U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

FEMP FIRST THURSDAY SEMIN@RS 2.0

energy, economy, environment...online, live, and anytime

Renewable Energy

Instructor: Andy Walker, National Renewable Energy Laboratory
FEMP Expert: Anne Crawley, Federal Energy Management Program

www.femp.energy.gov/training

FEMP Federal Energy Management Program

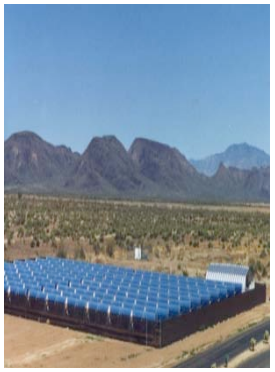
Seminar Objectives

After completing this seminar, the learner will:

1. Discuss various types of renewable technologies – their benefits, uses, and limitations
2. Discuss processes for considering renewable energy technologies for your site
3. Discuss steps in the project delivery process from screening to procurement to commissioning
4. Consider financing alternatives
5. Discuss options for purchasing renewable energy

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

What are the Federal Mandates?

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

What are the Federal Mandates?

EPAct 2005

- 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

What are the Federal Mandates?

Executive Order. 13423

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

Executive Order 13514

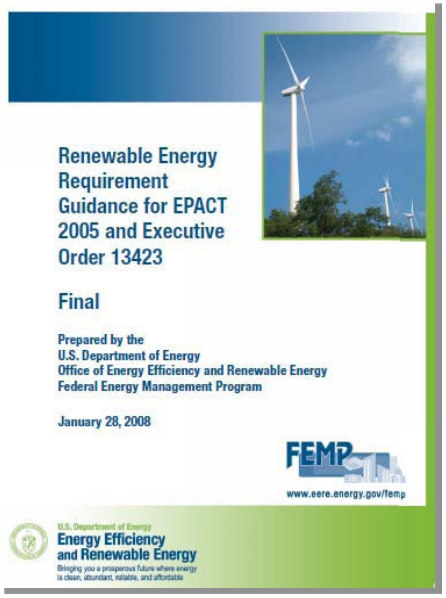
- GHG accounting and sustainability plans

What are the Federal Mandates?

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

What Guidance is Available from FEMP?

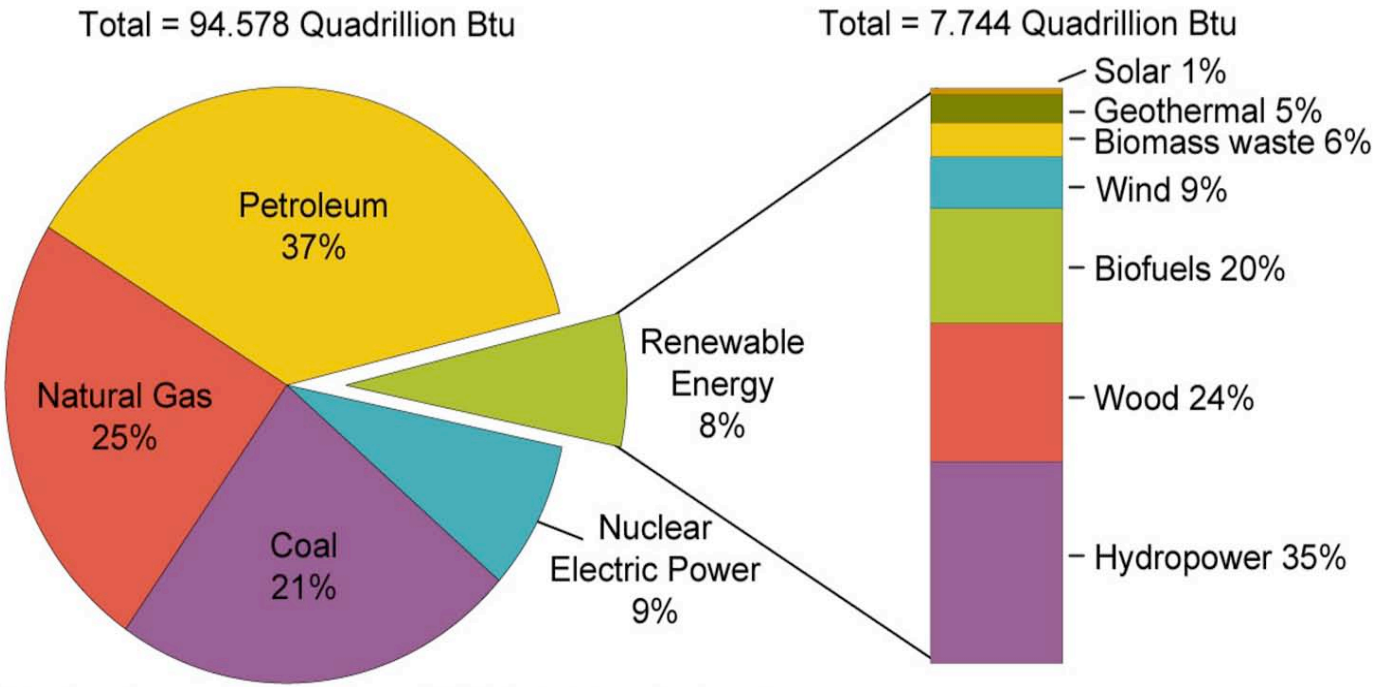


- For on-site projects, agency must retain or replace RECs to show use
- Simply hosting a renewable project without RECs does not help meet Federal goals
- Excludes system mix energy and energy used to meet state RPS requirements
- Rules are stricter for GHG accounting than for EPACT 05 accounting

www1.eere.energy.gov/femp/pdfs/epact05_fedrenewenergyguid.pdf

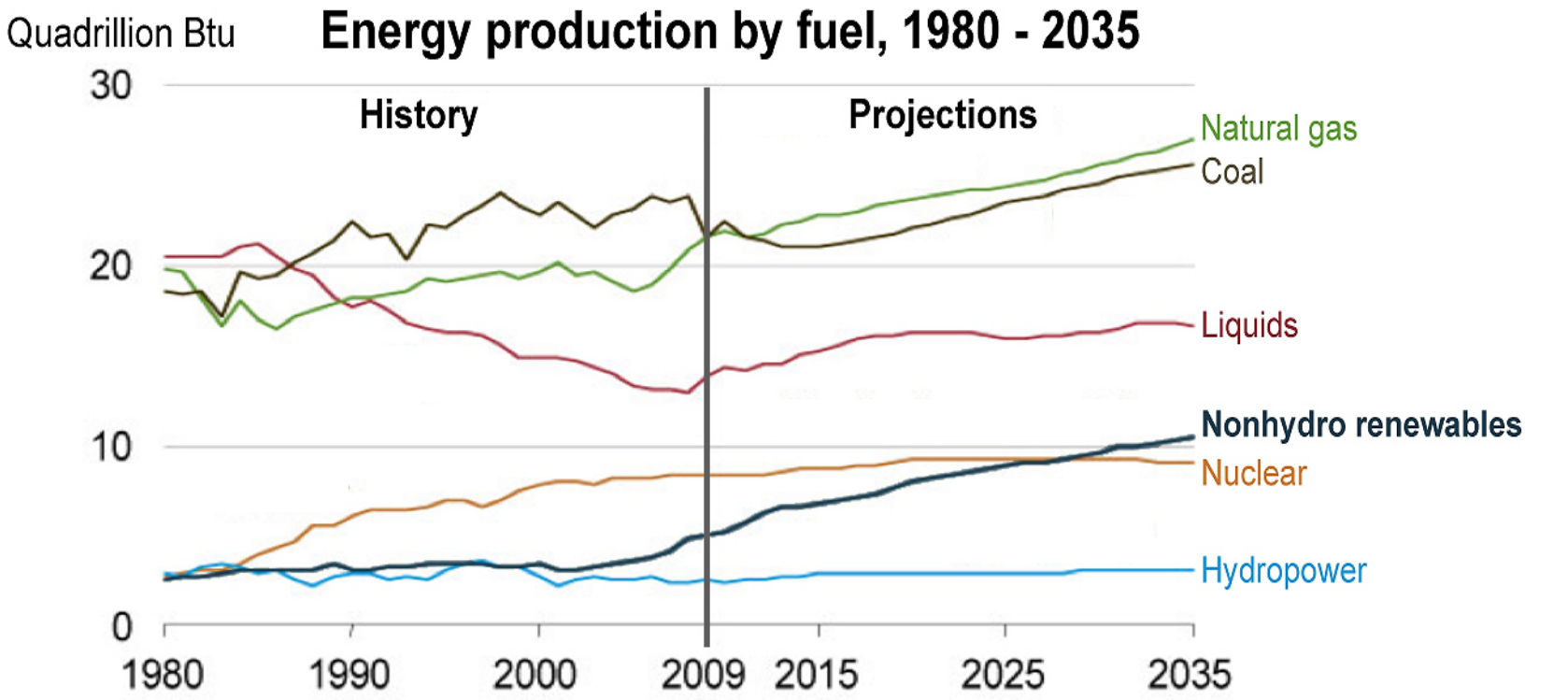
What is the U.S. Energy Consumption by Energy Source?

U.S. Energy Consumption by Energy Source, 2009



Note: Sum of components may not equal 100% due to independent rounding.
Source: U.S. Energy Information Administration, *Annual Energy Review 2009*, Table 1.3, Primary Energy Consumption by Energy Source, 1949-2009 (August 2010).

What is the projection for Renewable Energy?



Source: REN 21

http://www.eia.doe.gov/forecasts/aeo/early_production.cfm

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Renewable Technologies

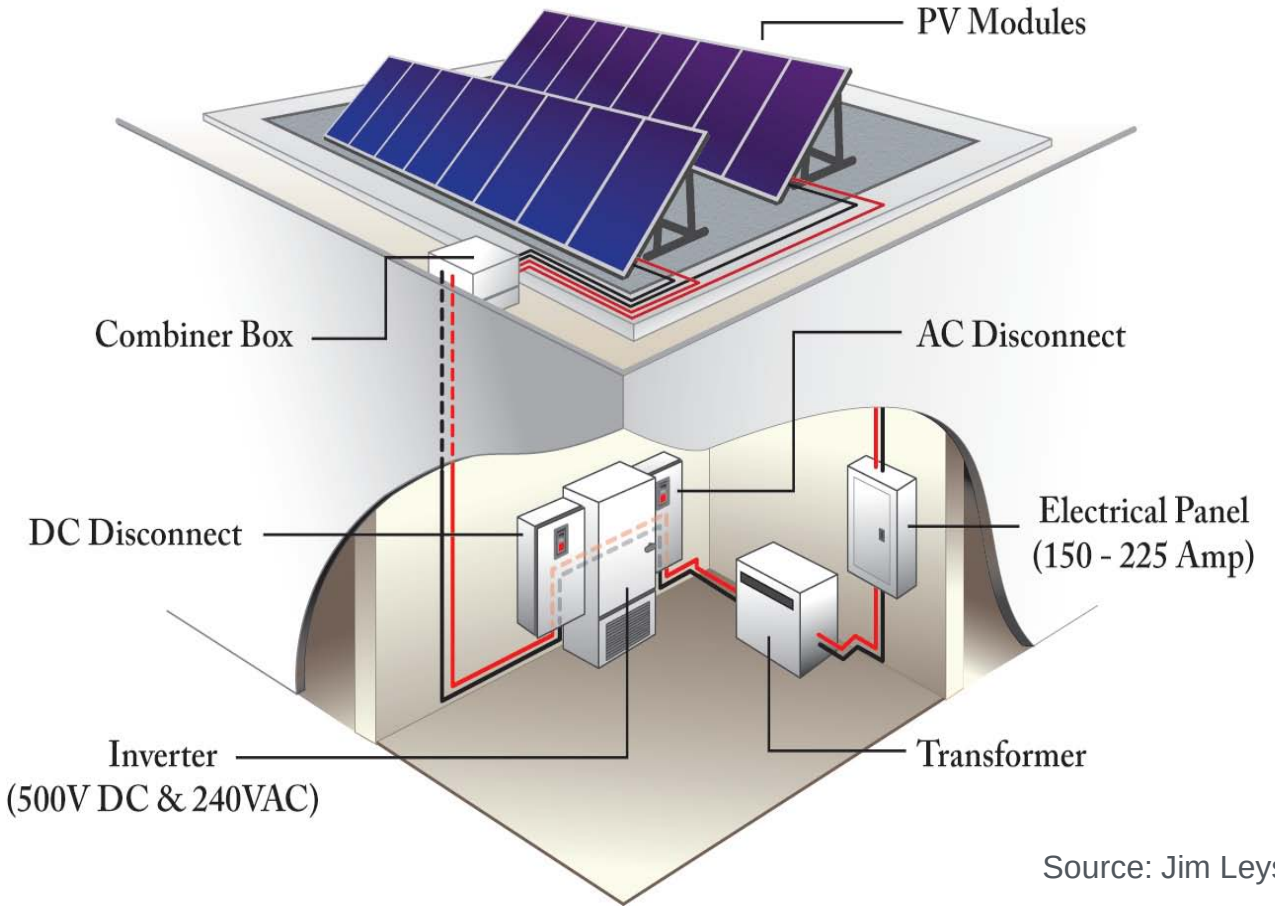
What Types of Solar Energy Technologies are Available?

- The solar energy reaching earth is enough to satisfy annual energy needs of the globe
- Technologies for electricity production include:
  - Photovoltaics
  - Concentrating Solar Power
- Thermal energy technologies include:
  - Solar Hot Water
  - Solar Ventilation Preheat

What are Photovoltaics (PV)?

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

Grid Connect PV System



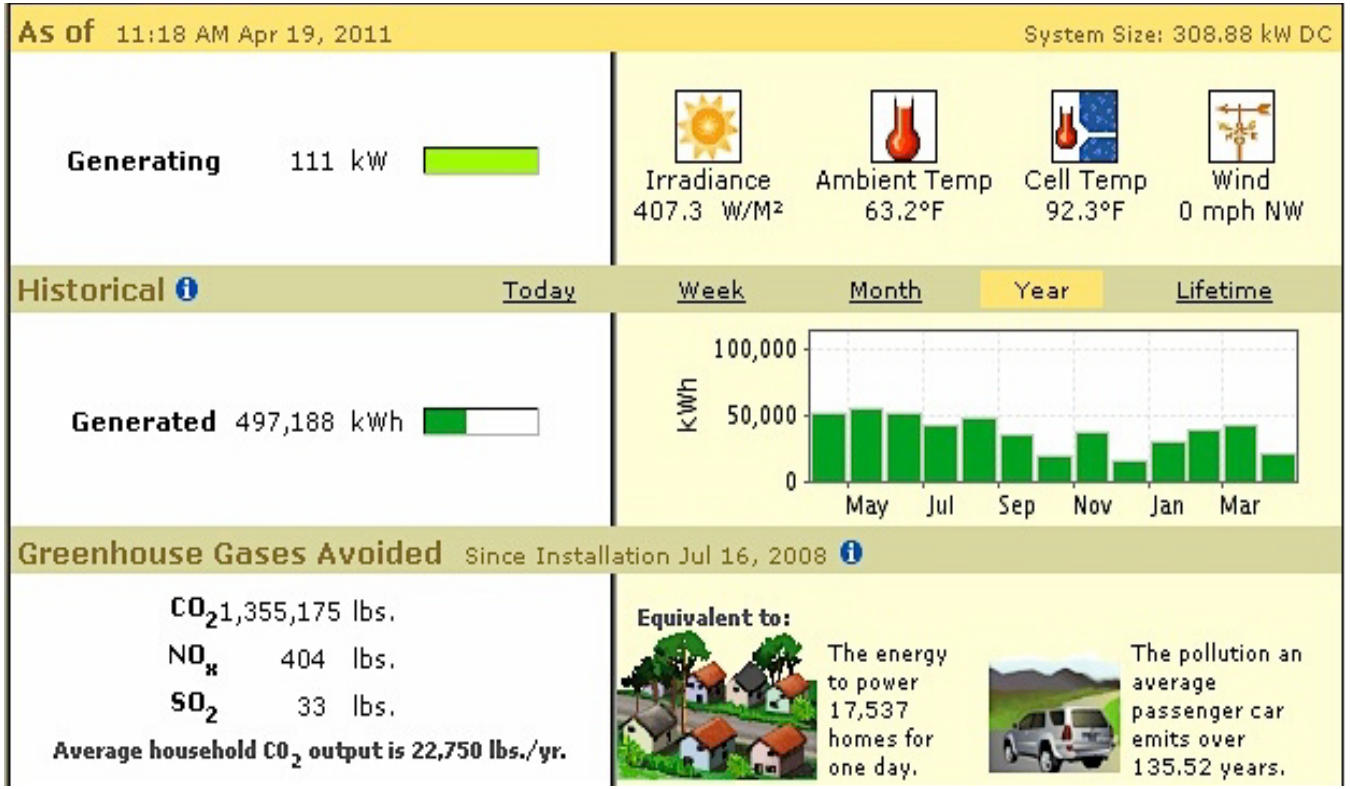
Source: Jim Leyshon, NREL

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

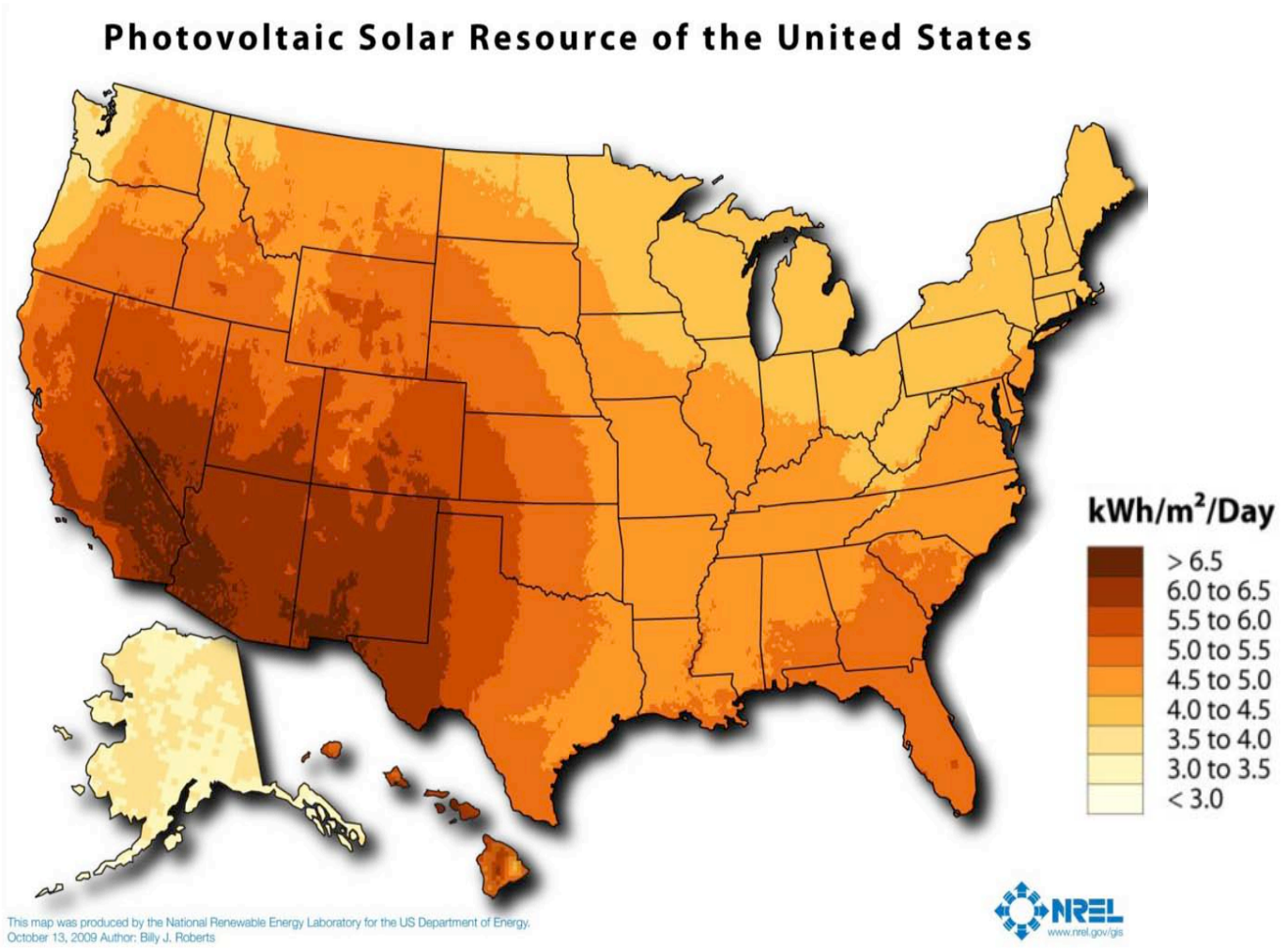
- 309 kWdc
- 1,584 PV modules
- SunLink racks minimum roof penetration
- Advanced Energy Solaron 333kW inverter
- Feasibility Study by NREL estimates: 475 MWh/year delivery; $60k/year savings; $2.9million cost without any incentives
- Procured off GSA Schedule for complete PV systems

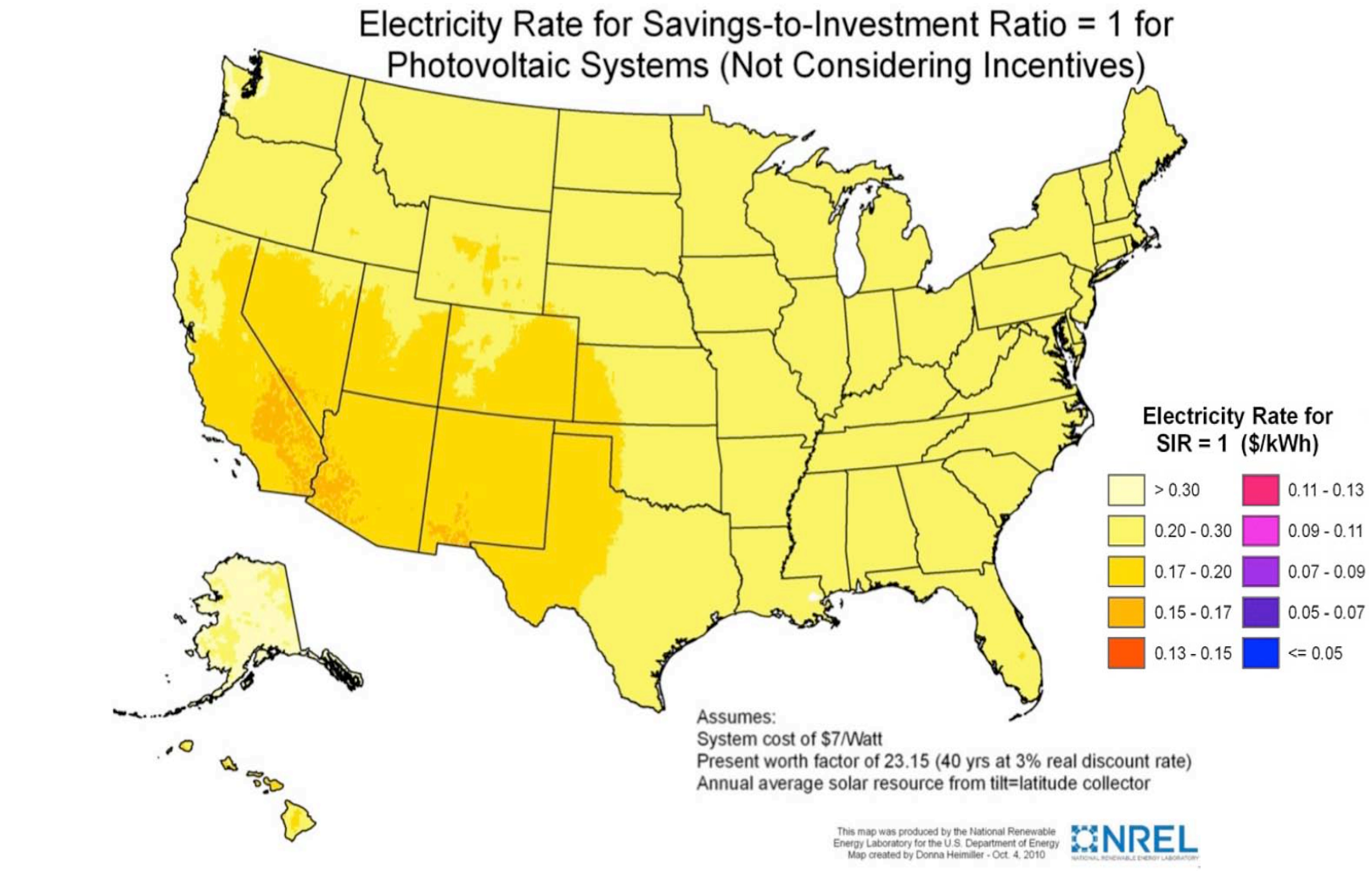
Results

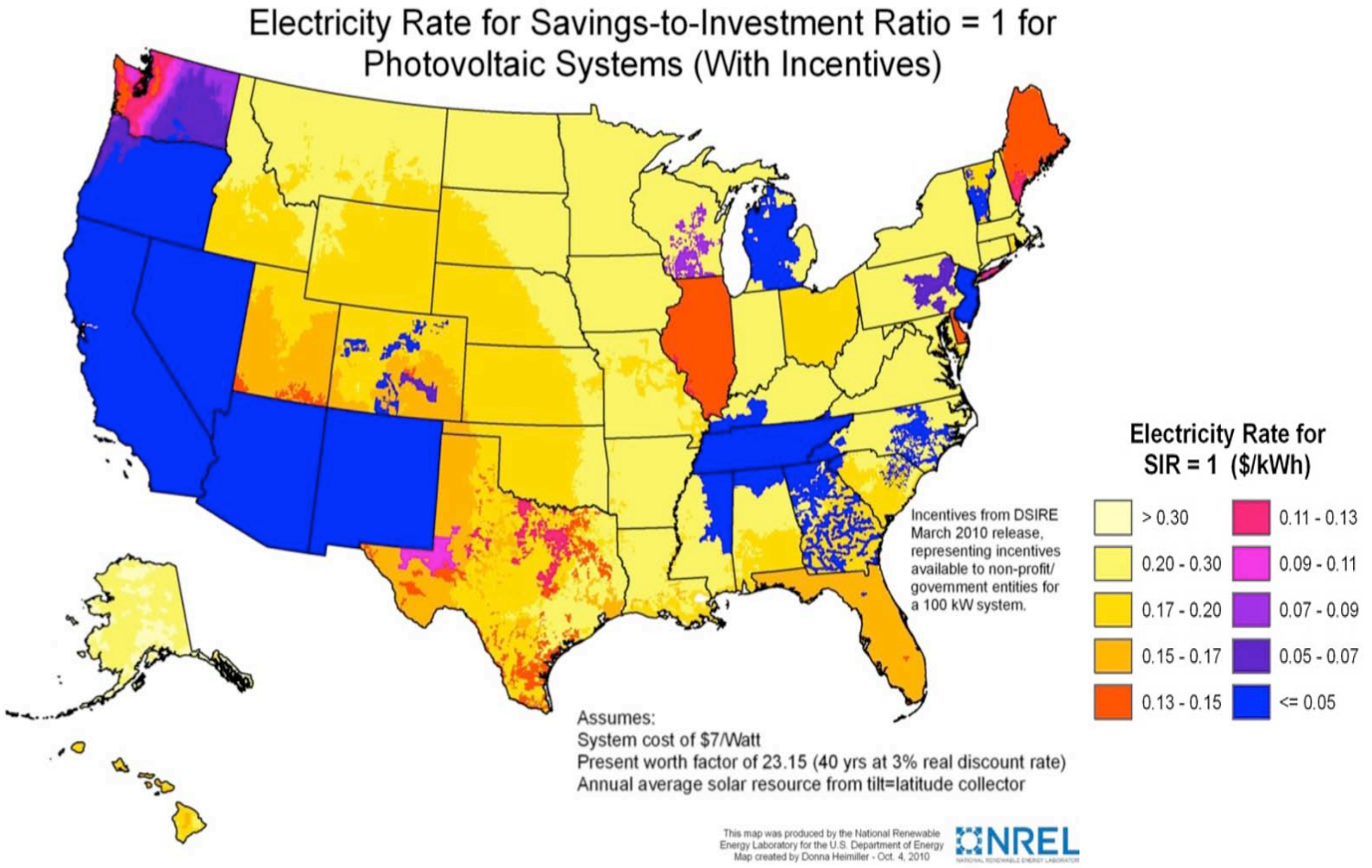
Veterans Administration Loma Linda, CA



Source: Fat Spaniel Technologies

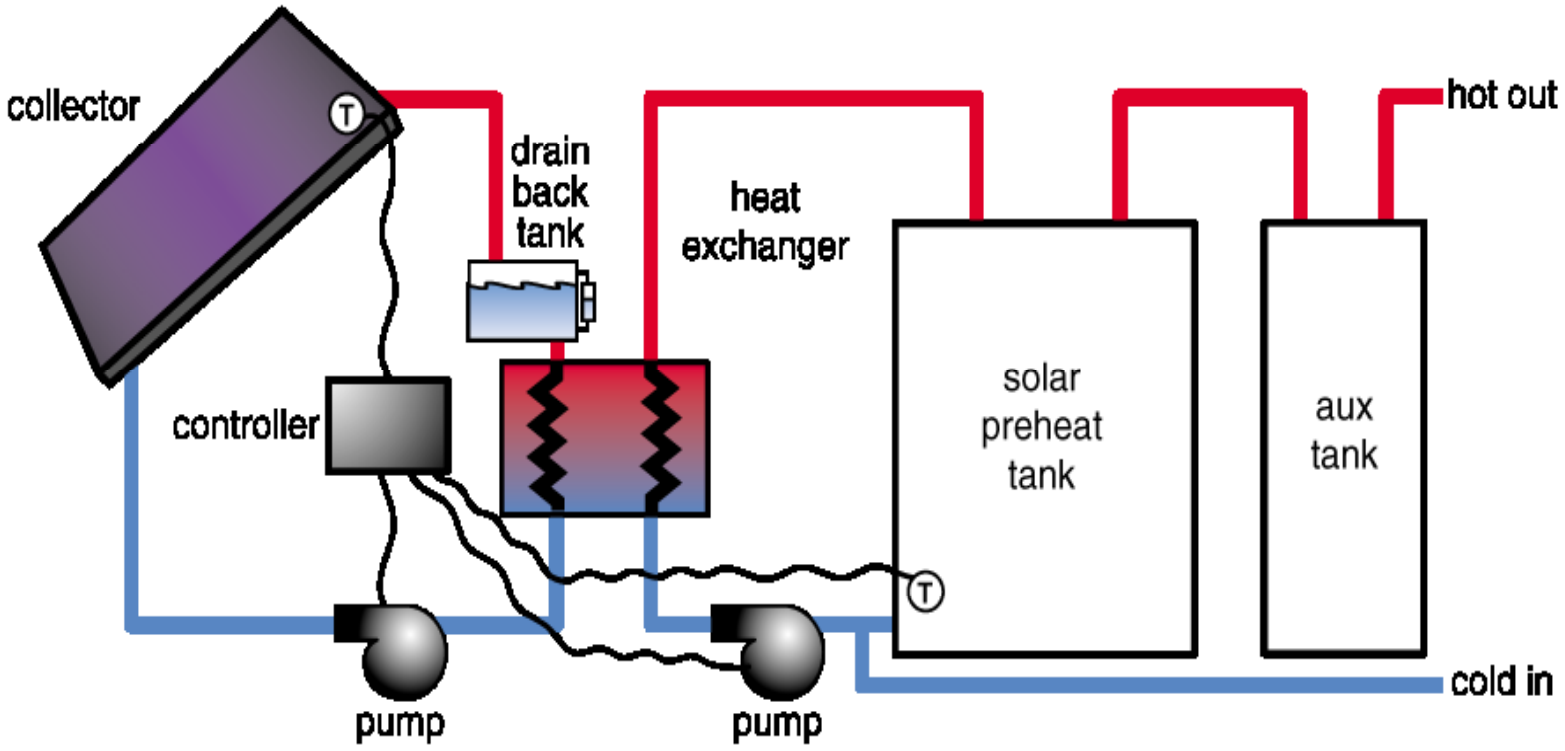

Photovoltaic Solar Resource of the United States
kWh/m²/Day
> 6.5
6.0 to 6.5
5.5 to 6.0
5.0 to 5.5
4.5 to 5.0
4.0 to 4.5
3.5 to 4.0
3.0 to 3.5
< 3.0
This map was produced by the National Renewable Energy Laboratory for the US Department of Energy.
October 13, 2009 Author: Billy J. Roberts
NREL
www.nrel.gov/gis

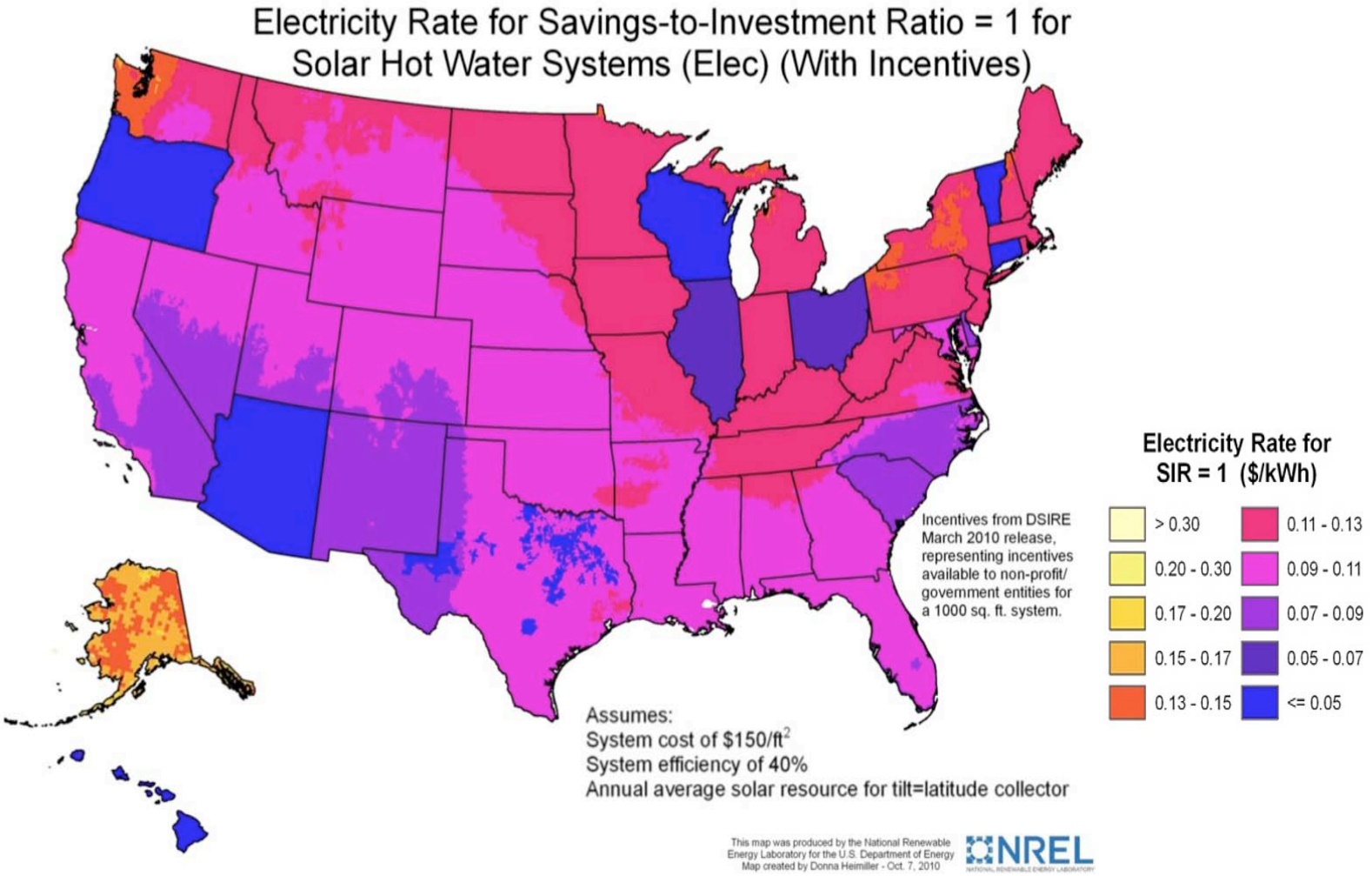

Electricity Rate for Savings-to-Investment Ratio = 1 for Photovoltaic Systems (Not Considering Incentives)
Electricity Rate for SIR = 1 ($/kWh)
> 0.30
0.20 - 0.30
0.17 - 0.20
0.15 - 0.17
0.13 - 0.15
0.11 - 0.13
0.09 - 0.11
0.07 - 0.09
0.05 - 0.07
<= 0.05
Assumes:
System cost of $7/Watt
Present worth factor of 23.15 (40 yrs at 3% real discount rate)
Annual average solar resource from tilt=latitude collector
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy
Map created by Donna Heimiller - Oct. 4, 2010
NREL


Electricity Rate for Savings-to-Investment Ratio = 1 for Photovoltaic Systems (With Incentives)
Incentives from DSIRE March 2010 release, representing incentives available to non-profit/ government entities for a 100 kW system.
Assumes:
System cost of $7/Watt
Present worth factor of 23.15 (40 yrs at 3% real discount rate)
Annual average solar resource from tilt=latitude collector
Electricity Rate for SIR = 1 ($/kWh)
> 0.30
0.20 - 0.30
0.17 - 0.20
0.15 - 0.17
0.13 - 0.15
0.11 - 0.13
0.09 - 0.11
0.07 - 0.09
0.05 - 0.07
<= 0.05
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy
Map created by Donna Heimiller - Oct. 4, 2010
NREL

What are Solar Thermal Applications?

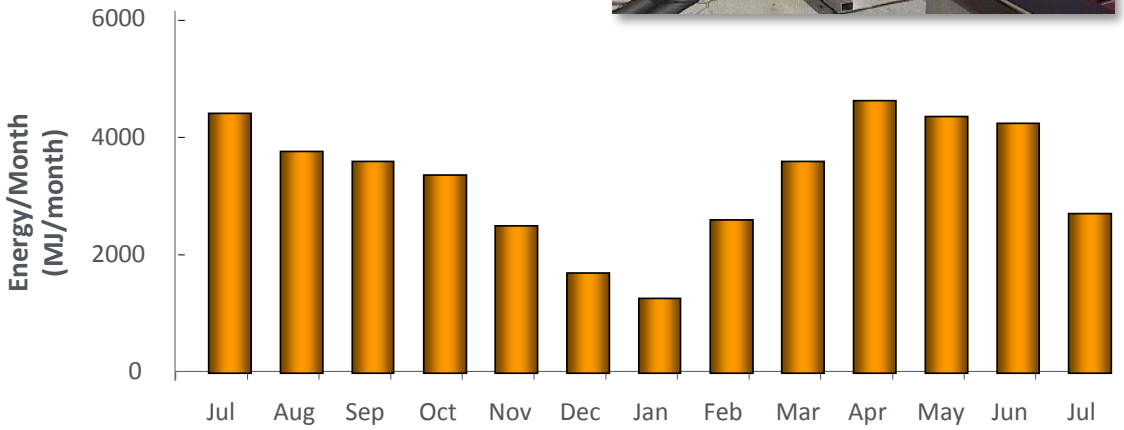
- Low Temperature
  - Swimming pool heating
- Medium Temperature
  - Domestic water and space heating
  - Commercial cafeterias, laundries, hotels
  - Industrial process heating
- High Temperature
  - Electricity generation


collector
T
drain
back
tank
heat
exchanger
hot out
controller
solar
preheat
tank
aux
tank
T
pump
pump
cold in

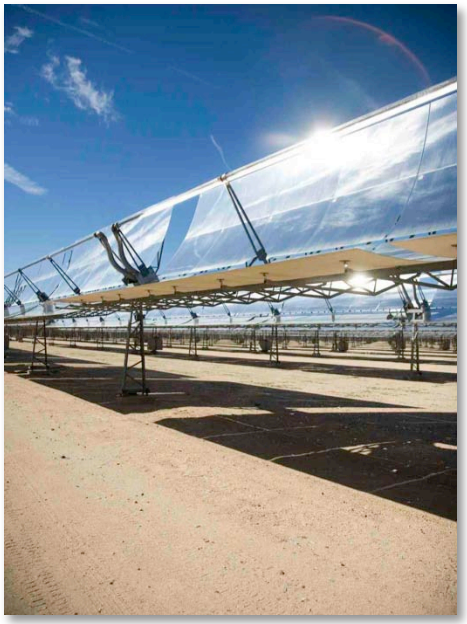

Electricity Rate for Savings-to-Investment Ratio = 1 for Solar Hot Water Systems (Elec) (With Incentives)
Incentives from DSIRE March 2010 release, representing incentives available to non-profit/ government entities for a 1000 sq. ft. system.
Assumes:
System cost of $150/ft2
System efficiency of 40%
Annual average solar resource for tilt=latitude collector
Electricity Rate for SIR = 1 ($/kWh)
> 0.30
0.20 - 0.30
0.17 - 0.20
0.15 - 0.17
0.13 - 0.15
0.11 - 0.13
0.09 - 0.11
0.07 - 0.09
0.05 - 0.07
<= 0.05
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
NREL

Solar Water Heating: Social Security Administration (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



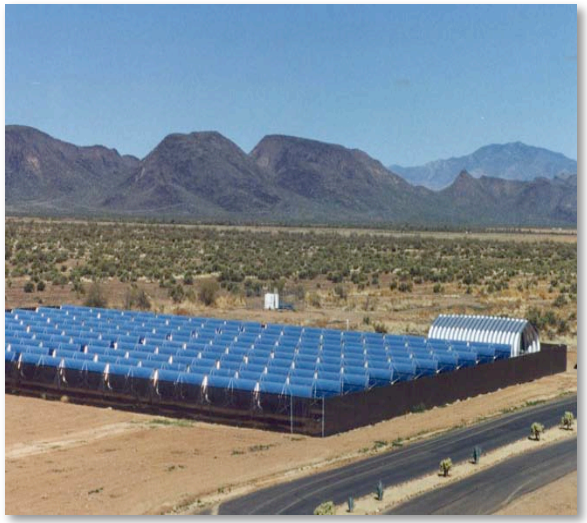
What is Concentrating Solar Power?



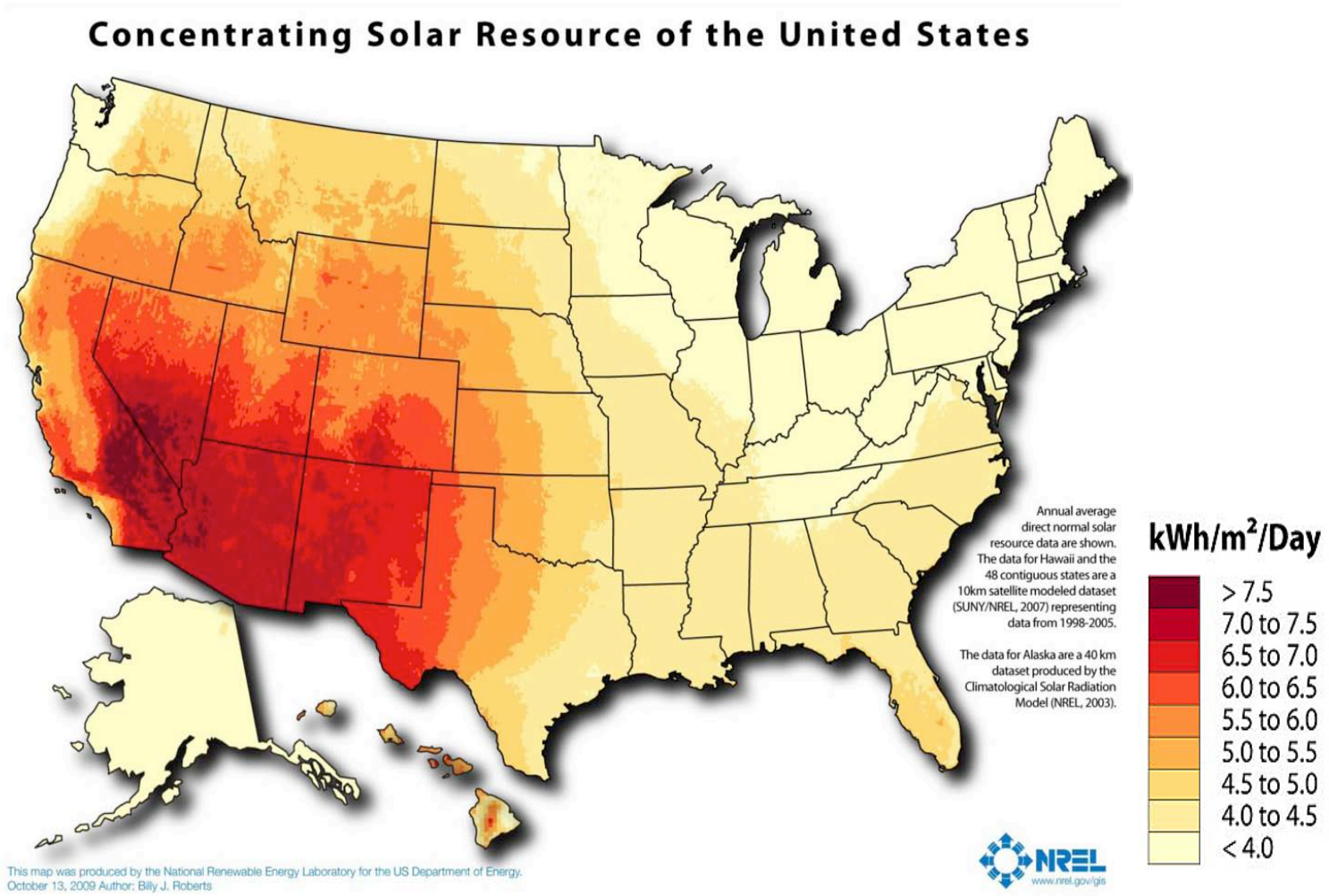
- Mirrors are used to reflect and concentrate sunlight onto receivers that collect this solar energy and convert it to heat
- Heat is used for generating hot water or steam
- Steam may be used to generate electricity

Concentrating Solar Heating

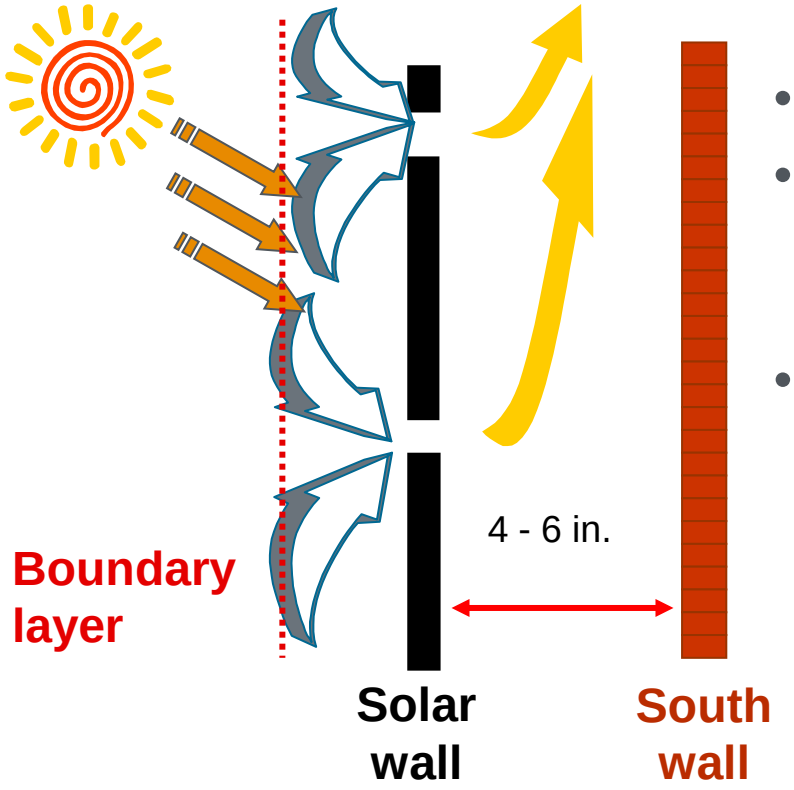
Federal Correctional Institute, Phoenix



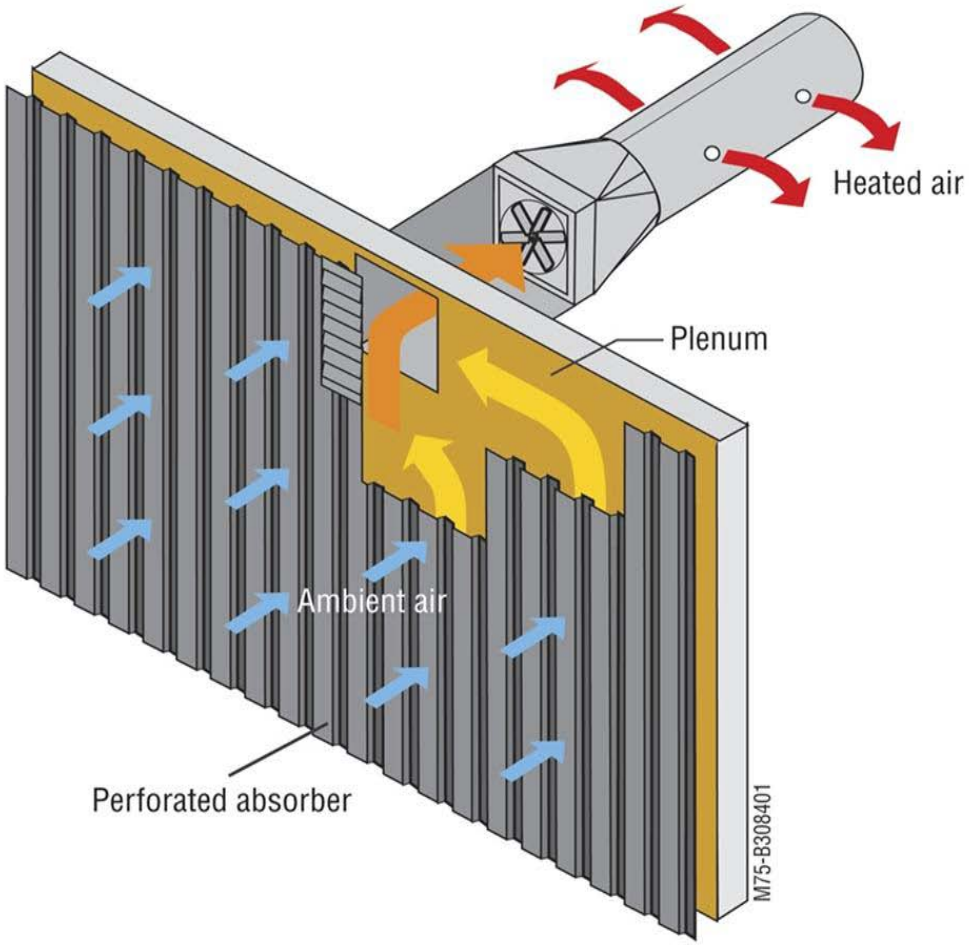
- 17,040 square feet of parabolic trough collectors
- 23,000 gallon storage tank
- Installed cost of $650,000
- Delivered 1,161,803 kWh in 1999 (87.1% of the water heating load)
- Saved $77,805 in 1999 Utility Costs


Concentrating Solar Resource of the United States
Annual average direct normal solar resource data are shown. The data for Hawaii and the 48 contiguous states are a 10km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.
The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).
kWh/m²/Day
> 7.5
7.0 to 7.5
6.5 to 7.0
6.0 to 6.5
5.5 to 6.0
5.0 to 5.5
4.5 to 5.0
4.0 to 4.5
< 4.0
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

What is Solar Ventilation Air Preheating?

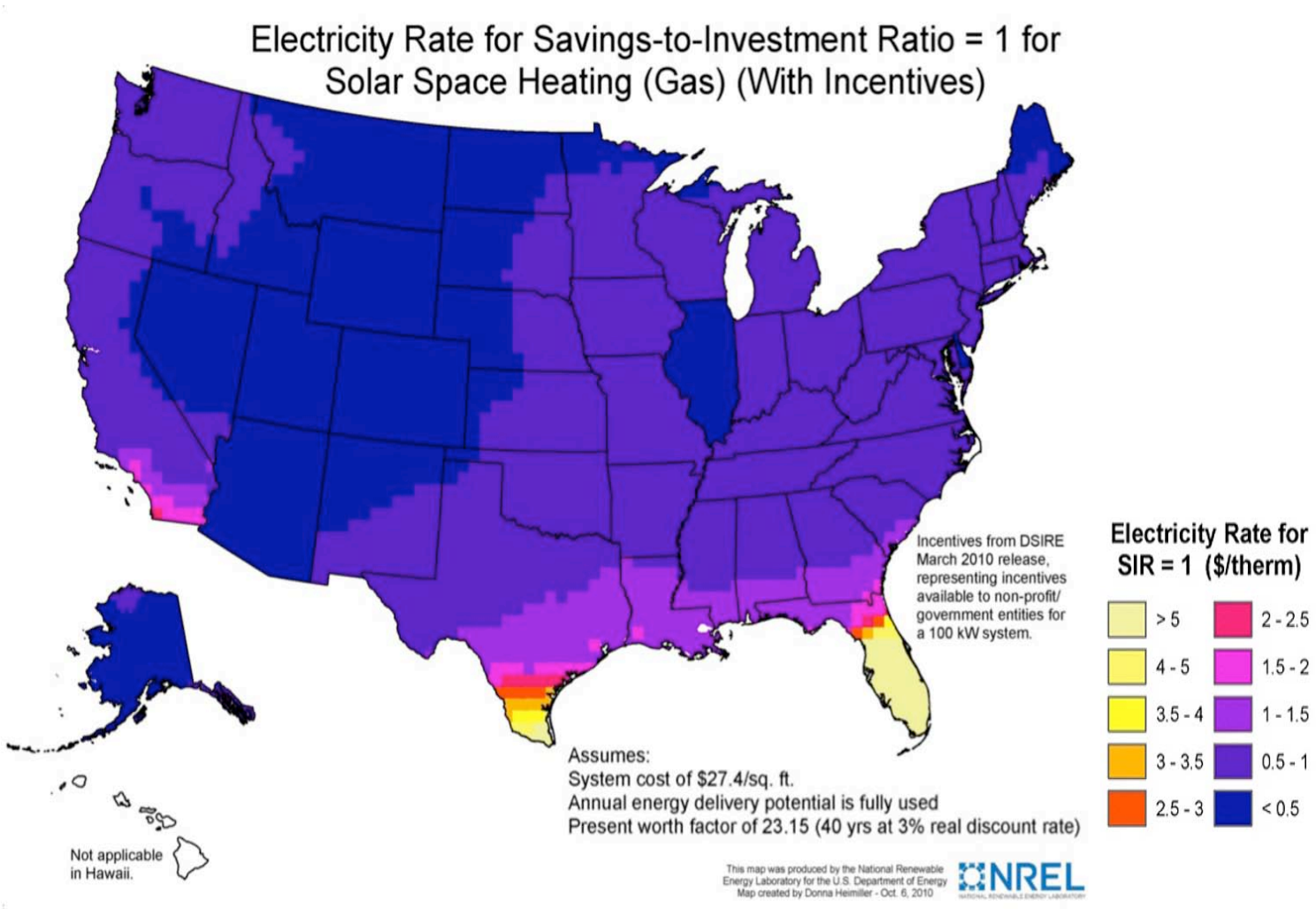


- Sun warms the collector surface
- Heat conducts from collector surface to thermal boundary layer of air (1 mm thick)
- Boundary layer is drawn into perforation by fan pressure before heat can escape by convection


Heated air
Plenum
Ambient air
Perforated absorber
M75-B308401

Solar Ventilation Applications

- Preheating outdoor ventilation air
- Process air heating


Electricity Rate for Savings-to-Investment Ratio = 1 for Solar Space Heating (Gas) (With Incentives)
Incentives from DSIRE March 2010 release, representing incentives available to non-profit/ government entities for a 100 kW system.
Electricity Rate for SIR = 1 ($/therm)
> 5
4 - 5
3.5 - 4
3 - 3.5
2.5 - 3
2 - 2.5
1.5 - 2
1 - 1.5
0.5 - 1
< 0.5
Assumes:
System cost of $27.4/sq. ft.
Annual energy delivery potential is fully used
Present worth factor of 23.15 (40 yrs at 3% real discount rate)
Not applicable in Hawaii.
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy
Map created by Donna Heimiller - Oct. 6, 2010
NREL

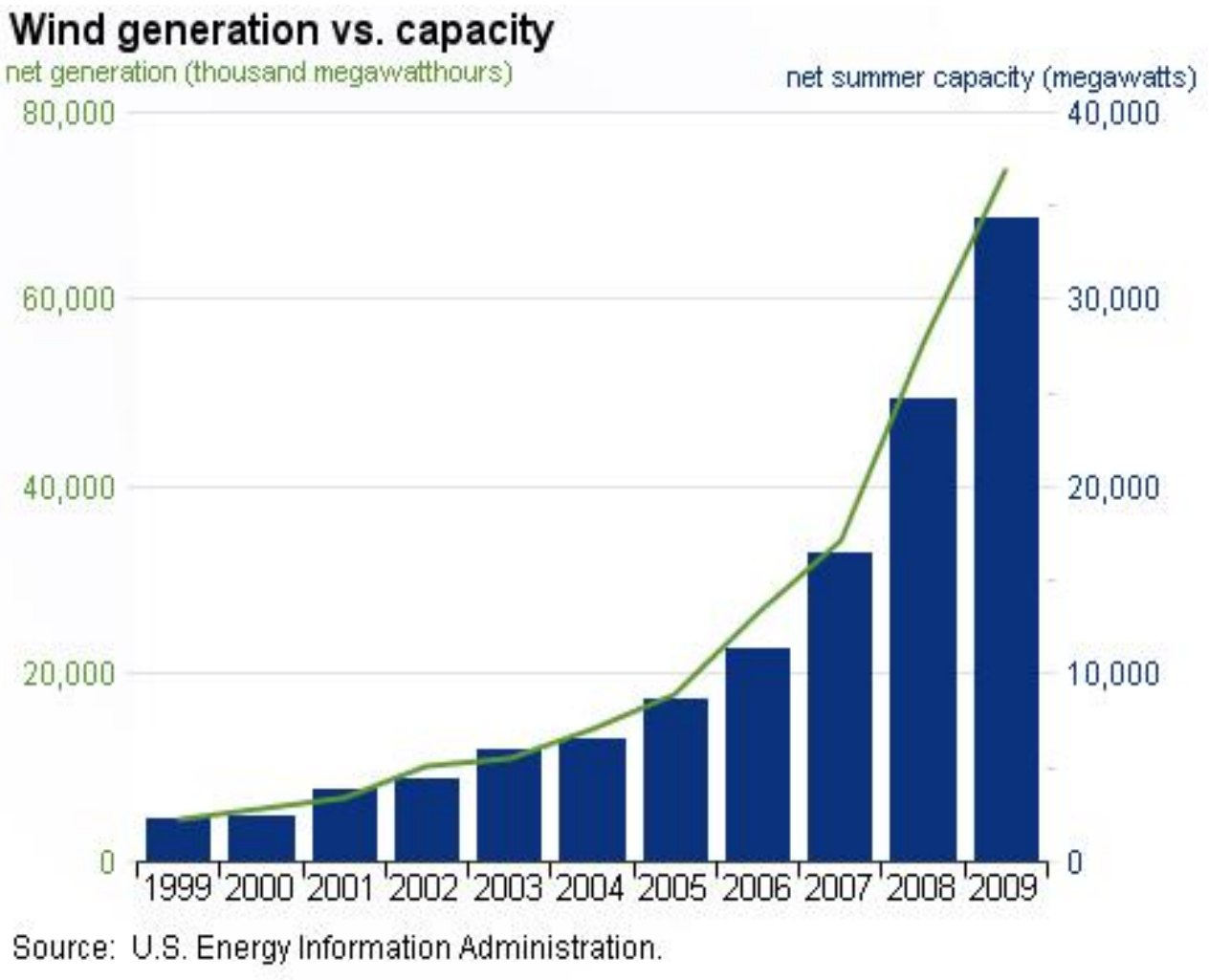
Solar Ventilation Air Preheating: EPA Lab (Golden, CO)

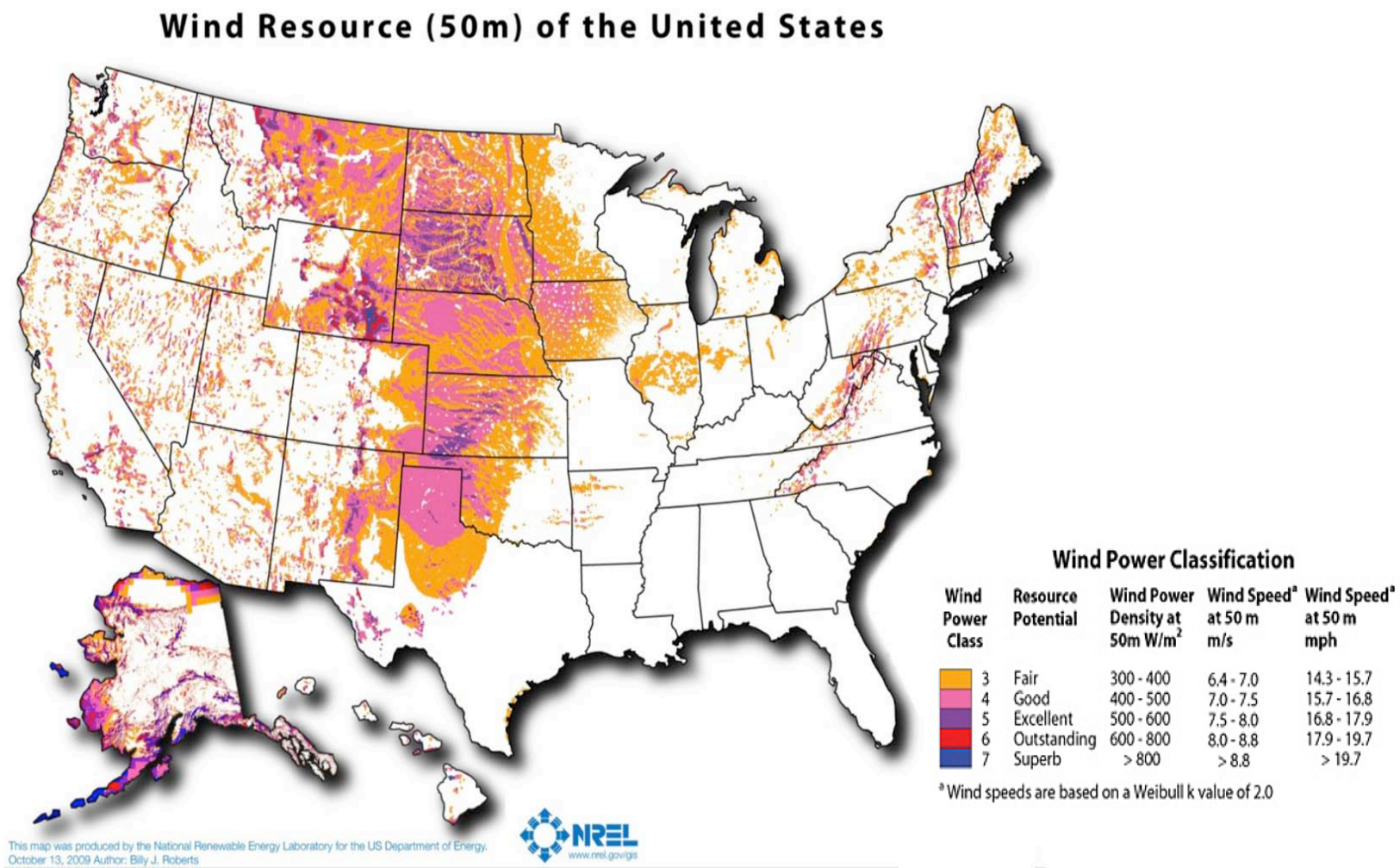
- Hazardous material storage building
- Installed in 2001
- 296 sf, 2000 cfm
- 58% measured efficiency
- Saves 60 Mil Btu/yr and $450/yr of natural gas
- Payback = 13 years

What Wind Technologies Are Available?

- Small
  - Home and farm applications
- Intermediate
  - Hybrid systems
  - Distributed power
- Large
  - Central station wind farms
  - Distributed power

Wind Generation in the U.S.




Wind Resource (50m) of the United States
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50m W/m²
Wind Speed[a] at 50 m m/s
Wind Speed[a] at 50 m mph
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb > 800 > 8.8 > 19.7
[a] Wind speeds are based on a Weibull k value of 2.0
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

Warren Air Force Base, Cheyenne

F.E.Warren AFB

- 600 kW wind turbines
- $2.5 million installed
- Generates energy to power 522 households on base
- Avoids 5,000 tons/year in GHG emissions
- Saves $3 million in energy costs over 20 years
- Additional capacity planned

What is Biomass in Terms of Renewable Technologies?

- Wood and wood waste
- Agricultural waste
- Bagasse
- Food processing residues
- Animal wastes
- Municipal solid waste
- Energy crops
- Landfill gas
- Methane from waste and wastewater treatment

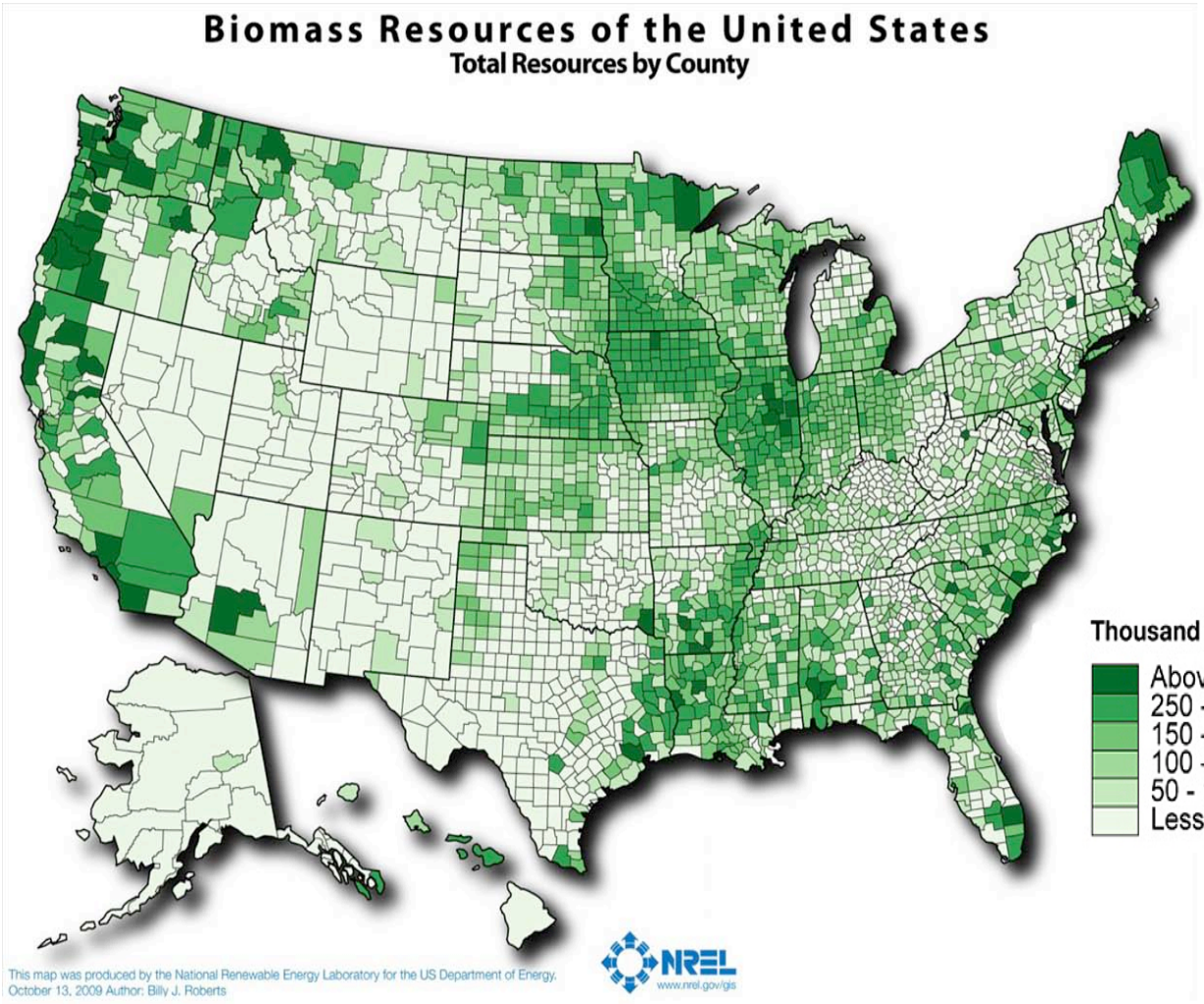
Biomass

Conversion Options

- Direct Combustion
- Gasification
- Liquidification (pyrolyses)
- Biological Processes

Technologies

- Co-firing rankine cycle
- Biomass only rankine cycle
- Biomass only GT
- Biomass only IGCC
- Biomass only IC engine
- Cofiring (coal or NG rankine)
- Co-gasification

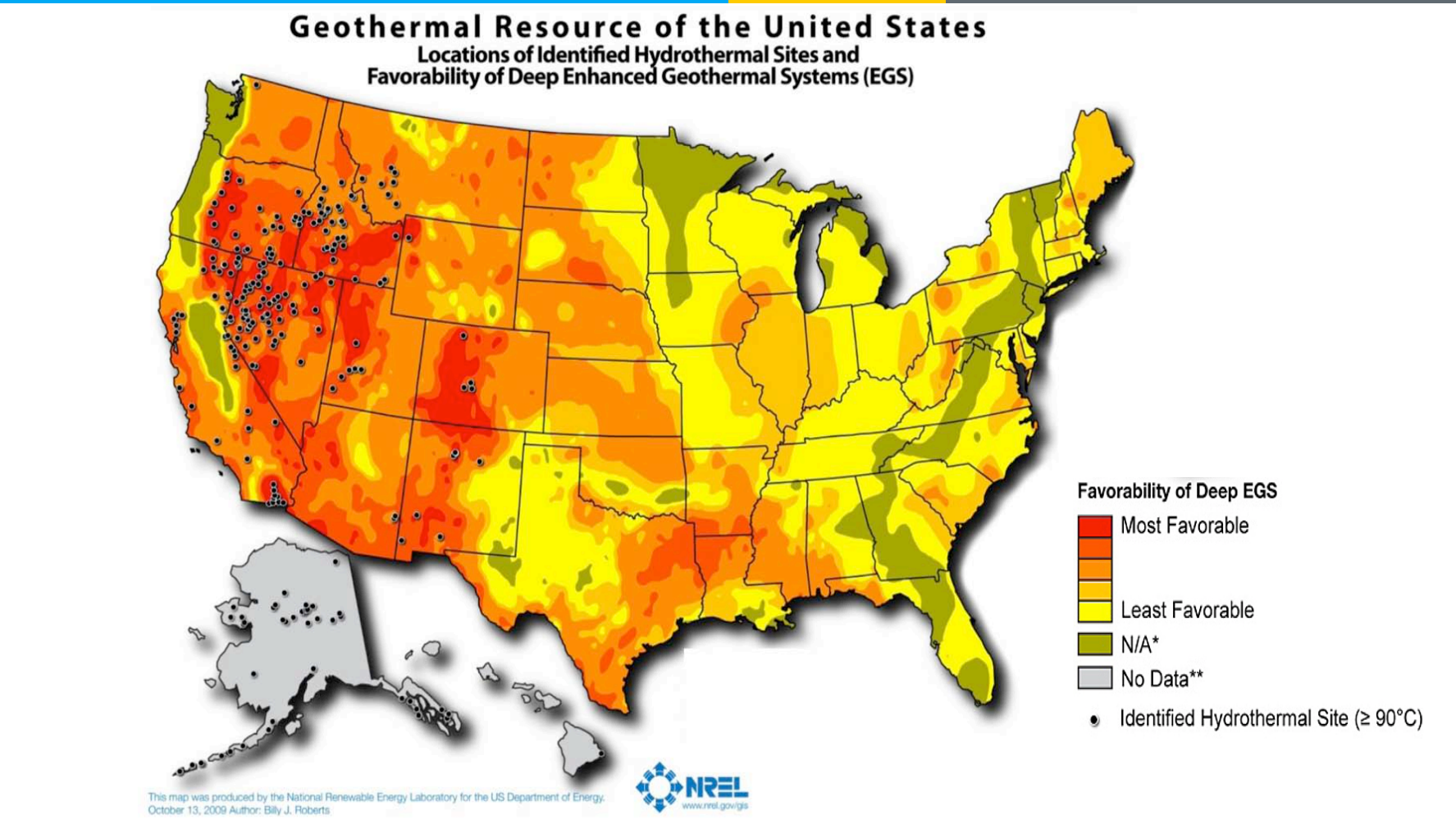

Biomass Resources of the United States
Total Resources by County
Thousand Tonnes/Year
Above 500
250 - 500
150 - 250
100 - 150
50 - 100
Less than 50
This map was produced by the National Renewable Energy Laboratory for the US Department of Energy.
October 13, 2009 Author: Billy J. Roberts
NREL
www.nrel.gov/gis

NREL Renewable Fuels Heating Plant (Golden, CO)

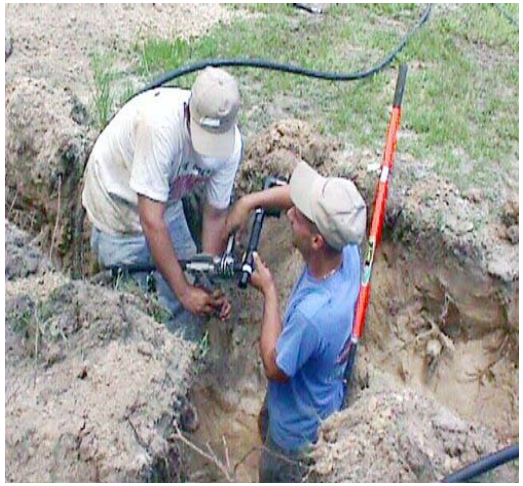
- $3.3 million cost under an ESPC
- Pine beetle waste wood
- 75% of the 50,000 million Btus to heat campus
- Cost savings projected $400,000/year
- The wood chips cost $29 per ton or $2.42 per million BTUs
- During cold weather, plant burns a truckload of wood chips per day; produces 600 gallons of hot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

What Geothermal Technologies are Available?

- Direct Use - hot water from springs or reservoirs near the surface
- Electricity generation –Using steam, heat or hot water from deep inside the earth to drive turbines
- Geothermal heat pumps –Using the earth, groundwater, or surface water as a heat source and heat sink


Geothermal Resource of the United States
Locations of Identified Hydrothermal Sites and
Favorability of Deep Enhanced Geothermal Systems (EGS)
Favorability of Deep EGS
Most Favorable
Least Favorable
N/A*
No Data**
Identified Hydrothermal Site (≥ 90°C)
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

Marine Corps Air Station, Beaufort, SC



- 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 pumps provide space heating, cooling, and domestic hot water for 1,235 family housing units at the Beaufort Marine Corps installation

What are the Hydropower and Ocean Energy Options?

- Hydropower is typically not cost-effective unless the site has access to existing hydroelectric dam
- Hydropower is a common form of Renewable Energy Credits

Renewable Technologies: Ocean

- Wave power
- Marine current power
- Tidal Energy
- Ocean Thermal Energy Conversion

Relatively immature

How Can Passive Solar Be Used?

- 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

Trombe Wall, NREL

Sunspace, NREL

Daylighting

- 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%

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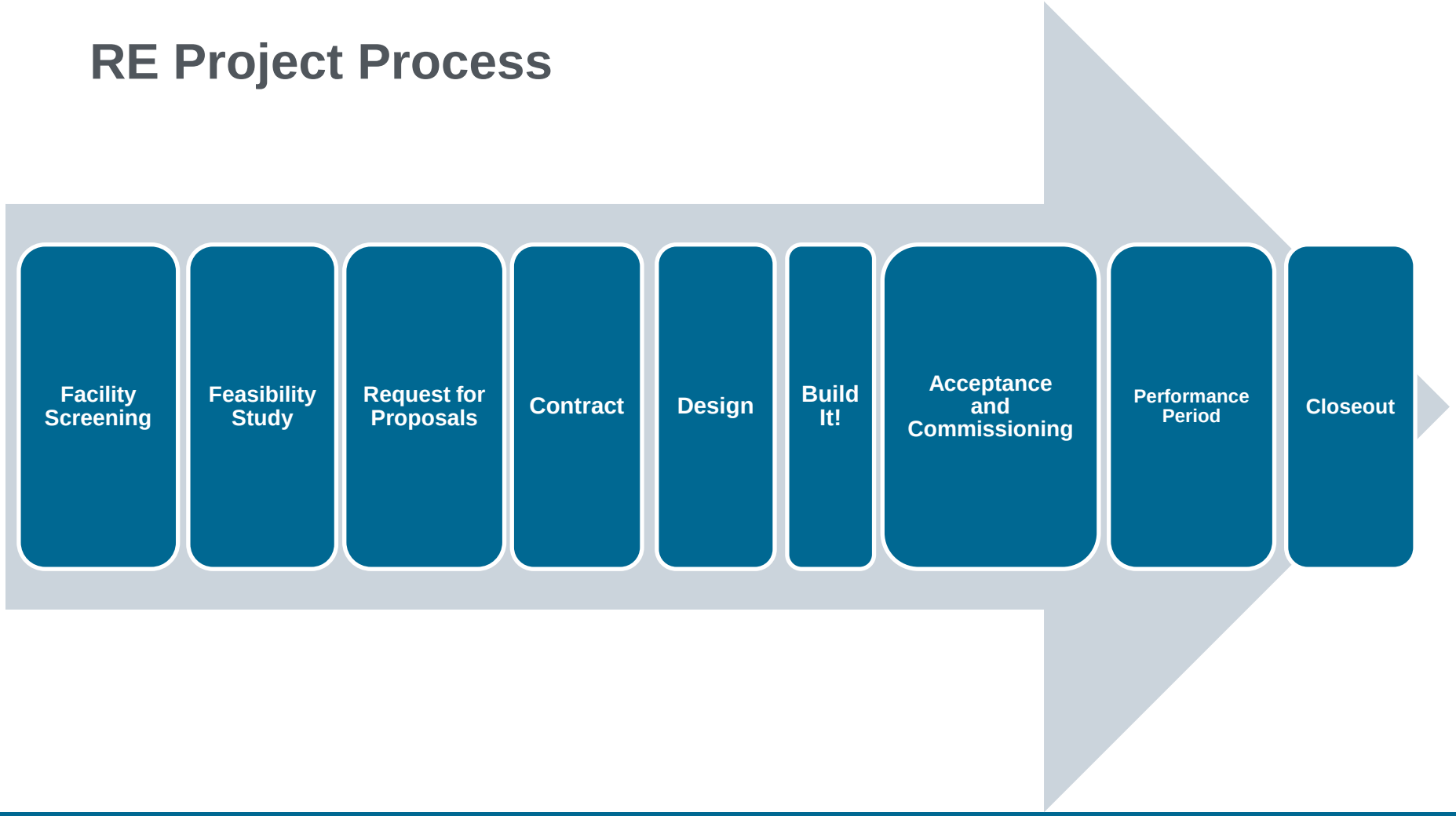
Renewable Energy Projects

RE Project Process



How Do You Determine Which Technologies to Consider?

- Establish baseline and site data
- Determine local RE resources
- Explore state and local financial incentives
- Consider characteristics of technologies

Screenings: Energy Manager

- NREL renewable energy resource maps
  http://www1.eere.energy.gov/maps_data/renewable_resources.html
- FEMP renewable energy financial analysis maps
  http://www.nrel.gov/gis/femp.html
- Savings to Investment Ratio (SIR)
  - Measure of project viability
  - SIR > 1, savings exceed costs, good investment
  - SIR < 1, costs exceed savings, poor investment
- Coming Soon: Levelized Cost of Electricity (LCOE) and Energy Performance and Cost Matrix

Screening Tools for Energy Manager

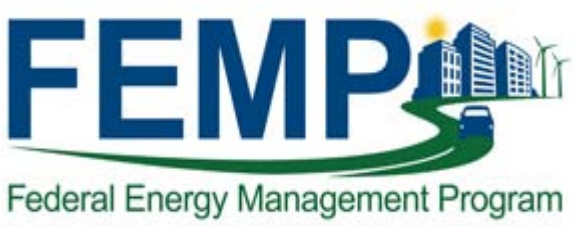
- **In My Back Yard (IMBY)** – PV and wind
  - Map-based interface
  - Choose location of your PV array or wind turbine
  - http://www.nrel.gov/eis/imby/

- **RET Screen**
  - Energy efficiency and RE technologies
  - http://www.retscreen.net/

Screening Tools for Energy Managers

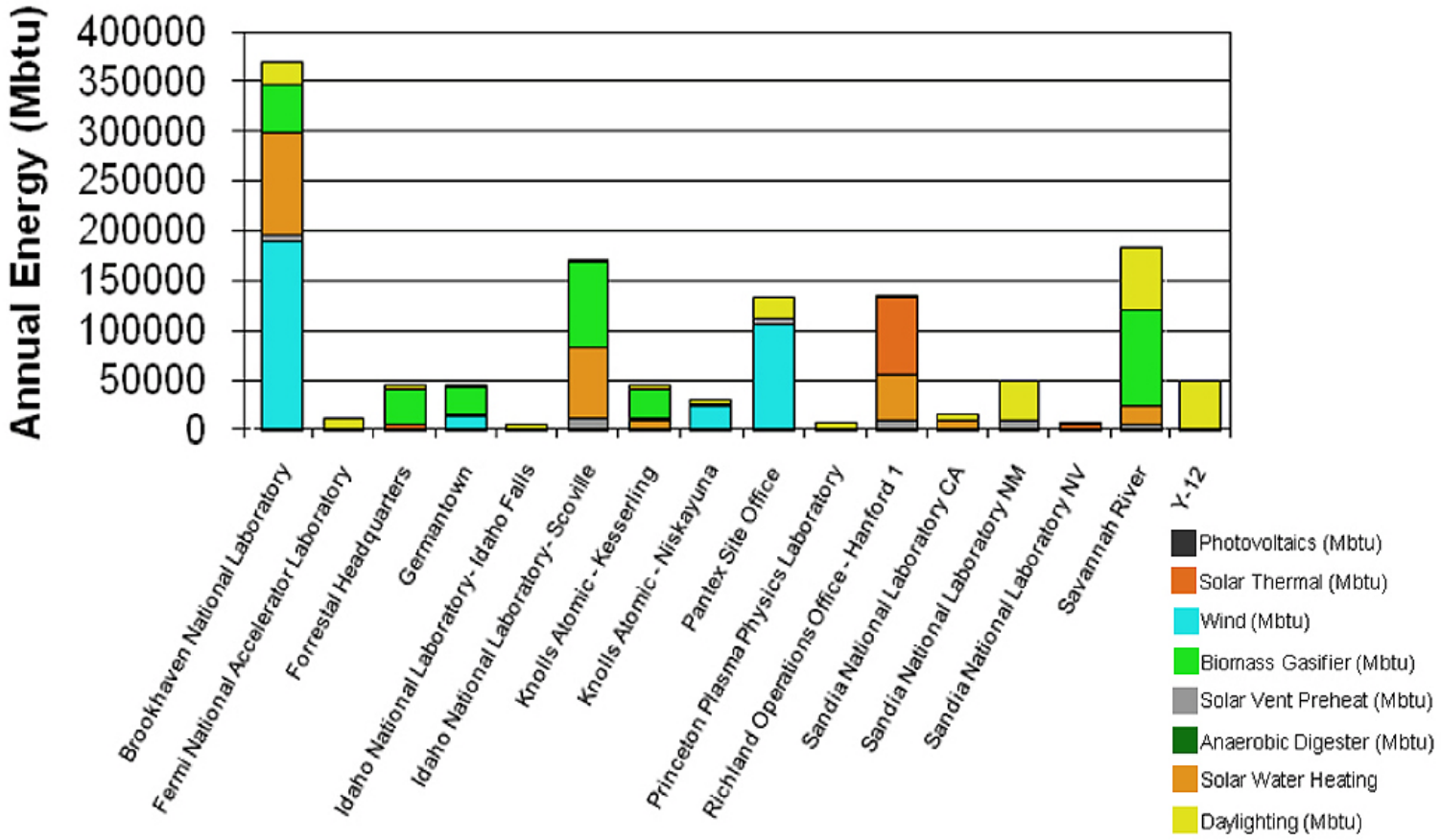
- FRESA
  - Under re-development
  - http://analysis.nrel.gov/fresa/
- HOMER
  - Multiple technologies simultaneously
  - https://analysis.nrel.gov/homer/

FEMP Assisted Screenings



- FEMP Technical Assistance Process
- Renewable Energy Optimization (REO) Service

Draft DOE Sites (Draft)

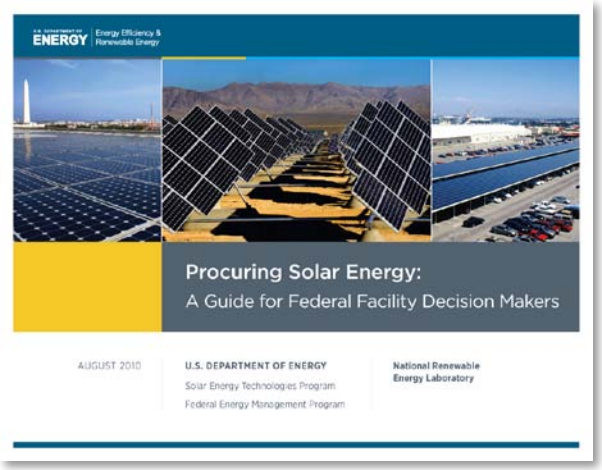


31 DOE Sites (DRAFT)

Initial Cost for Renewable Energy Projects	$269,634,839
Annual Electric Savings (kWh/year)	217,734,776
Annual Gas/Fuel Savings ($/year)	$8,693,565
Annual Cost Savings ($/year)	$26,241,533
Simple Payback Period (years)	10.3
Rate of Return	**11.3%**

Procuring Solar Energy:
A Guide for Federal Facility Decision Makers

- Plan
  - Goals and Team
- Execute
  - Financing and Contracts
- Available
  - Webinar available on demand from FEMP web site
  - http://www1.eere.energy.gov/solar/federal_guide/



What Options Are Available for Financing Renewable Energy Projects?

- Agency funding
- ESPC
- UESC
- Energy Project Incentive Funds from state and local sources
- Federal and state tax credits
- Enhanced Use Lease

Operational Phase – O&M

- **Energy Savings Performance Contract** –
  You pay for delivered energy
- **Guaranteed Energy Savings Contract** –
  You don't pay if energy is not delivered
- **Service Contract and Warranty** –
  You pay fixed service costs, whether needed or not
- **Facility does maintenance** -

  Or, possibly, facility doesn't do maintenance:
  - Low priority (always have hot water at the tap)
  - No inventory of parts and little expertise
  - Utility bill is always paid while efforts to reduce maintenance budgets are ongoing
- **Agency owned or third party owned**

Operational Phase – Measurement and Verification (M&V)

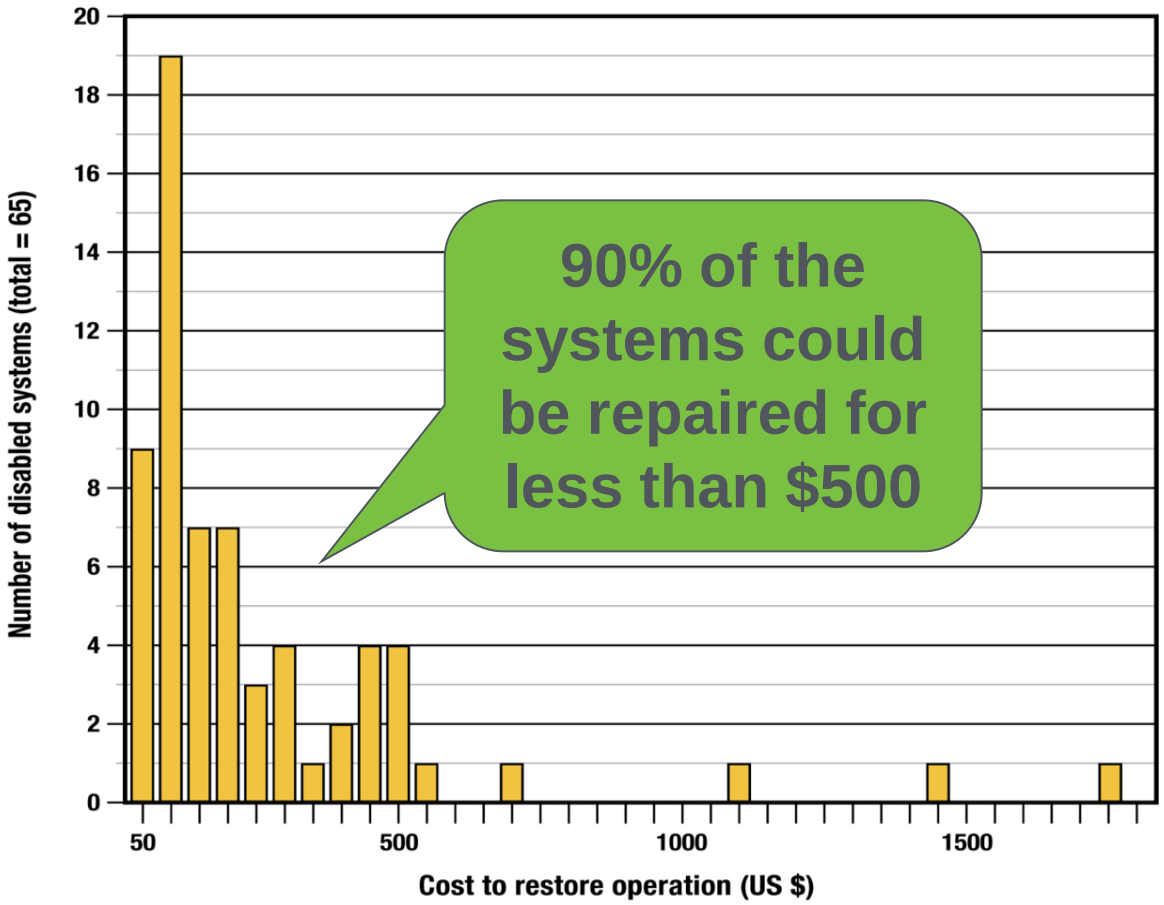
- Validation of reduction in energy use
- Measuring reductions in GHG
- The FEMP M&V Guidelines: www1.eere.energy.gov/femp/financing/superespcs_mvresources.html
- International Performance Measurement and Verification Protocol- "Concepts and Practices for Determining Savings in Renewable Energy Applications," Walker, A., Mills, D., Katz G. March 2000, revised January 2003. IPMVP, (report number DOE/EE-0157), available at http://www.evo-world.org/

"It is easier to measure energy delivery from a RE system than to infer savings from an efficiency measure"

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Operational Phase – Rehabilitation of Older Systems

O&M Survey of 185 Solar Water Heating Systems



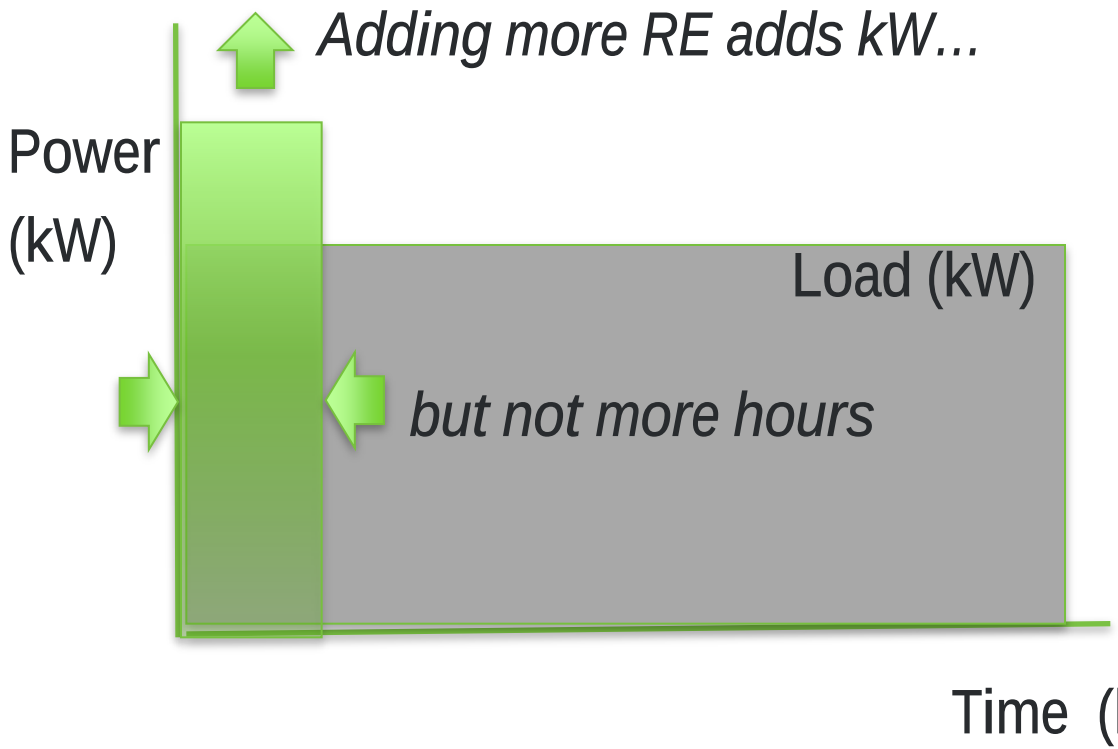
Renewable Energy in New Construction

- Using renewable energy along with low-energy design
  - can greatly reduce facility's energy bills and O&M costs
  - FEMP can assist with financing options
- Include cost and benefits in prospectus
- Provide space in architectural program
- Coordinate among design team
- Inter-connect with conventional systems
- Integrate with controls

Integrating Renewable Technologies into Existing Technologies

- Electric Power
  - Feed Existing Building Panel
  - Upgrade Existing Building Panel
  - Line-side Tap at Utility Service Entrance
- Thermal Energy
  - Preheat for existing heating equipment
  - Add back-up to new RE system

Selling Excess Power To Utility



Excess Valued at:

- Net metering
  - same as retail rate
- Avoided Cost
  - wholesale<retail
- No Credit

Purchasing Renewable Energy

What Are the Options for Purchasing Renewable Energy?

- Regulated Utility Green Pricing Programs
- Renewable Energy Certificates (RECs)
- Competitive Renewable Power
- Power Purchase Agreements (PPA)
  http://www1.eere.energy.gov/femp/technologies/renewable_training.html

Renewable Energy Certificates

- RECs represent the renewable and other attributes of electricity generated from a renewable project
- RECs are usually sold in one - megawatt-hour blocks
- Created at the source of electricity generation

Reasons to Buy RECs

- Satisfy renewable energy goals
- Support renewable energy economy
- Support development of renewable energy
- Create jobs in rural areas

Advantages of Buying RECs

- Improves market efficiency of Renewable Power
- Without RECs users would have to contract directly for delivery of the electricity including transmission and firming intermittent solar and wind energy

Resources for Buying RECs

- Western Area Power Administration (Western) through Renewable Resources for Federal Agencies program (RRFA) http://www.wapa.gov/powerm/pmtags.htm
- DLA Energy (formerly Defense Energy Support Center) http://www.desc.dla.mil/DCM/DCMPage.asp?pageid=589
- General Services Administration (GSA)
- Federal Energy Management Program (FEMP) available for technical assistance

Renewable Energy Certificates (RECs) for On-site Projects

- Federal agencies could sell RECs but…
- DOE requires RECs for RE Goal, and CEQ requires RECs for GHG Goal so…
- Renewable guidance allows agencies to purchase cheap replacement RECs if valuable RECs (like solar) are sold, to improve project cost-effectiveness

Power Purchase Agreements (PPAs)

- PPAs are long-term agreements between a Federal agency and a private developer.
  - The agency leases a portion of its facility or land to a partner, which uses that space to develop renewable energy systems
  - The agency then purchases energy generated from the system, which is owned, operated, and maintained by the partner

Nellis AFB PV project in Nevada

http://www1.eere.energy.gov/femp/financing/power_purchase_agreements.html

Purchasing Renewable Energy

- Purchasing RECs or electricity in deregulated states
  - Competitive acquisition rules apply
  - Usually General Services Administration(GSA) or DLA Energy execute purchases
- No competition required for Utility Green Pricing Plans in regulated states

Summary

FEMP Website on Renewable Energy

- Requirements
- Technologies
- Project Processes
- Maps
- Tools
- Training
- Case Studies

http://www1.eere.energy.gov/femp/technologies/renewable_energy.html

Renewable Energy Working Group

Provides a forum for Federal agencies and the renewable energy industry to exchange information on

- existing and planned projects
- lessons learned
- project funding sources
- available technologies
- guidance

How Do I Get Started?

Questions to Ask

- What are the objectives of my renewable energy project?
- What renewable resources are available in my area?
- Which applications are best for my facility?
- How big (or small) should my project be?
- How much funding do I need?
- What kinds of assistance can FEMP provide?

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