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

Data Centers Workshop: Renewable Energy Opportunities

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FEMP's RE Program Mission Statement

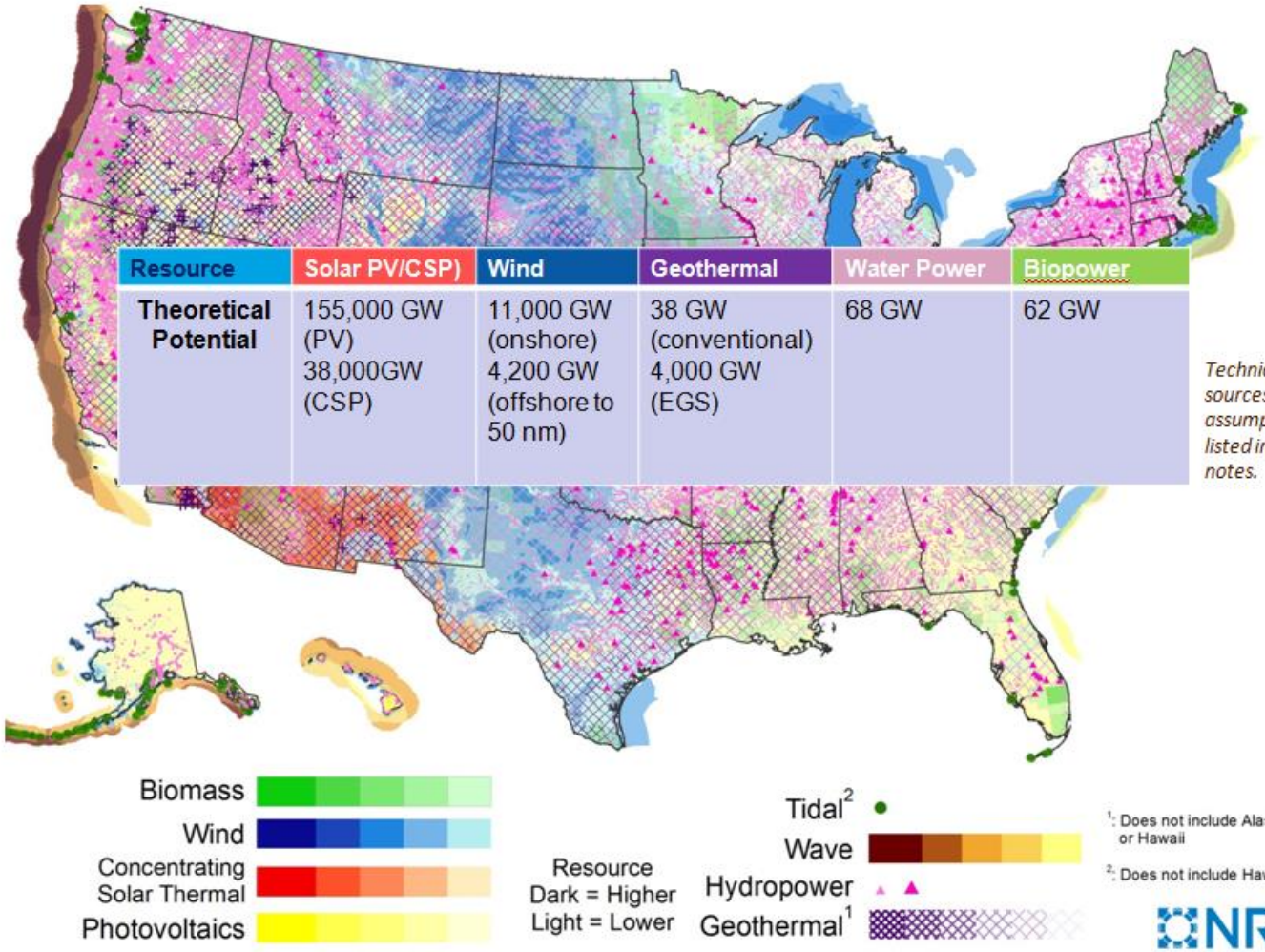
FEMP's Renewable Energy (RE) Program partners with key individuals to advance their renewable energy-related goals, yielding environmentally responsible and cost-effective approaches to policy development and project implementation.

Motivations for Renewable Energy Implementation

- Increase sales, gain more customers, keep existing customers satisfied - Marketing
- Energy Cost Savings
- Avoid cost of infrastructure (power line extension, upgrade)
- Reduced Emissions (tons CO2/year)
- Reduced volatility (fuel adjustment charge)
- Hedge against rate increases (%/year)
- Hedge against fuel/power supply interruptions

U.S. Renewable Resources

- Solar PV/CSP
- Wind
- Geothermal
- Water Power
- Biopower



Resource	Solar PV/CSP)	Wind	Geothermal	Water Power	Biopower
Theoretical Potential	155,000 GW (PV) 38,000GW (CSP)	11,000 GW (onshore) 4,200 GW (offshore to 50 nm)	38 GW (conventional) 4,000 GW (EGS)	68 GW	62 GW

Technical potential sources and assumptions are listed in the slide notes.

NREL NATIONAL RENEWABLE ENERGY LABORATORY

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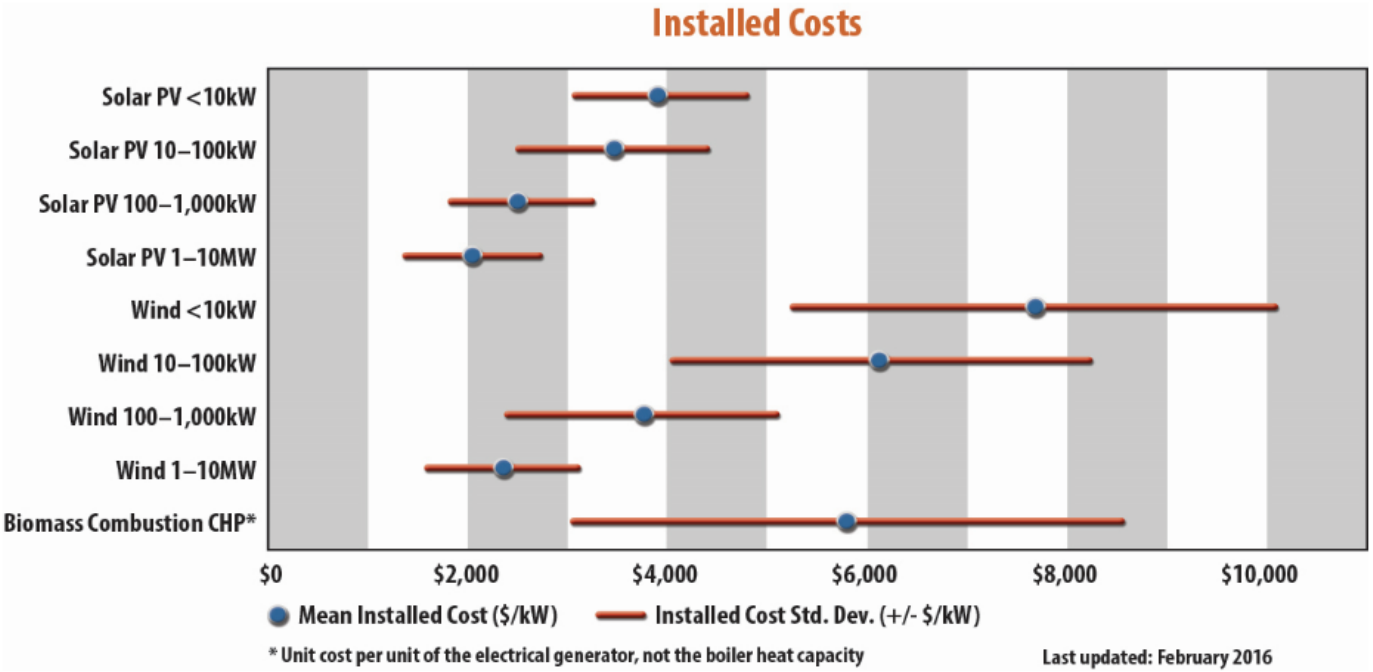
Factors Impacting RE Implementation

RE viability depends on:

- Impact on facility mission
- Your cost of energy
- Your local renewable energy resources
- Technology characteristics
  - Cost ($/kW installed; O&M costs)
  - Performance (efficiency)
- State, utility policies (interconnection, net metering, charge structure)
- Compliance requirements
  - Environmental (NEPA)
  - Historic (NHPA)
- State, Utility and Federal incentives
- Economic parameters (interest rate, escalation rates)
- Your organizations policies and mandates

Cost and Performance Matrix

Initial Cost for Renewable Energy Technologies

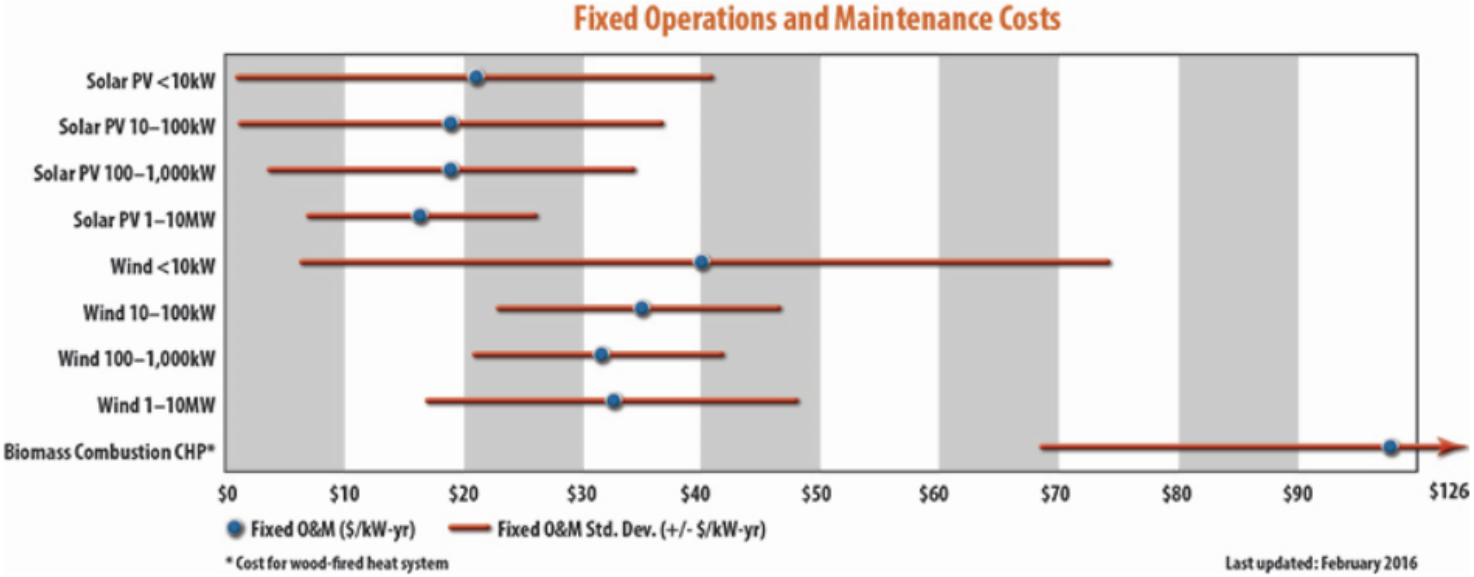


Costs for Thermal Technologies

Technology Type	Mean Installed Cost	Installed Cost Std. Dev. (+/-)
Solar Water Heat, flat plate and evacuated tube ($/ft^2)	$162	$61
Solar Water Heat, plastic collector ($/ft^2)	$59	$15
Solar Vent Preheat ($/ft^2)	$31	$14
Biomass Wood Heat ($/kW)	$575	$252
Ground Source Heat Pump ($/ton)	$7,765	$4,632

http://www.nrel.gov/analysis/tech_cost_dg.html

O&M for Renewable Energy Technologies



Variable O&M Costs

	Variable O&M ($/kWh)	Variable O&M Std. Dev. (+/- $/kWh)
Biomass Combustion Combined Heat and Power*	$0.07	$0.02
*Unit cost is per unit kWh of the electrical generator, not the boiler heat capacity.		

O&M Costs for Thermal Technologies

	O&M
Solar Water Heat, flat plate and evacuated tube	0.5 to 1.0% initial installed cost
Solar Water Heat, plastic collector	0.5 to 1.0% initial installed cost
Solar Vent Preheat	1 Watt/ft^2 fan power
Biomass Wood Heat	$91/kW +/-$33/kW
Ground Source Heat Pump	$109 +/-94/ton

http://www.nrel.gov/analysis/tech_cost_om_dg.html

Renewable Energy Technologies

Photovoltaics

Wind Power

Solar Water Heating

Solar Vent Air Preheat

Concentrating Solar Heat/Power

Biomass Heat/Power

Daylighting

Ground Source Heat Pump

Landfill Gas

FEMP RE Tools and Resources

- RE Cost and Performance Matrix
  - http://www.nrel.gov/analysis/tech_cost_dg.html
  - Initial cost, O&M cost, useful life; LCOE calculator
- GIS Tools and Data
  - http://maps.nrel.gov/femp
  - Resources, topography, environmental concerns, boundaries
  - LCC analysis for PV, wind, solar water heating, and solar ventilation air preheat
- REOpt Development
  - http://www.nrel.gov/tech_deployment/tools_reopt.html
  - Optimizes a portfolio of RE projects based on LCC
- RE Website
  - http://www.energy.gov/eere/femp/federal-renewable-energy-projects-and-technologies
  - Publications, data, technical assistance portal
- RE Training
  - http://www.energy.gov/eere/femp/federal-energy-management-program-training
  - Project development, technology, O&M

Thank You

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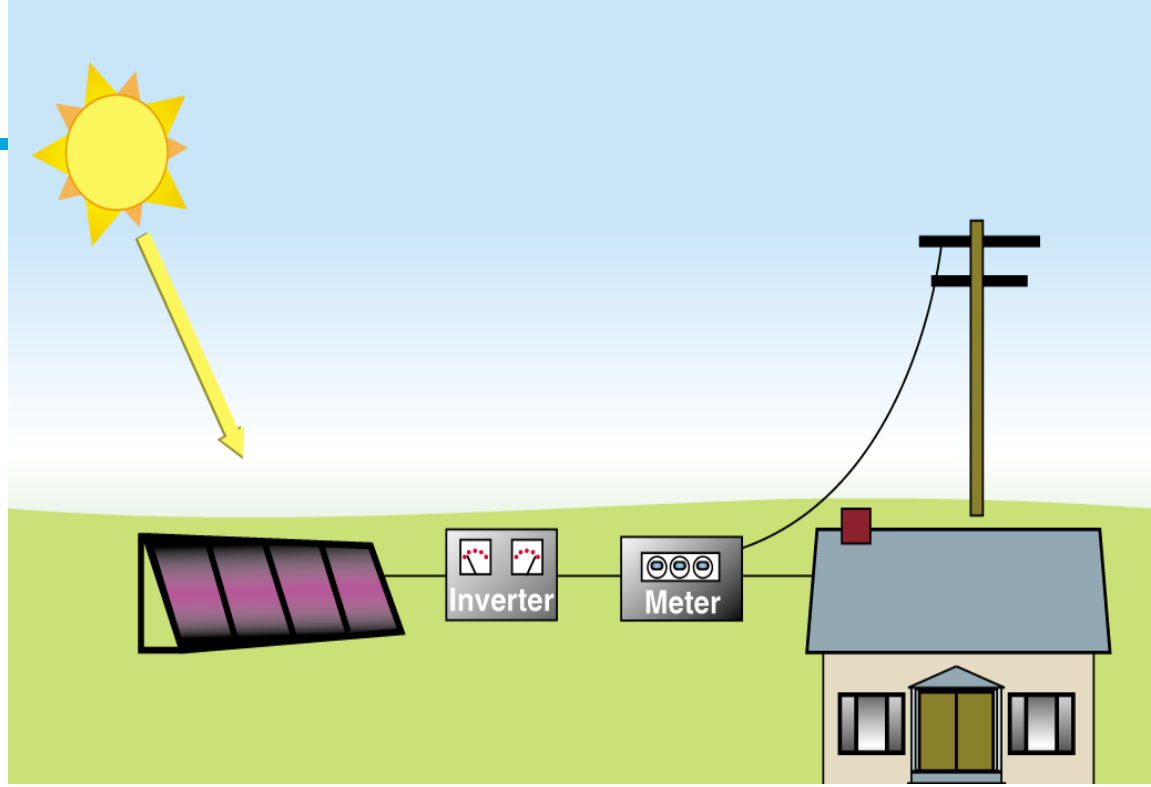
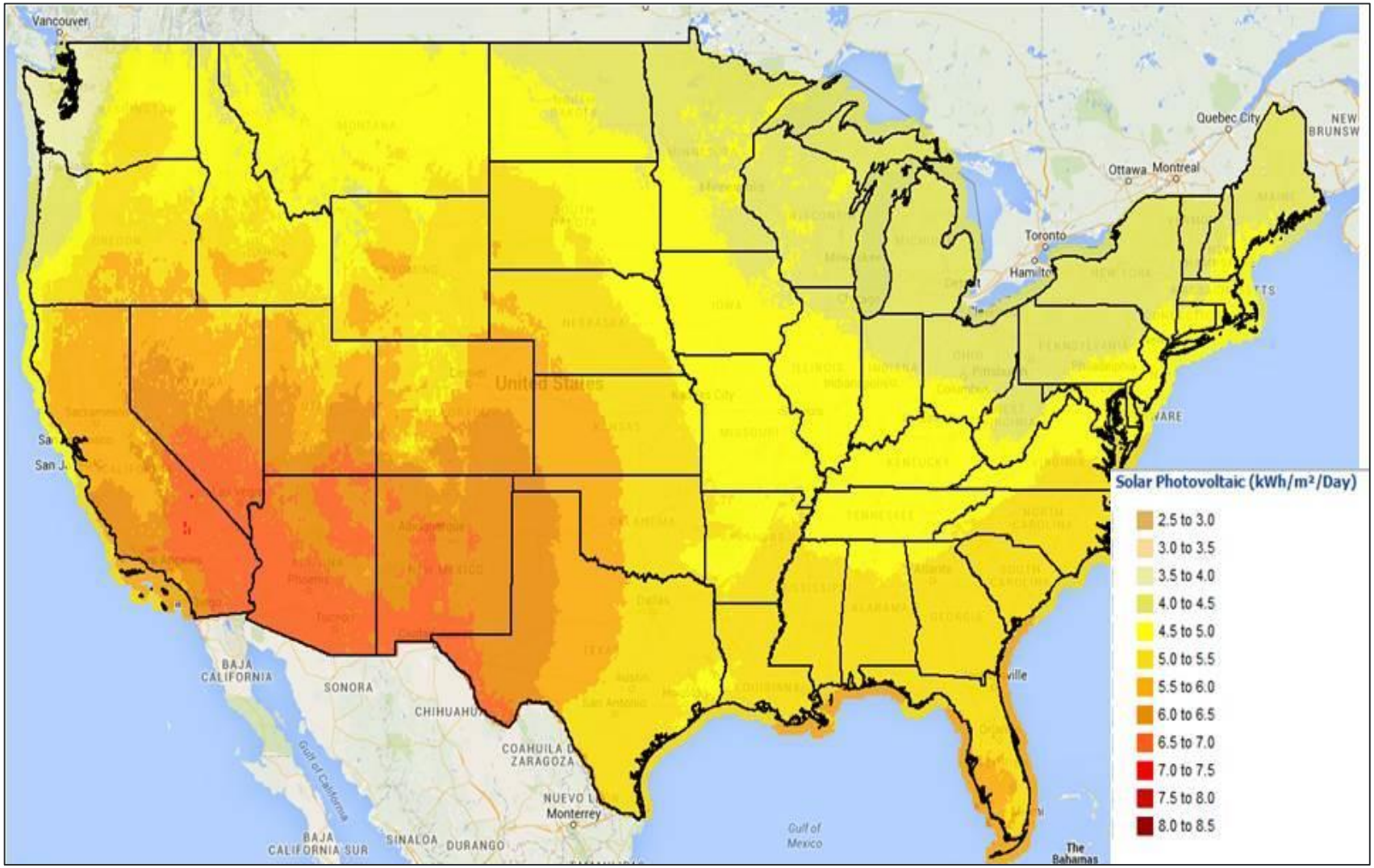
Solar

PV Technology Overview



- Direct conversion of sunlight into DC electricity
- DC converted to AC by inverter
- Solid-state electronics, no-moving parts
- High reliability, warranties of 25 years
- PV modules are wired in series and parallel to meet voltage and current requirements

Solar Resource: Tilt = Local Latitude

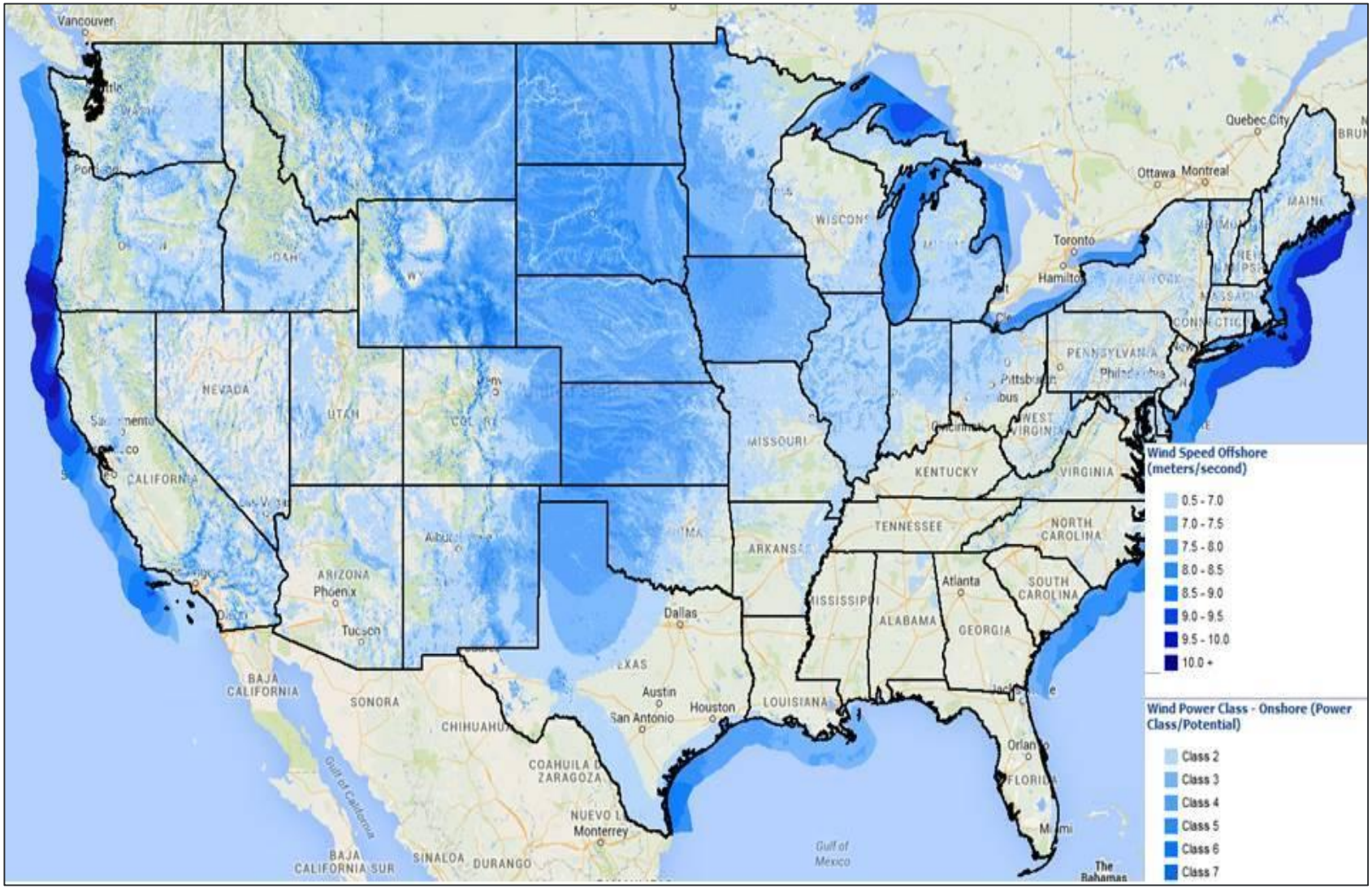


Annual average kWh/m^2/year

Source: FEMP's Renewable Energy Geospatial Screening Tool

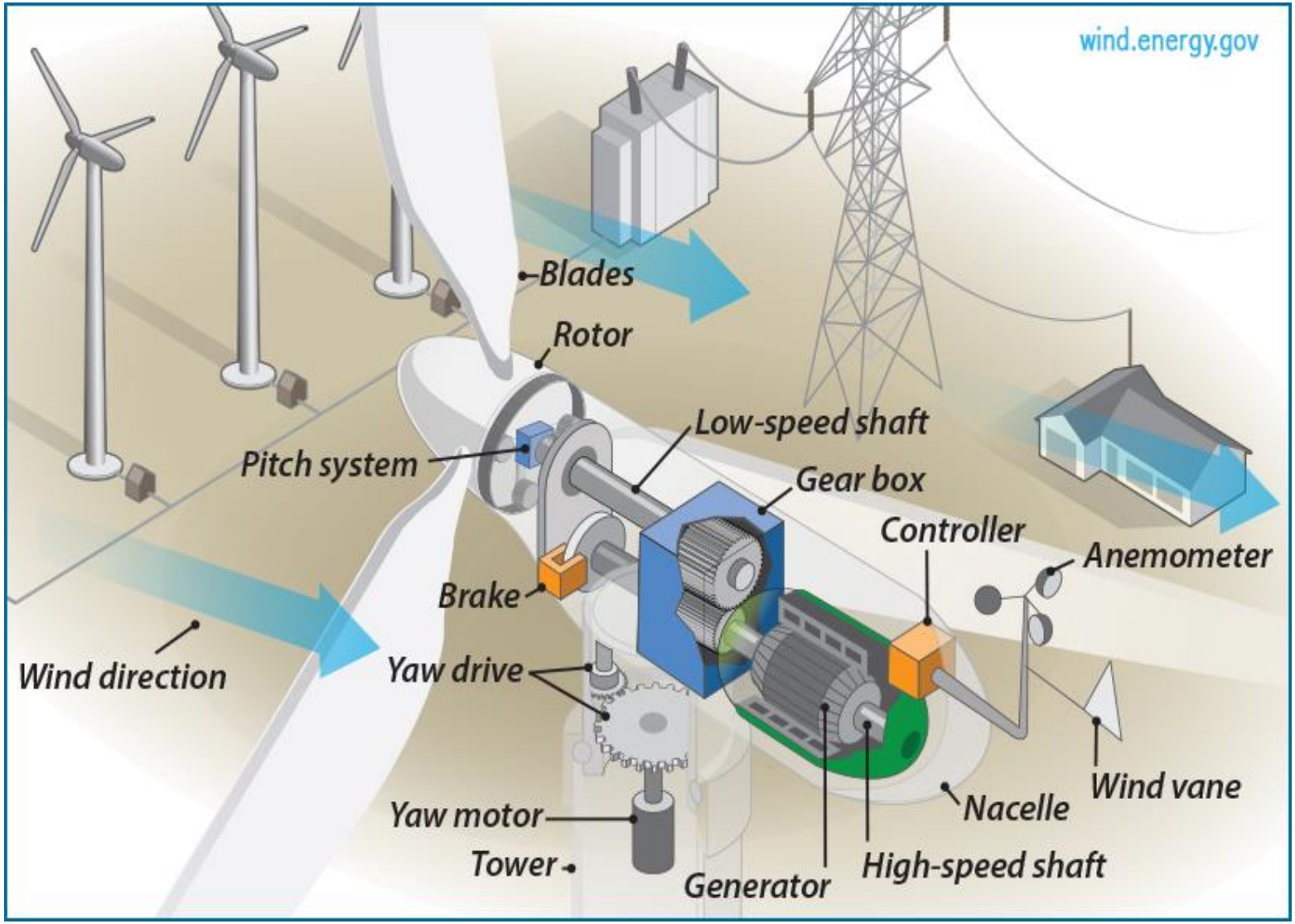
Wind

Wind Energy Resource



Source: FEMP's Renewable Energy Geospatial Screening Tool

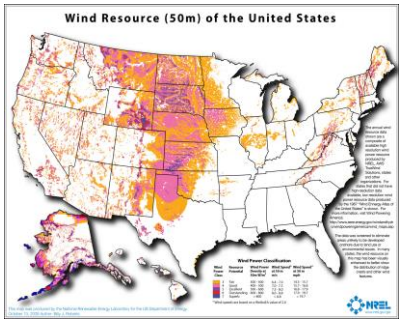
Wind Turbine Diagram



REopt Slides

REopt: Techno-Economic Decision Support Tool

- Techno-economic decision support tool to evaluate energy opportunities
- Integration & Optimization: Recommends a mix of technologies and an operating strategy that meets client goals at minimum lifecycle cost
  - Considers interactions between multiple technologies
  - Estimates costs and energy savings
- Draws on site data, NREL GIS resource data, DSIRE incentive database, and RE technology info
- Has been used to assess opportunities at 2000+ sites
- Technologies currently modeled:
  - PV
  - Wind
  - Solar hot water
  - Solar vent preheat
  - Biomass
  - Waste to energy
  - Landfill gas
  - GSHP
  - Diesel and natural gas generators
  - Electric and thermal storage





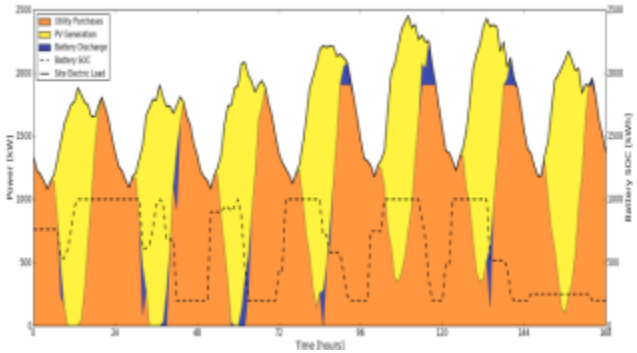



REopt: Decision Support Throughout the Energy Planning Process

Optimization • Integration • Automation

Master Planning	Project Development	Energy Security Analysis
• Renewable & fossil mix • Cost to meet goals • Site prioritization	• Technology types & sizes • Installation & operating cost • Optimal operating strategies	• Microgrid dispatch • Generation & storage sizing • Energy security evaluation

Cost-effective PV at Army bases

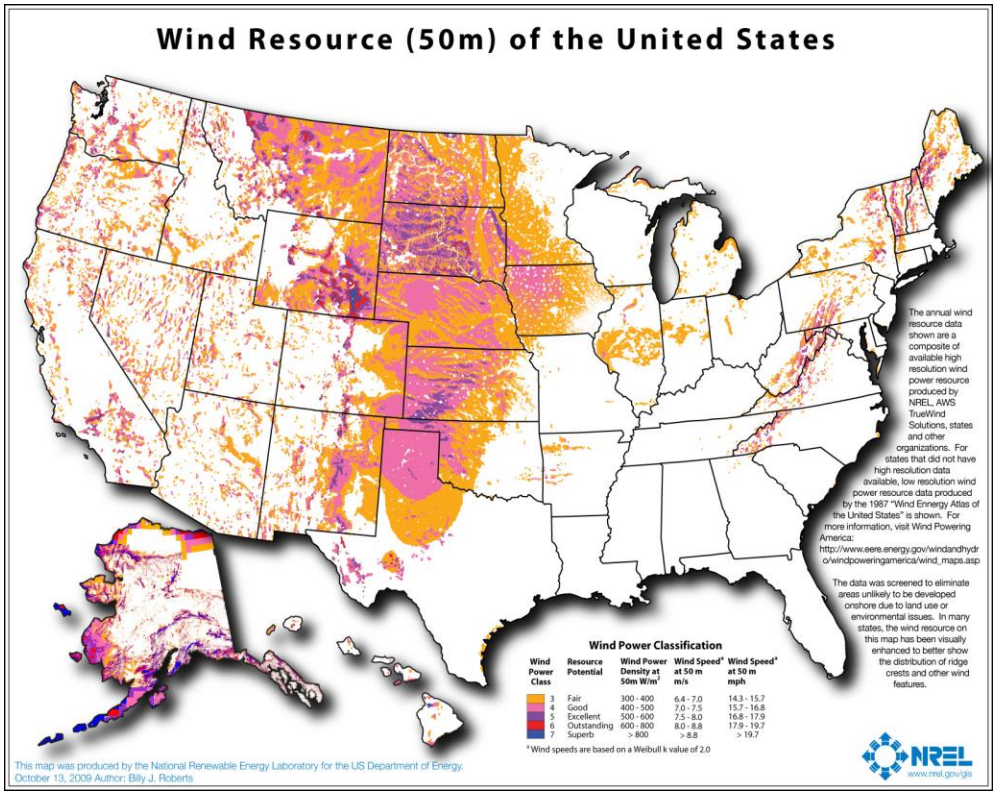


Cost-optimal Operating Strategies

CORE Microgrid Design Process

REopt Inputs

- Site data
  - Location
  - Electric and thermal loads
  - Utility costs
  - Space available for RE
- NREL GIS resource data
- RE technology info
  - Capital & operating costs
  - Energy generation
- Incentives data
- Ownership scenario
- Site energy goals



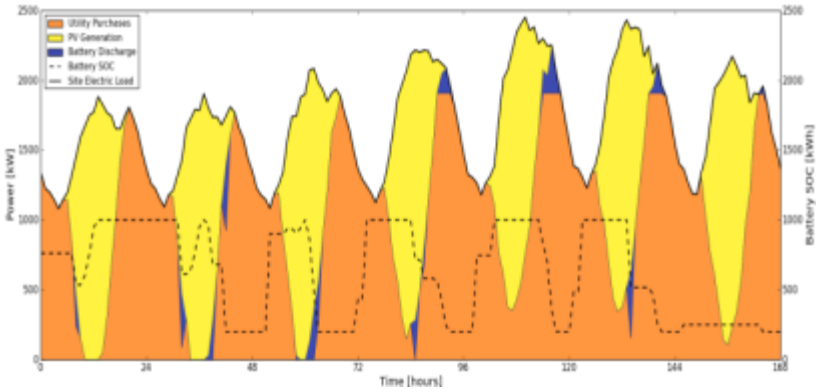
REopt Outputs

- Optimized Minimum Cost Solution
- Recommended Technologies
  - Size
  - Cost
  - Production
- Dispatch Strategies
  - What to do
  - When to do it
- Prioritized list of sites
- Estimate of cost to meet goals

Ranked List of Projects

	Site	Technology	Size
1	C	PV	100 kW
2	G	Wind	1 MW
3	A	LFG	2 MW

Dispatch Strategy



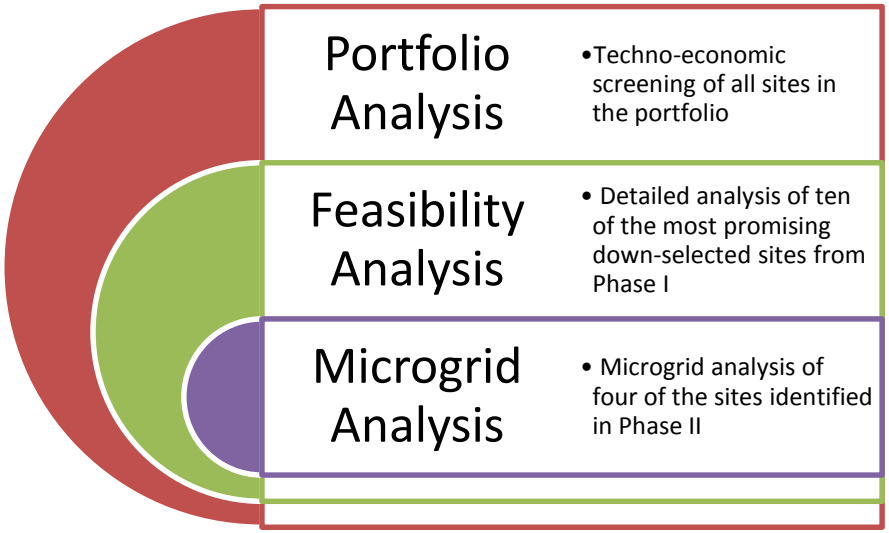
Who Uses REopt?

REopt has been used to assess opportunities at over 8000 sites for:

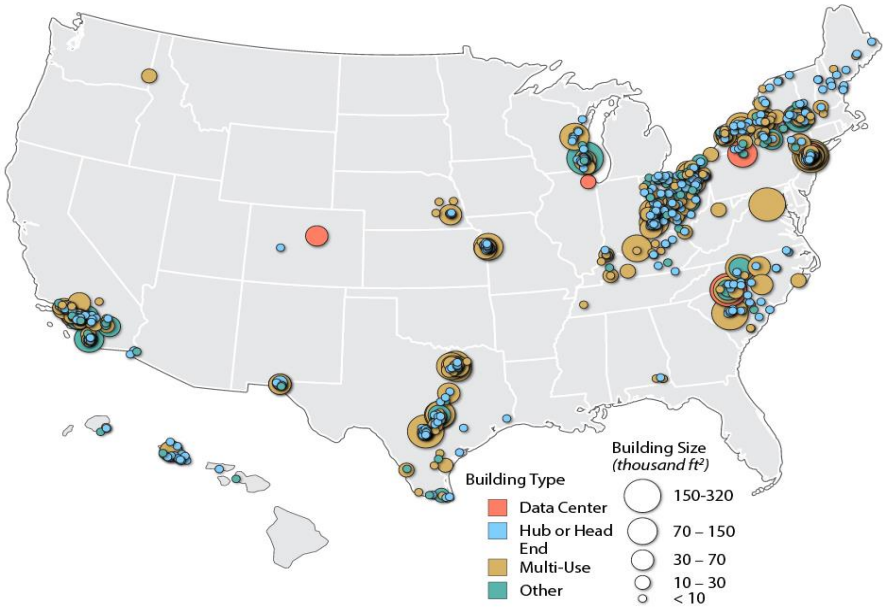
- US Forest Service
- National Park Service
- Fish and Wildlife Service
- Department of Defense
- Department of Energy
- Department of Commerce
- Department of State
- General Services Administration
- US Department of Veteran's Affairs
- Department of Homeland Security
- US Department of Agriculture
- US Bureau of Reclamation
- Bureau of Land Management
- Indian Health Service
- Western Area Power Administration
- Navajo Generating Station
- Natural Energy Laboratory of Hawaii
- Remote communities in Alaska
- National Zoo
- Town of Greensburg, KS
- Towns of North Hempstead and East Hampton, NY
- High School in Sun Valley, ID
- Frito Lay
- Anheuser Busch
- E&J Gallo
- Time Warner Cable
- Wells Fargo
- Microsoft
- San Diego Gas & Electric
- Arizona State University
- Miami University of Ohio
- City University of New York
- University of Minnesota Duluth

Project Example- Time Warner Cable

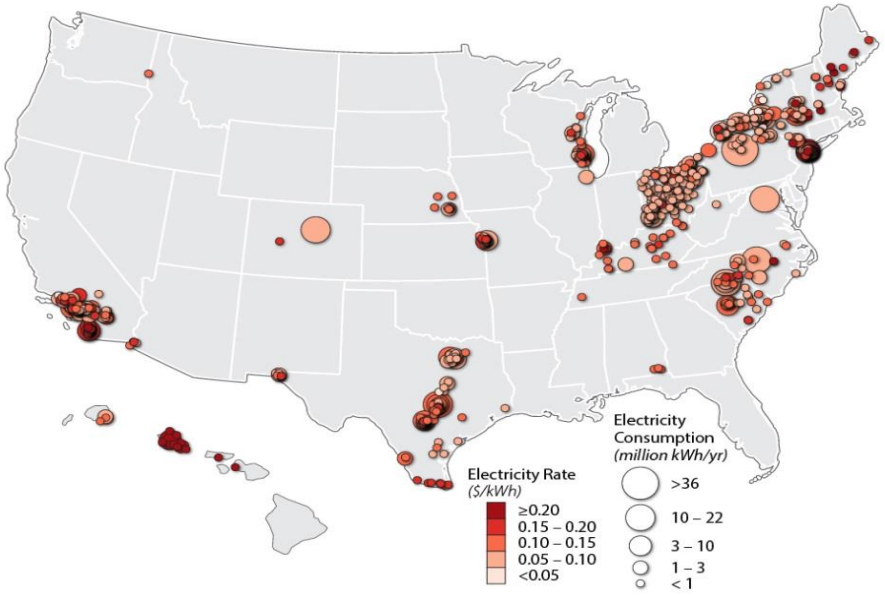
- Assess the technical and economic potential for RE generation at TWC facilities
- Evaluate off-grid solutions that may enable carbon emission reduction and grid independence at select facilities.



Project Scope



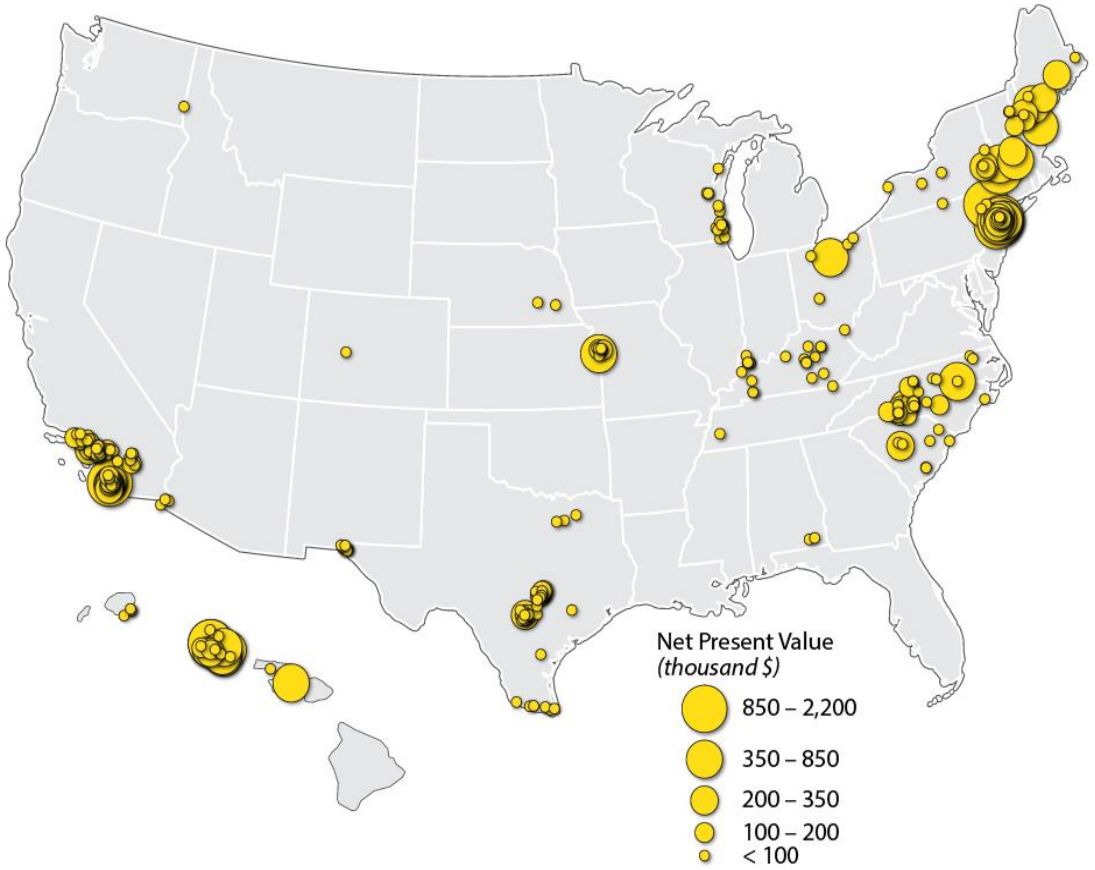
Building Types and Sizes for Each of the 696 Sites in the Portfolio Analysis



Electricity Consumption and Blended Electricity Rate for Each of the 696 Sites in the Portfolio Analysis

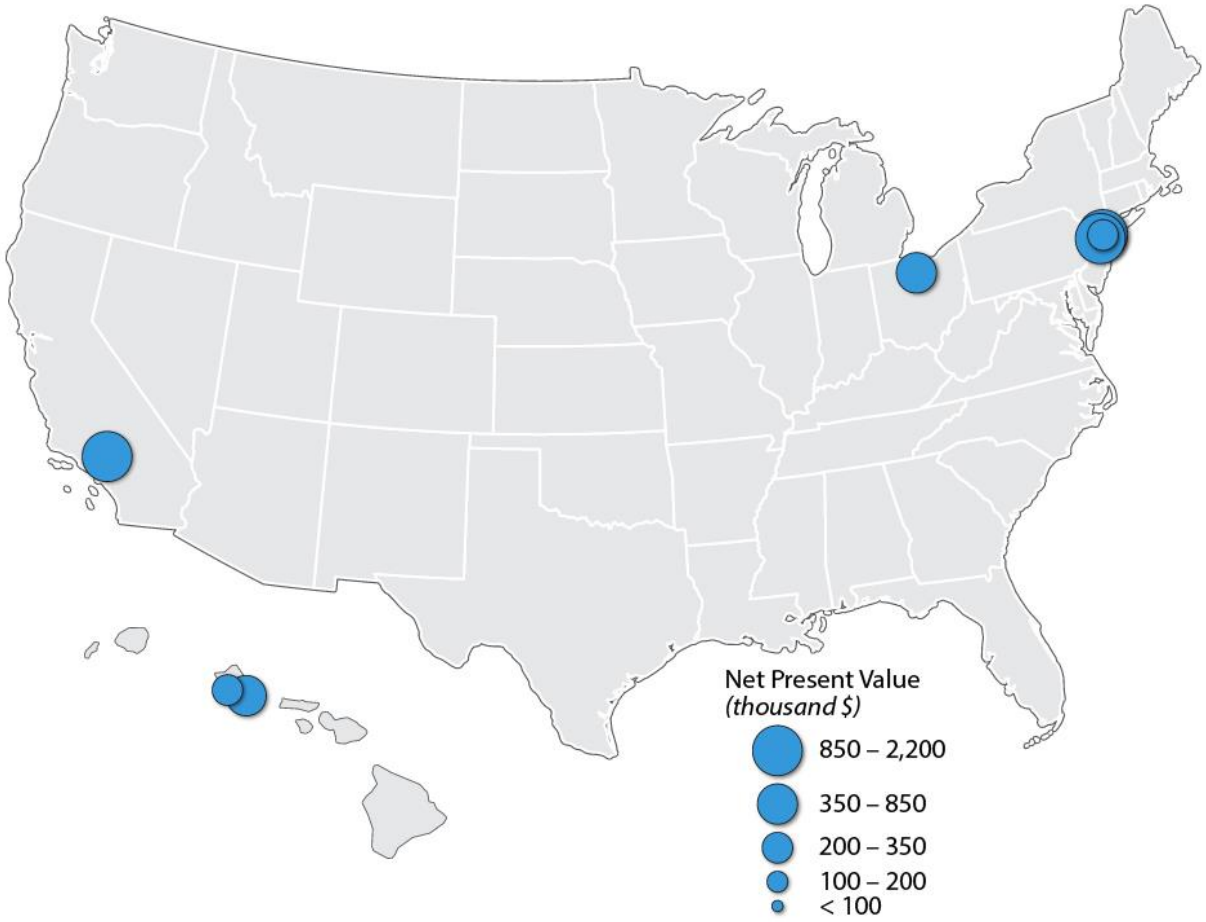
Cost-Effective PV Projects Identified

Sites	696
Sites with Cost-Effective Projects	306
NPV (Millions of U. S. Dollars [USD])	$37
Annual Electric Generation (GWh)	64.7
Renewable Electricity Penetration (%)	10.5
PV (MW)	38.79



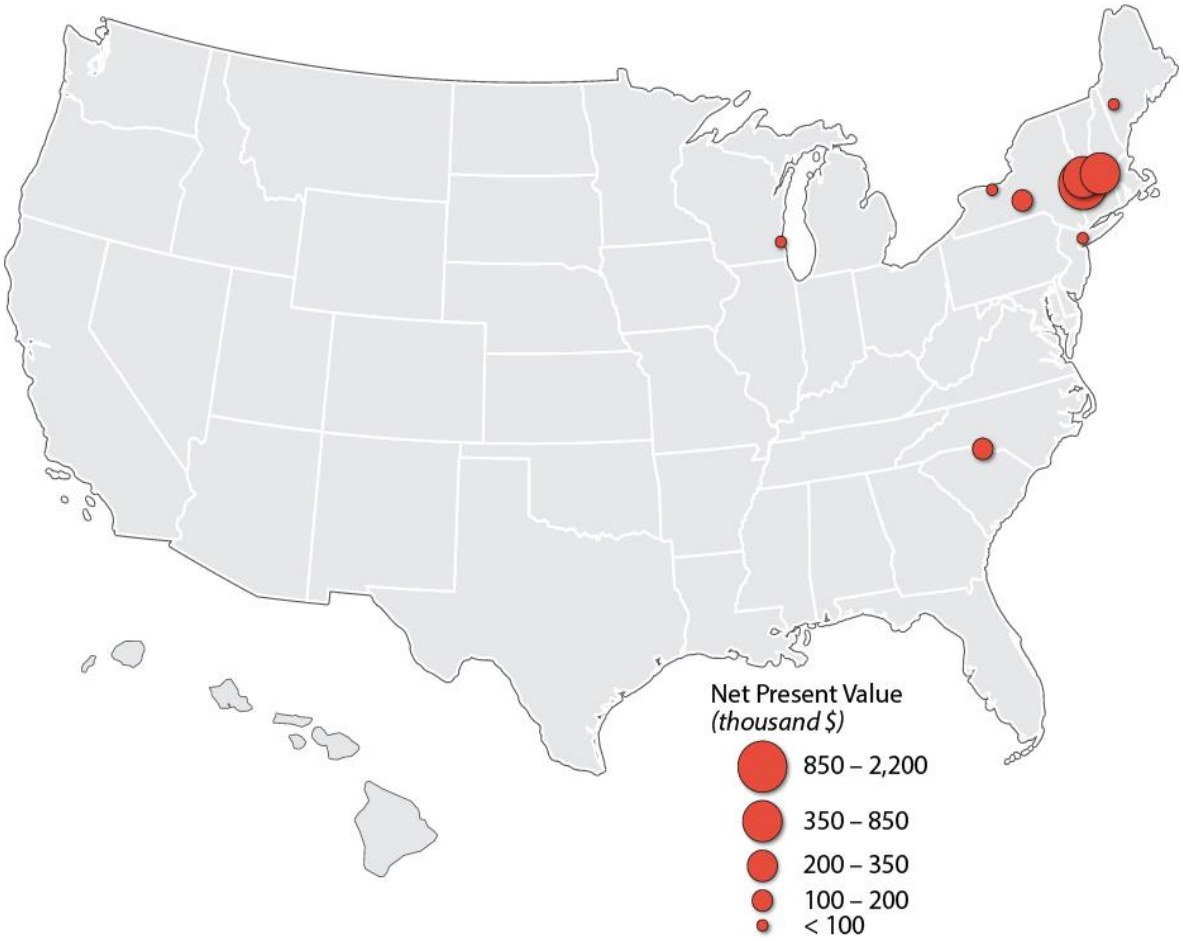
Cost-Effective Wind Projects Identified

Sites	696
Sites with Cost-Effective Projects	306
NPV (Millions of U. S. Dollars [USD])	$37
Annual Electric Generation (GWh)	64.7
Renewable Electricity Penetration (%)	10.5
Wind (MW)	7.23



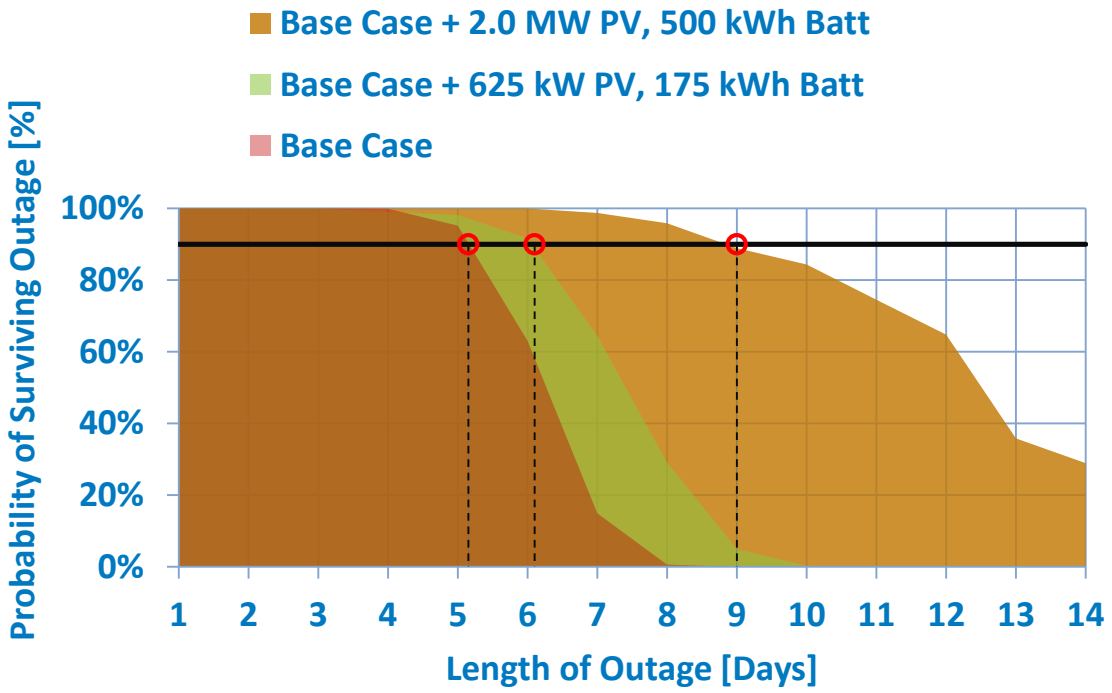
Cost-Effective Ground Source Heat Pump Projects Identified

Sites	696
Sites with Cost-Effective Projects	306
NPV (Millions of U. S. Dollars [USD])	$37
Annual Electric Generation (GWh)	64.7
Renewable Electricity Penetration (%)	10.5
Ground Source Heat Pump (tons)	396



Energy Security Example

- NREL evaluated thousands of random grid outage occurrences and durations throughout the year
- Compared number of hours site could survive with diesel gensets and fixed fuel supply only vs. gensets augmented with PV and battery
- Found PV and battery gave site 90% probability of surviving an additional 1-4 days at no additional cost



	LCC ($MM)	Outage Survivability (Days)
Base Case*	20.0	5
Scenario 1	19.5	6
Scenario 2	20.1	9

***Base case = 2.5 MW diesel gensets, 4,500 gallons of fuel**

QUESTIONS?

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