



Achieving Data Center Cost Savings Through Renewable Energy

Tuesday - May 16

3:45 PM – 5:00 PM



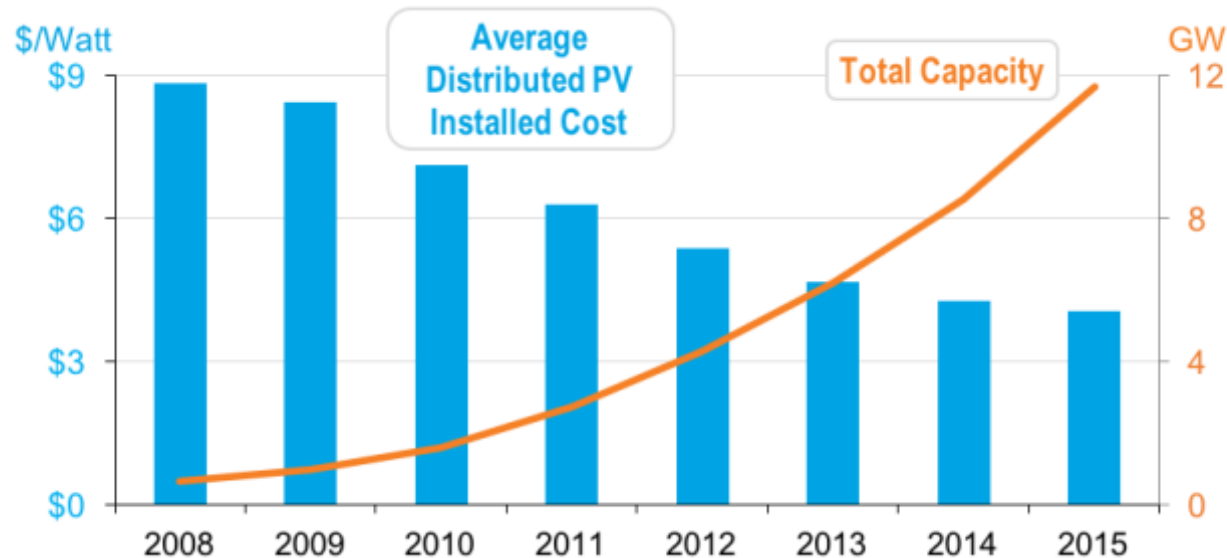
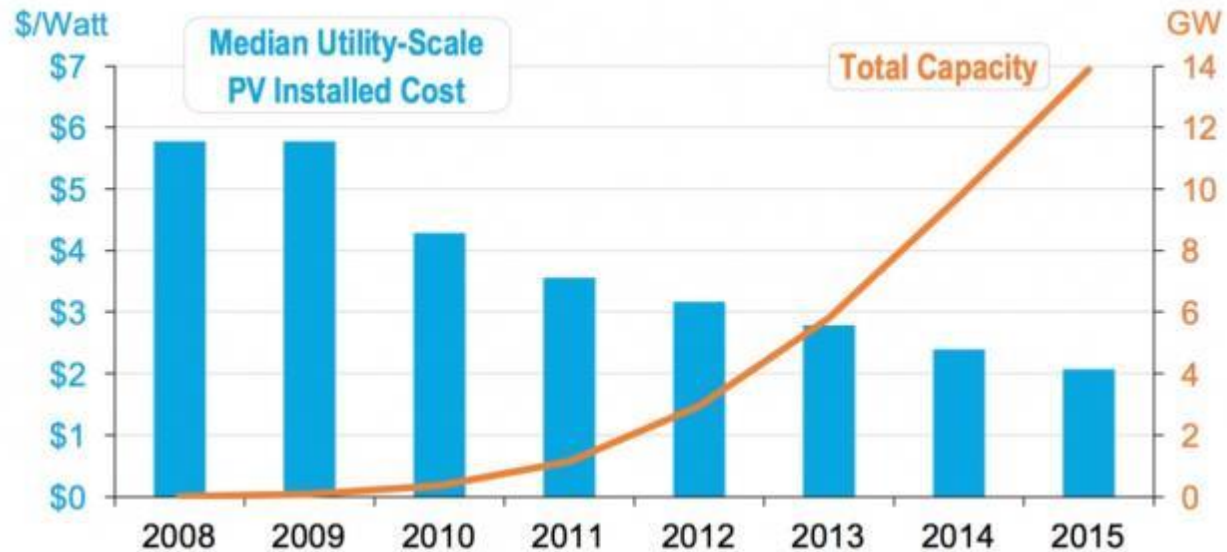
Panelists

- Brad Gustafson, Department of Energy
- Otto VanGeet, National Renewable Energy Laboratory
- Isaac Negusse, Iron Mountain

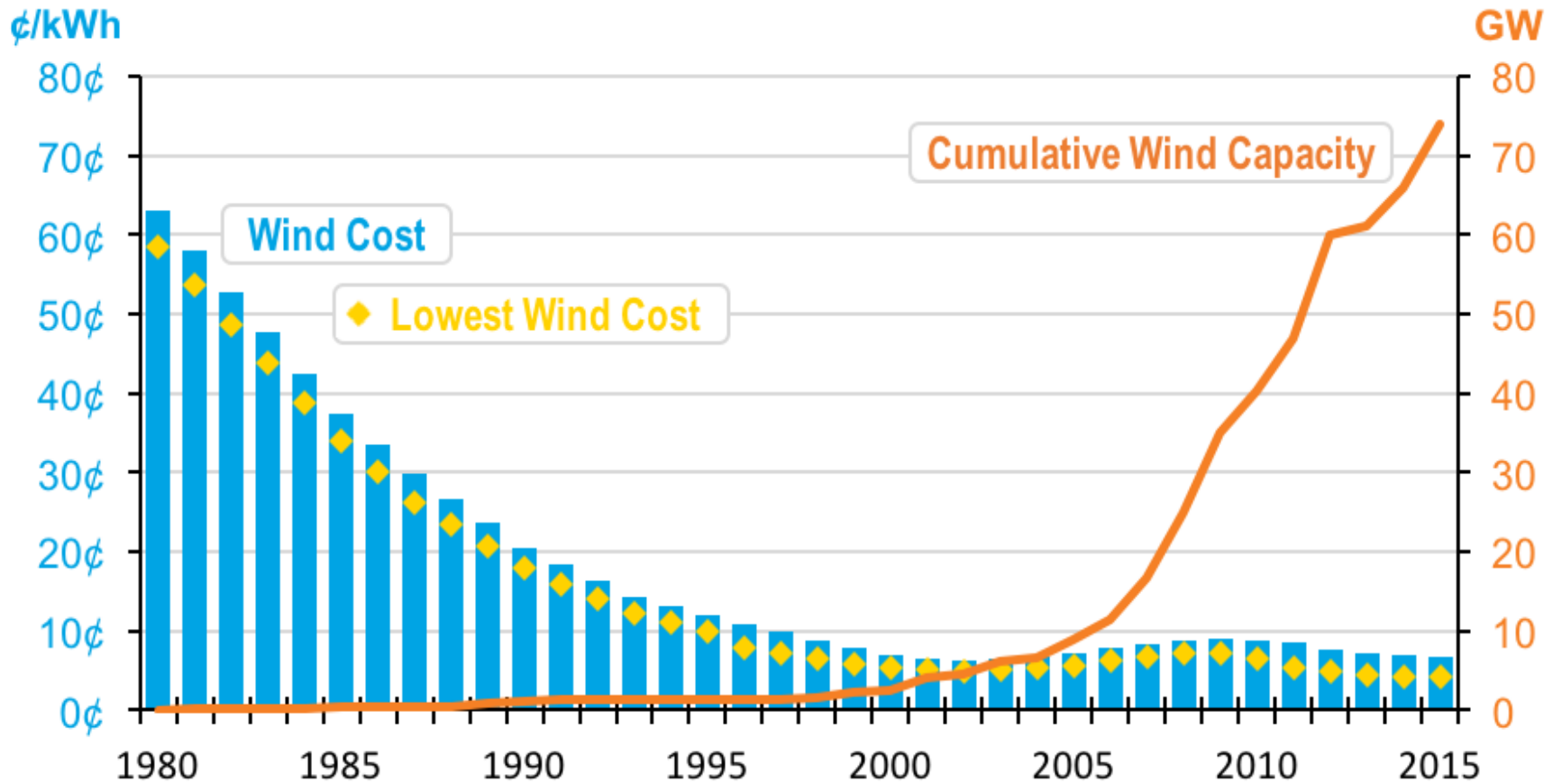
Topics

- RE Costs Trends
- RE Generation U.S. Generation Capacity Additions
- Motivations for Renewable Energy Implementation
- Factors Impacting RE Implementation
- Project Identification and Development
- Resources

Solar Growth and Declining Costs

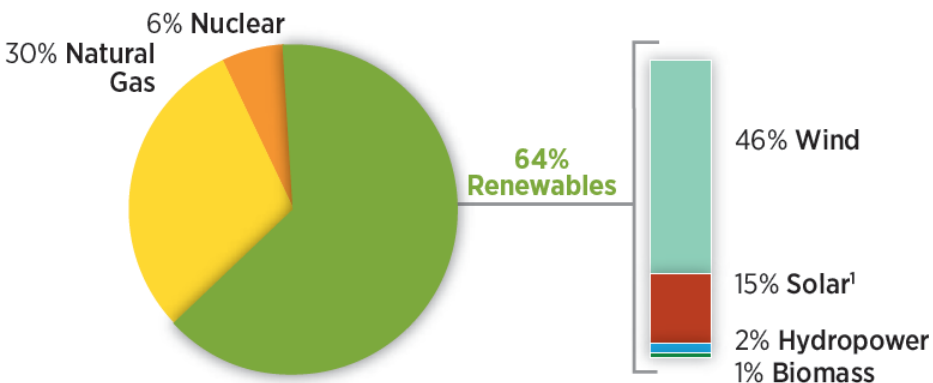


Wind Growth and Declining Costs

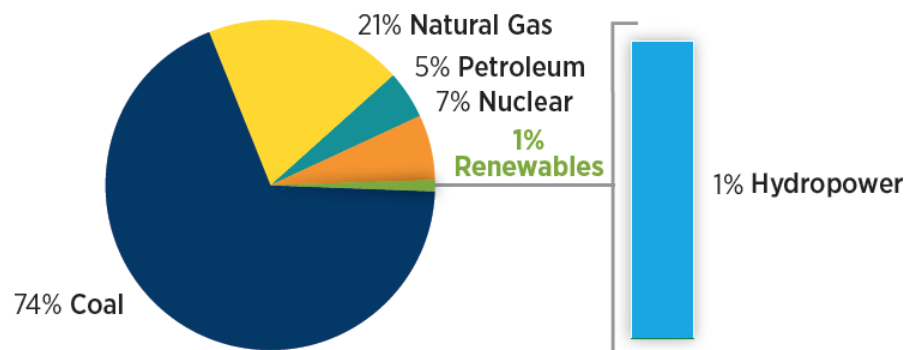


2015 Capacity Additions and Retirements

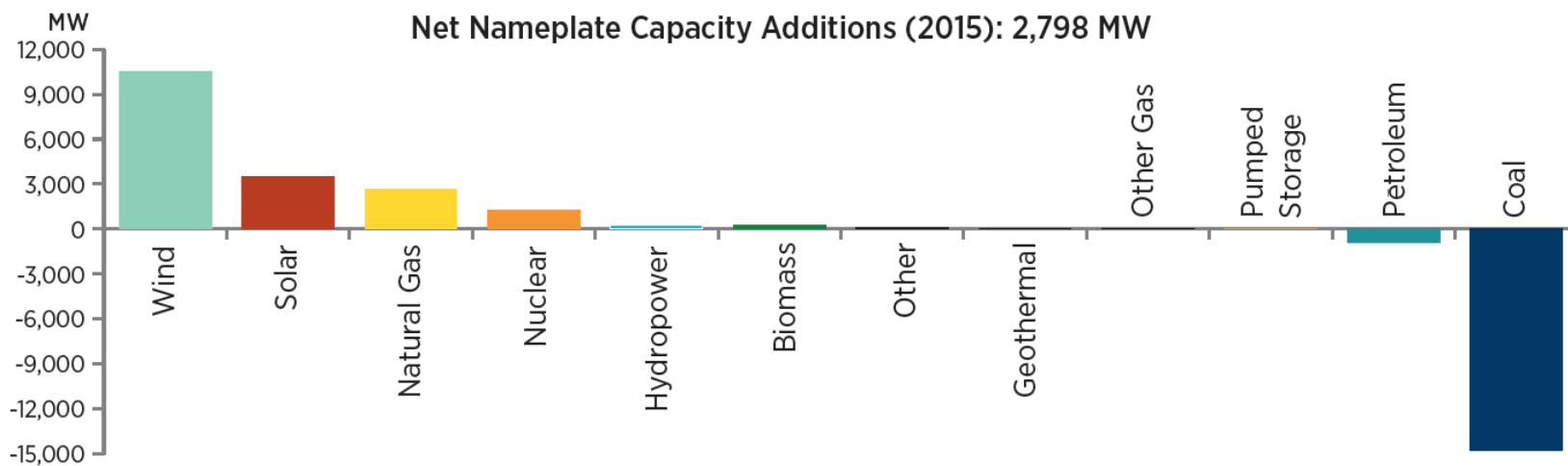
Capacity Additions (2015): 22,995 MW



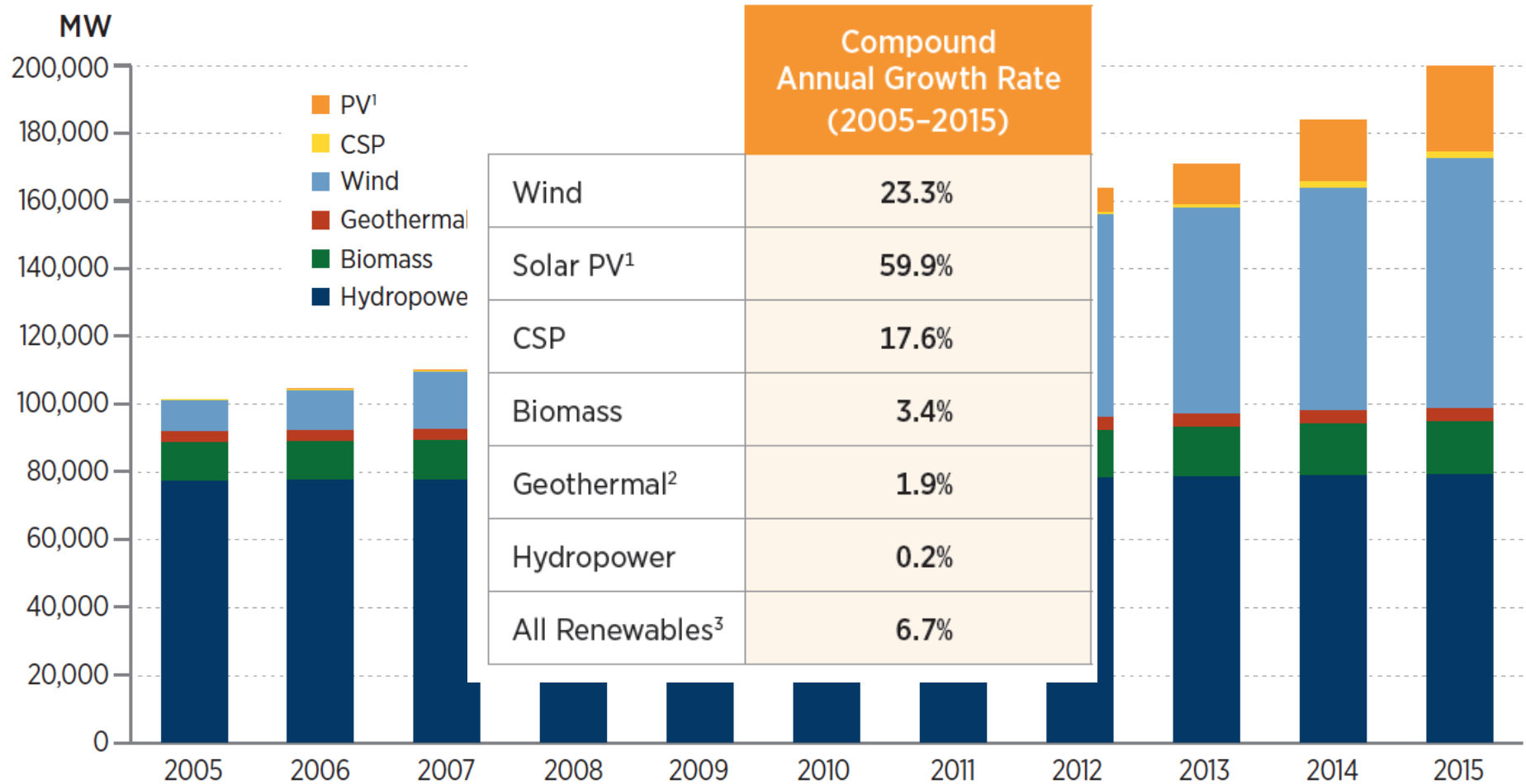
Capacity Retirements (2015): 21,197 MW



Net Nameplate Capacity Additions (2015): 2,798 MW



U.S. Renewable Generation Capacity Growth



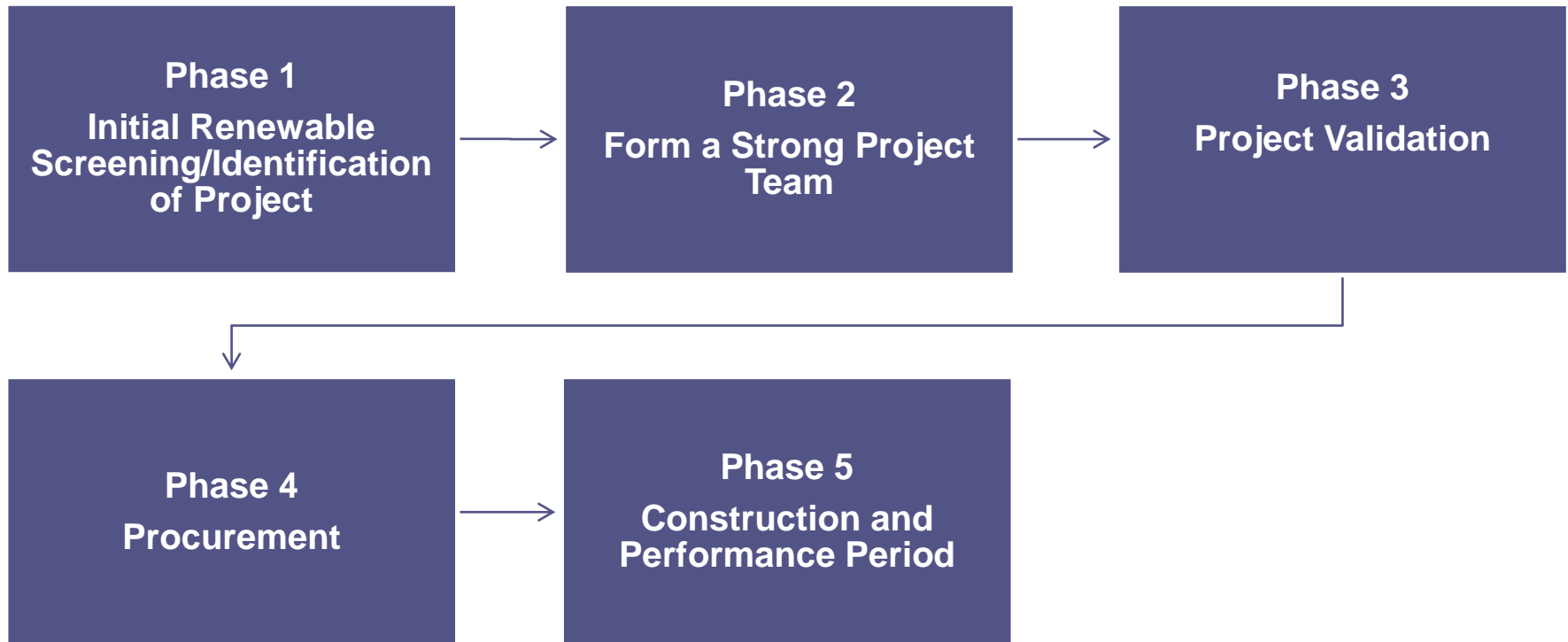
Motivations for Renewable Energy Implementation

- 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

Factors Impacting RE Implementation

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

On-Site Project Implementation Process*



*Based off of FEMP's Guide to Integrating Renewable Energy in Federal Construction, Large-Scale Renewable Energy Guide, Small- to Medium-Scale Federal Renewable Energy Projects, and Energy Savings Performance Contract Energy Sales Agreement (ESPC ESA) Toolkit

Small- To Medium-Scale Renewable Energy Projects

- **PRELIMINARY SCREENINGS**

Determine whether a renewable energy project is worth exploring. At the headquarters or regional level, prescreen multiple sites to identify and prioritize locations for further study.

- **SCREENINGS**

Narrow site and project options. Identify technologies to pursue, and comparison of financing mechanisms to consider.

- **FEASIBILITY STUDIES**

Feasibility studies provide technology and financing recommendations.

<https://energy.gov/eere/femp/small-medium-scale-federal-renewable-energy-projects>

Project Feasibility Analysis

1) Economic Feasibility: Life Cycle Cost

Initial cost; O&M cost; utility cost savings; insurance/bonding; salvage value; debt service; tax and other incentives; guarantees and warranties

2) Technical Feasibility

Resource; yield forecast; utility rate impacts; land or roof space

3) Engineering Feasibility

Plant layout; ground survey; roof strength and condition; ground soil conditions and geotechnical data; electrical interconnect locations; electrical interconnection capacities (amps); theft and vandalism protection; maintenance and land management; storm water

4) Legal Feasibility

PPA legality; site control (easement, lease, other); utility interconnection agreements; operating, maintenance and insurance contracts

5) Compliance Issues

Environmental (National Environmental Policy Act [NEPA]) and cultural/historic issues (National Historic Preservation Act [NHPA]); glare hazard (Federal Aviation Administration [FAA])

Construction and Performance Period: Important Considerations

1) Complete the design

Design documents and design review process; construction contract or performance contract; design-bid-build or design-build

2) Begin construction

Establish a single point of contact; review milestone progress frequently; maintain close contact with the utility; involve inspection officials early; keep occupants in the loop

3) Commission the System

Third-party commissioning authority (CA); prepare “commissioning plan”; verify system complies with specifications; update documents to “as built” condition; perform testing of components and complete system

4) Perform Operations and Maintenance

O&M manual by installer; O&M plan including administration, monitoring, preventative maintenance, and corrective maintenance (repair)

5) Close out the Project

Refurnish system and extend life or remove and restore site; design for recyclability and control toxic materials; liability or asset; recycling

Large Scale Renewable Project Steps

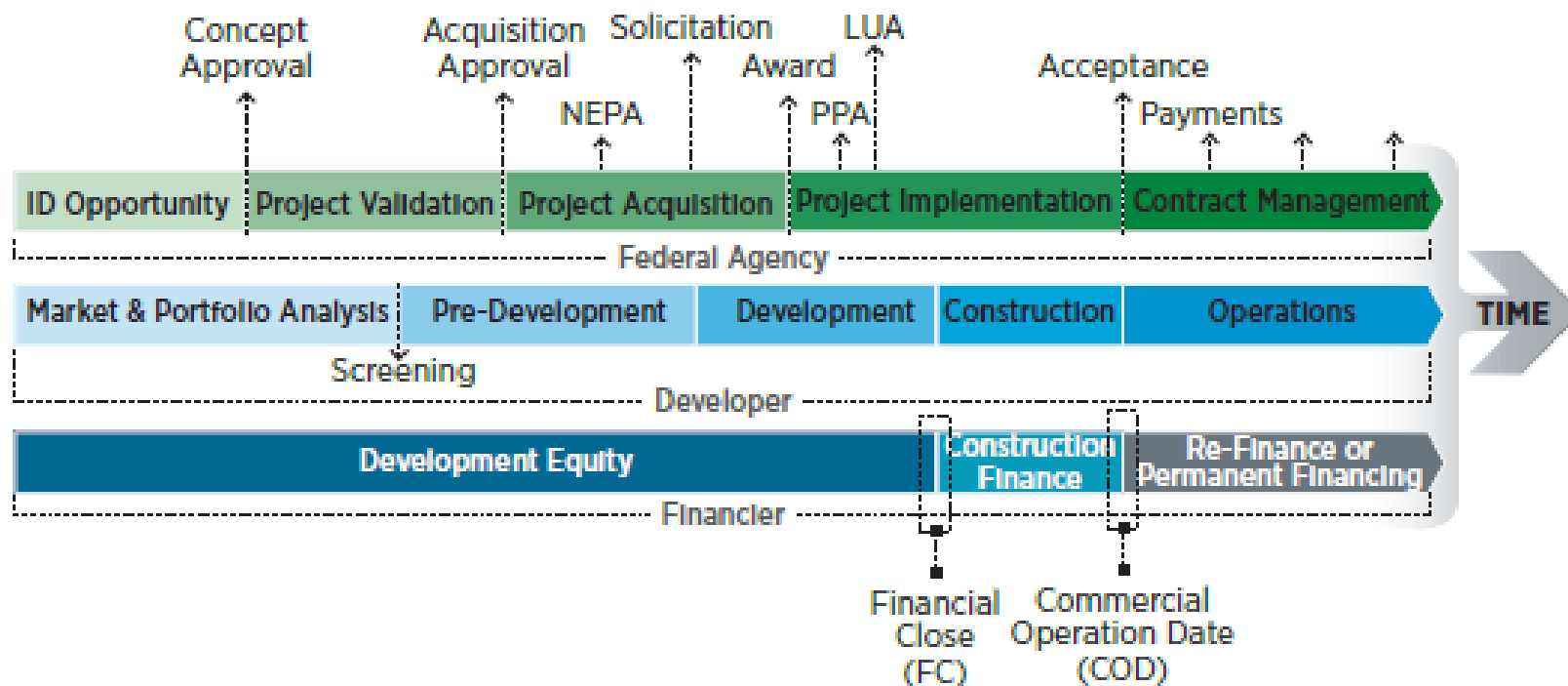
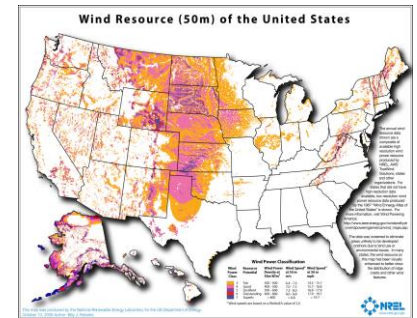


Figure 1. Developing a common language ³

<https://energy.gov/sites/prod/files/2013/10/f3/large-scalereguide.pdf>

Renewable Energy Optimization (Reopt)

- Decision support service to evaluate energy opportunities
- 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 8000+ 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

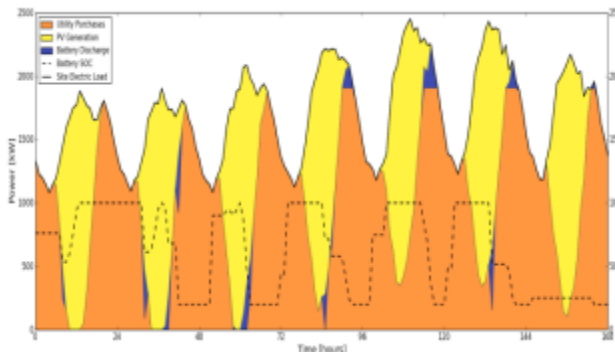
Project
Development

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



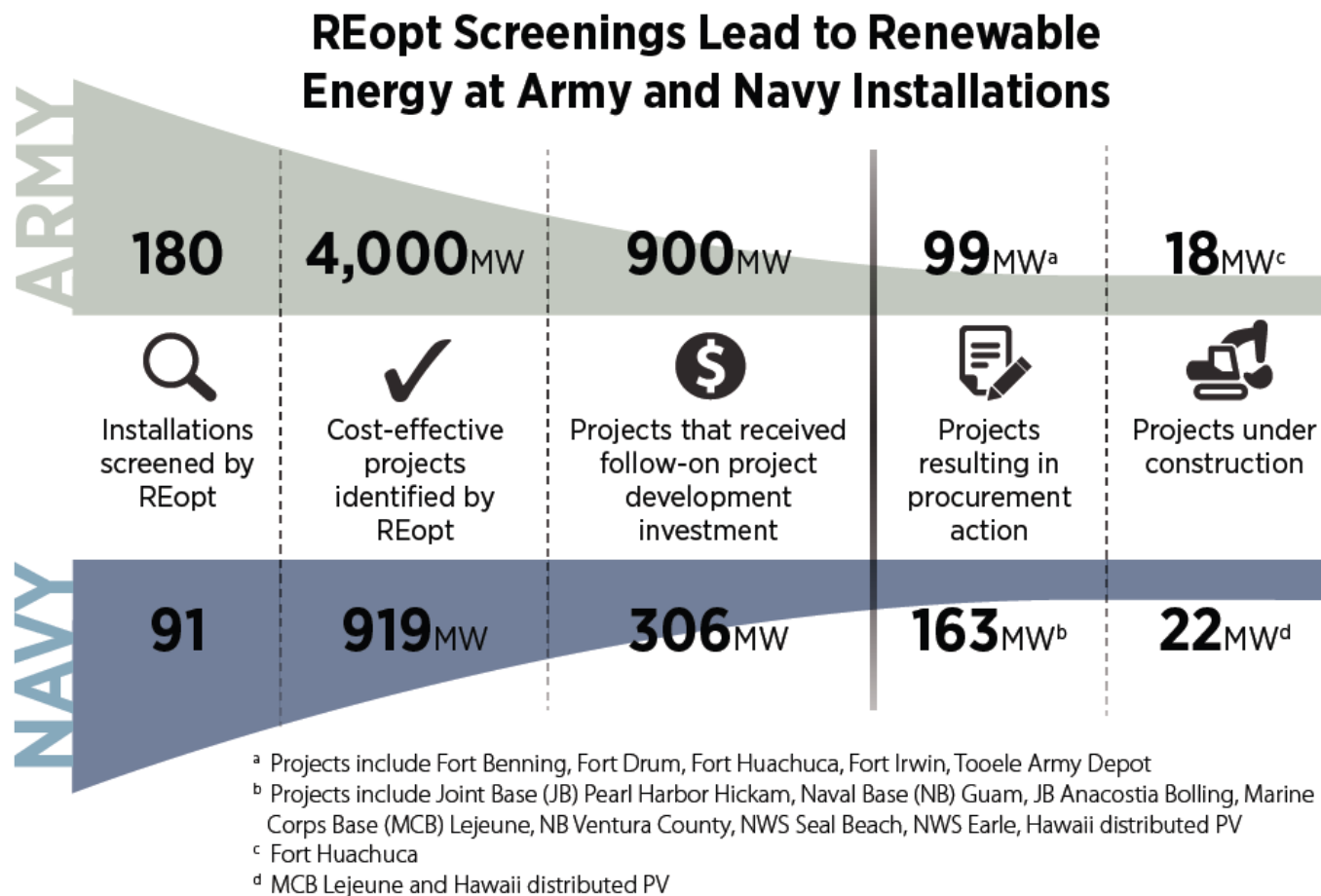
CORE Microgrid Design Process

Reopt Users

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**

REopt Example: Army and Navy Installations



REopt: Publically Available Web Tool



Mission: Provide access to site-specific, optimized, and integrated renewable energy decision analysis

Vision: Advance data-driven decision-making and deployment of renewable energy and energy storage technologies

A screenshot of the REopt web tool interface. A large green starburst with the text "Coming Soon!" is overlaid on the left side. The interface has a blue header with "REopt" and the NREL logo. Below the header, there are input fields for "Enter a location", "Land available (acres)" (set to "Unlimited"), and "Roofspace available (sq ft)" (set to "Unlimited"). There are also dropdown menus for "Type of building" and "Electricity rate". At the bottom, there are radio buttons for "Do you want to evaluate PV and/or Battery?" with options "PV", "Battery", and "Both" (selected). A "GET RESULTS" button is at the bottom right. A "Log In/Register" link is in the top right. A "Required field" asterisk is at the bottom left.

FEMP has sponsored NREL to develop a publically available web version of REopt. The first version of the tool will include:

- Estimates the optimal size of PV and battery that minimizes the cost of energy to a site
- Evaluate the economics of PV and battery storage

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

Power Purchase Opportunities

- The Environmental Protection Agency's Green Power Partnership has a Project Matching Initiative that works to connect renewable power users with new, not-yet-built renewable projects. <https://www.epa.gov/greenpower/project-matching-initiative>).
- Bureau of Land Management's hosts a list of renewable energy projects with signed leases on BLM land, many of which are still seeking an off-taker. This list focuses on projects west of the Mississippi. <https://www.blm.gov/programs/energy-and-minerals/renewable-energy/data>
- The Rocky Mountain Institute's Business Renewables Center (member-based) hosts a marketplace database that lists 81 projects totaling 13,000 MW from 28 developers, as of July 2016. <http://businessrenewables.org/how-to-join/>

Thank You

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National Renewable Energy Laboratory (NREL)

Only National Laboratory Dedicated Solely to Energy Efficiency and Renewable Energy

- Leading clean-energy innovation for 35 years
- 1740 employees with world-class facilities
- Campus is a living model of sustainable energy
- Owned by the Department of Energy
- Operated by the Alliance for Sustainable Energy

<http://www.nrel.gov/>



Mission



Energy Efficiency

Residential
Buildings

Commercial
Buildings

Personal and
Commercial
Vehicles



Renewable Energy

Solar

Wind and Water

Biomass

Hydrogen

Geothermal



Systems Integration

Grid
Infrastructure

Distributed
Energy

Interconnection

Battery and
Thermal Storage

Transportation



Market Focus

Private Industry

Federal Agencies

Defense Dept.

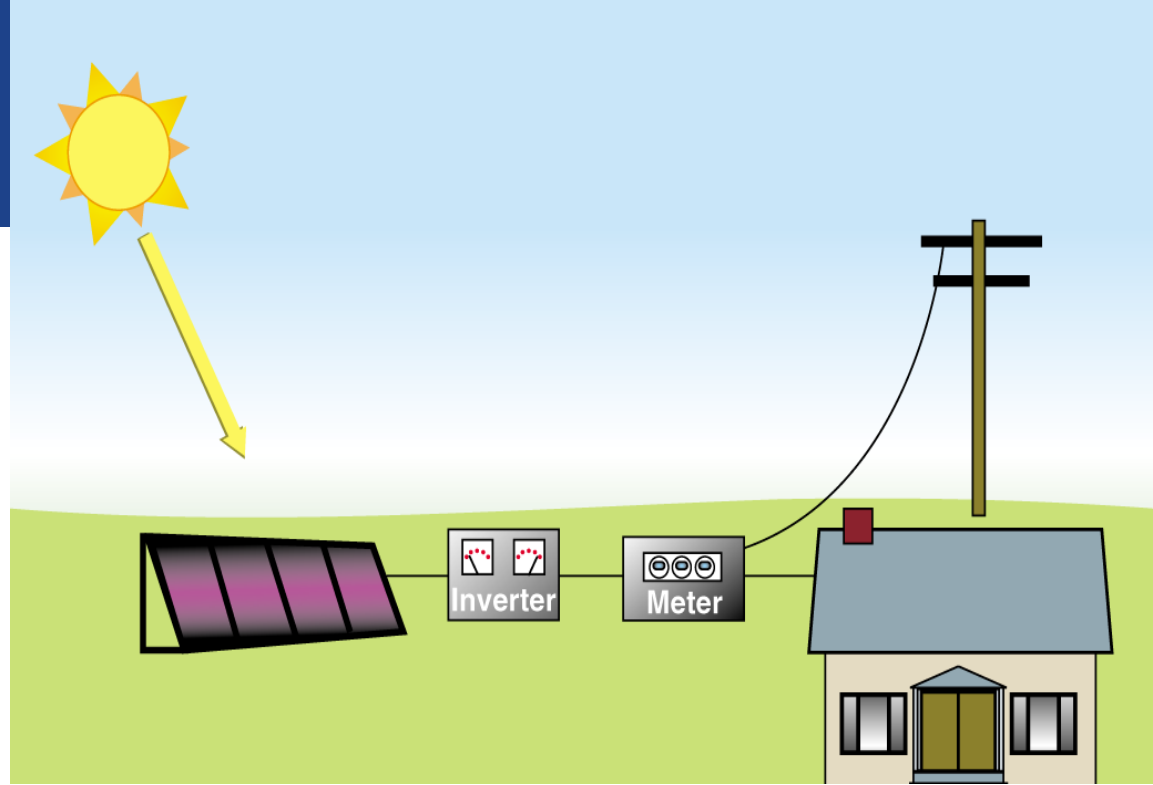
State/Local Govt.

International

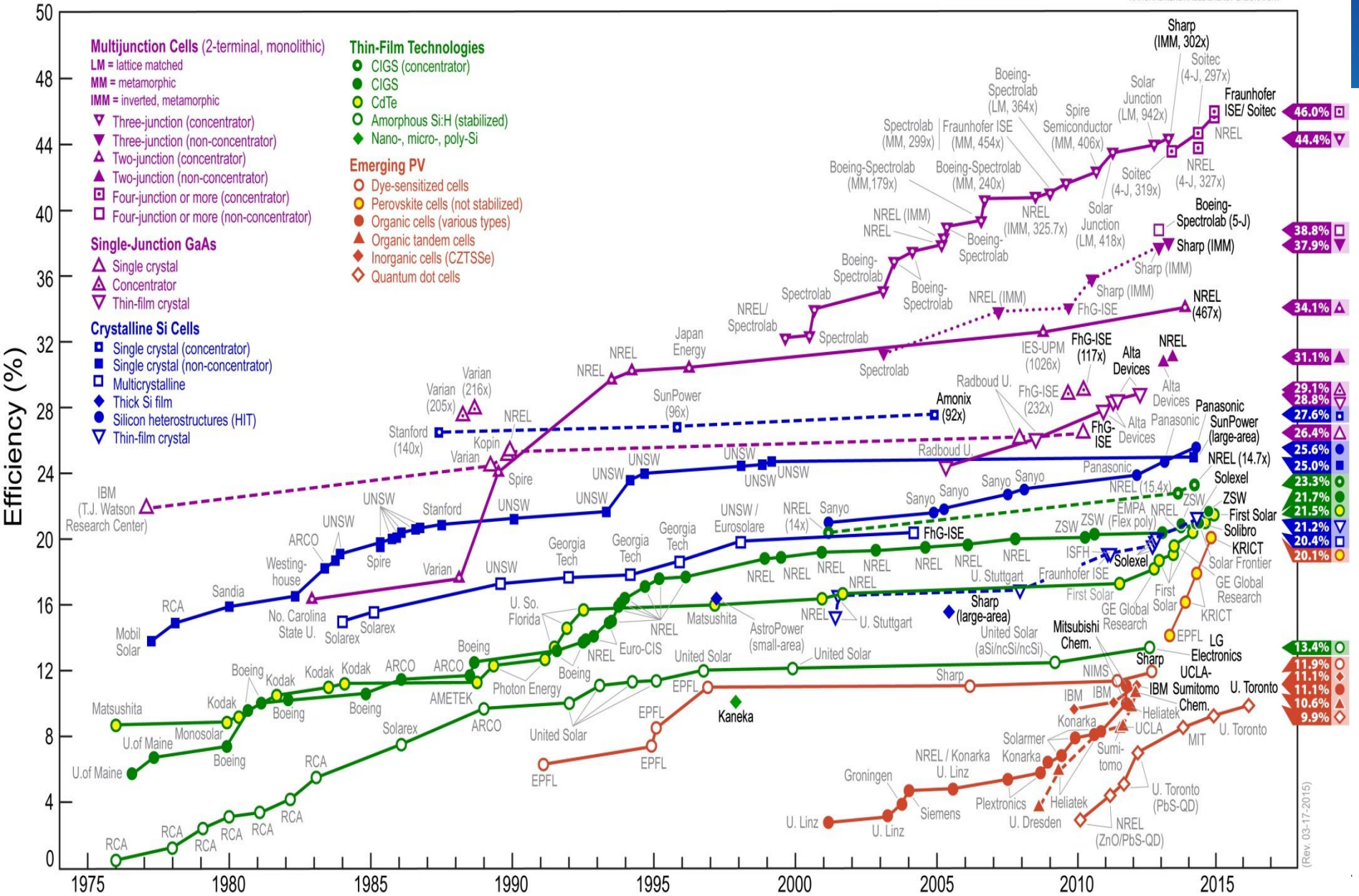
Solar

PV Technology Overview

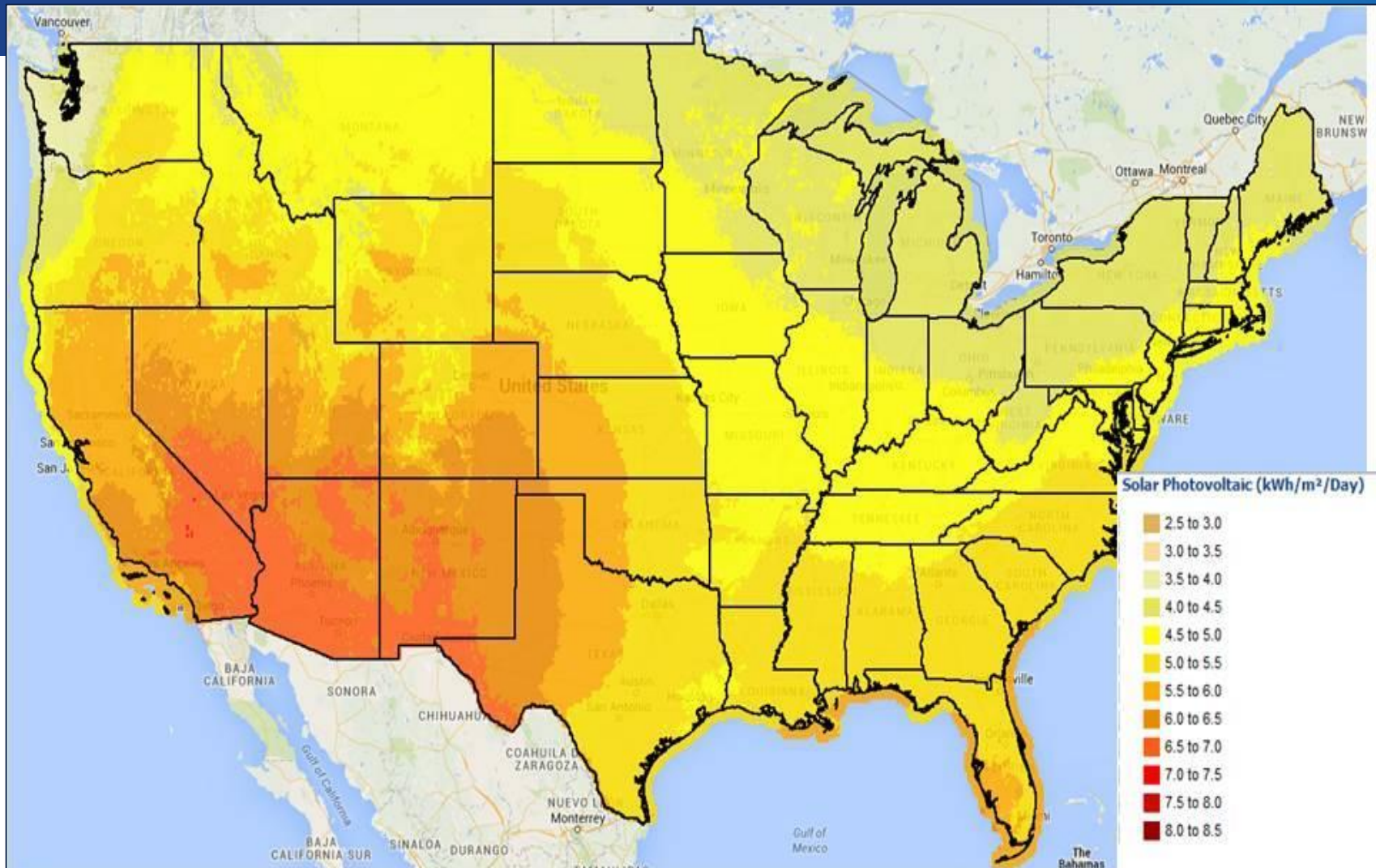
- Direct conversion of sunlight into DC electricity
- DC converted to AC by inverter
- Solid-state electronics, no-moving parts
- High reliability, warranties of 25 years
- PV modules are wired in series and parallel to meet



Best Research-Cell Efficiencies



Solar Resource: Tilt = Local Latitude



Annual average kWh/m²/year

Flat Plate PV Systems

Dangling Rope Marina, Glen Canyon National Recreation Area, UT



Arizona Public Service, Prescott, AZ

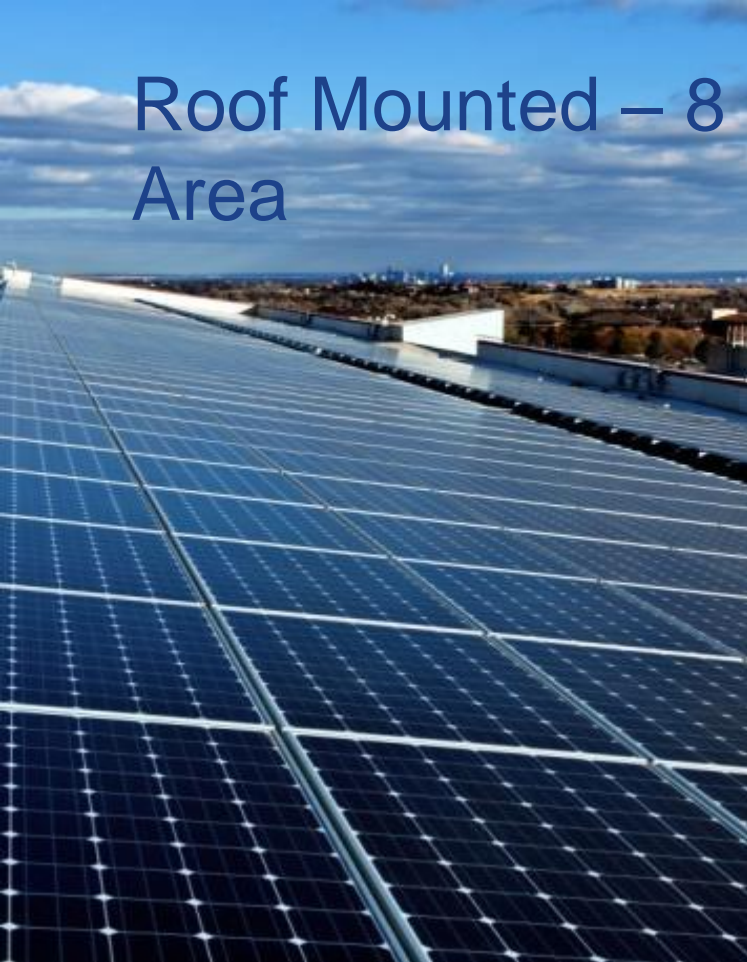
Alamosa PV System, Alamosa, CO



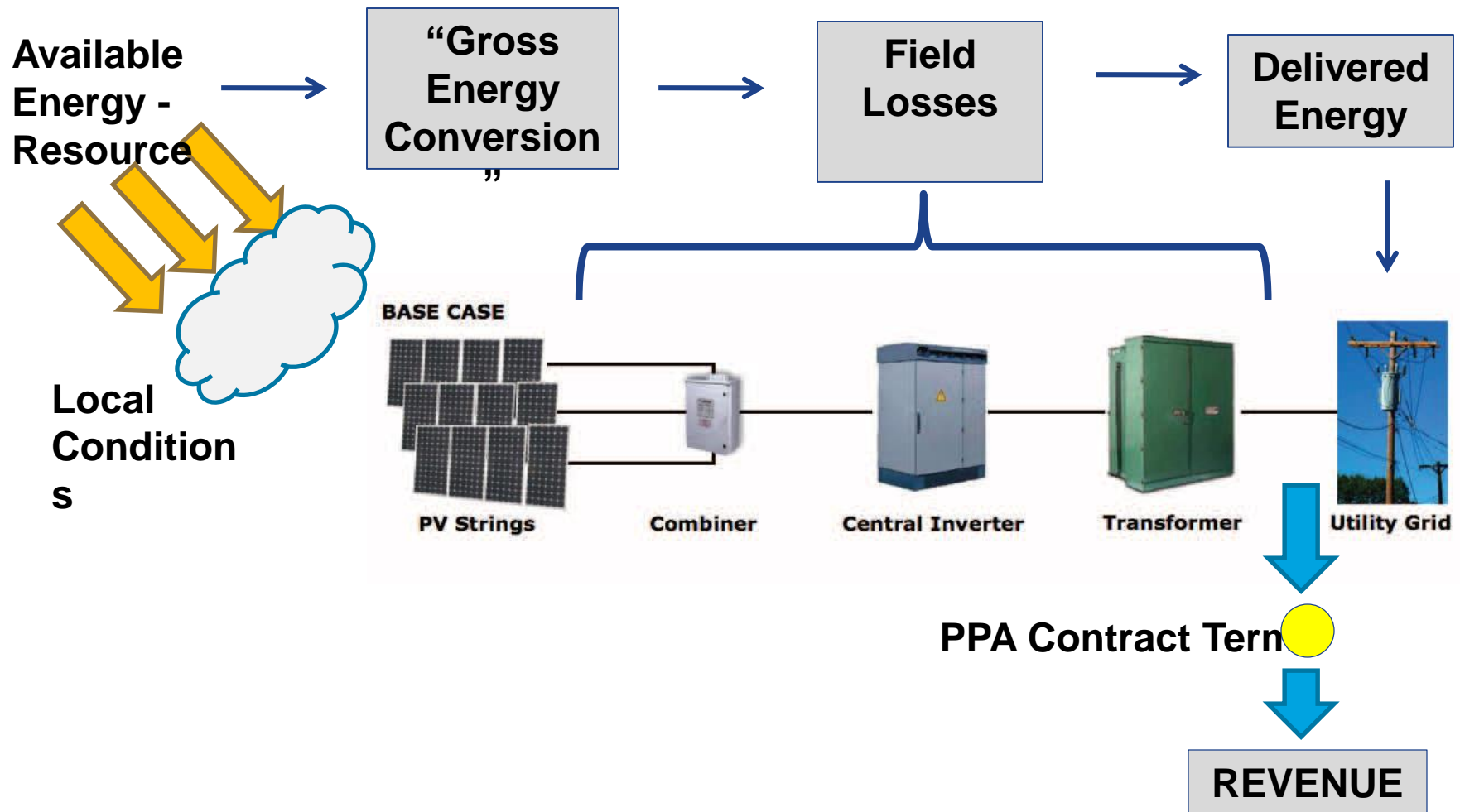
5 – 10 acres per MW for PV systems

Land can be left as is or graded

Roof Mounted – 8 to 18 W/ Sq. Ft. Available Area



System Diagram – Gross to Net



PV Watts

- Select default values or input customized system parameters for size, electric cost, array type, tilt angle, and azimuth angle.
- Typical Meteorological Year weather data for the selected location (TMY files) used to calculate incident solar radiation and PV cell temperature for each hour of the year.

- **Benefits**

- Easy to use
- Very Quick
- Useful for users of all technical levels
- Widely accepted tool

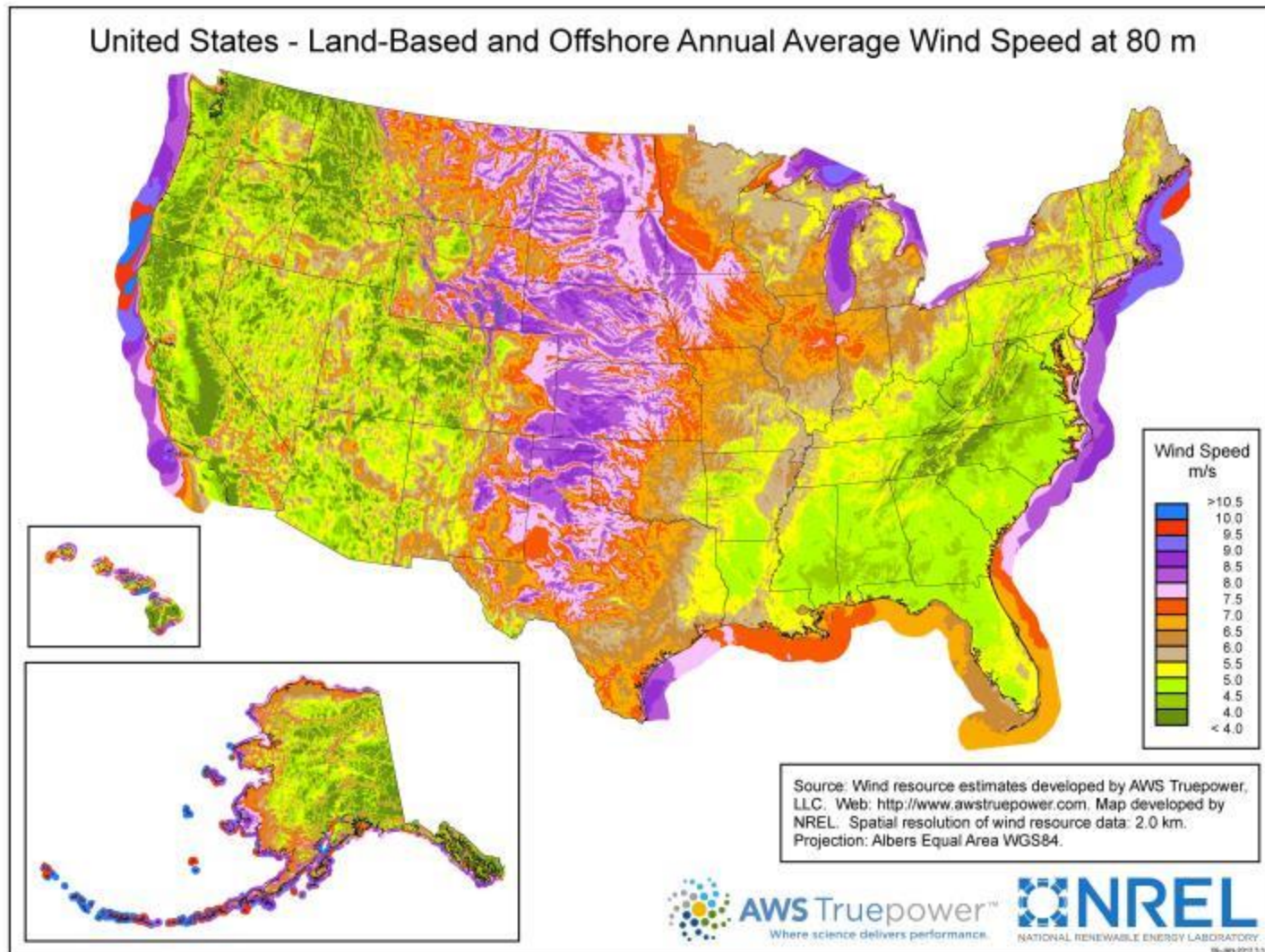
The screenshot shows the PVWatts Calculator website. At the top, there's a header with the 'PVWatts® Calculator' title and the NREL logo. Below the header is a navigation bar with links for 'Get Started:', 'Release Notice (?)', 'HELP', 'FEEDBACK', and 'ALL NREL SOLAR TOOLS'. The main content area features a large orange cross icon and the text 'NREL's PVWatts® Calculator'. It describes the tool as estimating energy production and cost for grid-connected photovoltaic (PV) systems. A 'What's New' button is visible on the right. The background of the main content area is a photograph of solar panels. At the bottom, there are social media links for Facebook, Twitter, LinkedIn, and YouTube, along with a 'Follow @PVWatts' button and a view count of 185.

PV Net Zero Energy Home Example in Boulder, CO

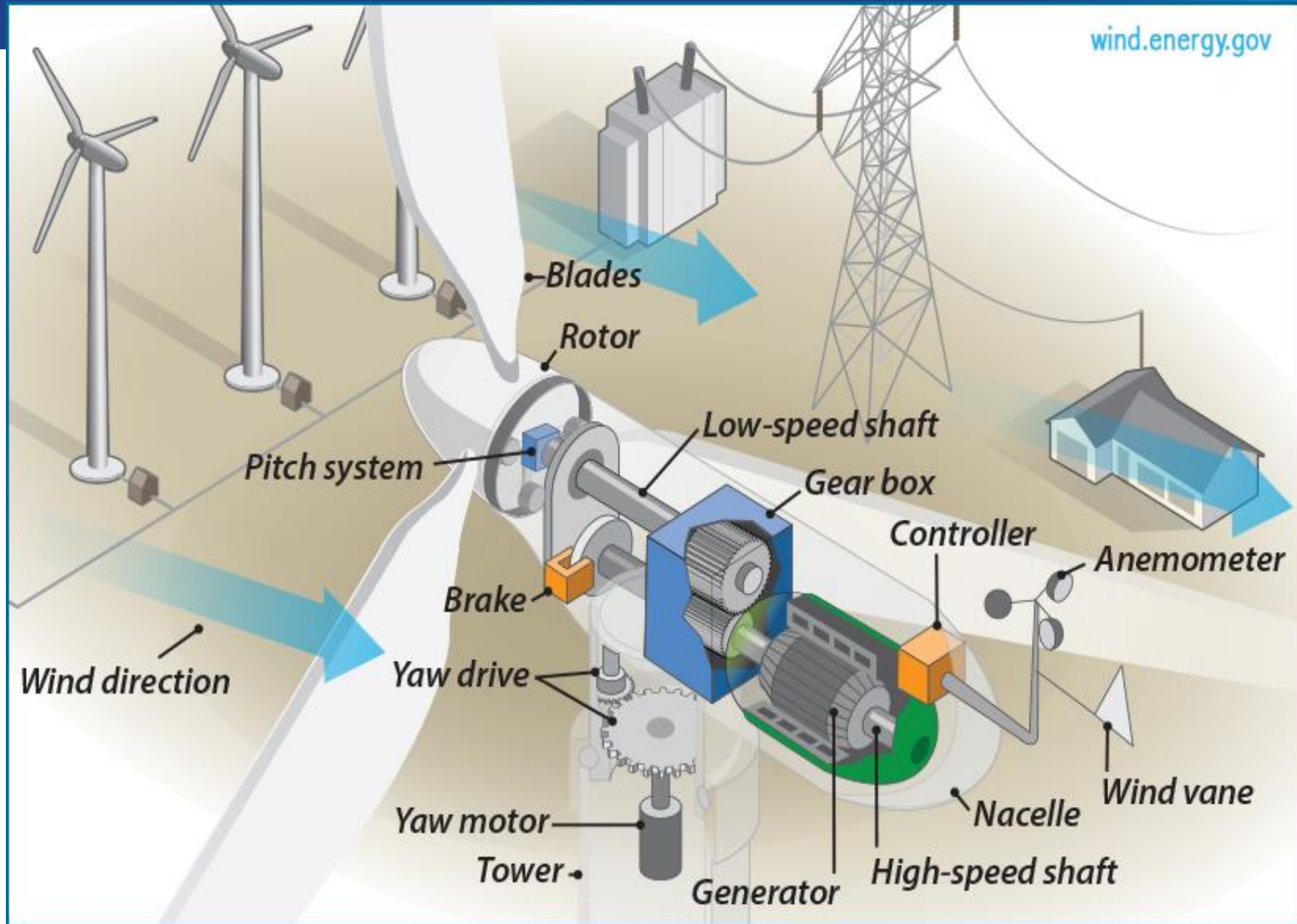
- **Annual Energy use = 6000 kWh**
- **PV on south facing roof sloped at 20 degrees produces 1512 kWh/kW Annual with 0.86 derate factor**
- **$6000 \text{ kWh} / 1512 \text{ kWh/kW} = 4 \text{ kW}$**
- **Expected cost at \$3.0/W = \$12K before incentives (30% ITC, Xcel Solar Rewards)**
- **Area required = $4000 \text{ W} / 12 \text{ W/sq ft} = 334 \text{ sq ft}$.**

Wind

Wind Resource



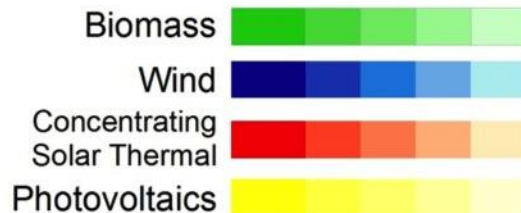
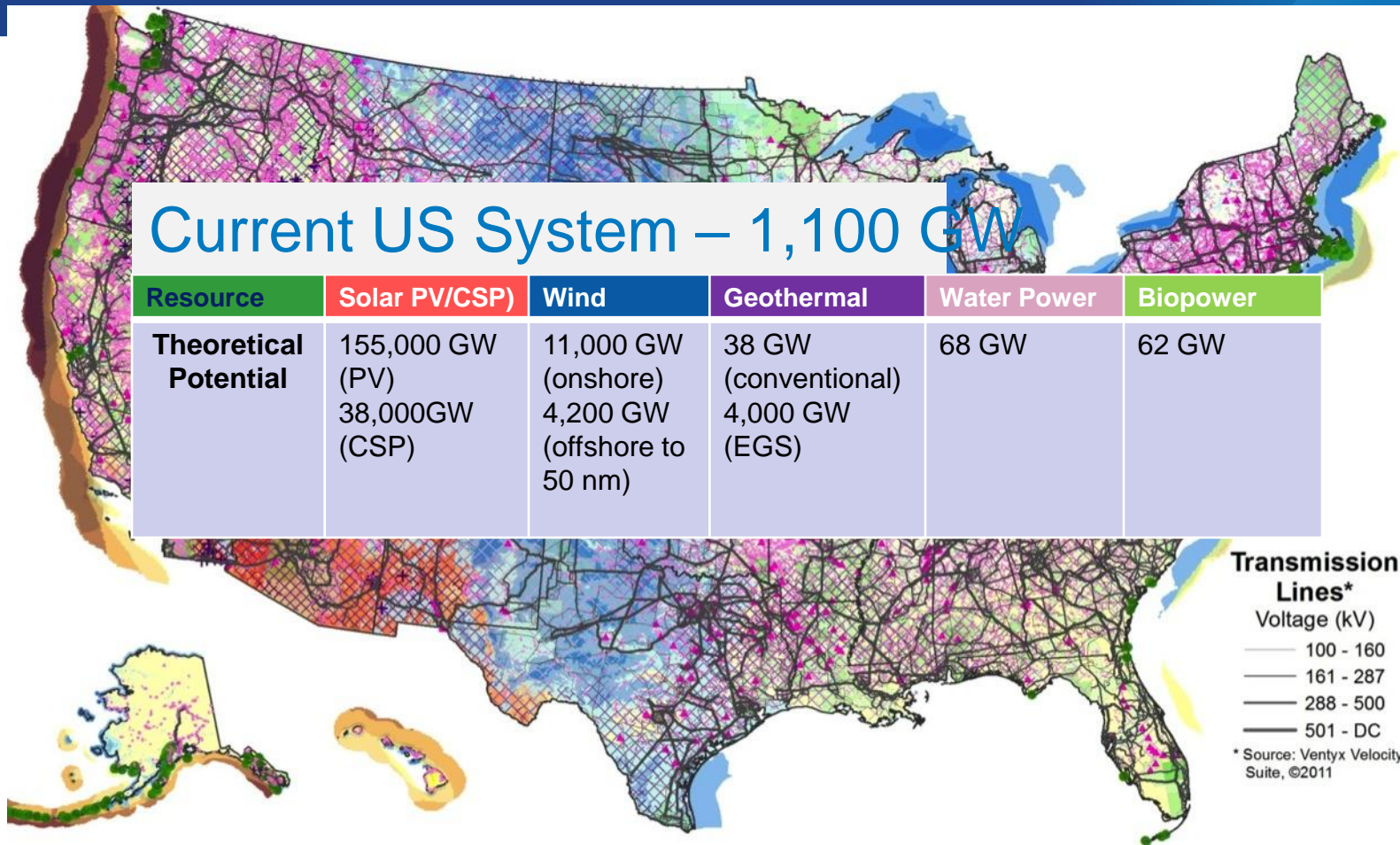
Wind Turbine Diagram



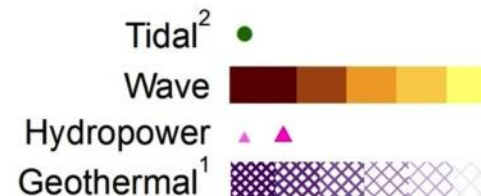
Xcel Energy to invest billions in new wind farms in west

- <https://www.bizjournals-com.cdn.ampproject.org/c/s/www.bizjournals.com/denver/news/2017/03/21/xcel-energy-to-invest-billions-in-new-wind-farms.amp.html>
- 3,380 megawatts (CO Rush Creek— 600 MW+ 90 mile trans, TX-NM-1,230 MW, MN-ND-SD-IO = 1,550 MW)
- ~\$4B(power 1,014,000 homes)
- \$20 per megawatt-hour, or 2 cents per kilowatt hour
- Most turbines Vestas - 3,500 people in CO
- Save customers about \$2.8 billion over a 30-year period due to reduced need for fossil fuel
- 2021 -Cut Xcel carbon 45% vs 2005 baseline

Converting Data to Information



Resource
Dark = Higher
Light = Lower

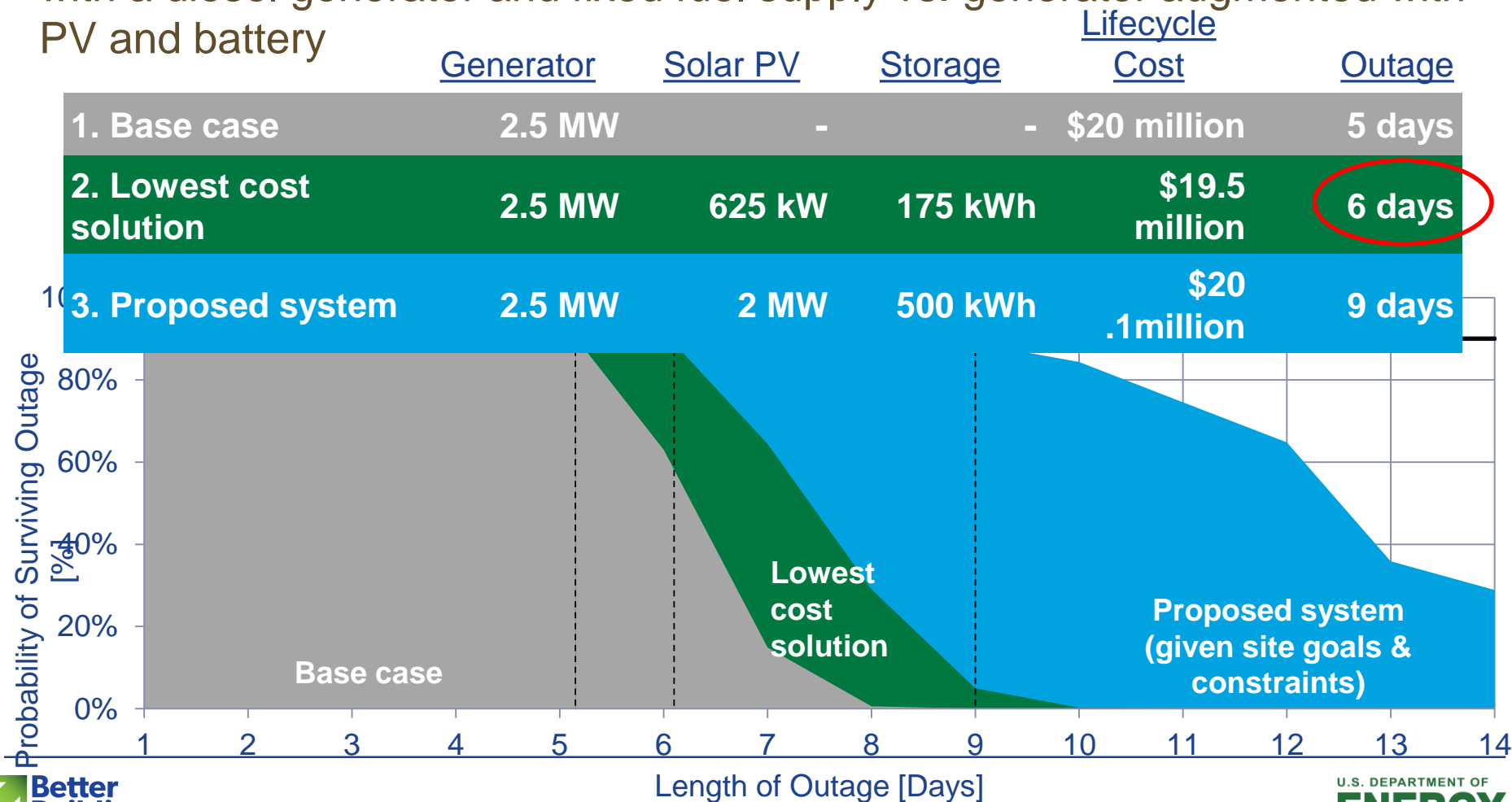


¹: Does not include Alaska or Hawaii

²: Does not include Hawaii

Resiliency Analysis

NREL evaluated thousands of random grid outages and durations throughout the year and compared number of hours the site could survive with a diesel generator and fixed fuel supply vs. generator augmented with PV and battery



QUESTIONS?

Otto VanGeet ♦ 303.384.7369 ♦ Otto.VanGeet@nrel.gov
Kate Anderson ♦ 303.384.7453 ♦ Kate.Anderson@nrel.gov



1,156 KW

50 KW

449 KW

408 KW

94 KW

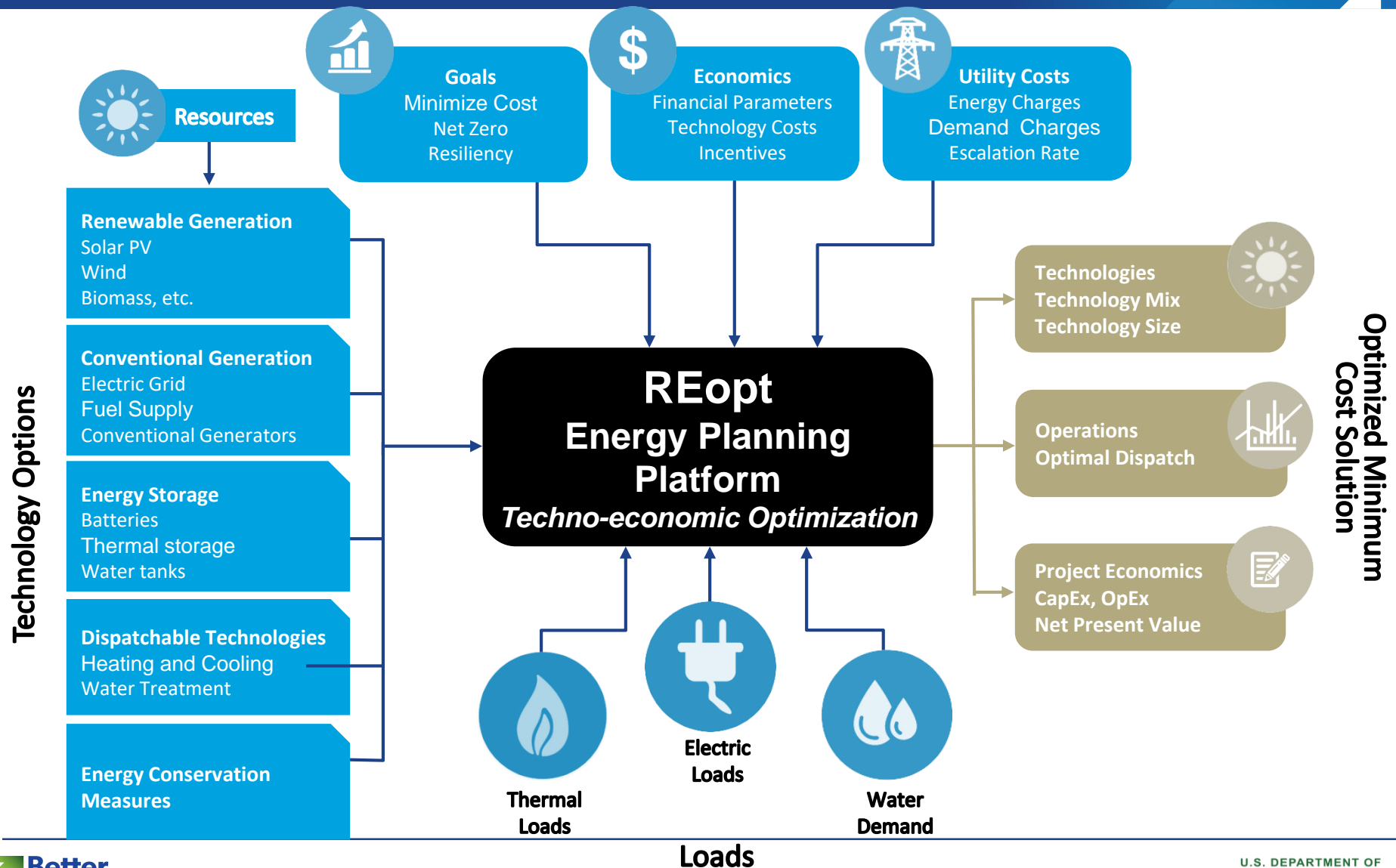
720 KW

524 KW

NREL PV Systems - South
Table Mesa Campus

The following slides provide more information.

REopt Inputs and Output



Renewable Energy Strategy

@KevinHagen

Director Corporate Responsibility



Global leader in storing, protecting and managing critical information and assets.

- **Records Management**
 - **Data Management**
 - **Document Management**
 - **Data Centers**
 - **Art Storage**
 - **Secure Shredding**



- **\$3.8B Sales**
- **25,000 employees**
- **+1400 secure Facilities**
- **46 Countries**
- **85 Million Sq ft**
- **220,000 customers**
- **94% of FORTUNE 500**
- **Publically Traded REIT (NYSE: IRM)**
- **Listed on the DJSI**



Latest GRI Sustainability Report

KEY FACTS AND FIGURES:

CLIMATE CHANGE:

In 2015 we set a goal to achieve zero increase in GHG emissions holding at 324,000 MTCO₂e and **ACHIEVED 15% YEAR-ON-YEAR REDUCTION OF TOTAL GHG EMISSIONS**



ENERGY EFFICIENCY:

In 2015 we committed to reducing facility energy use by 3 percent to 534,000 MWh and **ACHIEVED 12 PERCENT YEAR-ON-YEAR REDUCTION OF TOTAL FACILITY ENERGY USAGE**



RENEWABLE ENERGY:

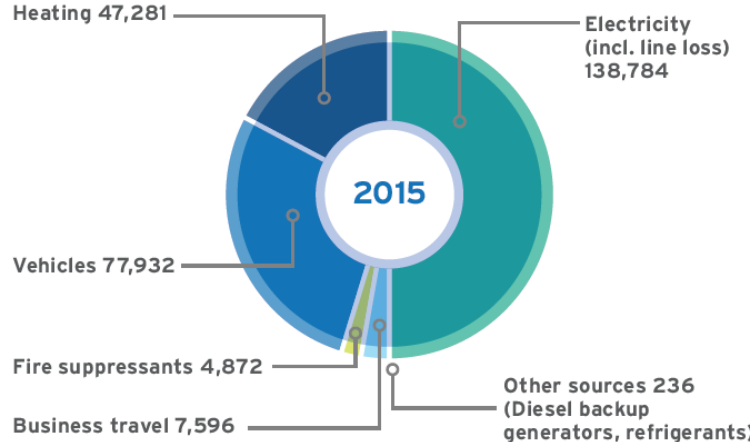
In 2015 we strived to increase the use of renewable energy such as on-site solar sixfold, to 2.4 million KWh and **ACHIEVED THAT GOAL THROUGH A COMBINATION OF ONSITE SOLAR AND DIRECT GREEN POWER PURCHASE**



GHG Impact Discussion

Priorities

GHG EMISSIONS BY SOURCE
276,702 (MTCO₂e)



- Scope II: North American Electricity
- Scope I: NA Fleet
- Scope I: NA Nat'l Gas for Heating
- Global Operations

4 Part Energy Strategy

5

**How much
we use**



Use less = Pay less

**When we
use it**



Avoid peak time
Reduce peak kW

**The rate
we pay**



Mitigate rate
increases

**The
Source**

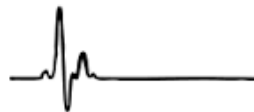


Increase percentage of
Green Power

Reduce total
consumption by as
much as 50% or
more

Complete control
when we use power
and how much is
pulled from the grid

Complete rate
certainty & stability



100%
Renewable



3 Tactics for Green Power Procurement



SOLAR

On-Site 20 year Solar PPAs

- 4.2 MW installed at existing locations
- Approx 4.5 MW under contract in development



WIND POWER

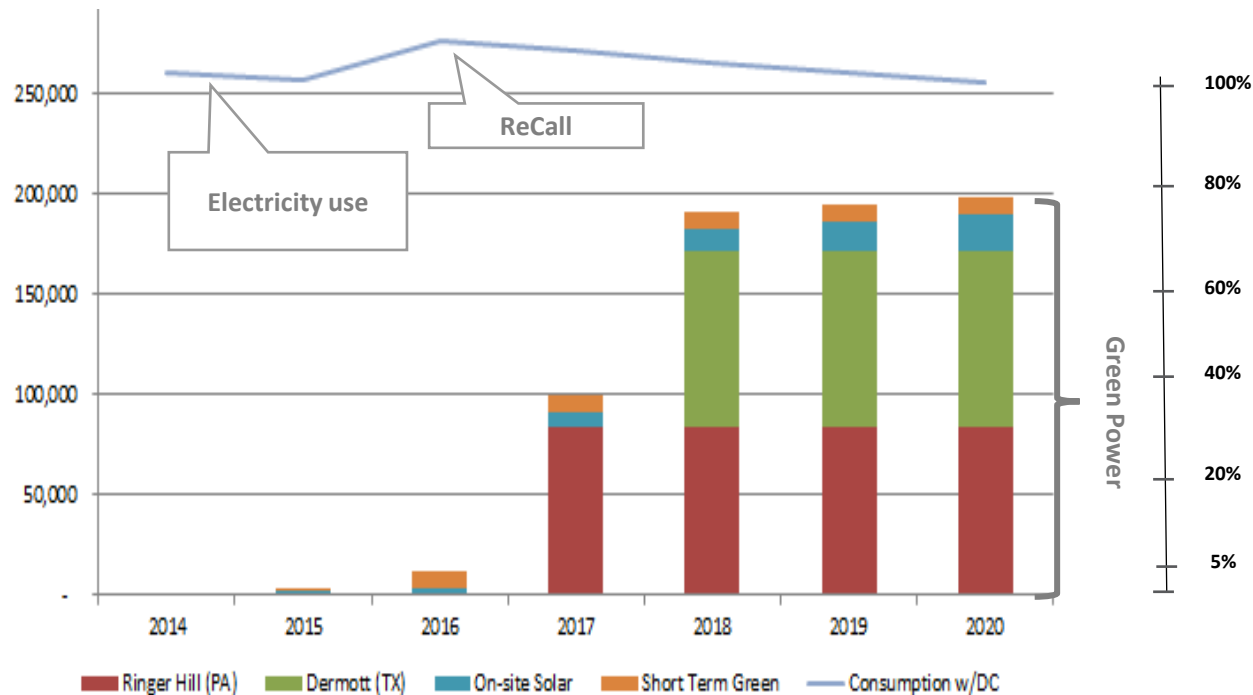
Short Term Direct Power Purchase

- 2016 1 yr/ 8,700 MWhrs Wind via RPD
- 2017 2 yr/ 31,000 MWhrs Wind via RPD

15 year “Virtual” Wind PPAs

- 25 MW with NJR Ringer Hill, PA
- 25 MW with Lincoln Clean Energy, Amazon Wind Farm TX

Forward View of Renewable Electricity in NA



Lessons Learned

- Sustainable business thinking reveals risks and opportunities we would not have otherwise seen
 - Organizational Blind Spots
- Energy was a great prototype of sustainable business change
 - From blind spot to risk/cost reduction to customer facing opportunity
- Sustainable Business Skills & Competencies
 - Metrics matter
 - Drives Innovation – dealing with complexity
 - Internal collaboration
 - And

Sustainability is a Team Sport

**CORPORATE RENEWABLE ENERGY
BUYERS' PRINCIPLES: INCREASING
ACCESS TO RENEWABLE ENERGY**



IMDC **Climate Neutral** Data Center Services



Launching a New Product:

ESG is moving from
Operational Impacts to
customer value.

Thank You

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