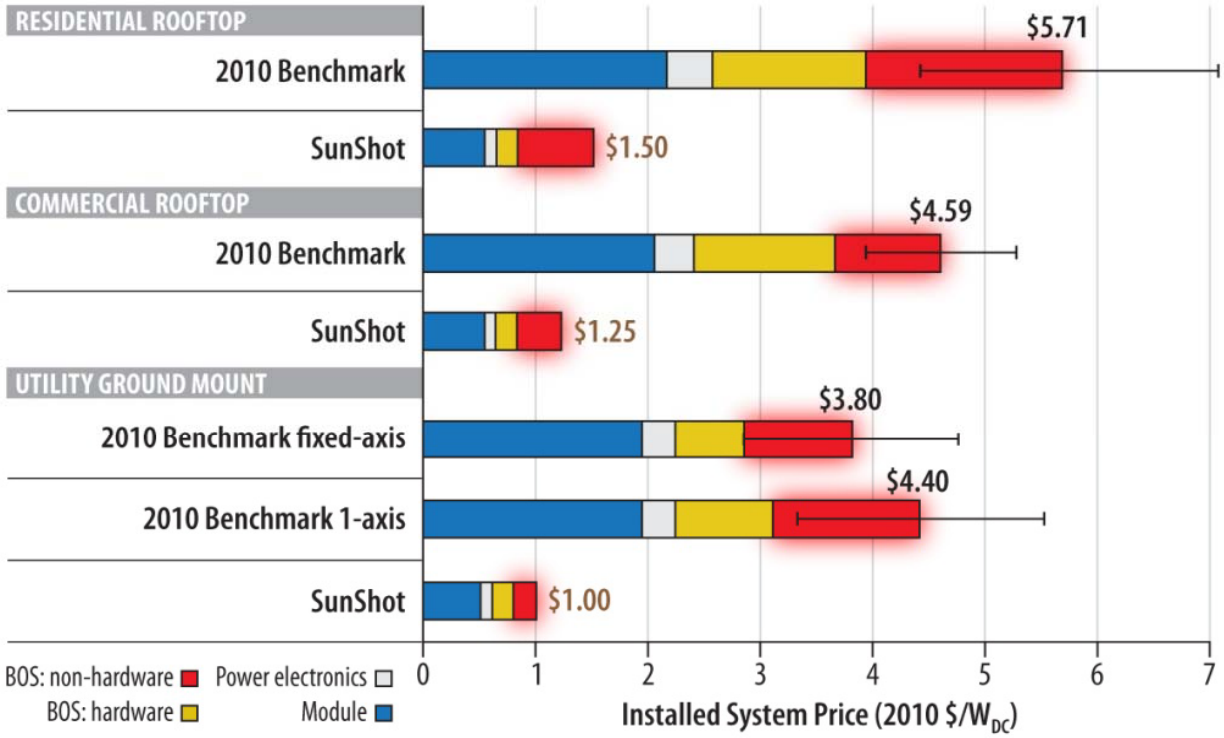



Best Research-Cell Efficiencies
Efficiency (%)
Multijunction Concentrators
Three-junction (2-terminal, monolithic)
Two-junction (2-terminal, monolithic)
Single-Junction GaAs
Single crystal
Concentrator
Thin film
Crystalline Si Cells
Single crystal
Multicrystalline
Thick Si film
Thin-Film Technologies
Cu(In,Ga)Se2
CdTe
Amorphous Si:H (stabilized)
Nano-, micro-, poly-Si
Multijunction polycrystalline
Emerging PV
Dye-sensitized cells
Organic cells (various technologies)
Spectrolab (metamorphic, 299x conc.)
Fraunhofer ISE (metamorphic, 454x conc.)
Boeing-Spectrolab (lattice matched, 364x conc.)
Boeing-Spectrolab (metamorphic, 236x conc.)
NREL (inverted, metamorphic, 325.7x conc.)
Boeing-Spectrolab
NREL (inverted, metamorphic)
Spectrolab
NREL/ Spectrolab
NREL (inverted, metamorphic, 1-sun)
Fraunhofer ISE (232x conc.)
Japan Energy
NREL
Varian (216x conc.)
SunPower (96x conc.)
Amonix (92x conc.)
Stanford (140x conc.)
FhG-ISE
Spire
Kopin
UNSW
NREL Cu(In,Ga)Se2 (14x conc.)
Spire
Stanford
UNSW
ARCO
Georgia Tech
Sharp
Westing-house
Varian
No. Carolina State Univ.
Solarex
University So. Florida
AstroPower (small-area)
Univ. Stuttgart (45 µm thin-film transfer)
Sharp (large-area)
NREL (CdTe/CIS)
United Solar (aSi/ncSi/ncSi)
Euro-CIS
United Solar
Kodak
Boeing
ARCO
AMETEK
Photon Energy
Matsushita
Monosolar
Kodak
Boeing
Solarex
United Solar
EPFL
Kaneka (2 µm on glass)
United Solar
Sharp
Solamer Inc.
University of Maine
Boeing
RCA
Solarex
NREL / Konarka Univ. Linz
Konarka
Groningen
Siemens
Plextronics
University Linz
University Linz
RCA
RCA
RCA
RCA
RCA
RCA
41.6%
33.8%
28.8%
27.6%
25.0%
20.4%
20.0%
16.7%
12.5%
11.1%
6.8%
(Rev. 09-2009)
1975
1980
1985
1990
1995
2000
2005
2010
0
4
8
12
16
20
24
28
32
36
40
44
48

Price of PV Modules



PV Cost, O&M, and Efficiency



PV System Type	Annual O&M Cost as a Percentage of Installed Cost
Ground Mounted - Fixed	0.17%
Ground Mounted - Tracking	0.35%

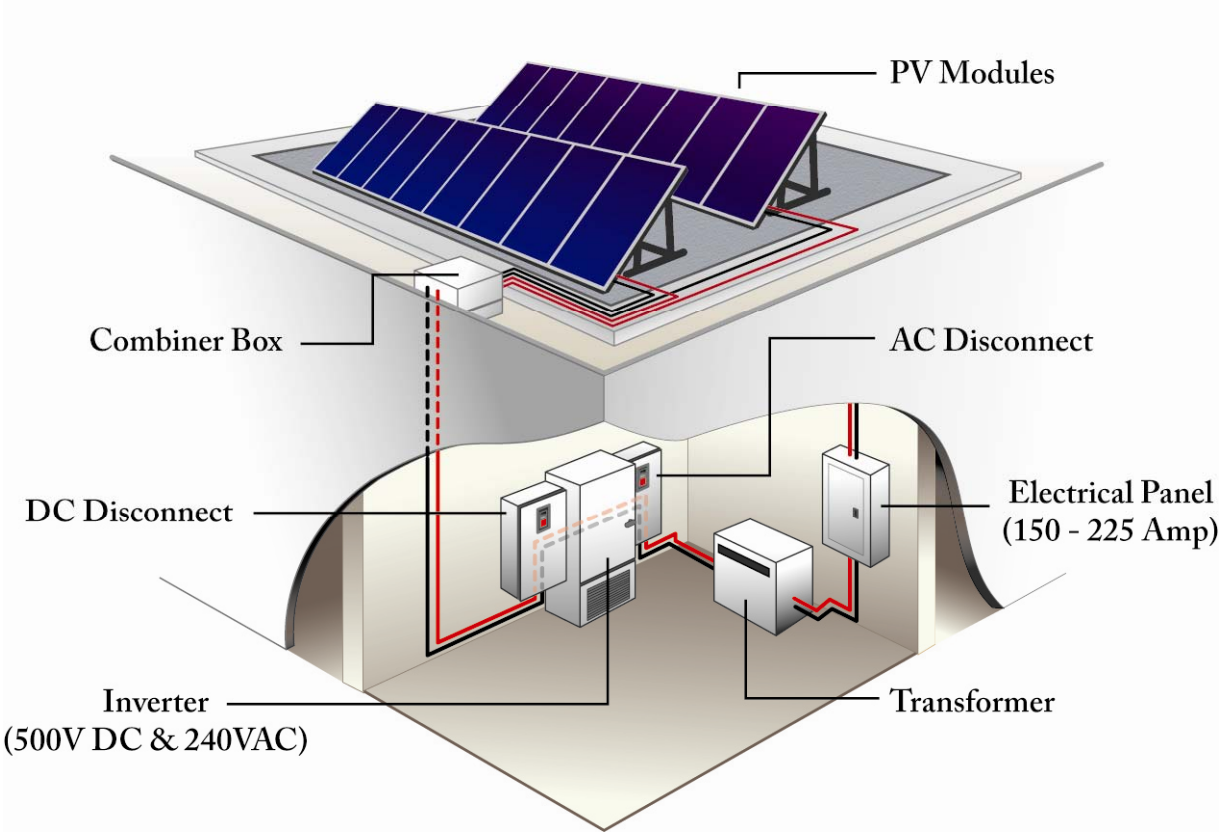
Efficiency= power out/power in

Module Efficiencies	Single Crystal	14-19%
	Multi Crystal	13-17%
	Thin Film	6-11%
Balance of System Efficiency		77%

Efficiency versus Size

- 1 kW of 15% eff. crystalline 71ft^2
- 1 kW of 9.5 % eff. amorphous 99ft^2
- 1 kW of 19.3% eff. hybrid 55ft^2

Grid Connect PV System



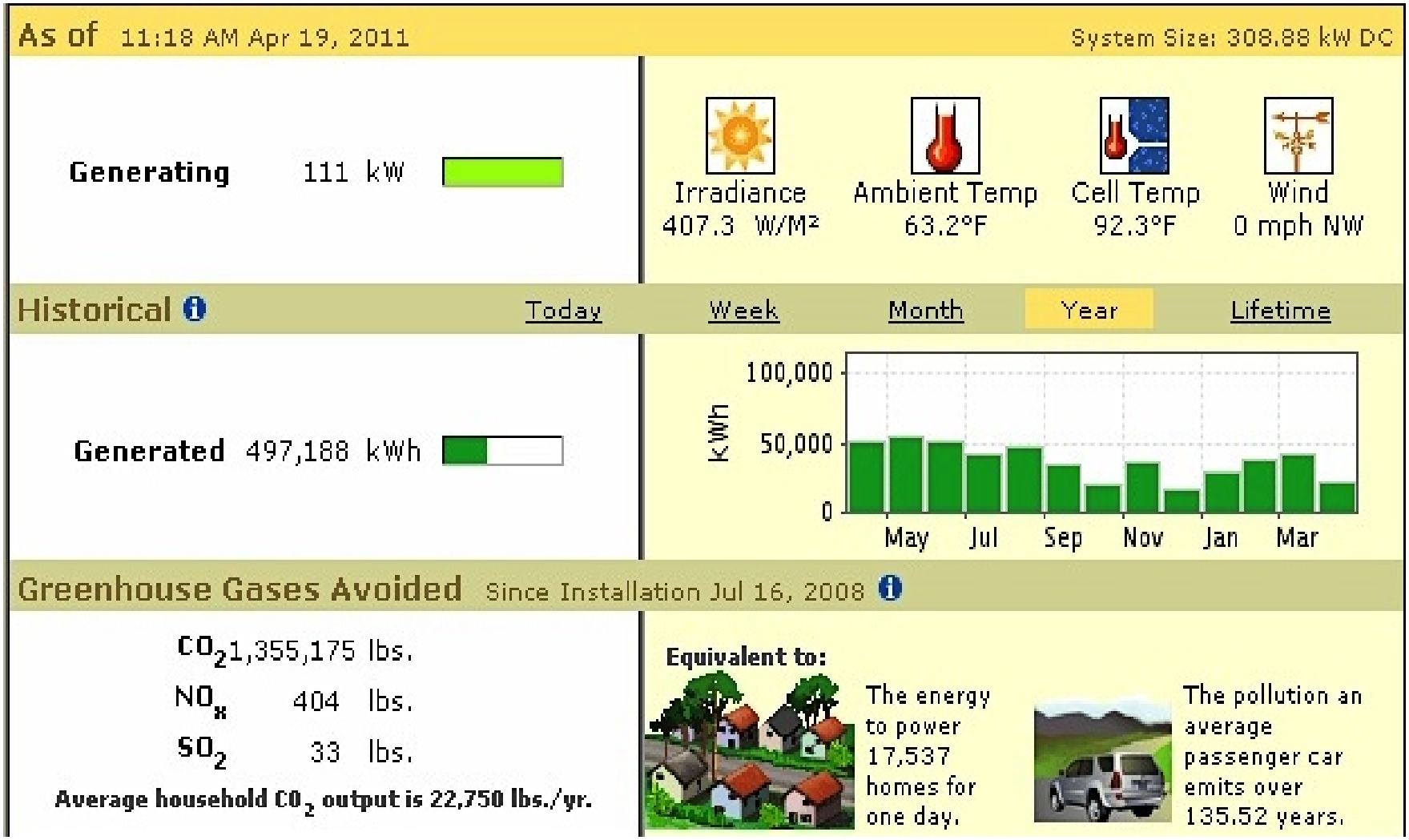
Source: Jim Leyshon, NREL

Veterans Administration - Jerry L. Pettis Memorial Medical Center in Loma Linda, CA

Photo by Andy Walker

- 309 kWdc
- 1,584 PV modules
- SunLink racks minimum roof penetration
- Advanced Energy Solaron 333kW inverter
- Feasibility Study by NREL estimates: 475 MWh/year delivery; $60k/year savings; $2 million cost without any incentives
- Procured off GSA Schedule for complete PV systems

Results
Veterans Administration, Loma Linda, CA



Source: Fat Spaniel Technologies, courtesy Sunwize Inc.

Building-Integrated Photovoltaics

Glazing

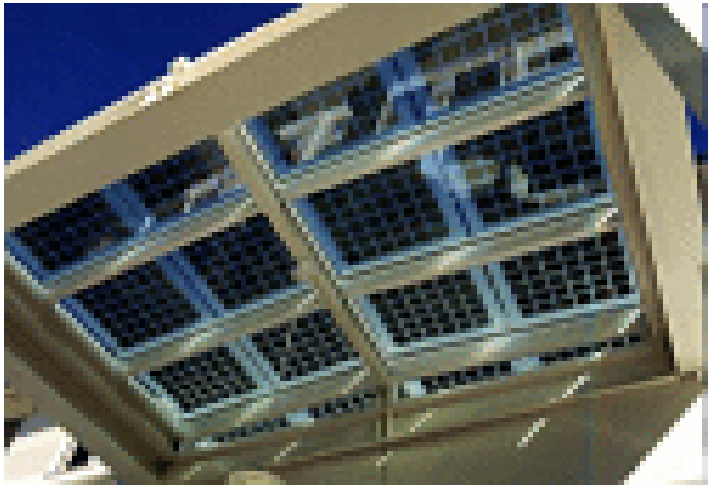
Shingles

Standing Seam

Single-Ply

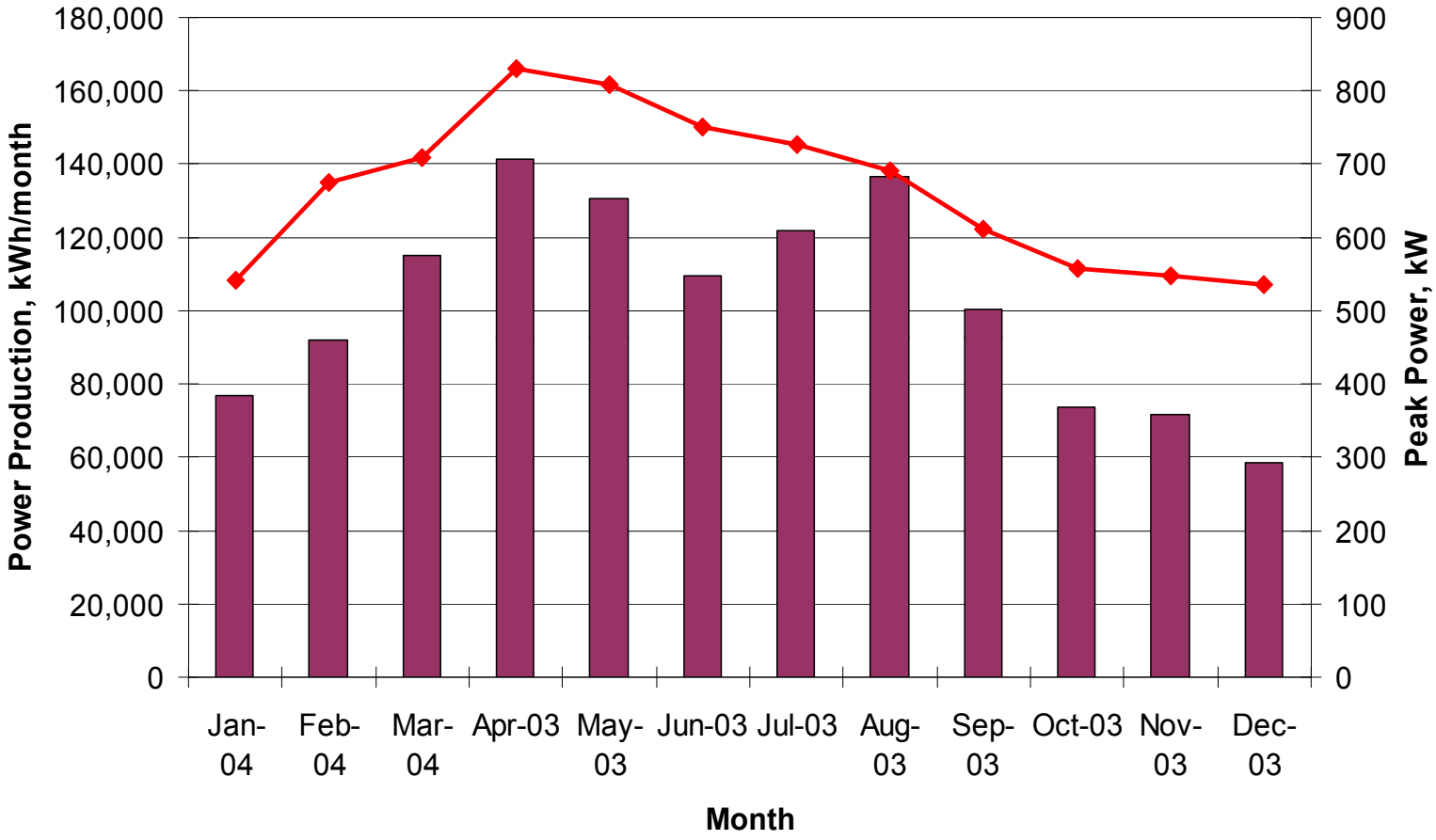
Building Integrated PV Example: Presidio Thoreau Center

- Building-Integrated Photovoltaics
- 1.25 kW PV Array
- Spacing between cells admits daylight into entry atrium below



Example: Coronado Island CA
924 kW, cost $7.7 million

Coronado Island CA - PV System Performance

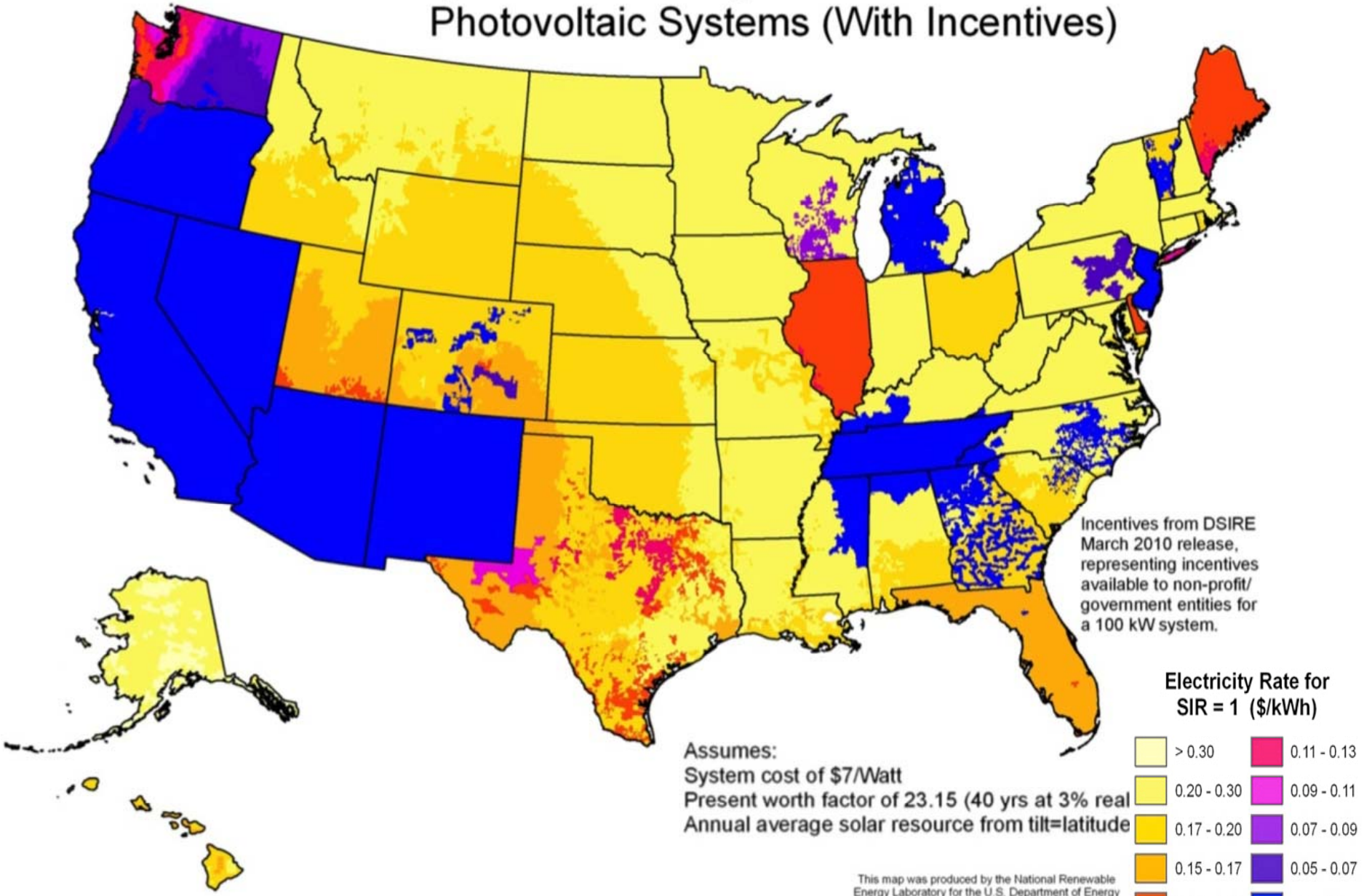


829 kW AC maximum delivery

1,228,658 kWh/year delivery

Photovoltaics on RSF

Electricity Rate for Savings-to-Investment Ratio = 1 for Photovoltaic Systems (With Incentives)



Where to Install Solar

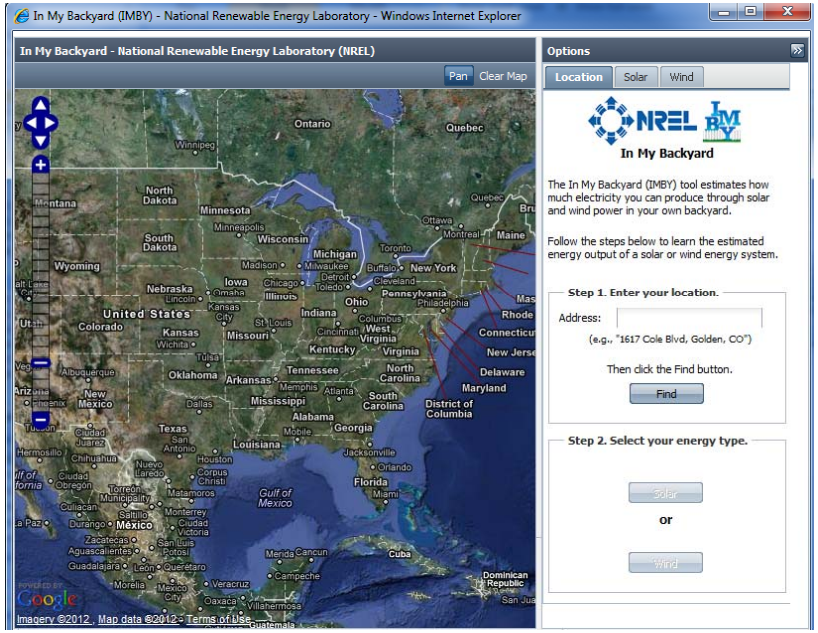
- **On the "Built Environment" where unshaded**
  - On existing building roofs that have an expected life of at least 15 more years and can accept added load. Reduces solar load on building. NEPA categorical exclusion.
  - On ALL new buildings – all new building should be "solar ready"
    - See http://www.nrel.gov/docs/fy10osti/46078.pdf
  - Over parking areas, pedestrian paths, etc. – energy generation and nice amenity.
- **On compromised lands such as landfills & brownfields.**
  - Saves green fields for nature.
  - IF installed on green fields minimize site disturbance, plant native low height vegetation as needed.

Photovoltaics Resources

- **Solar Energy Resources**
  - NREL
    - http://www.nrel.gov/rredc/
  - Firstlook
    - http://firstlook.3tiergroup.com/
  - TMY or Weather Data
    - http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

- **State and Utility Incentives and Utility Policies**
  - http://www.dsireusa.org

- **Solar PV Analytical Tools**
  - Solar Advisor Model (SAM)
    - https://www.nrel.gov/analysis/sam/
  - HOMER
    - https://analysis.nrel.gov/homer/
  - PVWatts
    - http://www.nrel.gov/rredc/pvwatts/
  - RETScreen
    - http://www.retscreen.net/
  - IMBY
    - http://www.nrel.gov/eis/imby/



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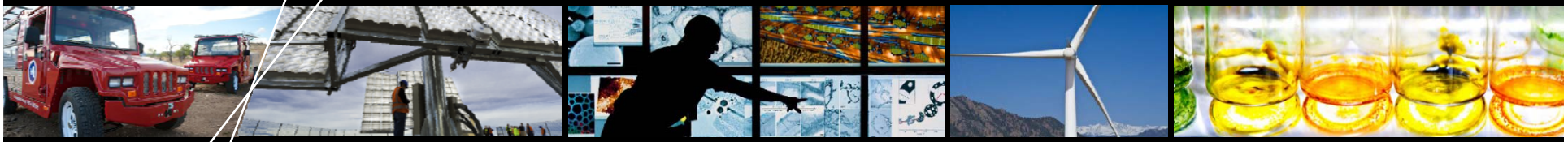


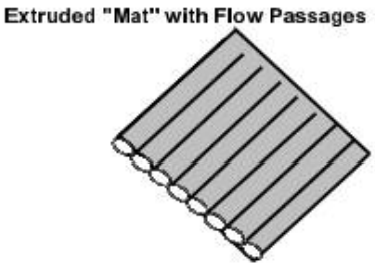
Solar Water Heating

Solar Water Heating Applications

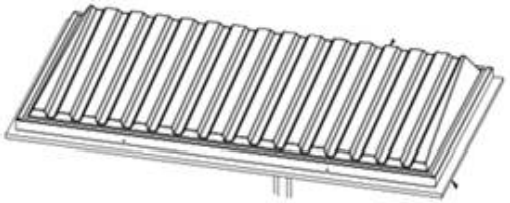
- **Low Temperature**
  - Swimming pool heating
- **Medium Temperature**
  - Domestic water and space heating
  - Commercial cafeterias, laundries, hotels
  - Industrial process heating
- **High Temperature**
  - Industrial process heating
  - Electricity generation

Solar Thermal Collector Types

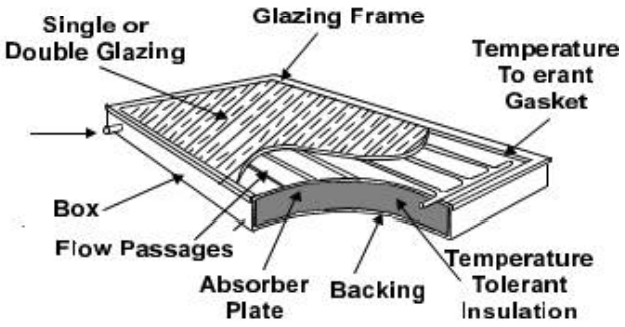
1. Unglazed



2. Low-Cost Plastic Flat Plate

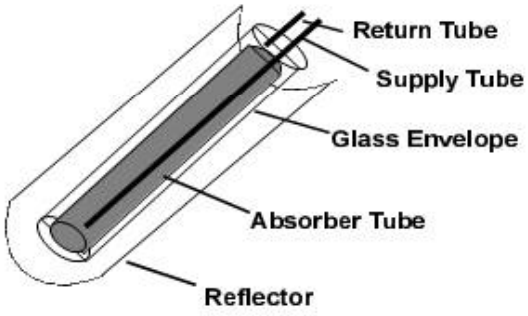


3. Glazed, Insulated Flat Plate



4. Integral Collector Storage (ICS)

5. Evacuated Tube



6. Parabolic Trough

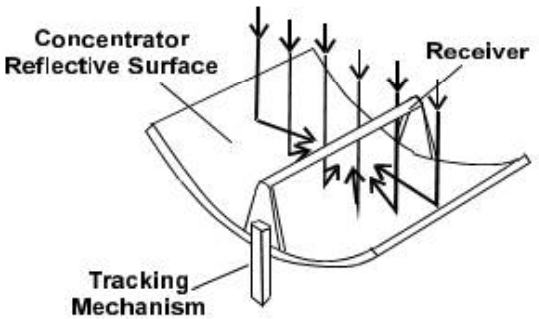


Figure by Jim Leyshon

Solar Water Heating System

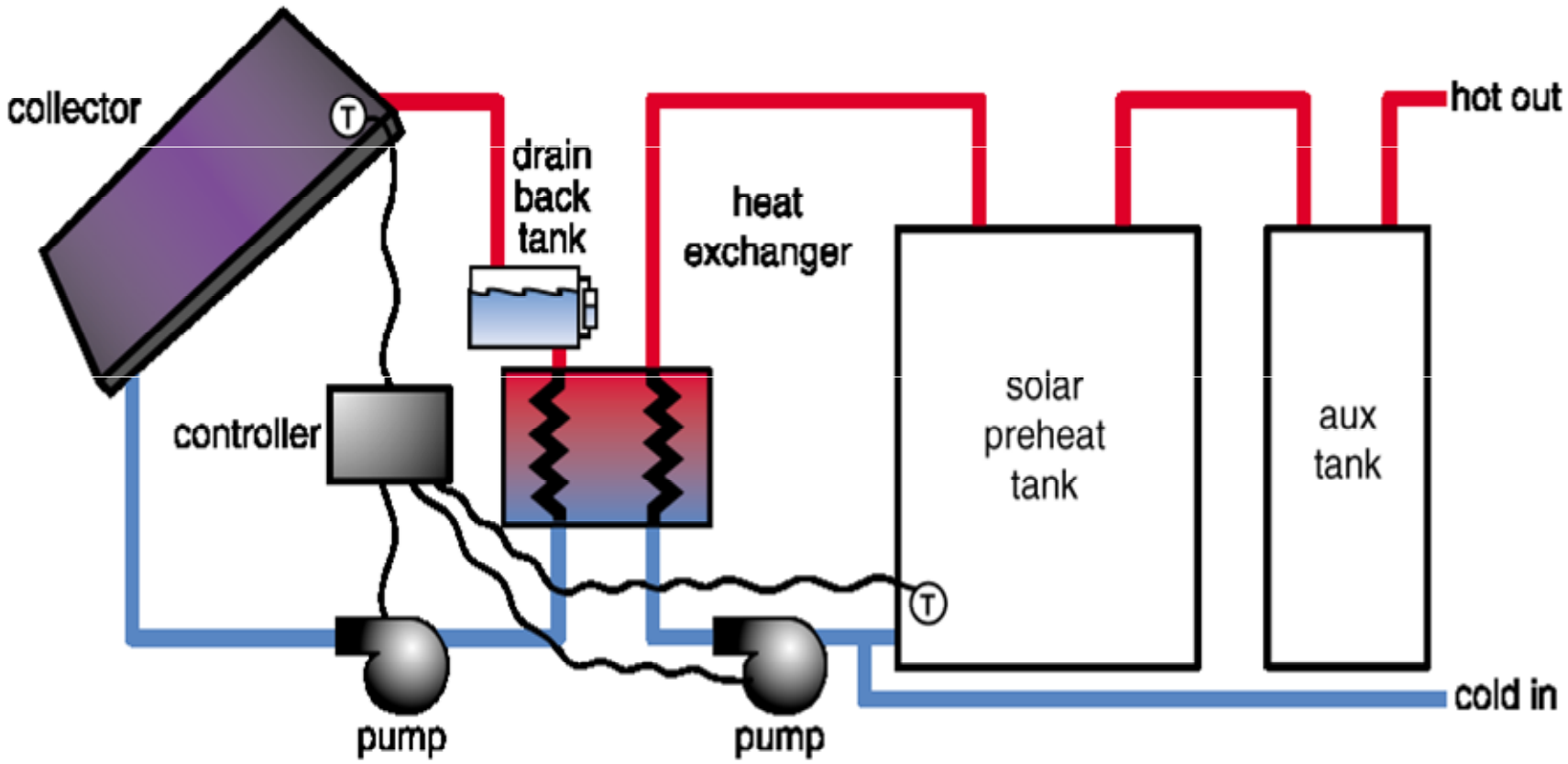
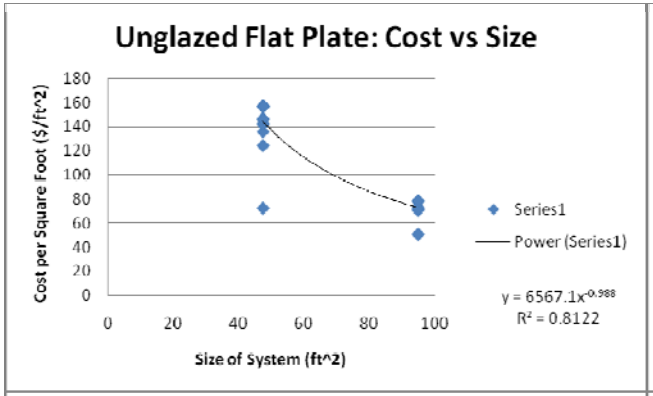
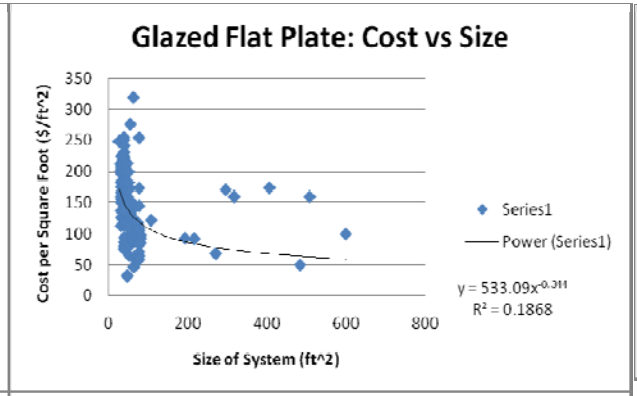
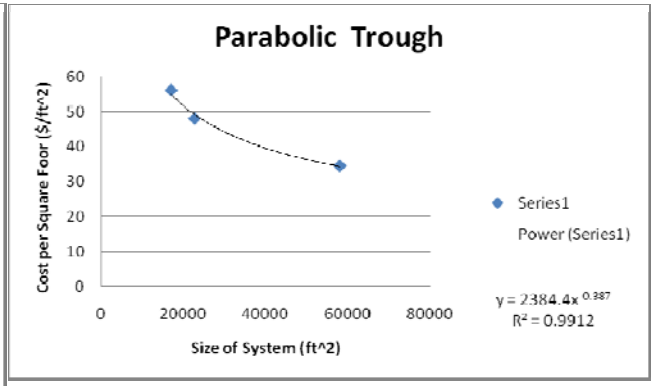


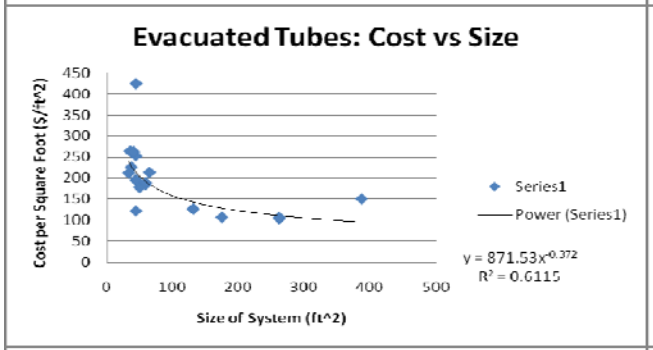
Figure by Jim Leyshon

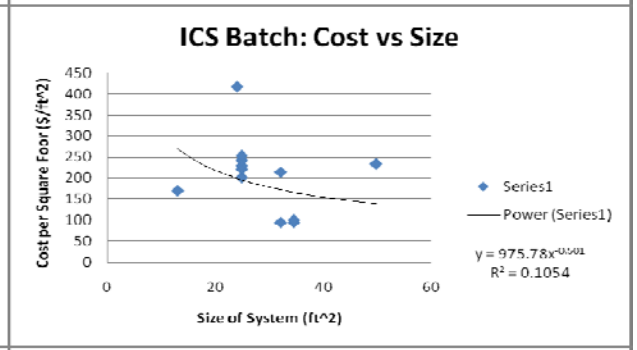
Solar Water Heating System Cost

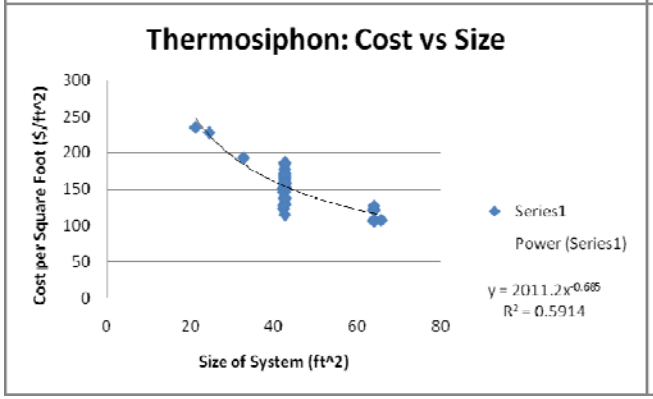


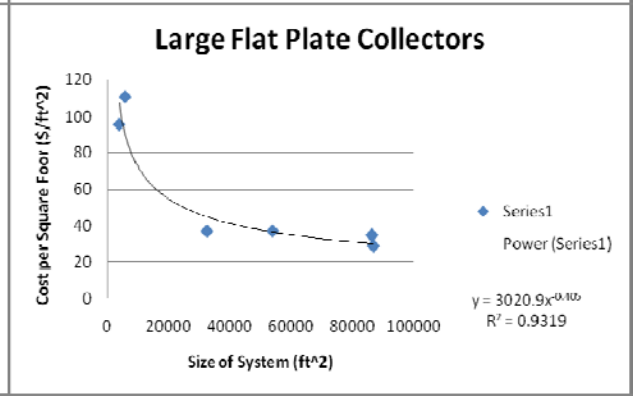












Average:
Around $150/sf

USCG Housing, Honolulu HI

Photp by Andy Walker

- 62 units installed 1998
- Savings of 9,700 kWh/yr and $822/yr per system
- $4000/system cost
- Simple payback of 4 years (with rebate)

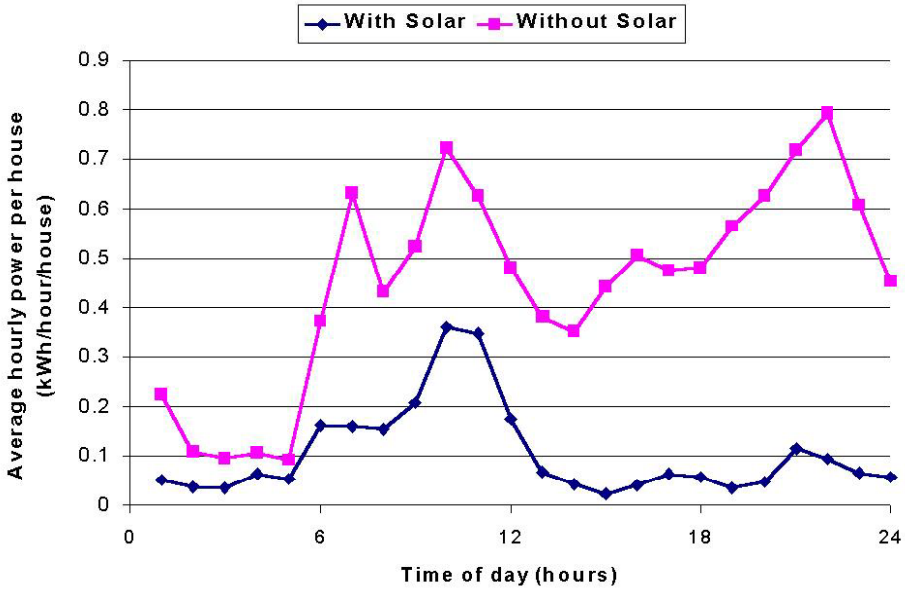
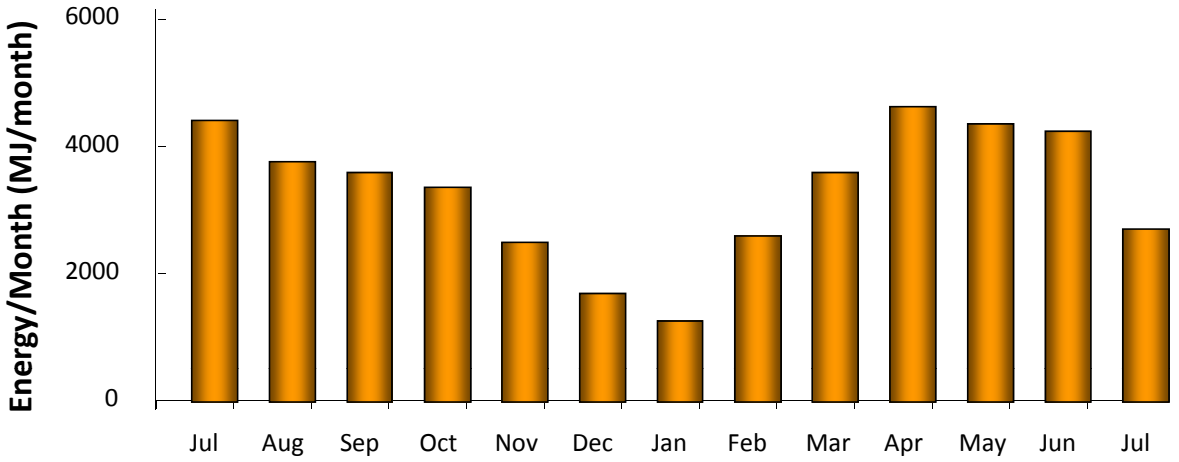


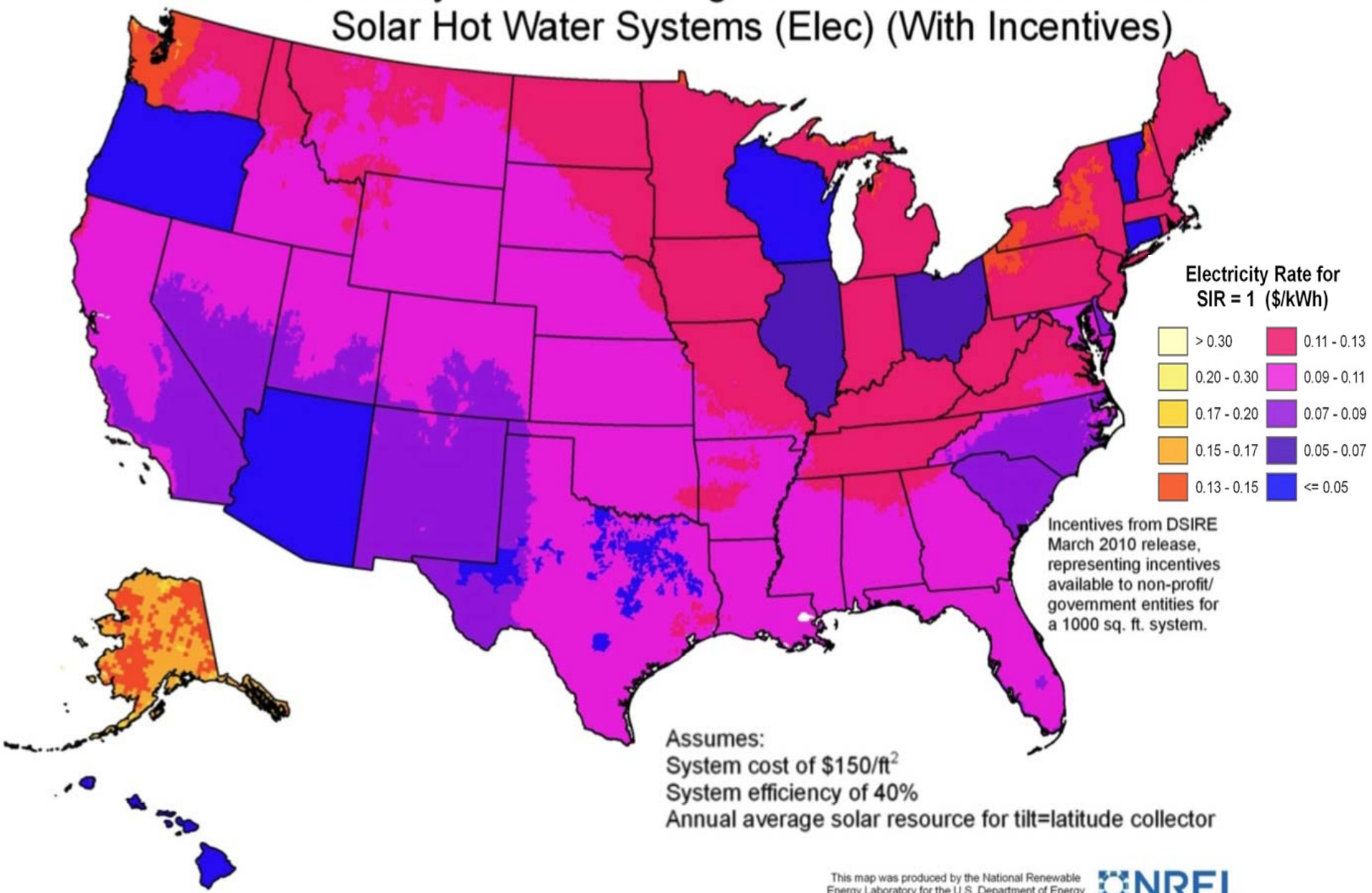
Figure by Andy Walker

Solar Water Heating Case Study:
Social Security Administration Building, Philadelphia, PA

- Reheats recirculation loop
- 180 evacuated heat-pipe collector tubes
- 27 m2 gross area
- Cost $37,500
- Delivers 38 GJ (36 million Btu)/year
- Installed 2004



Electricity Rate for Savings-to-Investment Ratio = 1 for Solar Hot Water Systems (Elec) (With Incentives)



This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy
Map created by Donna Heimiller - Oct. 7, 2010

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Solar Water Heating Resources

- **Design Tools**
  - RETScreen - Solar Hot Water
    - http://www.retscreen.net/ang/g_solarw.php

- **Fchart – Active and Passive Systems Analysis**
  - http://www.fchart.com/fchart/

- **Resources**
  - DOE Energy Efficiency and Renewable Energy Solar Energy Technologies Program
    - http://www1.eere.energy.gov/solar/solar_heating.html
  - FEMP Federal Technology Alerts
    - www.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf
    - www.eere.energy.gov/femp/pdfs/FTA_para_trough.pdf
  - FEMP Case Studies
    - www.eere.energy.gov/femp/technologies/renewable_casestudies.html
  - Resource maps
    - http://www.nrel.gov/gis/solar.html
  - Solar Radiation Data Manual
    - http://rredc.nrel.gov/solar/pubs/redbook

NREL
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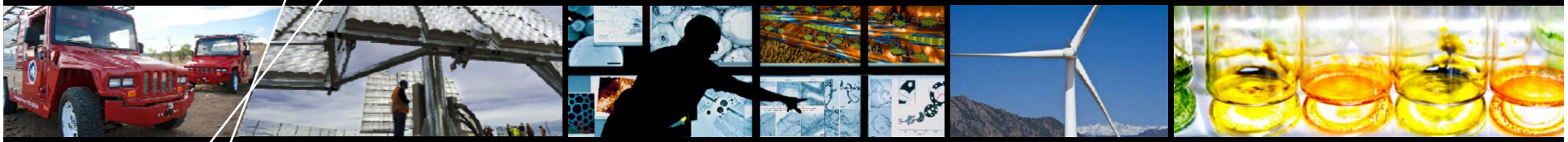


Solar Ventilation Air Pre-heat

Project Considerations

- **Panels are aluminum or steel**
- **Roll-punch slots with three porosity options**
- **Corrugated to increase structural rigidity**

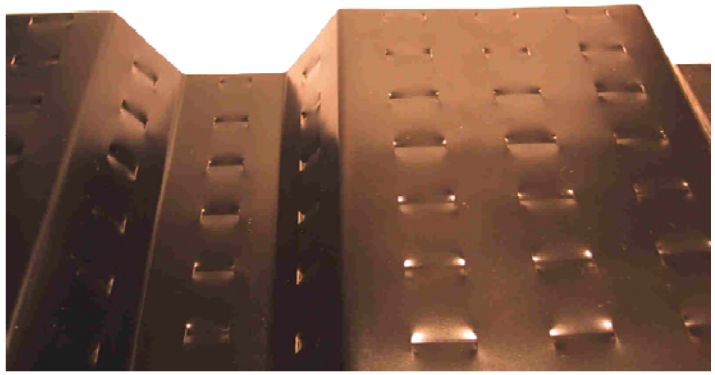
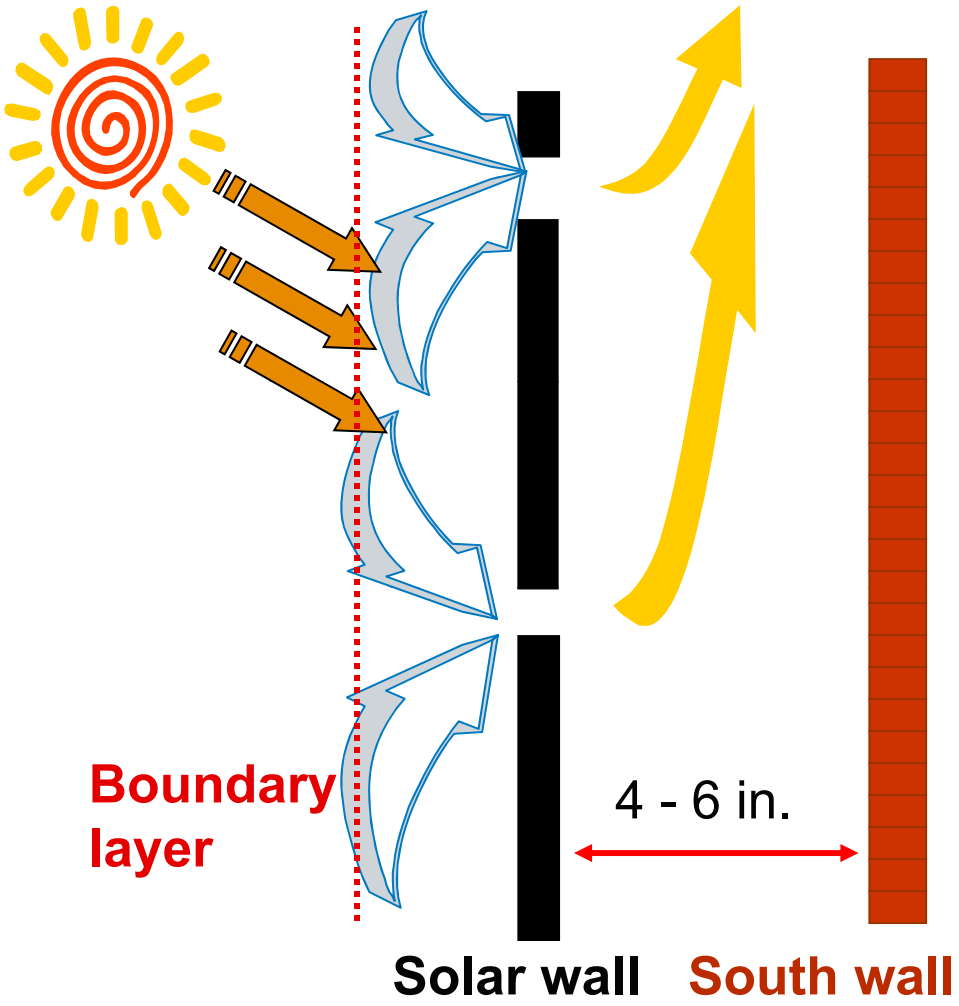


Photo by Andy Walker

Pix 608

- **High outdoor air ventilation requirement in heating dominated climate**
- **South-facing wall surface is best**
  - 45° of south gives 80%
- **Unshaded surface**
  - Especially during low winter sun angles
- **Dark collector color**
  - Black is best, other colors have efficiency loss up to 10%

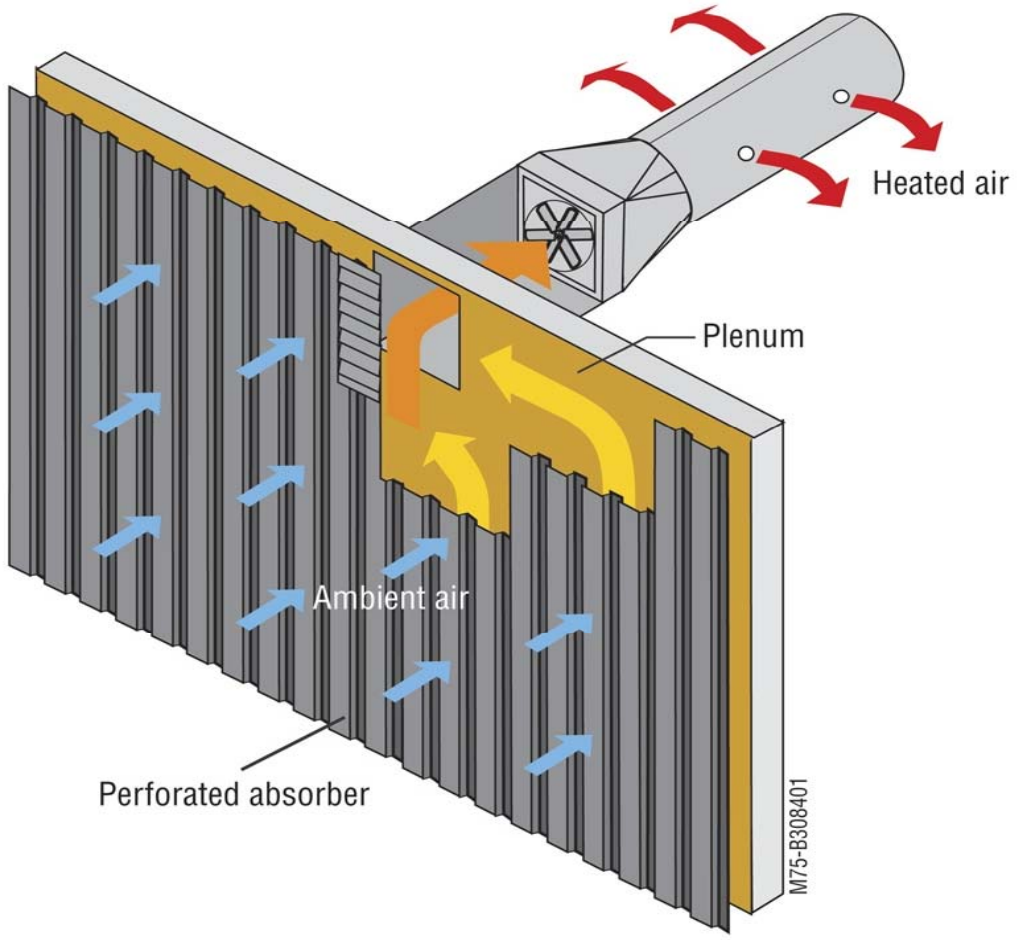
Solar Vent Preheat Principle



- Sun warms the collector surface
- Heat conducts from collector surface to thermal boundary layer of air (1 mm thick)
- Boundary layer is drawn into perforation by fan pressure before heat can escape by convection

System Components

- **Transpired solar collector**
  - Perforated sheet of corrugated metal
- **Air distribution**
  - Ductwork, fan and bypass damper
- **Controls**
  - Temperature and timeclock, or EMCS

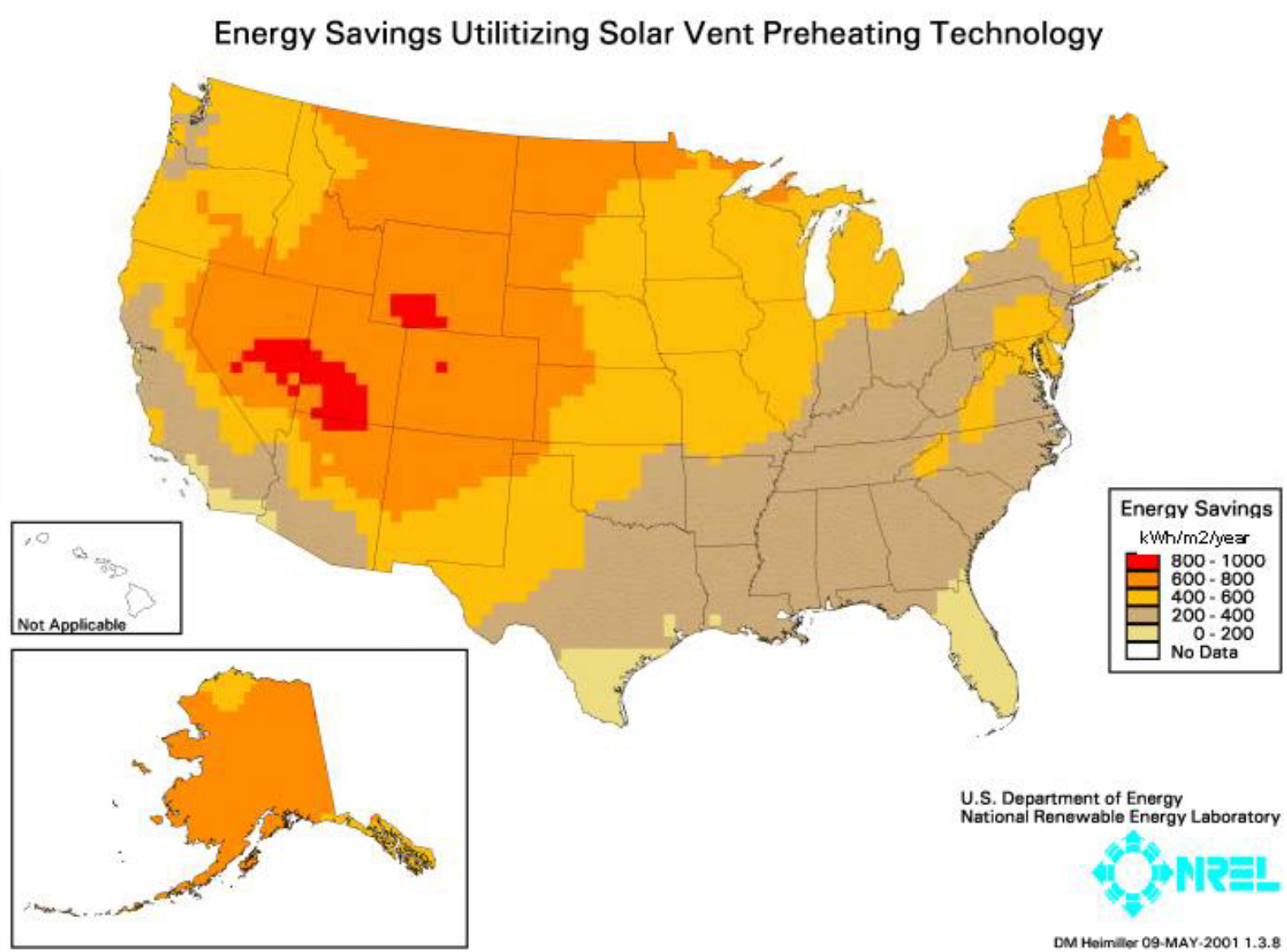


Design Considerations

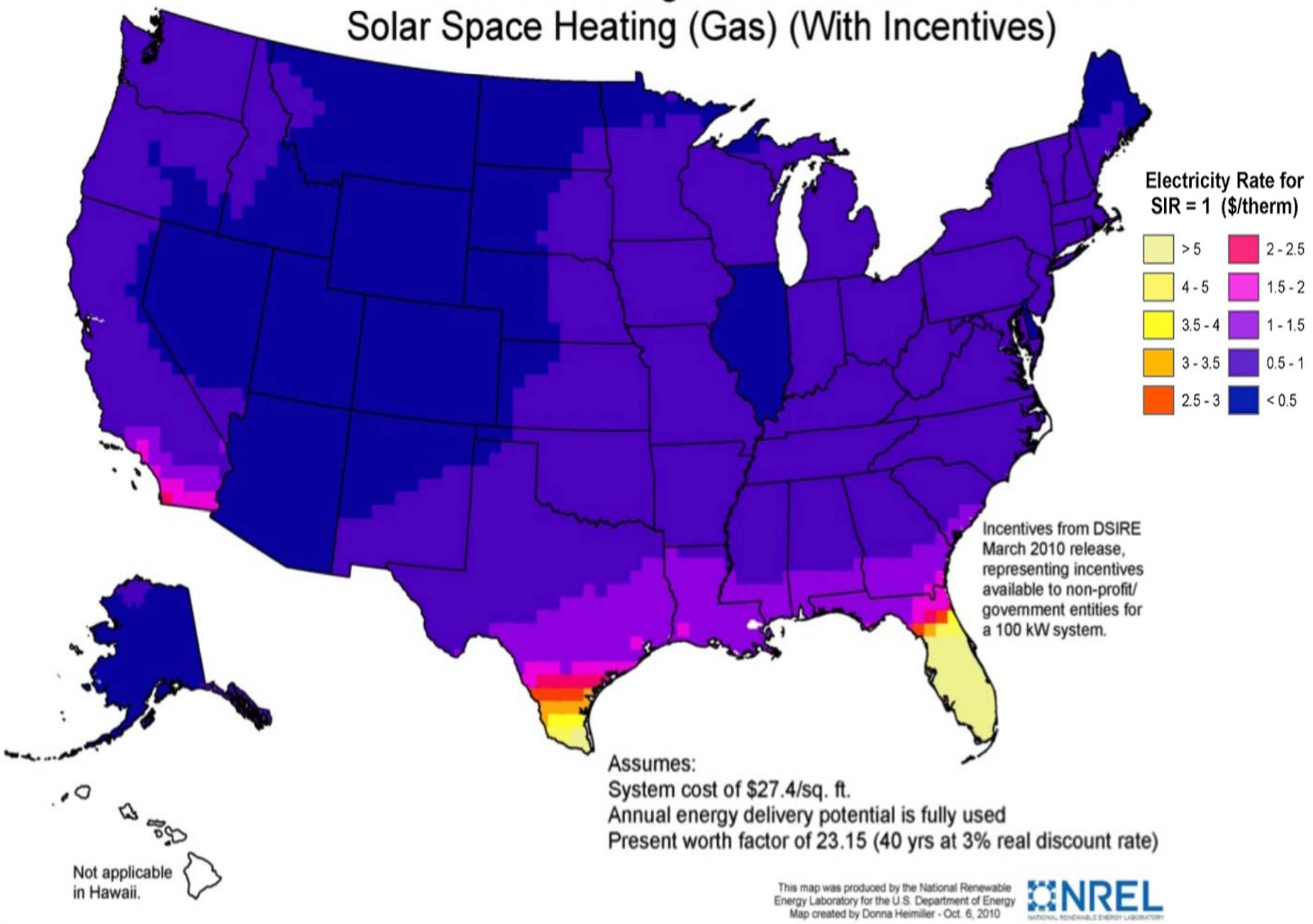
Standard Colors

* Actual colors may differ from displayed colors

Solar Vent Preheat Resource



Energy Rate for Savings-to-Investment Ratio = 1 for Solar Space Heating (Gas) (With Incentives)



Advantages

- **Relatively low cost for on-site renewable energy utilization**
- **Reliability of equipment and system**
  - Only moving part is the fan
  - Operates at ambient temperature
- **Very low maintenance**
- **High efficiency**
- **No storage**

Pix 17424

Pix 17826

Solar Vent Preheat Resources

- **FEMP Federal Technology Alert**
  - www.eere.energy.gov/femp/pdfs/FTA_trans_coll.pdf
  - Solar Ventilation Preheating Resources and Technologies
    - http://www1.eere.energy.gov/femp/technologies/renewable_svp.html
- **NREL**
  - Solar Process Heat
    - http://www.nrel.gov/learning/re_solar_process.html
  - Solar Space Heating Maps
    - http://www.nrel.gov/gis/femp.html#space
- **Conserval Systems, Inc.: SOLARWALL®**
  - www.solarwall.com/sw/solarwall.html
- **ATAS International, Inc.: InSpire™**
  - www.atas.com
- **American Solar Inc.: Solar Thermal Tile System**
  - www.americansolar.com
- **RETScreen® International Clean Energy Project Analysis Software**
  - www.retscreen.net

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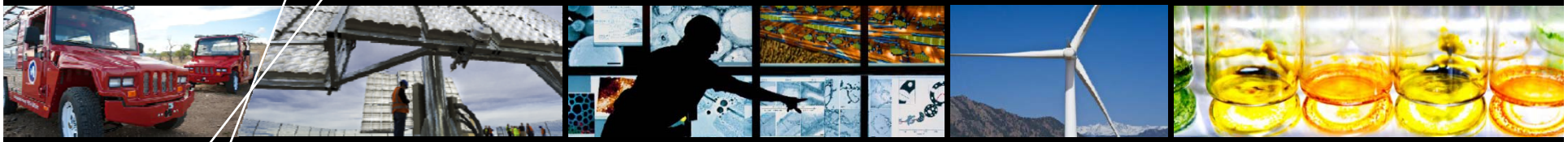

Passive Solar in New Construction

Passive Solar

- **Types:**
  - Direct Gain
  - Sunspace
  - Thermal Storage Wall (Trombe Wall)
- **For new construction, in areas with low internal heat gain**
- **South-facing Solar Apertures**
- **Added thermal mass to absorb heat and release at night**
- **Controls such as operable shades and windows**

Direct Gain NREL

Pix 12573

Trombe Wall, NREL

Pix 1693

Sunspace, NREL

Pix 2194

Daylighting

PIX 17041

- **Lighting accounts for 25% of total electricity used in Federal sector**
- **Daylighting uses windows & skylights in conjunction with automatic light controls to minimize the need for electric lighting during daylight hours**
- **Daylighting combined with lighting controls can reduce lighting energy consumption by 40 -60%**

NREL
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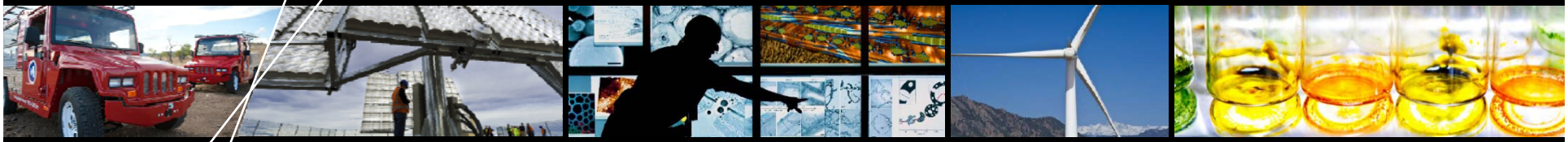
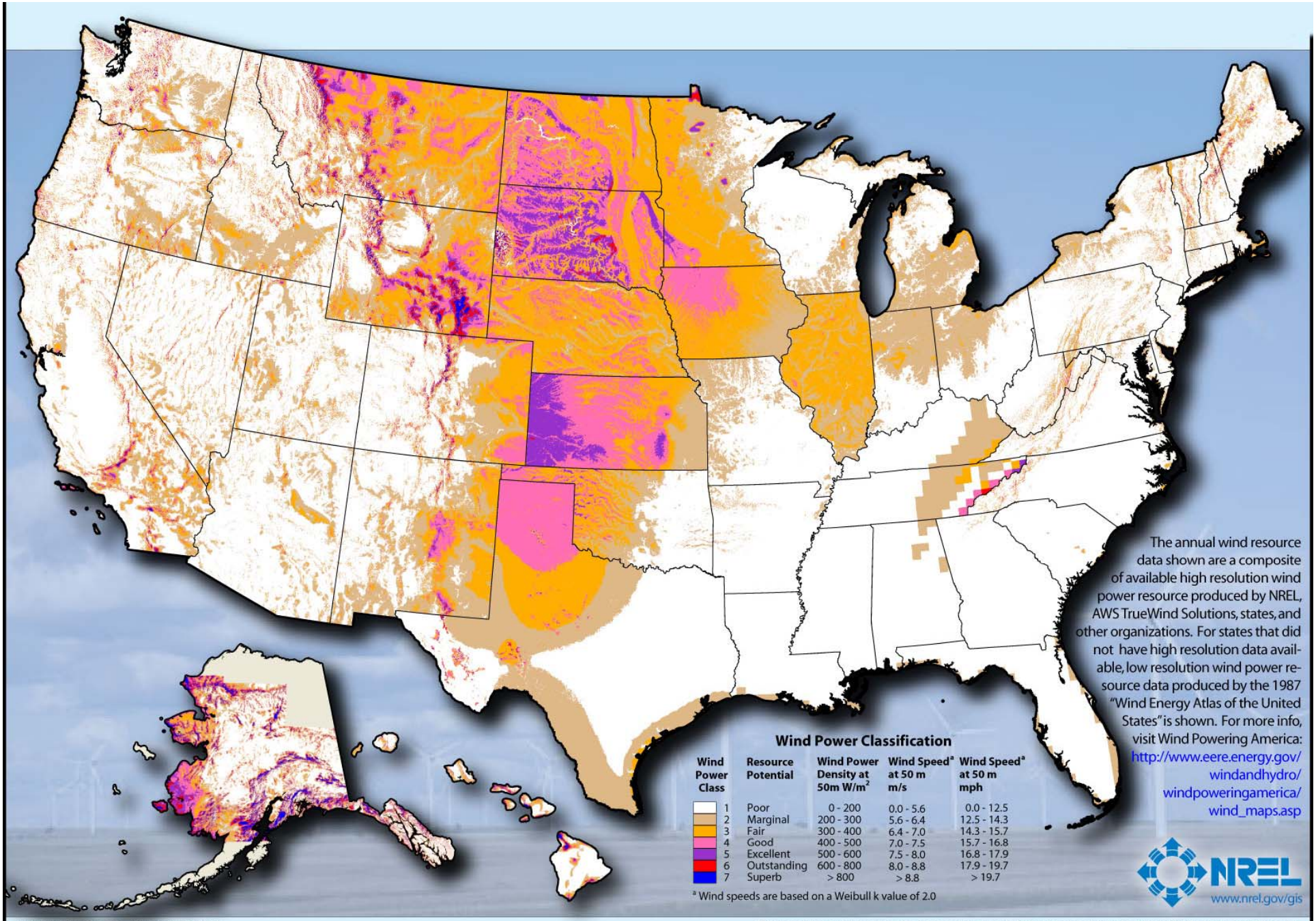


Wind



Author : Billy Roberts - October 20, 2008

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

Installed Costs and O&M Costs

Installed Costs	
< 500kW	$2500 to $3500/kW
>500kW	$2000/kW
Operation and Maintenance Costs	
< 500kW	$0.035/kWh
>500kW	$0.025/kWh

These numbers can be used for feasibility calculations. There is huge variability depending on the current market and the site selected.

Wind Resources

- **AWEA Web site**
  - http://www.awea.org
- **NWTC Web site**
  - http://www.nrel.gov/wind
- **National Wind Coordinating Collaborative**
  - http://www.nationalwind.org
- **Utility Wind Interest Group site**
  - http://www.uwig.org
- **WPA Web site**
  - http://www.windpoweringamerica.gov
- **Homepower Web Site**
  - http://www.homepower.com
- **Windustry Project**
  - http://www.windustry.com
- **Best Links**
  - www.fresh-energy.org

Other Wind Resources

- **American Wind Energy Association http://www.awea.org/**
  - AWEA Small Wind Toolbox
    - www.awea.org/smallwind/

- **AWS Scientific Inc. "Wind Resource Assessment Handbook" produced for the National Renewable Energy Laboratory, Subcontract number TAT-5-15283-01, 1997**
  - http://www.nrel.gov/publications

- **Wind Energy Explained;J. F. Manwell, J. G. McGowan, A. L. Rogers; John Wiley & Sons Ltd. 2002.**

- **Wind Power; Gipe, Paul; Chelsea Green Publishing, 2004**

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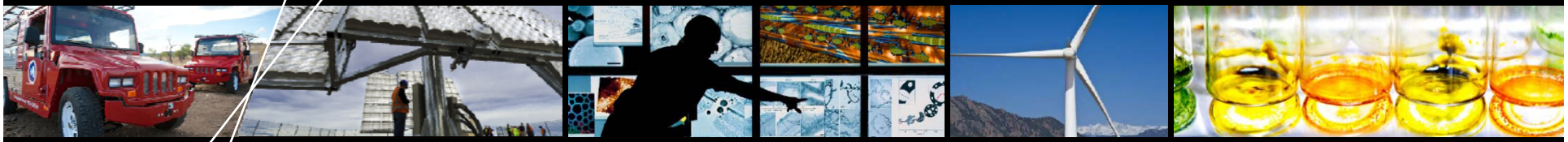
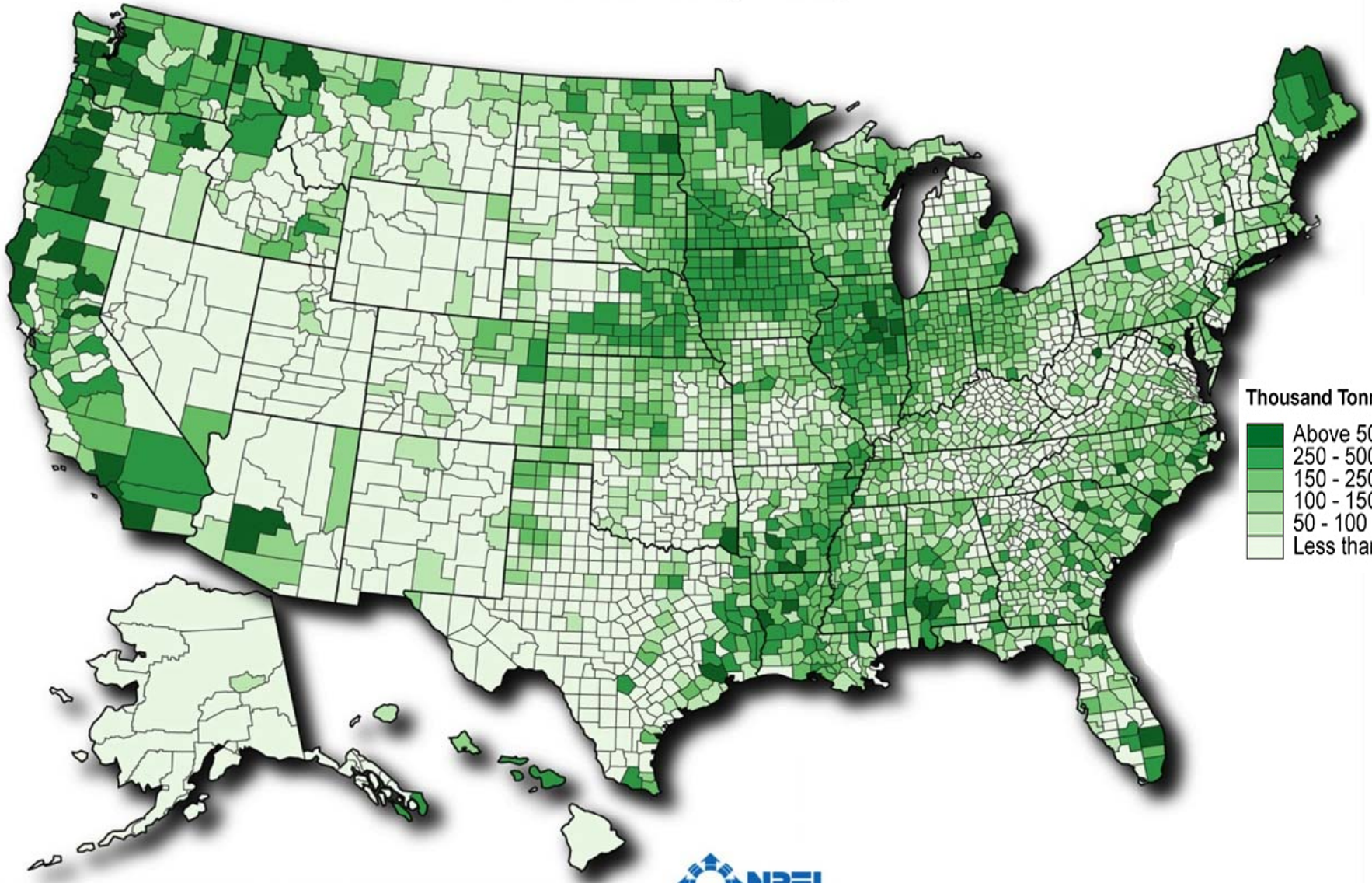


Biomass

Biomass Resources of the United States

Total Resources by County



This map was produced by the National Renewable Energy Laboratory for the US Department of Energy.
October 13, 2009 Author: Billy J. Roberts

NREL
www.nrel.gov/gis

NREL Renewable Fuels Heating Plant (Golden, CO)

Pix 15830

- $3.3 million cost under an ESPC
- Pine beetle waste wood
- 75% of the 50,000 million Btus to heat campus.
- Cost savings projected $400,000/year
- The wood chips cost $29 per ton or $2.42 per million BTUs
- During cold weather, plant burns a truckload of wood chips per day; produces 600 gallons of hot water per minute
- Stores four days of wood chip fuel

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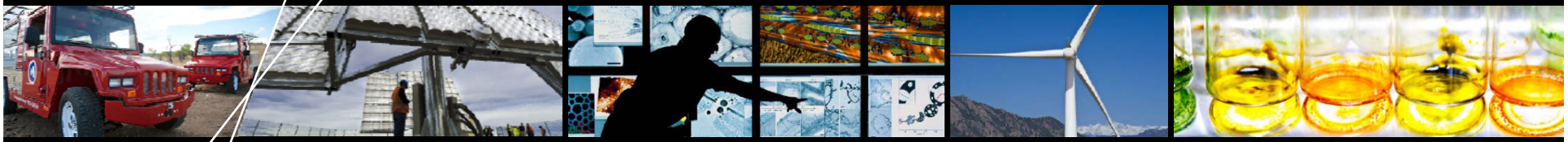
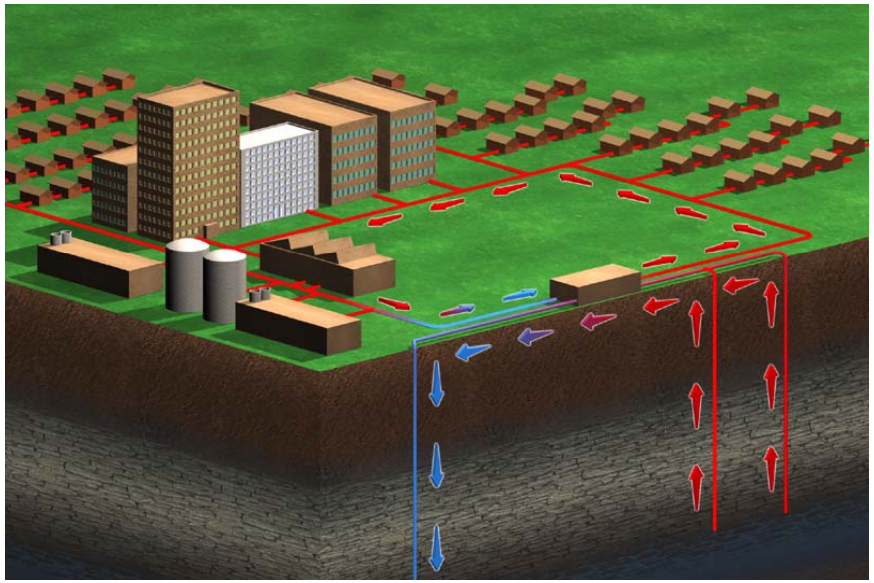
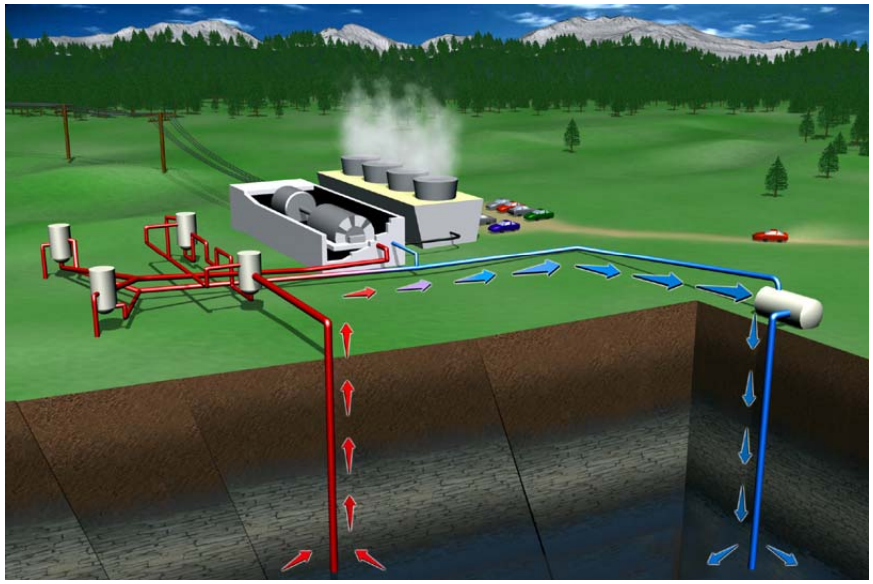


Geothermal





Heat Production

- District Heating
- Process Heat
- Agriculture
- Aquaculture

Electricity Generation

- Distributed Power
- Central Station Power

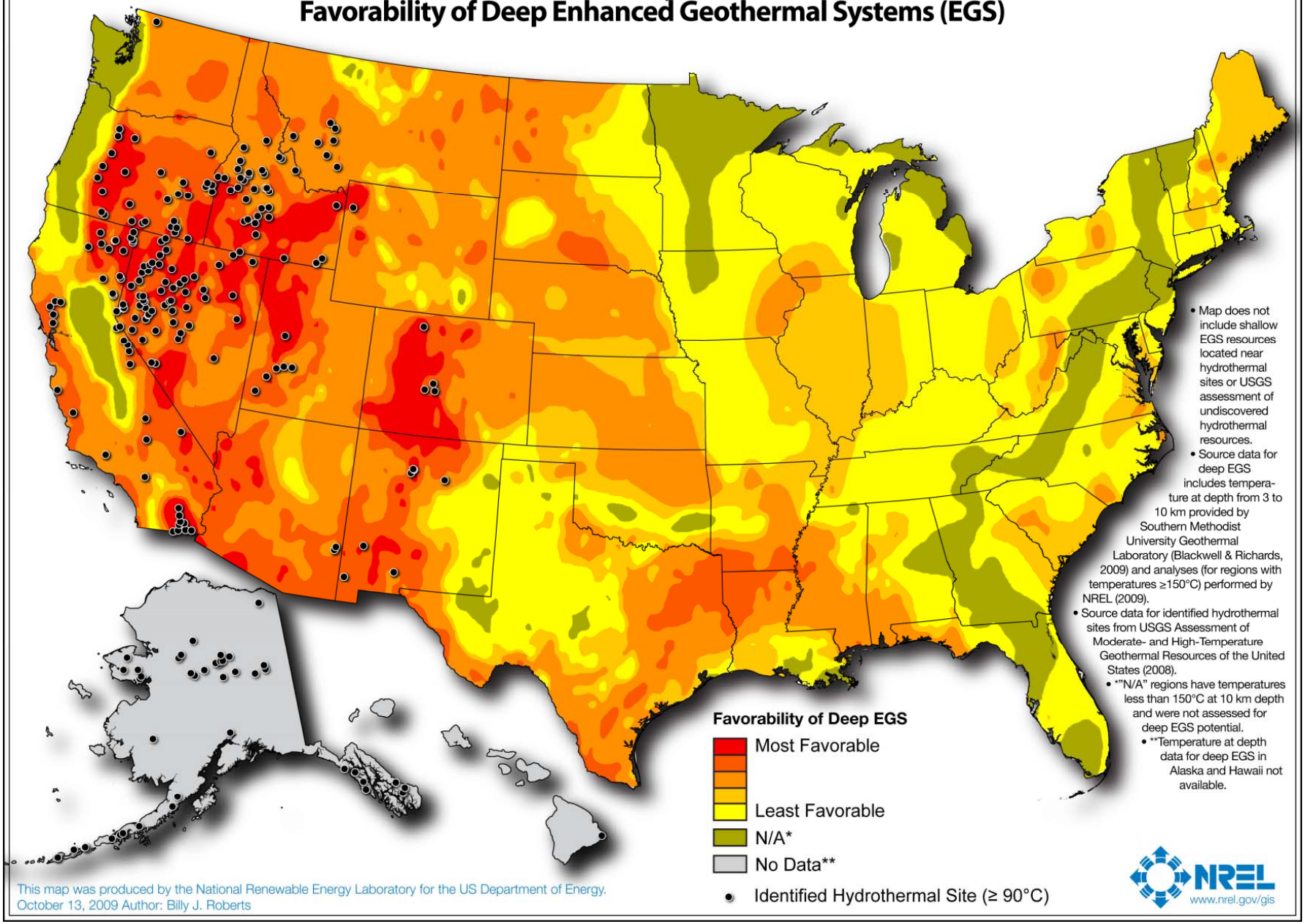
Ground Source Heat Pumps
Marine Corps Air Station, Beaufort, SC

Pix 7090

- Geothermal heat pump technology is the energy-saving centerpiece of this Marine housing facility.
- Energy-efficient geothermal heat pumps replaced 2,500 tons of existing HVAC systems and hot water heaters.
- These heat pups provide space heating, cooling, and domestic hot water for 1,235 family housing units at the Beaufort Marine Corps installation.

Geothermal Resource of the United States

Locations of Identified Hydrothermal Sites and Favorability of Deep Enhanced Geothermal Systems (EGS)



- Map does not include shallow EGS resources located near hydrothermal sites or USGS assessment of undiscovered hydrothermal resources.
- Source data for deep EGS includes temperature at depth from 3 to 10 km provided by Southern Methodist University Geothermal Laboratory (Blackwell & Richards, 2009) and analyses (for regions with temperatures ≥150°C) performed by NREL (2009).
- Source data for identified hydrothermal sites from USGS Assessment of Moderate- and High-Temperature Geothermal Resources of the United States (2008).
- *"N/A" regions have temperatures less than 150°C at 10 km depth and were not assessed for deep EGS potential.
- **Temperature at depth data for deep EGS in Alaska and Hawaii not available.

NREL
www.nrel.gov/gis

This map was produced by the National Renewable Energy Laboratory for the US Department of Energy.
October 13, 2009 Author: Billy J. Roberts

Geothermal Resources

- **Western Area Power Administration**
  - http://www.wapa.gov/es/pubs/fctsheet/GHP.pdf
- **DOE Geothermal Technologies Program**
  - http://www1.eere.energy.gov/geothermal/faqs.html
- **Resource Maps**
  - http://www.nrel.gov/gis/geothermal.html

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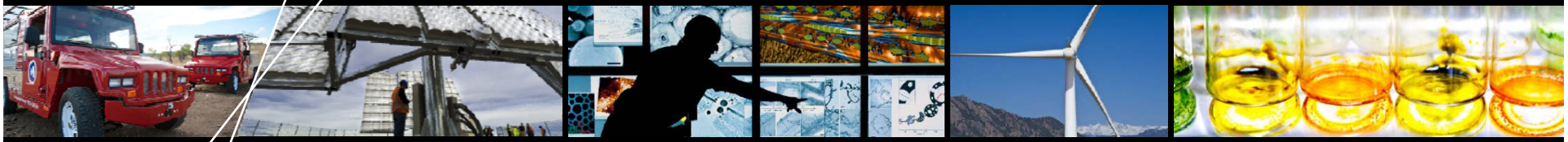
NATIONAL RENEWABLE ENERGY LABORATORY



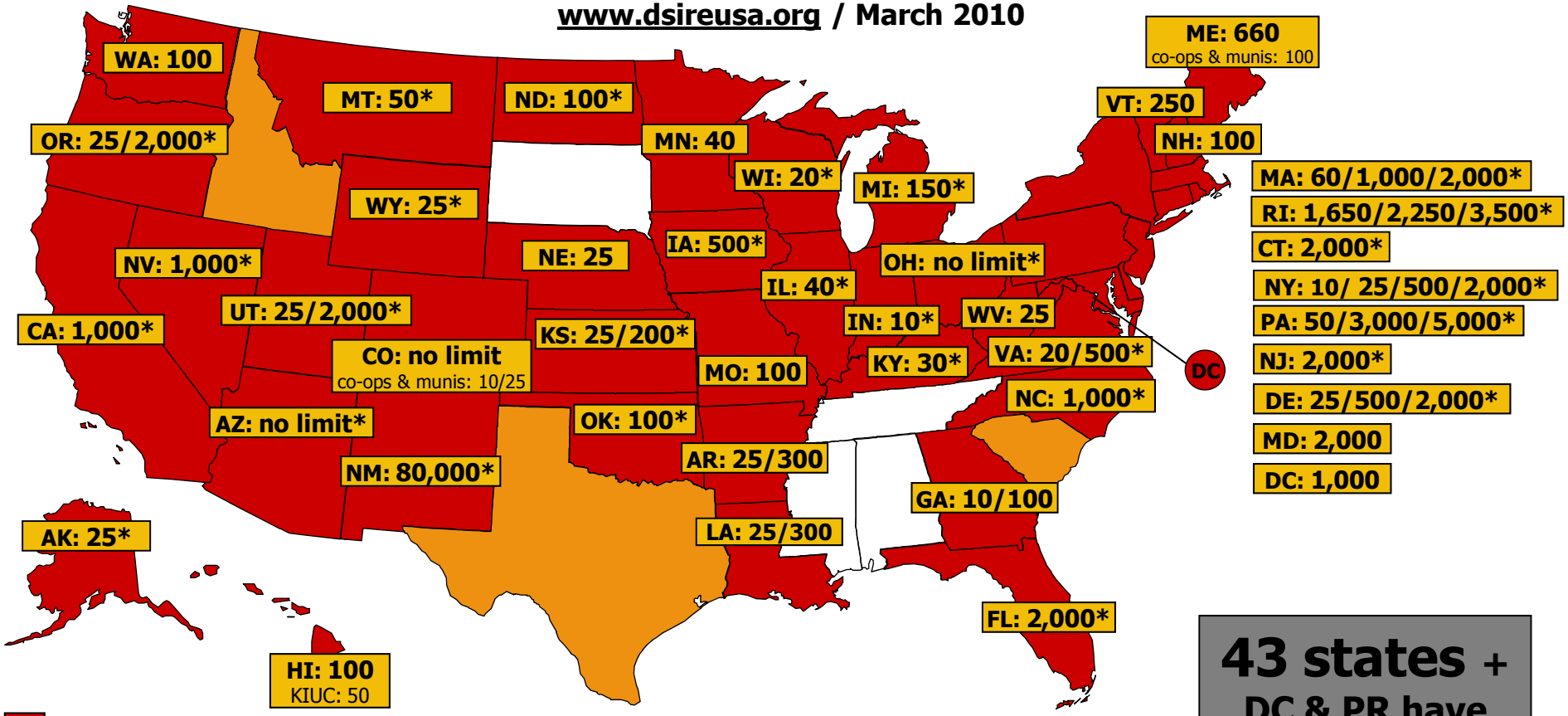
Integration Issues

DSIRE
Database of State Incentives for Renewables & Efficiency

U.S. Department of Energy Energy Efficiency and Renewable Energy
North Carolina Solar Center
IREC

Net Metering

www.dsireusa.org / March 2010



43 states + **DC & PR have adopted a net metering policy**

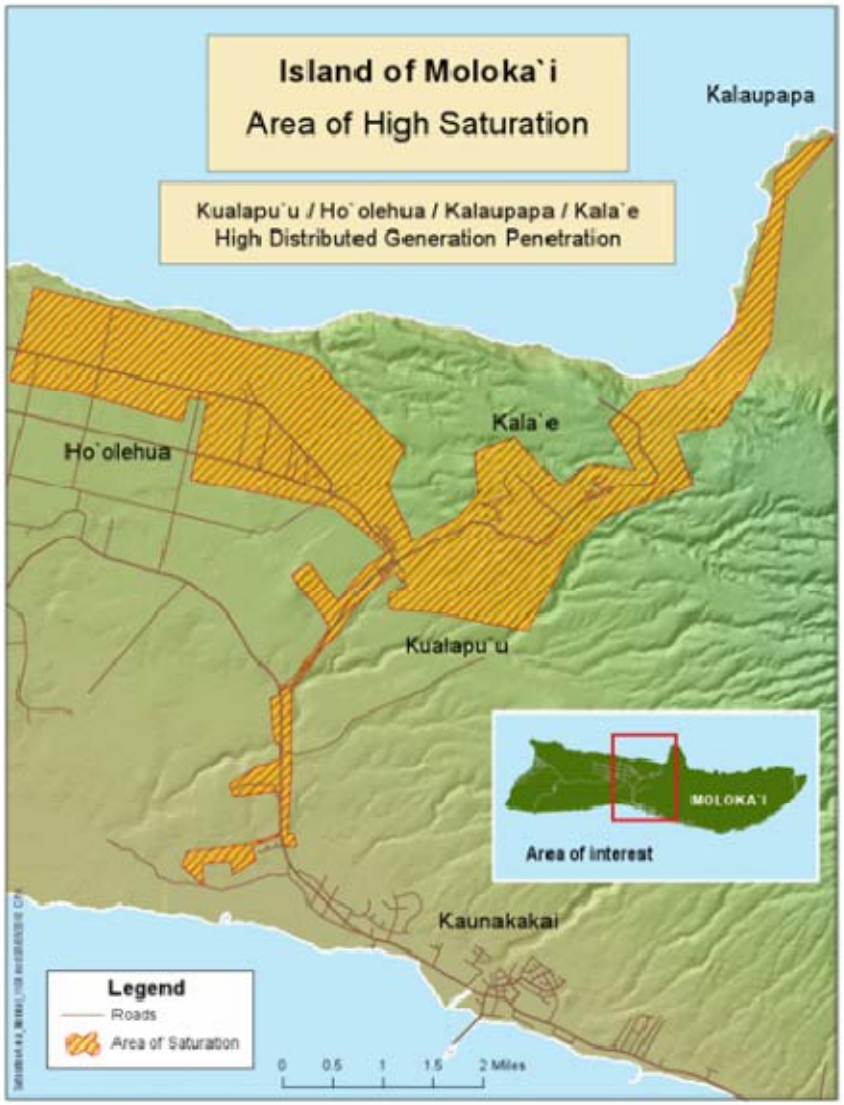
State policy

Voluntary utility program(s) only

* State policy applies to certain utility types only (e.g., investor-owned utilities)

Note: Numbers indicate individual system capacity limit in kW. Some limits vary by customer type, technology and/or application. Other limits might also apply.

Problems with "Net" Metering

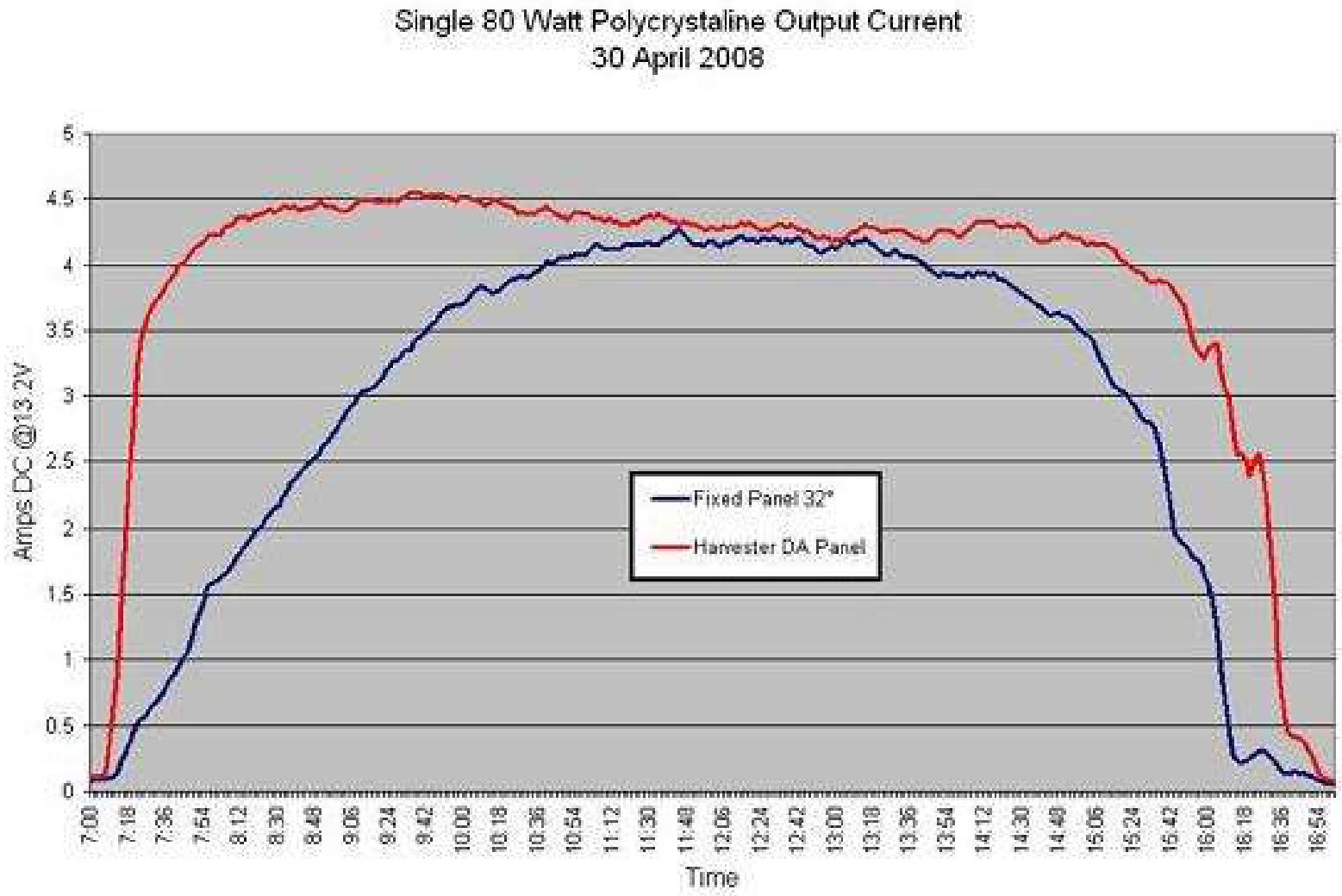


- **Pros:**
  - Incentive for RE
  - Saves Some Fuel (up to a limit)
- **Cons:**
  - Limits to Fuel Savings
  - Doesn't save any other utility operating costs
  - RE may be curtailed; limits on installations (eg 15% in HI)
  - Socio-economic problem: foists utility costs on those least able to afford it.
- **Utility Cost Recovery**
  - Spinning Reserve
  - Retail/buy-back spread (c/kWh)
  - Stand-by Charges ($/kW/month)

Zero = EE+RE+Microgrid

- **Strategies for "Zero" rather than "Net Zero"**
  - Tracking Solar
  - Solar on different orientations (East-South-West)
  - Spatial Diversity
  - Diversity of RE Measures (Solar, Wind, Etc)
  - Dispatchable RE (biomass, hydro, geothermal, landfill gas)
  - Flexible Grid Layout (circuits) to route power around
  - Isolate Critical Circuits: exercise Demand Control
  - Energy Storage (short and long term, electric and thermal)
  - Micro-grid controls
    - Control requirement: maintain required frequency and voltage levels
    - Grid disconnect and seamless resynchronization
    - Micro-grid start-up ("black start")
    - Load control (interfaces with SCADA and EMCS)
    - Supply control (optimized operation of DERs)

Tracking the Sun



Zero = EE+RE+Microgrid

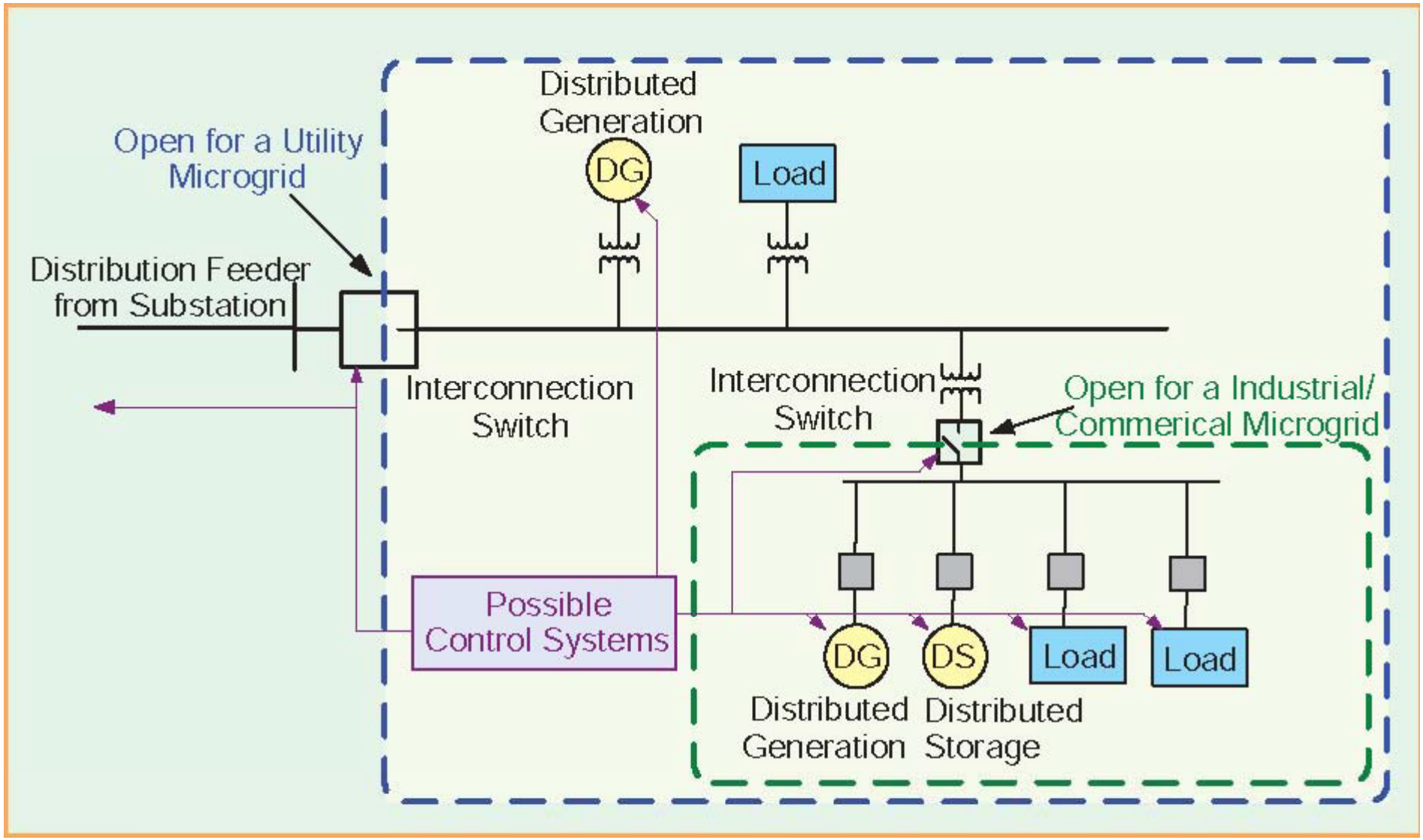


Figure by Ben Kroposki, NREL

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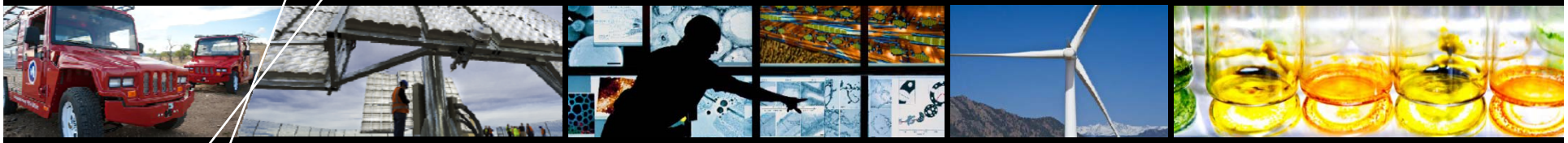
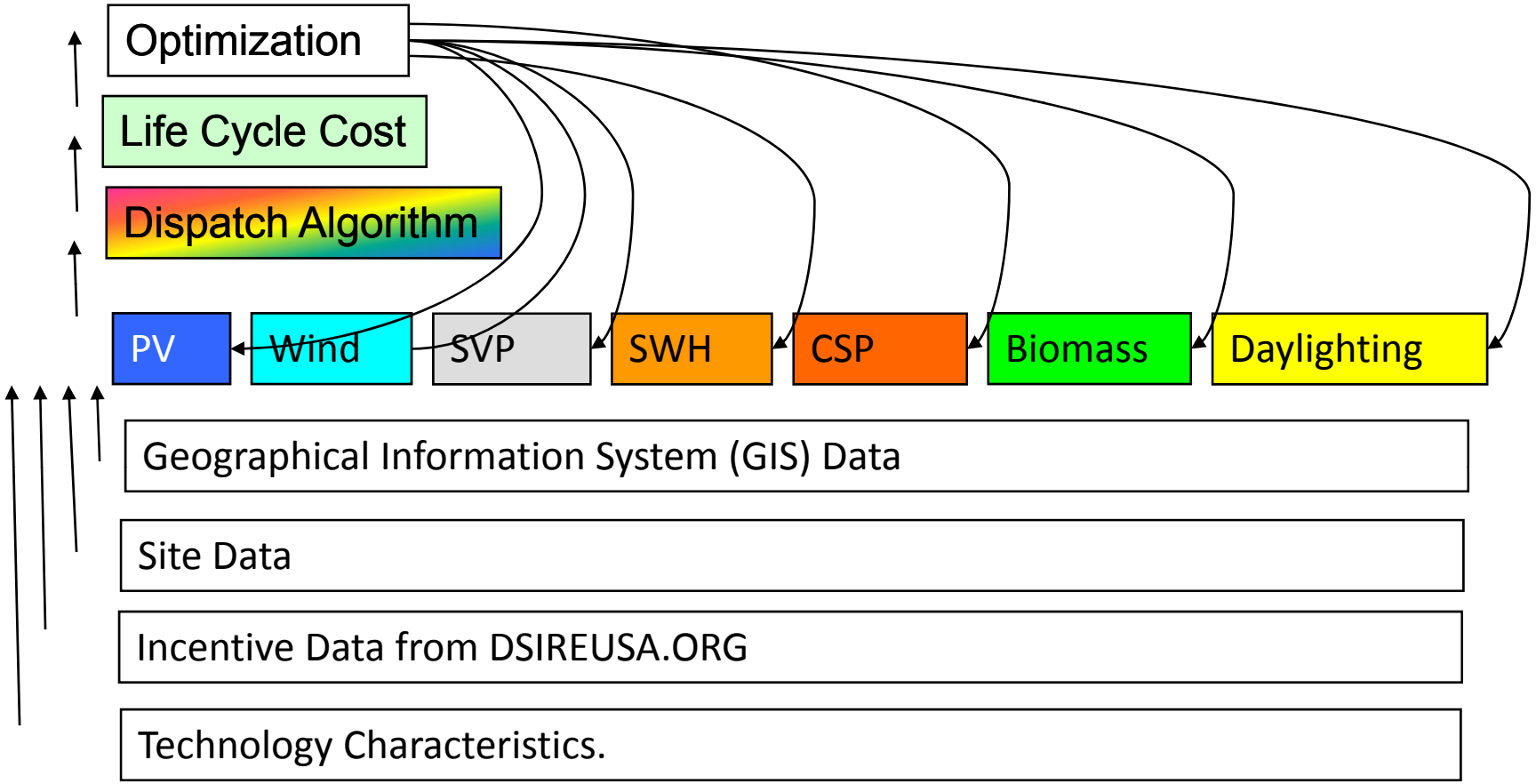


RE Project Planning

Best Mix of Renewable Energy Technologies Depends on:

- **Renewable Energy Resources**
- **Technology Characterization**
  - Cost ($/kW installed, O&M Cost)
  - Performance (efficiency)
- **Economic Parameters**
  - Discount rates
  - Fuel Escalation Rates
- **State, Utility and Federal Incentives**
- **Mandates (Executive Order, Legislation)**

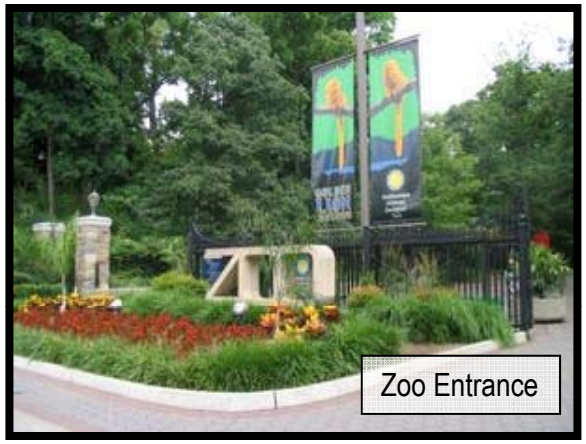
REO: Renewable Energy Optimization

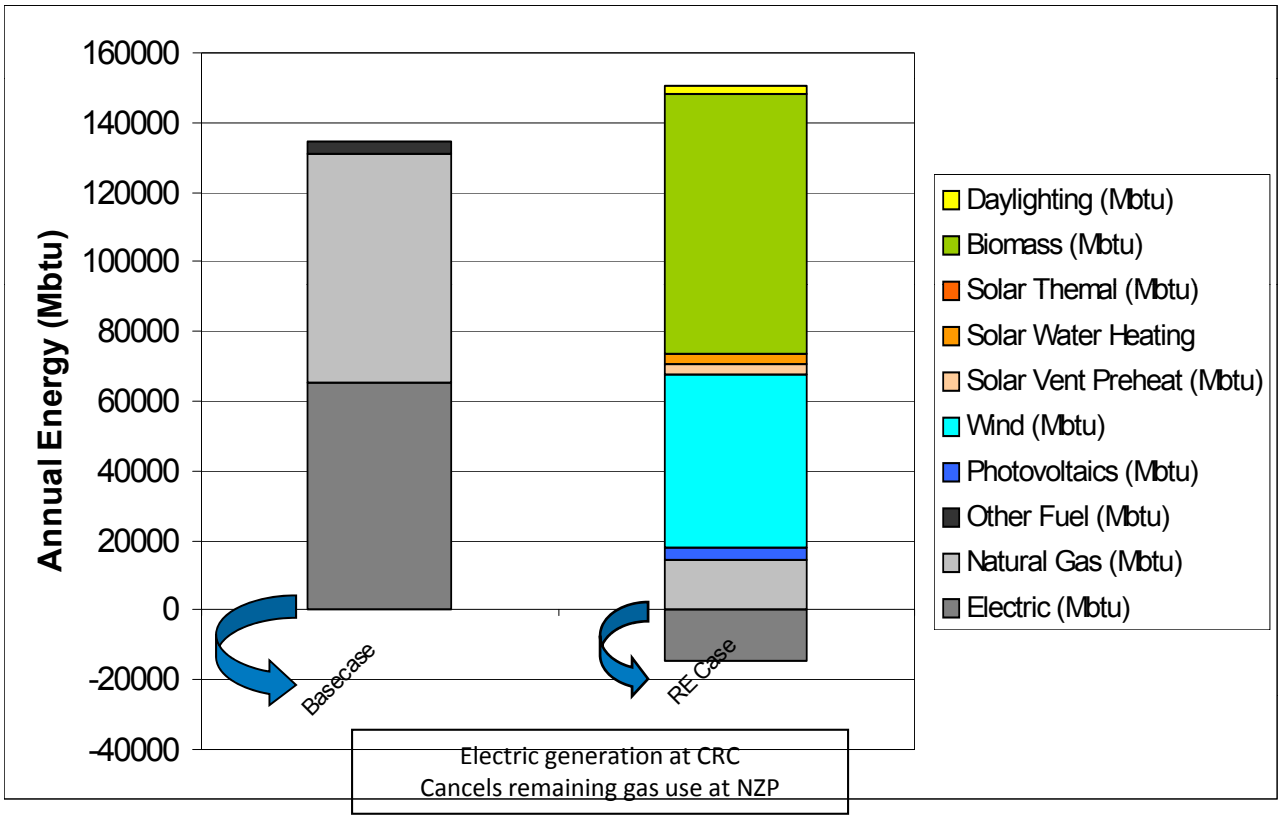


RENEWABLE ENERGY OPTIMIZATION (REO)

Example results using the Renewable Energy Optimization to create a "net zero" energy zoo.

National Zoological Park (NZP) and Conservation Research Center (CRC), Washington DC





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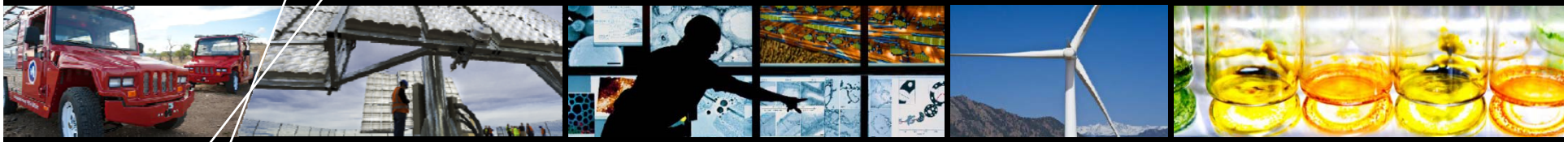


Questions?

Thank you!

Andy Walker
National Renewable Energy Laboratory
Andy.walker@nrel.gov

Funding Options for RE in Federal Facilities

- **Financing Options**
  - Appropriations
  - Energy Savings Performance Contracts (ESPC)
  - On-site Renewable Power Purchase Agreements (PPA)
  - PPA within ESPC
  - Utility Energy Service Contracts (UESC)
  - Utility Renewable Energy Service Contracts (URESC, PPA with serving utility)
  - Enhanced Use Lease

Appropriations

- **Agency funds projects with capital improvement: ECIP; Minor Construction ≤ $750k; O&M Funds**
- **Facilitated by GSA Schedules**
  - FAC 03 871 Energy Services (audits and project planning)
  - MAS 56 871 Hardware and turnkey implementation services
- **Advantages**
  - Lowest cost of funds (discount rate); no financing costs; no ESCO overhead
  - Agency retains all cost savings and environmental attributes
  - Very practiced contracting
- **Disadvantages**
  - Agency responsible for long-term O&M
  - Available funds not sufficient to meet goals
  - Cannot monetize tax incentives
  - No performance guarantee

Examples: Appropriations

GSA Federal Center, Denver, Colorado	Social Security Administration, Philadelphia, Pennsylvania
 Photo Credit: Dave Mowers; U.S. General Services Administration (GSA). PIX 17421	 Photo Credit: Ed Hancock, Mountain Energy Partnership
▪ 1.19-MW PV system ▪ 6 acres of land ▪ Generated 1,726,000 kWh in 2008	▪ High-temperature hot water ▪ 54 m^2 gross collector area (evacuated tube) ▪ 143 million Btu/year (estimated)
www.gsa.gov/portal/content/105165	www1.eere.energy.gov/femp/services/yhtp/energy_projects_detail.cfm/id=8

Energy Savings Performance Contract (ESPC)

- **Authorized by EPAct 1992 (codified 42USC8287): term less than 25 years; annual verification of savings; payments less than savings in energy, O&M and water.**
- **Army Corps of Engineers MATOC or DOE FEMP IDIQ or site-specific/full and open competition (from DOE qualified bidders)**
- **Renewables often "bundled" with efficiency measures.**
- **Advantages**
  - No capital investment by government
  - Guarantee of performance
  - Project Facilitation and Contracting by Army Corps of Engineers or DOE
  - 25-years is sufficient to amortize high initial cost of RE
- **Disadvantages**
  - Interest on financing is significant expense in long term.
  - Energy Service Company (ESCO) overhead and profit on top of project costs.
  - Title ordinarily resides with government, so not eligible for tax incentives; however regulation allows title to reside with ESCO.

Examples: ESPC

U.S. Marine Corps, Twenty-Nine Palms, California	Federal Correctional Institution, Phoenix, Arizona
 Photo Credit: Daniel C. Kariuki, Energy Projects Manager, Marine Corps Air Ground Combat Center, 29 Palms, California	 Photo Credit: Ed Hancock, Mountain Energy Partnership. PIX 09048
▪ 1.1-MW PV system ▪ 6.5 acres of land	▪ Parabolic trough solar water heating system ▪ 17,040 ft^2 of collectors ▪ 1,161,803 kWh in 1999 (87.1% of water heating load)
www.bp.com/liveassets/bp_internet/solar/bp_solar_usa/STAGING/local_assets/downloads_pdfs/29PalmsTag.pdf	www.eere.energy.gov/femp/pdfs/33211.pdf

Power Purchase Agreement (PPA)

- **On-site generation (as opposed to Green Power Purchase)**
- **Authority: 10 USC 2922a (DOD only); FAR Part 41**
- **PPA provider owns, installs and maintains system**
- **Agency agrees to purchase power at competed rate for term of PPA**
- **Involves land lease or other land use agreement (easement, license, other)**
- **Requires OMB notification and review**
- **Advantages:**
  - No capital expense or O&M to government
  - Performance guaranteed by contractor (pay only for energy)
  - Private ownership may be eligible for tax incentives (credit and MACRS)
- **Disadvantages**
  - Not all states allow PPAs check http://www.dsireusa.org/documents/summarymaps/3rd_Party_PPA_map.ppt
  - Private Sector and Government requirements sometimes at odds: termination for convenience; indemnification; etc.

Examples: PPA

NREL, Golden, Colorado	Fort Carson, Colorado Springs, Colorado
	
Photo Credit: SunEdison, PIX 17423	Photo Credit: U.S. Army Fort Carson. PIX 17394
▪ 720-kW PV system (Generates 1,200 MWh/year) ▪ 20-year contract using WAPA	▪ 2-MW PV system (Generated 3,200 MWh in the first year)
www1.eere.energy.gov/femp/pdfs/team_reproject_nrel.pdf	http://www.3phases.com/news/news-item. php?id=32

PPA within ESPC

- New option – process in development
- **Uses 25 year authority of ESPC**
- **Must meet all ESPC authority requirements, including utility energy and cost savings**
- **OMB Supports ESPCs that incorporate purchase of on-site renewable energy (OMB Memo 8/16/2012)**
  - Requires OMB notification and review
- **ESPC rules do allow title to reside with contractor (use of tax credits)**
- **Advantages**
  - Only 25 year authority generally available to civilian agencies
  - Way to use tax credits and depreciation to support cost-effectiveness
- **Disadvantages**
  - ESCO adds layer of overhead and profit if using MATOC or IDIQ Contract (can also do site-specific, full and open competition so that contract is directly with renewable developer, as long as ESCO is on the DOE qualified list by the time of award)

PPA in ESPC: Examples

US Army Fort Bliss	US Army White Sands Missile Range
3 PV systems for total 1.6 MW	3.8 MW PV System
COE Huntsville MATOC Johnson Controls Inc. Signed December 2011 Not constructed yet	COE Huntsville MATOC Siemens Inc. Signed December 2011 Not constructed yet

Utility Energy Service Contract (UESC)

- **Authorized by EPAct 1992, codified 42 USC 8256**
- **DOD specific Regulations NDAA 2007, codified 10 USC 2911 and 10 USC 2913**
- **GSA area-wide provides simplified contracting vehicle**
  - Over 120 utilities
  - GSA authorizes 25 year financing term
- **May use site specific contract where area-wide not in place**
- **Advantages:**
  - Utility and agency have existing contract/relationship
  - Streamlined acquisition process
  - High credit rating of utility and limited payment risk results in low cost financing
- **Disadvantages**
  - OSD limits contract financing term to 10 years
  - 2913 requires Government to take title of equipment, complicates monetizing tax benefits

Examples: UESC

Camp Pendleton, North San Diego County, California	Joshua Tree National Park, California
	
Photo Credit: U.S. Marine Corps. PIX 16462	Photo Credit: Harry Carpenter. PIX 07260
▪ 75-kW PV system (Generating 116,000kWh/year) ▪ 10-year contract term	▪ 20.5-kW PV system with a 613-kWh battery and a 35-kW propane generator
www.eere.energy.gov/femp/pdfs/46348.pdf	www.eere.energy.gov/femp/pdfs/26358.pdf

Utility Renewable Energy Service Contract (URESC)

- **Contract to purchase energy from utility owned on-site renewable generation facility**
- **Authorities: DOD sites would use several authorities together**
  - FAR Part 41
  - 10USC 2922a
  - 10USC 2913
  - Nothing in these regulations prohibits using them together, in some states it may be required for projects to move forward
- **FAR Part 41.501c4 and FAR 52.241-5 (Contractor's Facilities) may apply**
- **Draft agreement developed through Energy Lawyers and Contracting Officer Working Group**
- **Advantages**
  - Utility and agency have existing contract/relationship
  - Private owner may be eligible for tax credits, depreciation
  - May allow for partial rate basing of asset or purchase of excess power by utility
  - May reduce need for stand-by charges
- **Disadvantages**
  - Public Utility Commission approval may be required
  - Its unclear how many utilities are willing to offer this option

Examples: URESC

US Air Force Academy, Colorado

Photo by Andy Walker

6 MW PV Systesm

Colorado Springs Utilities/Sunpower

http://www.usafa.af.mil/news/story.asp?id=123259829

Enhanced Use Lease (EUL)

- **Authorized for DOD by 10 USC 2667;**
- **EUL derives income from underutilized but non-excess land.**
- **Prospective developers compete**
- **Payment monetary or in-kind (Energy)**
- **Advantages**
  - Suitable for large ground-mounted projects
- **Disadvantages**
  - Not suitable for small, distributed generation

Examples: EUL

NASA Kennedy Space Center, Merritt Island, Florida	Fort Irwin, Barstow, California (PROPOSED)

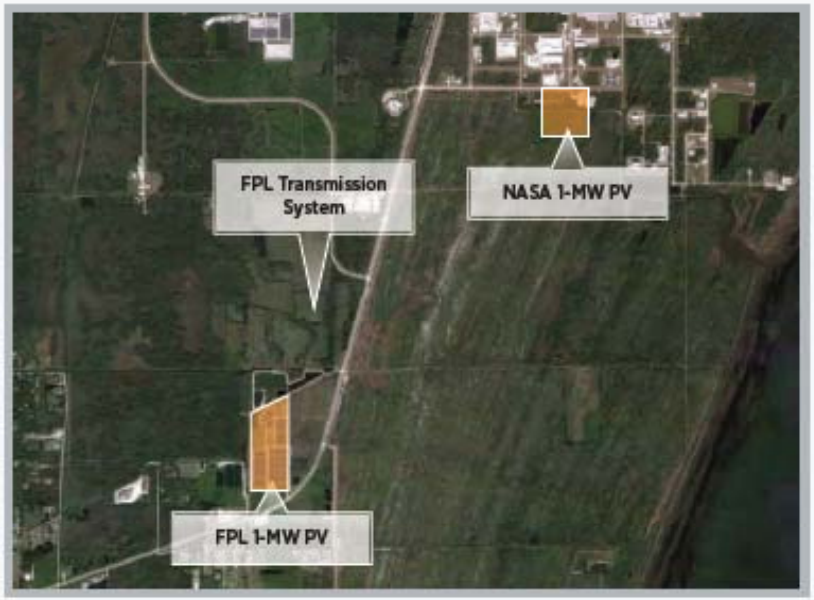



Photo Credit: NASA Kennedy Space Center/Florida Power & Light	Photo Credit: Google maps
▪ Florida Power & Light (FPL) 10-MW PV system ▪ On leased land that feeds FPL transmission ▪ Separate 990-kW PV system for NASA	▪ First phase: 500-MW of solar thermal and PV planned
www.smartgridnews.com/artman/uploads/1/nasa_space_coast_solar.pdf and www.fpl.com/environment/solar/spacecoast.shtml	http://eul.army.mil/ftirwin

Resources

The Department of Energy's Federal Energy Management Program (FEMP) website http://www1.eere.energy.gov/femp/

FEMP trainings http://apps1.eere.energy.gov/femp/training/

FEMP Project Funding Options - http://www1.eere.energy.gov/femp/financing/mechanisms.html

FEMP *PPA Quick Guide:* www.nrel.gov/docs/fy11osti/51662.pdf.

PPA in ESPC: OMB/CEQ Memo: "Supporting Energy and Sustainability Goal Achievement Through Efficiency and Deployment of Clean Energy Technology" (August 16, 2011) http://www.whitehouse.gov/sites/default/files/omb/procurement/memo/supporting-energy-and-sustainability-goal-achievement-through-efficiency-and-deployment-of-clean-energy-technology.pdf)

UESC Laws, Regulations, and Legal Opinions ; http://www1.eere.energy.gov/femp/financing/uescs_regulations.html#lo

UESC Enabling Documents: www1.eere.energy.gov/femp/pdfs/uesc_enabling_documents09.pdf

List of Utilities offering UESC: : http://www. gsa.gov/portal/content/104187.

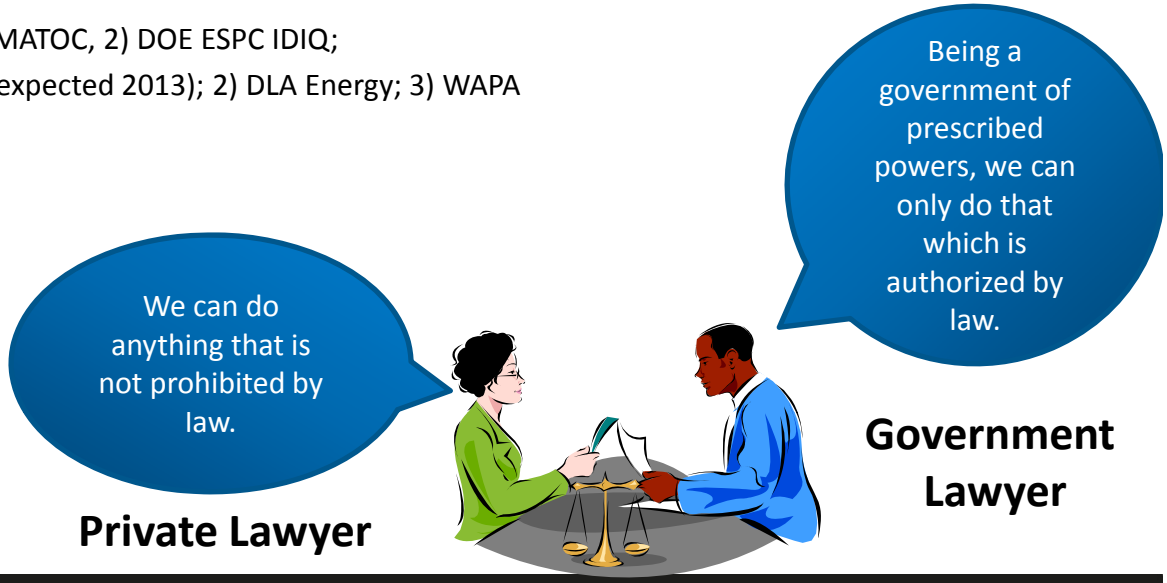
***Procuring Solar Energy: A Guide for Federal Facility Decision Makers* (http://www1.eere.energy.gov/solar/federal_guide/)**

***Solar Photovoltaic Financing: Deployment by Federal Government Agencies* (http://www.nrel.gov/docs/fy09osti/46397.pdf) This**

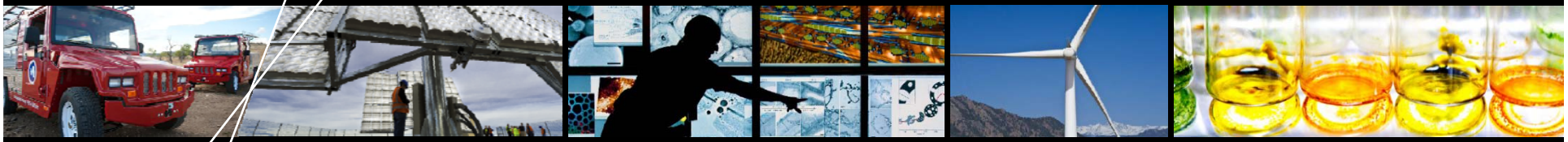
Slides and a transcript of a presentation based on *Procuring Solar Energy* http://www1.eere.energy.gov/femp/pdfs/ns/solarfedguide_presentation.pdf and http://www1.eere.energy.gov/femp/pdfs/ns/solarfedguide_transcript. pdf

Issues to Consider

- **Incentives (State, Utility, Federal; www.dsireusa.org)**
- **Economics: Project Cost; Utility Cost Savings; Payback**
- **Available land or roof area; mission requirements; future site plans**
- **Land ownership issues; BLM land withdrawal.**
- **Land use agreement : real estate authorities.**
- **Environmental considerations—NEPA; Categorical Exclusion; Environmental Assessment; Environmental Impact Statement.**
- **Off-take of power: use on-site; net metering, feed-in tariffs; limits on export**
- **Utility Policy: interconnection requirements (application, study, queue/timeline and costs); interconnection agreement – who signs?, terms and conditions; potential tariff changes with significant load reductions; standby charges;**
- **Renewable Energy Certificates (RECs): ownership options, EPAct 2005 and EO13423 requirements and guidance (REC retention requirements, REC swap option, etc).**
- **Ownership and tax incentive eligibility—tax credits; depreciation.**
- **Existing Offices and Contracting Vehicles**
  - ESPC: 1) Army Corps of Engineers ESPC MATOC, 2) DOE ESPC IDIQ;
  - PPA: 1) USACE Huntsville PPA MATOC (expected 2013); 2) DLA Energy; 3) WAPA
- **Authorities**



NREL
NATIONAL RENEWABLE ENERGY LABORATORY



Thank You!