

Insights and Opportunities: Technologies, Policies, and Markets for Clean Energy Solutions



**NREL Industry Growth
Forum**

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Director, Analysis Center**

**November 2009
Denver, CO**

NREL/PR-6A2-47122

Strategic Energy Analysis

Integrated technical and economic analyses that advance the understanding of the value of technology in the context of dynamic global, national, and local markets, policies, energy resources and loads, and infrastructure.

Energy-Economic Market Characterization

Analyze benefits and impacts of programs, portfolios, and policy options

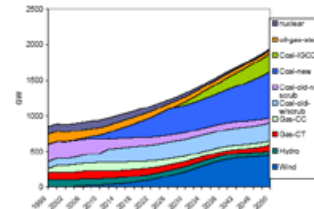
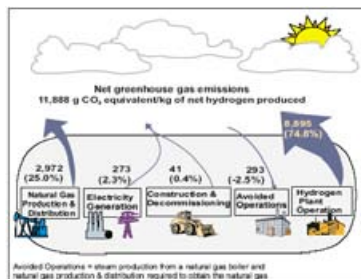


Figure 6: Capacity Expansion in the WGS FHEV40 Case

System

Analyze system performance and technology interfaces in the context of the overall system



Technology/Component

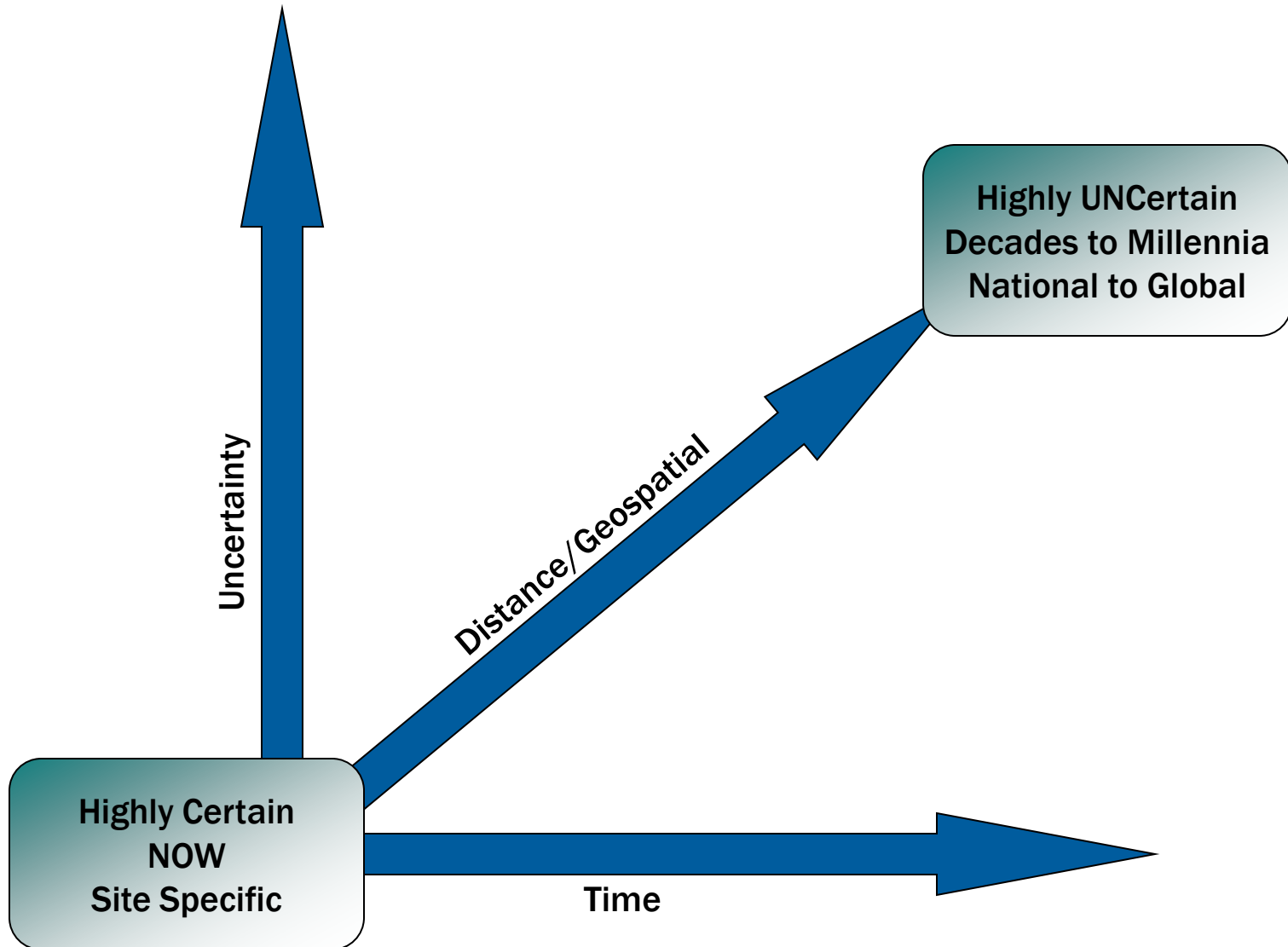
Analyze technology and component performance, cost, and other attributes



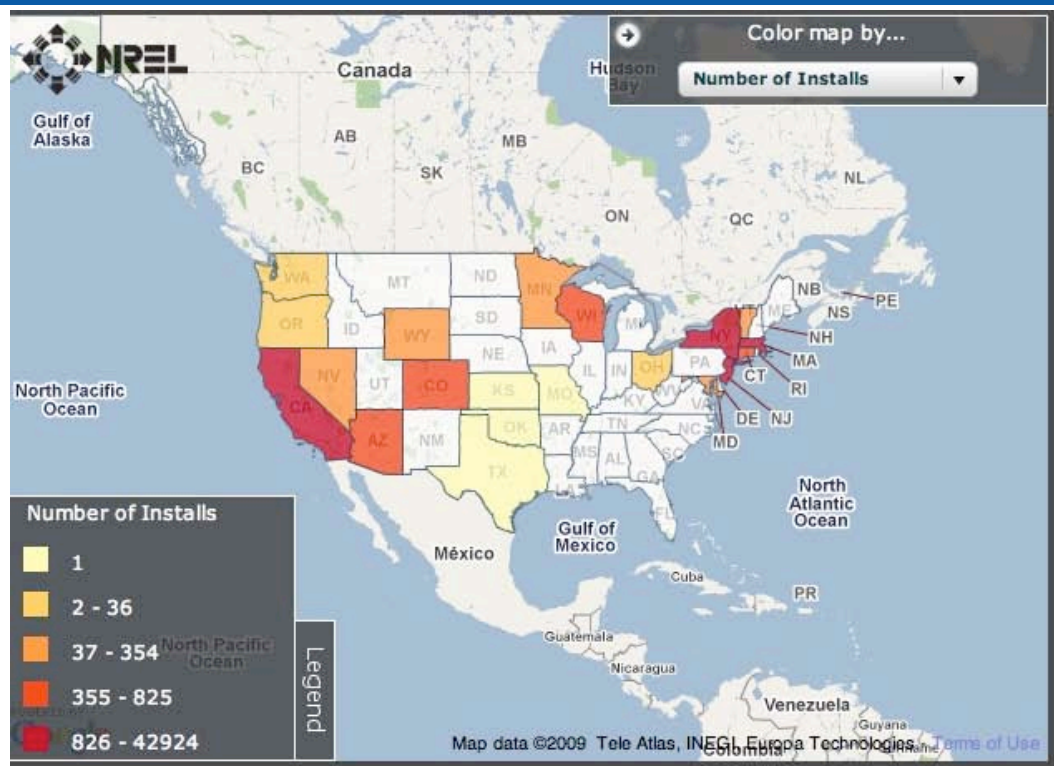
Resource

Assess resource availability and characteristics

Driving Innovation In Energy Analysis



OpenPV – PV Market Information



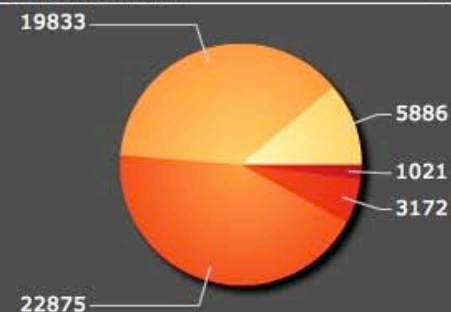
US Statistics

Total Number of Installs: **52788**

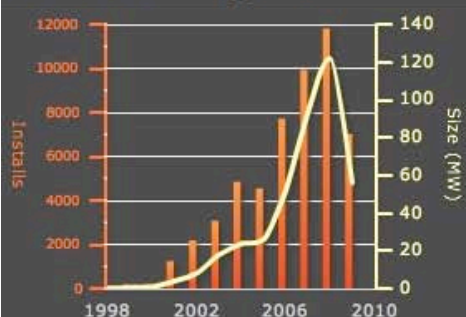
Installed Capacity (MW): **403.269**

Average Cost (\$/W): **9**

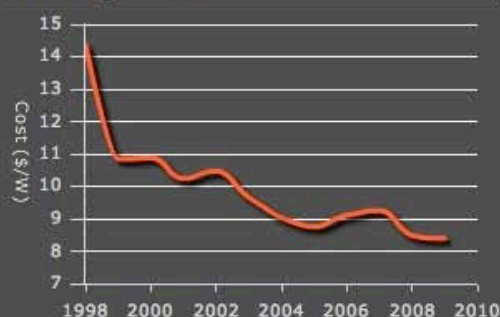
US Size Breakdown



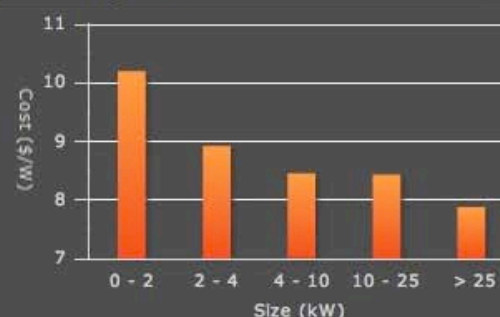
US Installs and Size by Year



US Cost by Year



US Cost by Size



IMBY – In My Back Yard

In My Backyard (IMBY) - National Renewable Energy Laboratory - Mozilla Firefox

http://mercatore.nrel.gov/imby/

In My Backyard - National Renewable Energy Laboratory (NREL)

Pan Clear Map

Options

Location Solar Wind

Solar Electricity Estimator

To estimate the solar electricity you can produce, follow the steps below.

Step 1. Draw your system.

Use the zoom tool on the left of the map, if needed. Click the Draw button, and draw your solar array on the map. Click to add a new point. Double-click to stop drawing.

Draw

If you make a mistake, click the Clear Map button at the top of the map to start over.


Step 2. Adjust the inputs.

Based on the size and location of your system IMBY suggests these inputs. To change these values, enter your information in the fields below. [Help](#)

Size (kW): 216.95
Derating: 0.8
Tilt angle (°): 39.7
Azimuth angle (°): 180
Data year: 2005

Step 3. Estimate your production.

Run



Google Imagery ©2008 U.S. Geological Survey, Map data ©2008 Tele Atlas - Terms of Use

Done

Rooftop PV or Small Wind System For Feasibility Analysis

Backyard (IMBY) - National Renewable Energy Laboratory - Mozilla Firefox

http://mercatore.nrel.gov/imby/

Backyard - National Renewable Energy Laboratory (NREL)

Pan Clear Map

Options

Location Solar Wind

Simulation Results

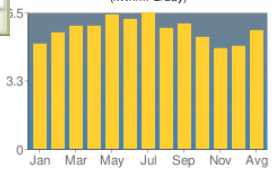
Summary PV Generation Profile

System Inputs

System Inputs	
State:	CO
County:	Jefferson
Latitude:	39.74
Longitude:	-105.15
DC Rating:	216.95
DC-to-AC Derate:	0.8
AC Rating:	173.56
Tilt:	39.7
Azimuth:	180
Data Year:	2003

Solar Resource

Solar Resource by Month (kWh/m²/day)



Month	Solar Radiation (kWh/m ² /day)	AC Power (kWh)
Jan:	4.992	23611.08
Feb:	5.57	23485.57
Mar:	5.855	26433.97
Apr:	5.9	30366.19
May:	6.411	28945.82
Jun:	6.191	27929.78
Jul:	6.531	29643.57
Aug:	5.741	28217.03
Sept:	6.045	30661.57
Oct:	5.32	29602.12
Nov:	4.853	23454.26
Dec:	4.948	25053.08
Year:	5.697	327404.04

System Outputs

Month Solar Radiation (kWh/m²/day) AC Power (kWh)

Jan: 4.992 23611.08
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Nov: 4.853 23454.26
Dec: 4.948 25053.08
Year: 5.697 327404.04

Load

Now compare your estimated solar electricity production with your electricity consumption.

Step 1. Select a load profile.

You may select a sample profile or upload your own custom load profile.

(A) Use a sample load profile.

Choose a city from the drop-down box below.

Sample Profile: Select...

or

(B) Upload a load profile.

Click the Upload File button below. Then browse to locate your load profile document. For help click [here](#)

Upload

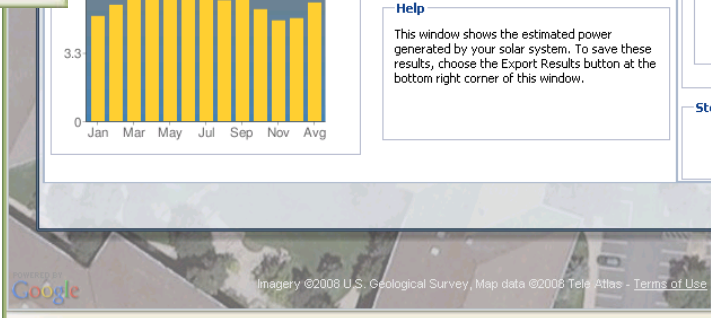
Step 2. Run load profile

Run

Export Results Close

Help

This window shows the estimated power generated by your solar system. To save these results, choose the Export Results button at the bottom right corner of this window.

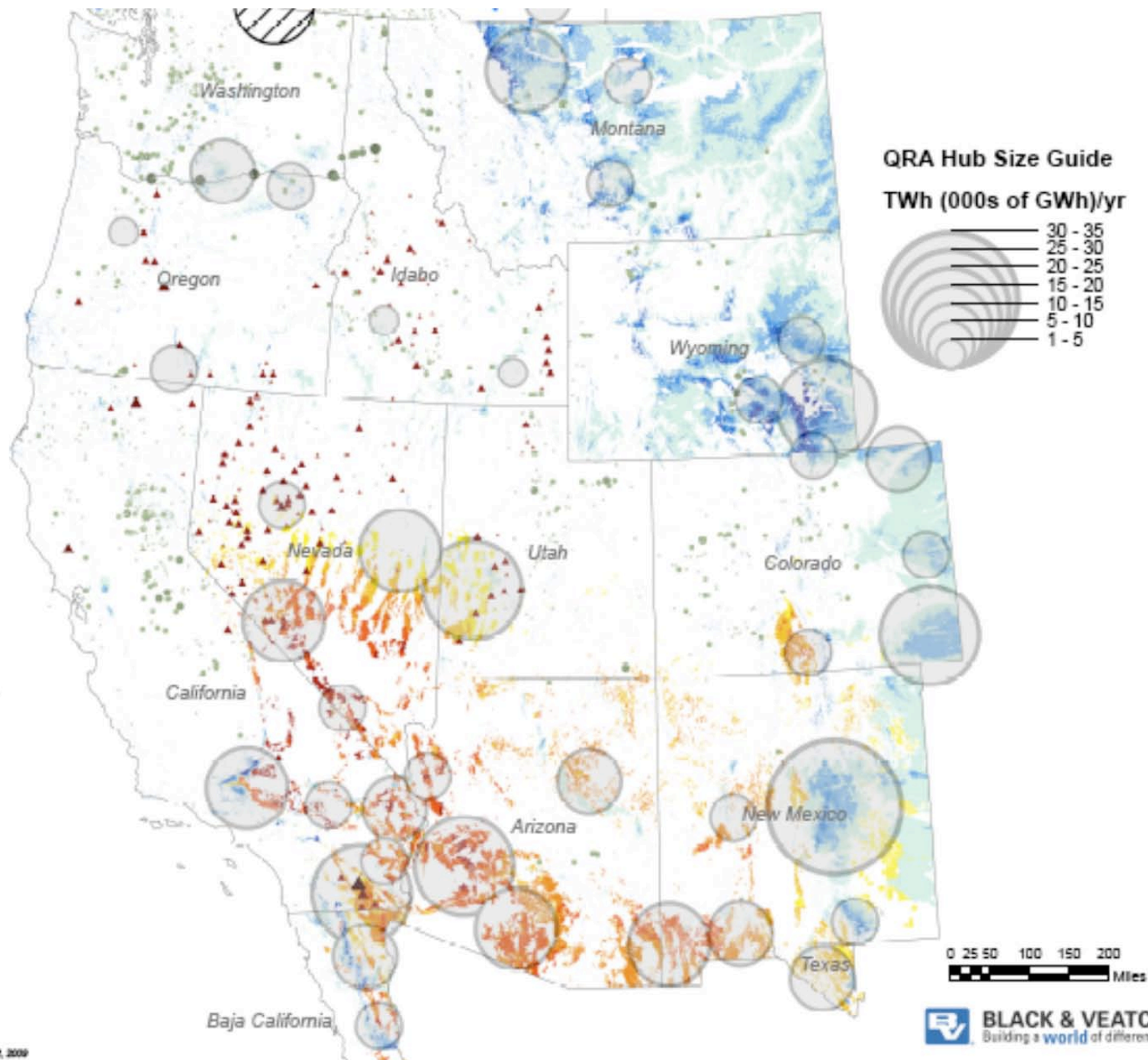


Google Imagery ©2008 U.S. Geological Survey, Map data ©2008 Tele Atlas - Terms of Use

Done

Segmentation and Geospatial Insights

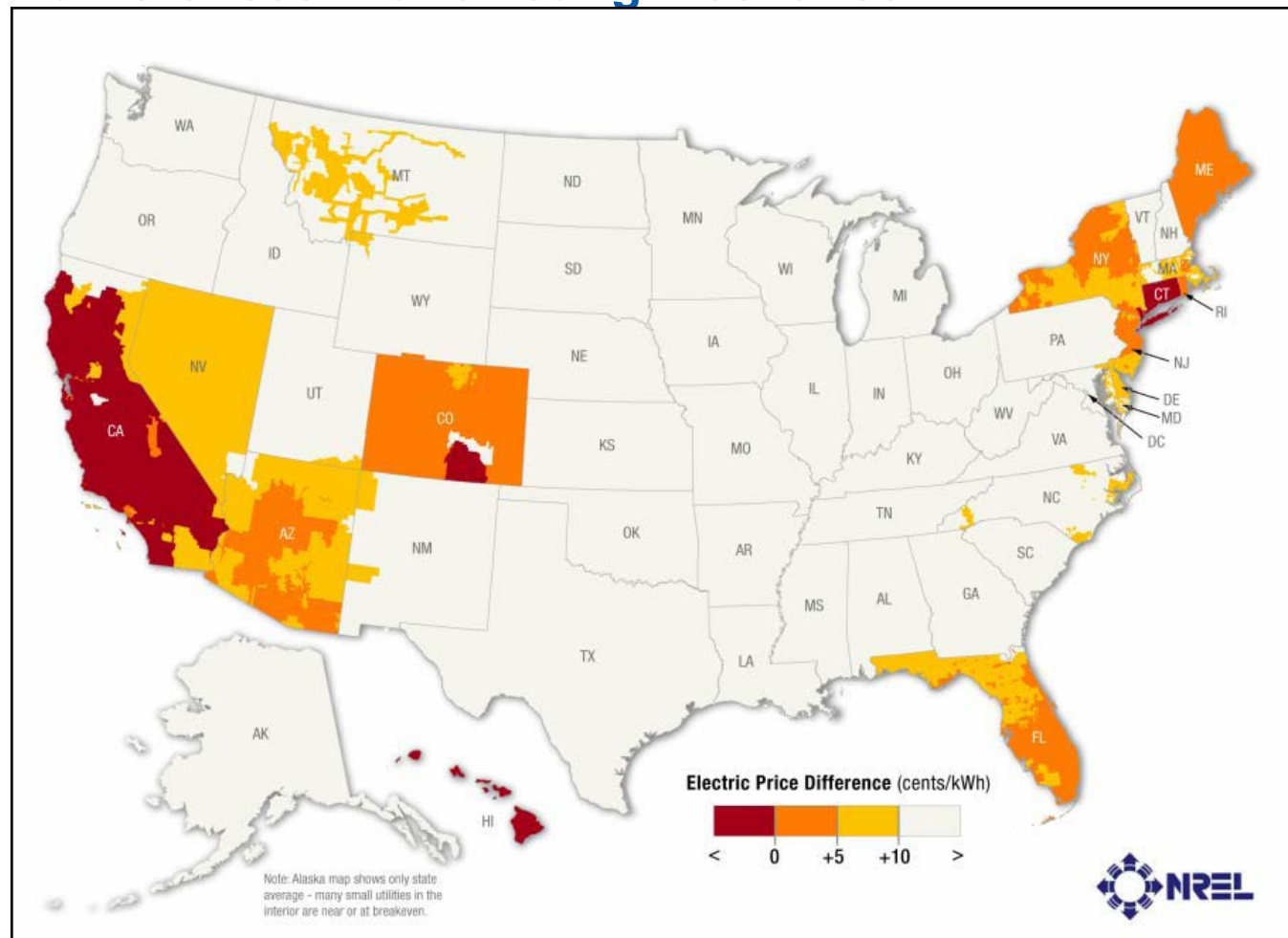




Policy analysis example: PV grid-parity analysis

2007 residential PV and electricity price differences with existing incentives

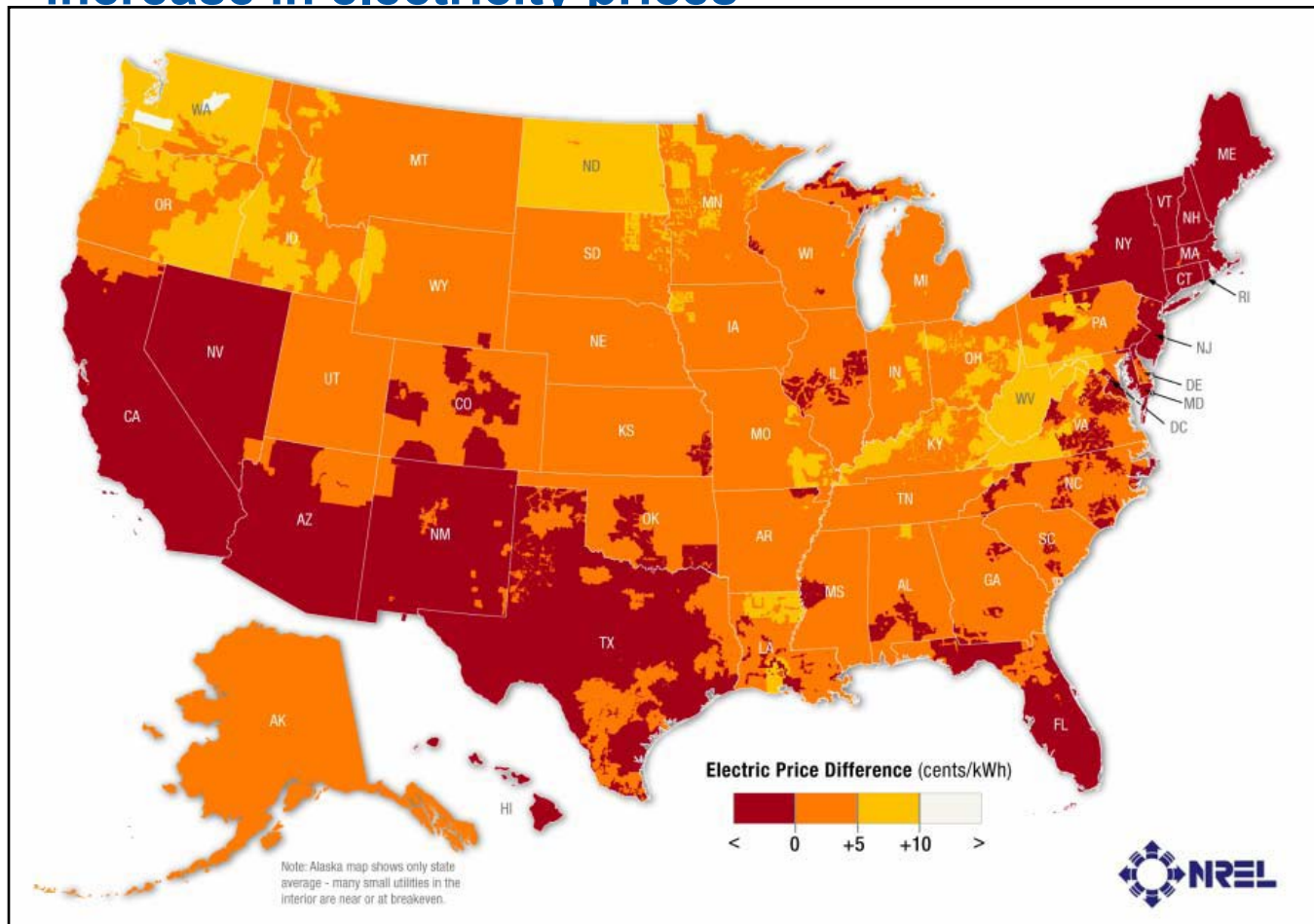
- Analysis for 1000 largest utilities in the U.S.
- Currently PV is only attractive where there is a combination of high electricity prices and incentives.



Policy analysis example: PV grid-parity analysis, 2015

2015 residential without incentives and moderate increase in electricity prices

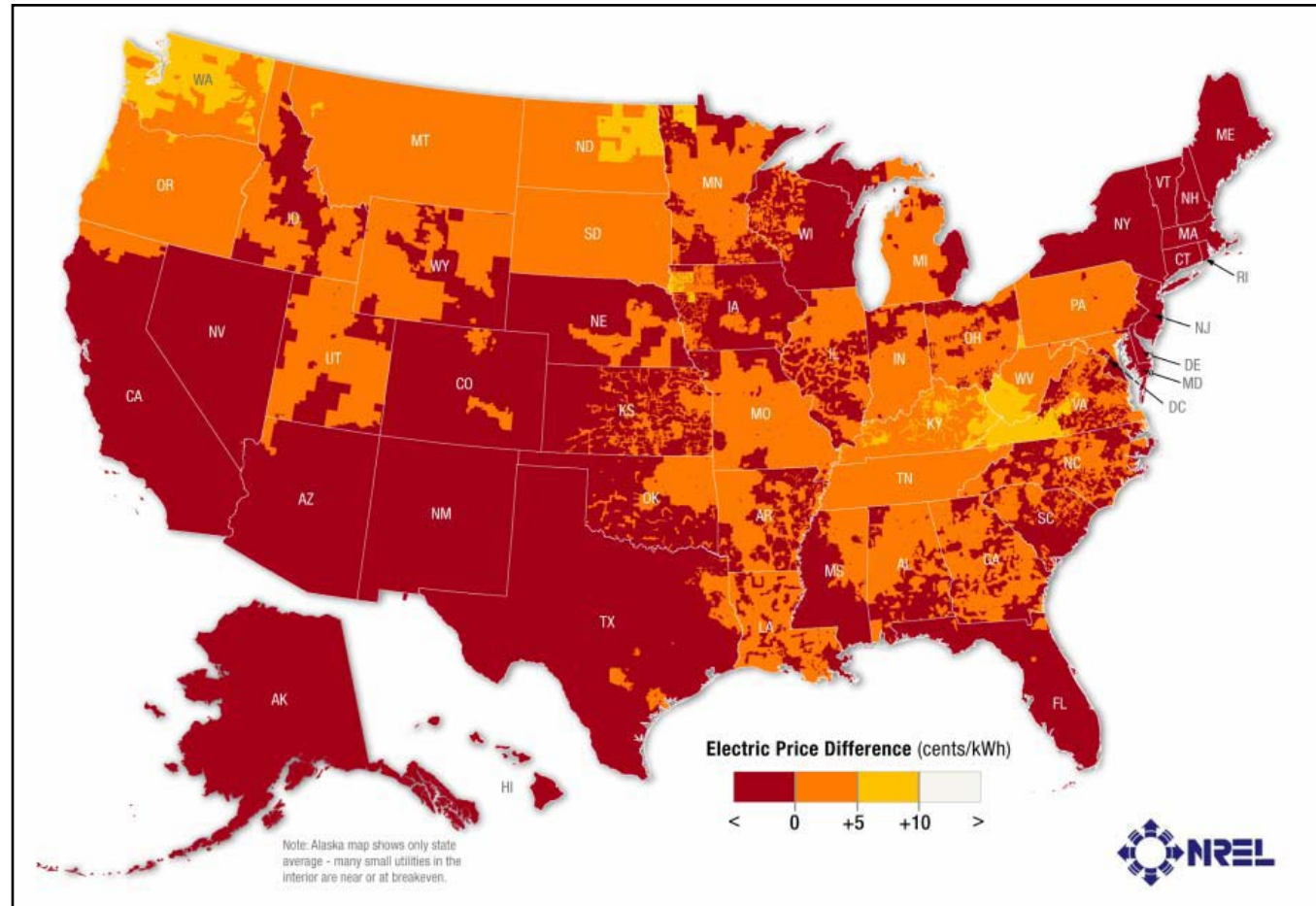
- Attractive in about 250 of 1,000 largest utilities, which provide ~37% of U.S. residential electricity sales.
- 85% of sales (in nearly 870 utilities) are projected to have a price difference of less than 5 ¢/kWh.



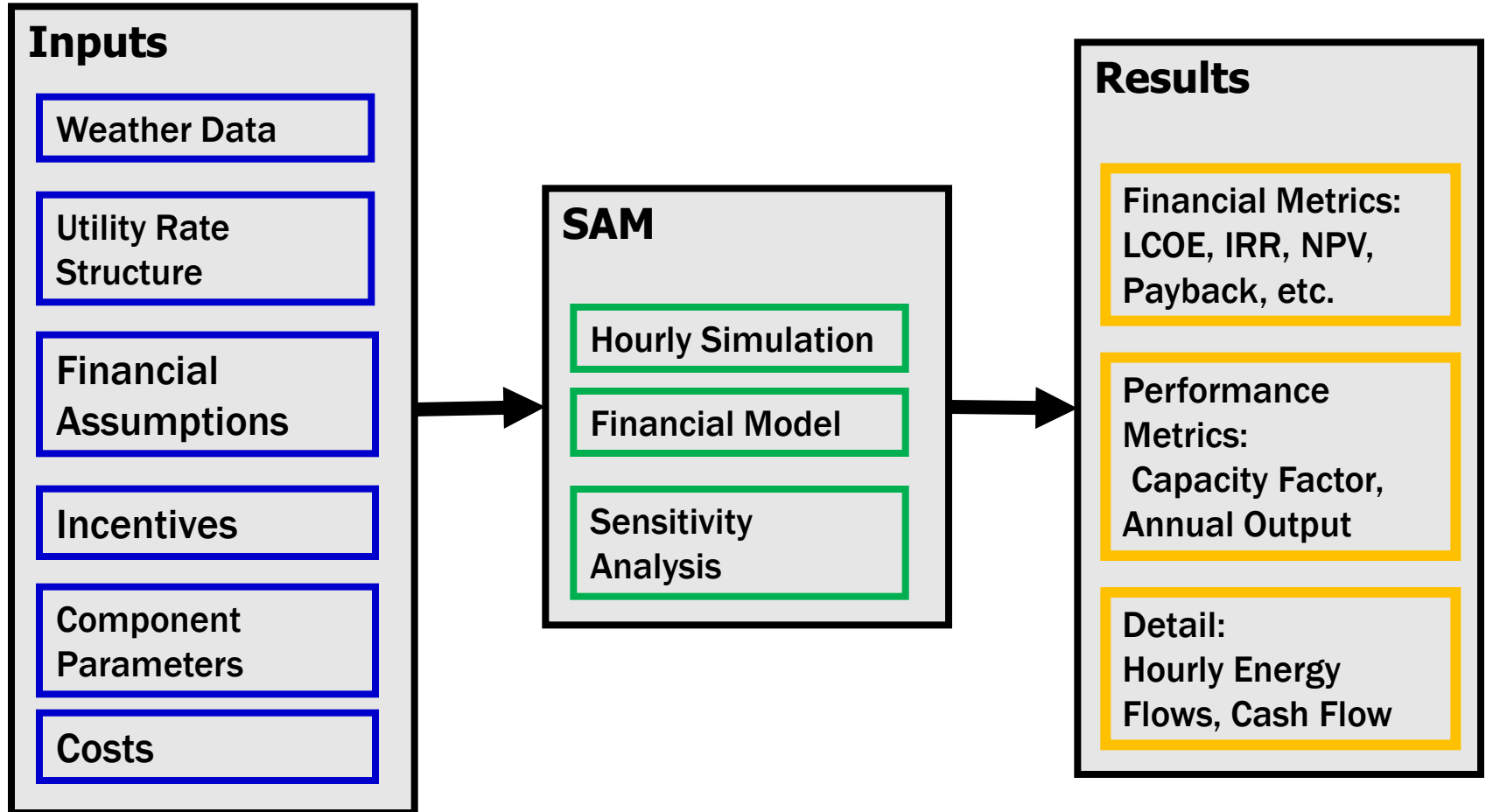
Policy analysis example: PV grid-parity analysis; Alternative Scenario

2015 residential without incentives and aggressive increase in electricity prices

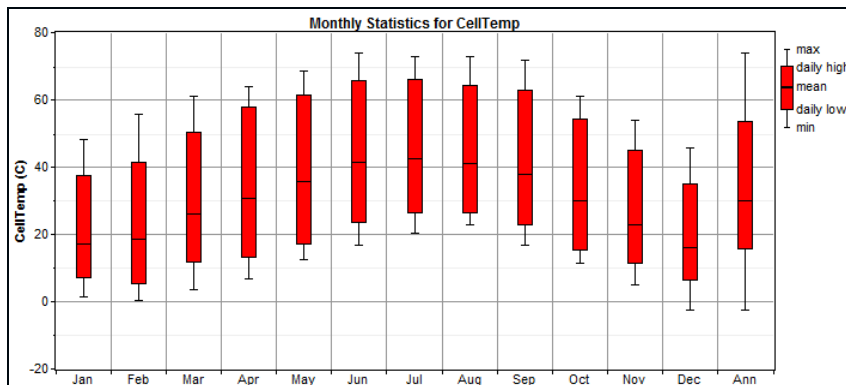
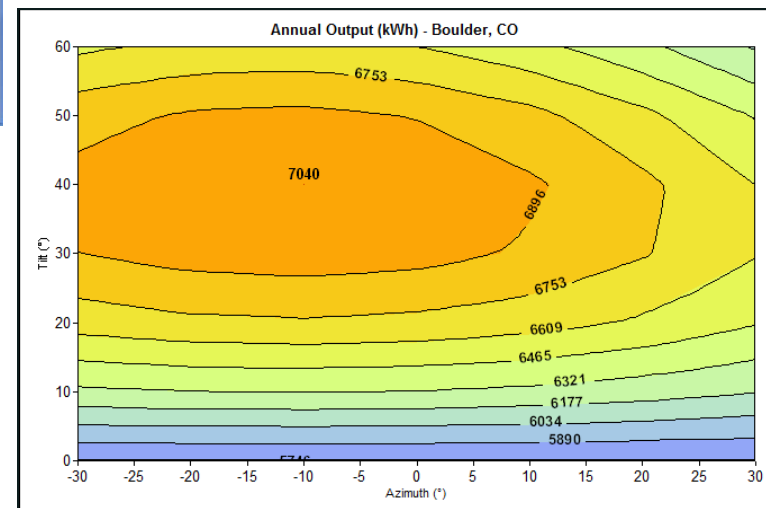
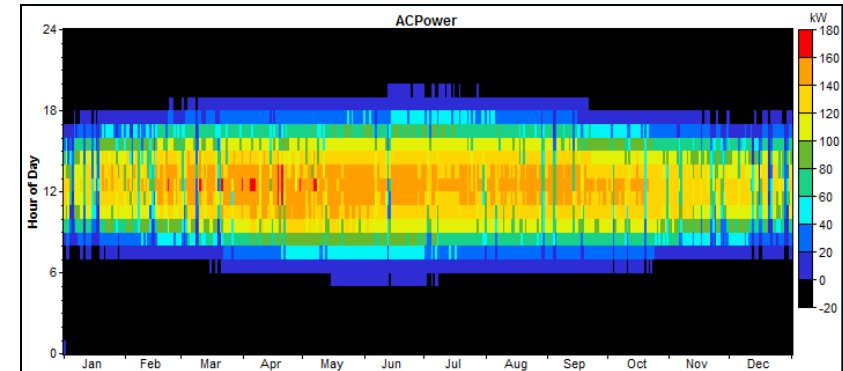
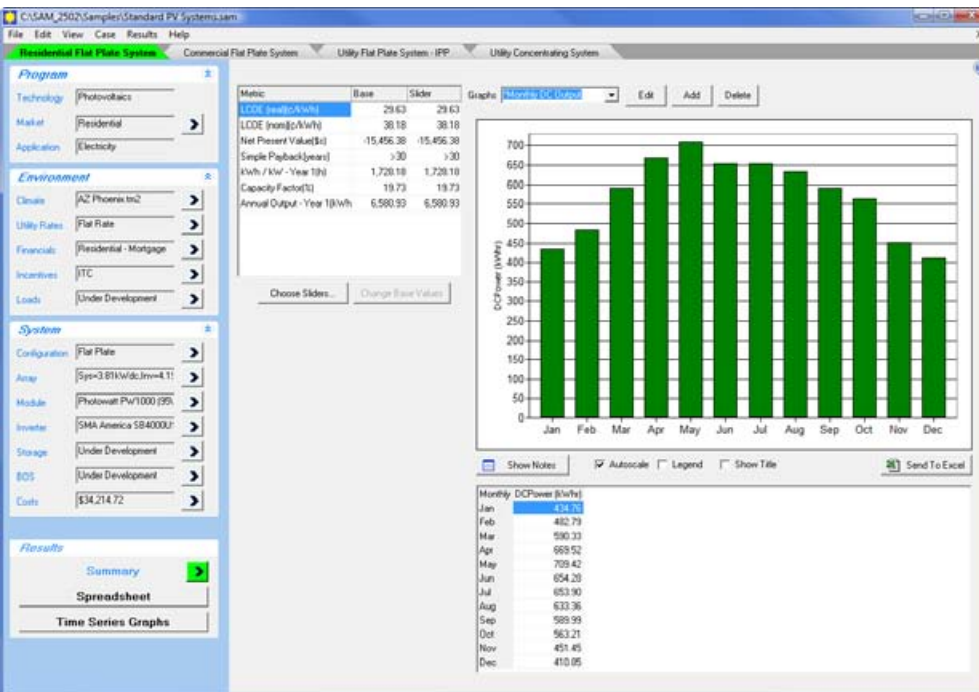
- Attractive in about 450 of 1,000 largest utilities, which provide ~50% of U.S. residential electricity sales.
- 91% of sales (in nearly 950 utilities) are projected to have a price difference of less than 5 ¢/kWh.



Value Differentiation: Systems and LCOE Example: Solar Advisor Model



Sample Outputs



Geospatial Energy-Economics: Systems Opportunities

Region Definitions

Time-slice Definitions

Transmission Data

Resource Data

Initial Capacity

Load Growth Forecast

Technology Cost/
Performance Forecasts

Fuel Price Forecasts

State/Federal
Rules/Incentives

Financing Assumptions

System Requirements

Electricity Price Forecasts

Fuel Demand Forecasts

Transmission
Requirements

Load Requirements

Installed Capacity

Fuel Prices

Technology Cost/
Performance Data

Wind Variability
Parameters

ReEDS
Optimization

New Generating Capacity

New Transmission
Capacity

Dispatch

$$\min_{\substack{gen, cap \\ oper res}} C_o \cdot gen + C_c \cdot cap$$

$$\text{s.t. } gen > load$$

$$cap > peak\ load \cdot (1 + res\ marg)$$

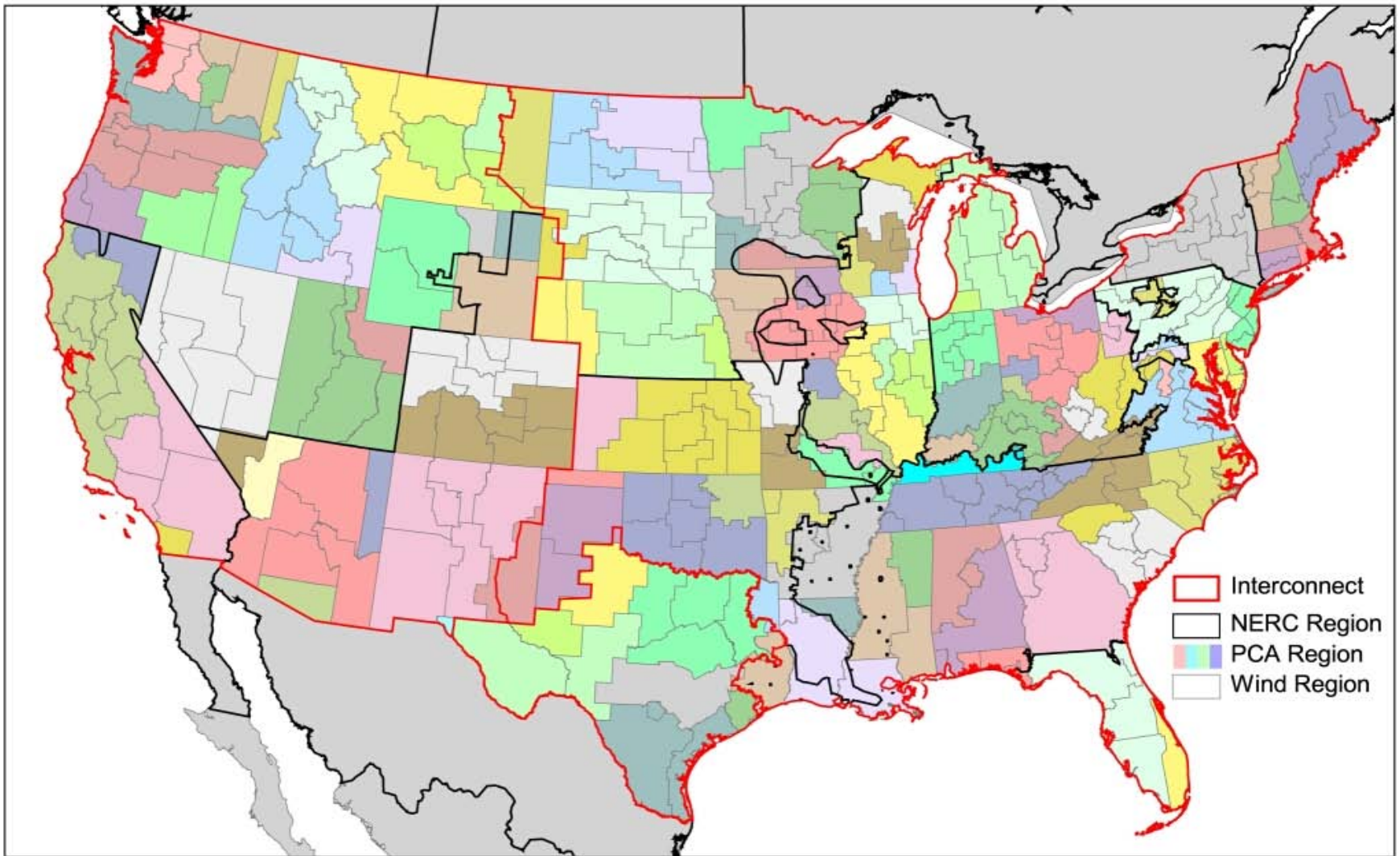
$$oper\ res > res\ reqt$$

$$gen + oper\ res < cap$$

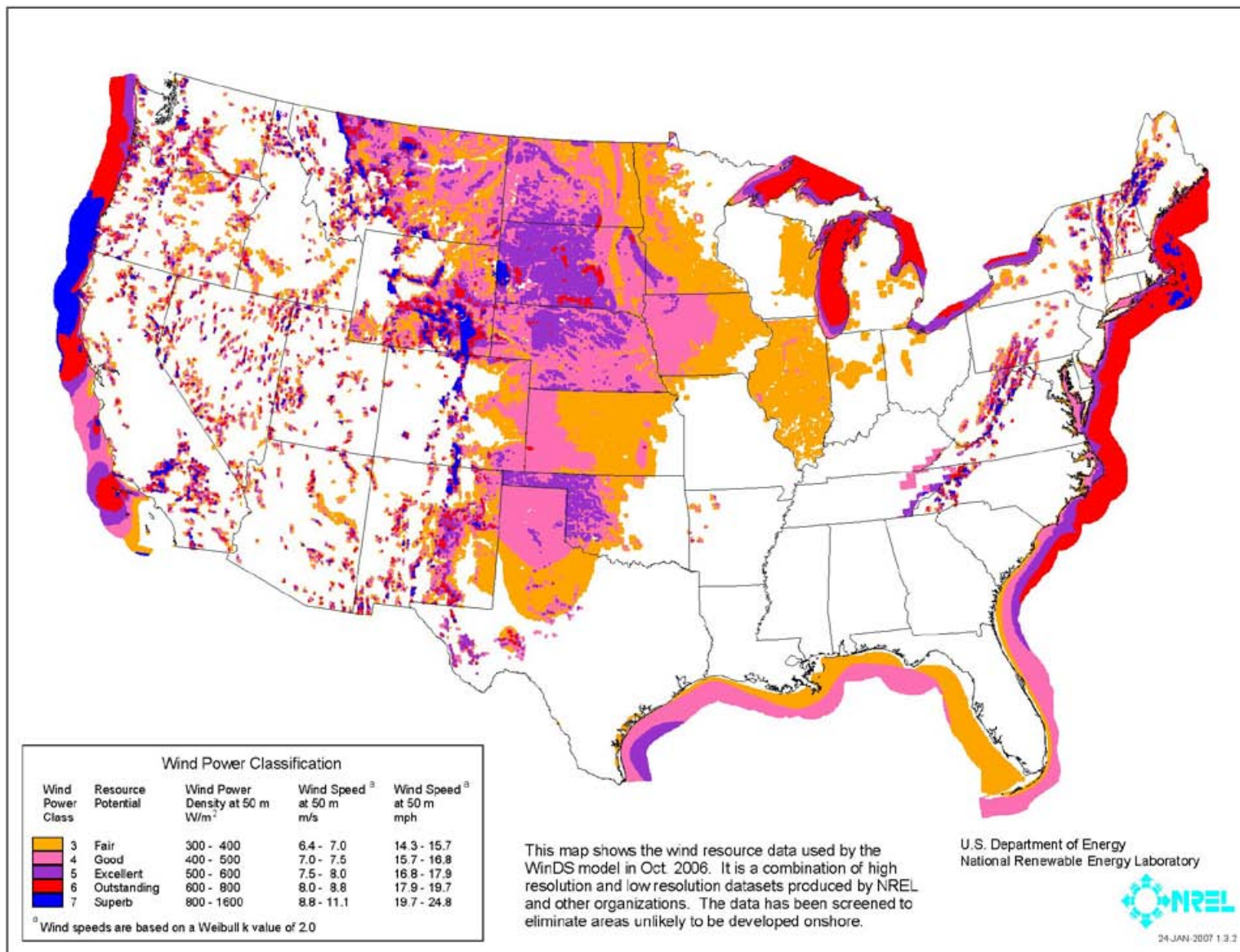
Electricity Price

Fuel Usage

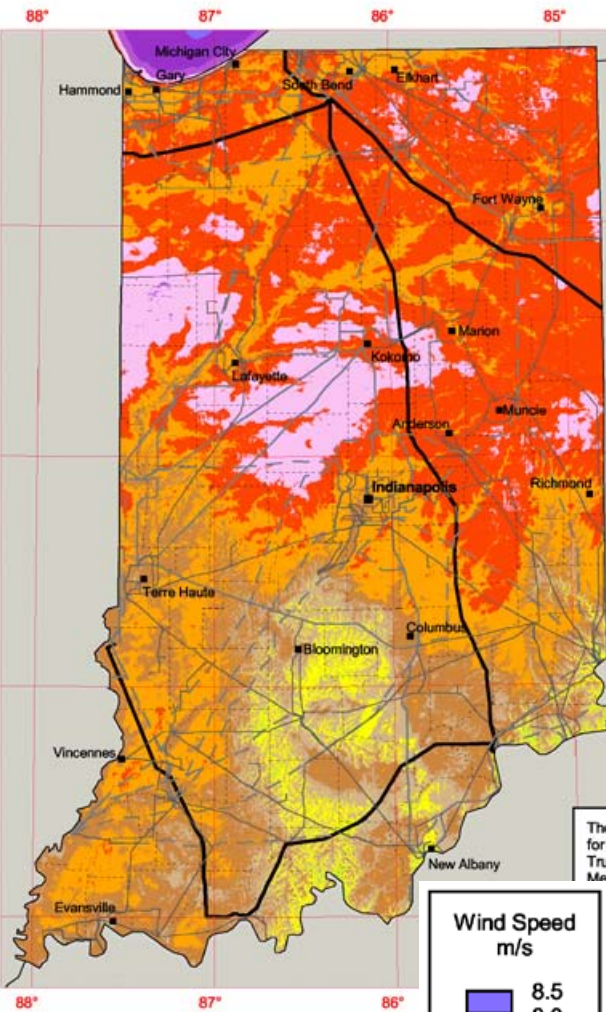
ReEDS Regions



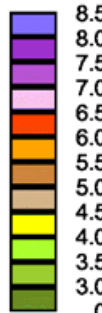
Wind Resource in ReEDS



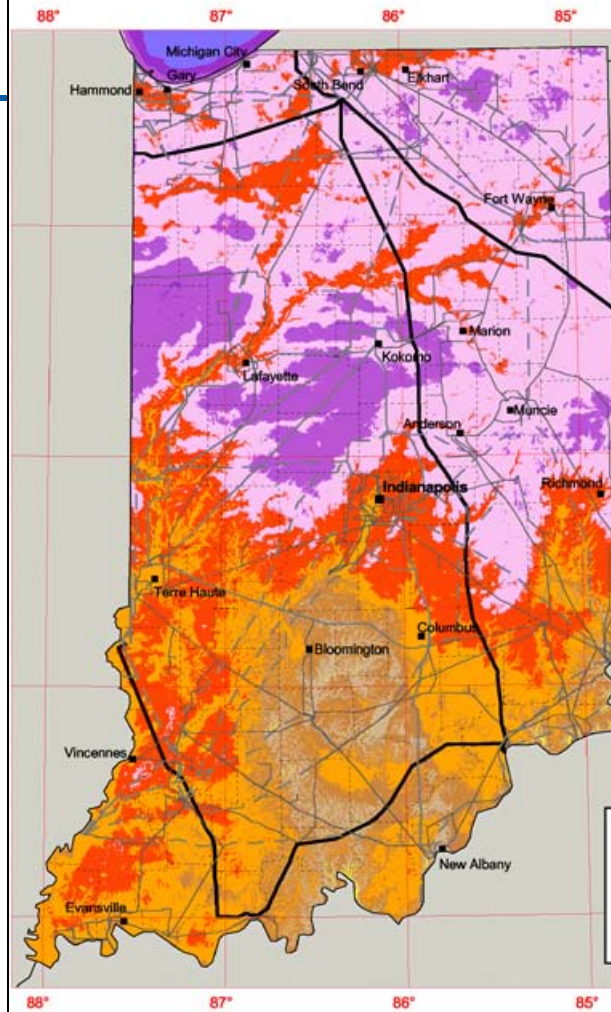
Indiana - 50 m Wind Speed



Wind Speed
m/s

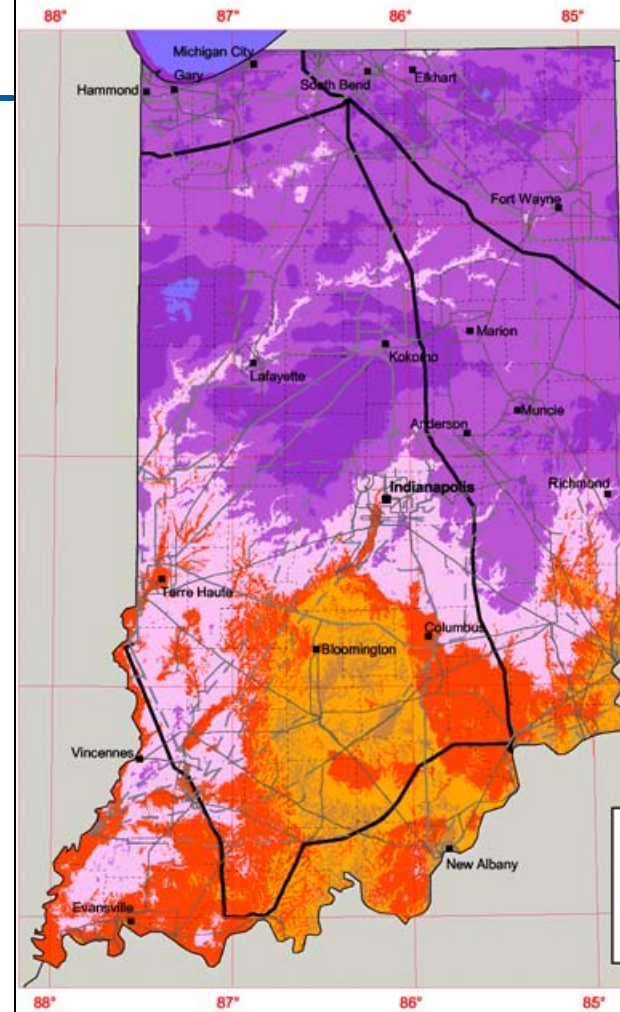


Indiana - 70 m Wind Speed



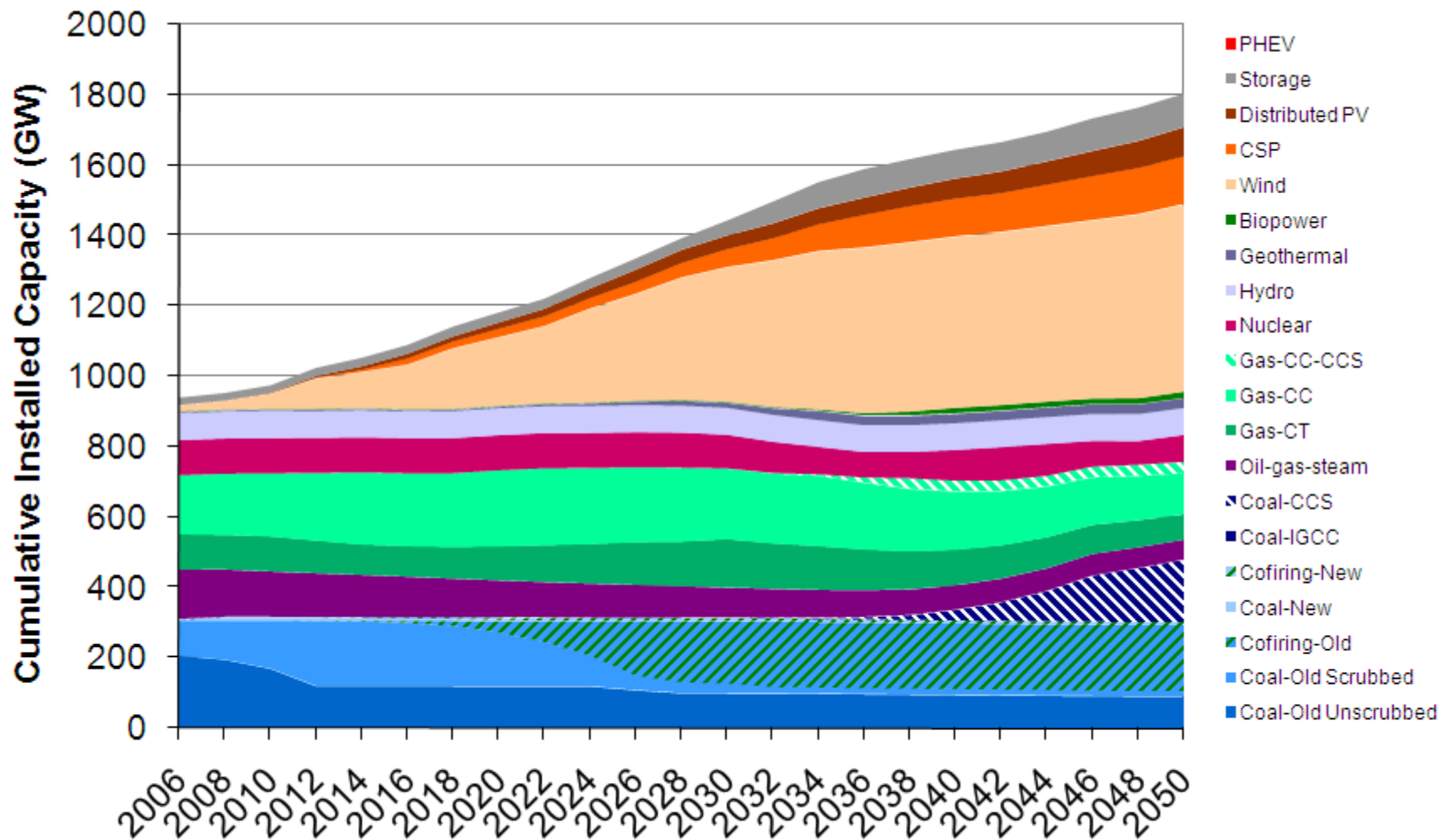
Wind Potential (8-12% Losses)
 30-36% Capacity Factor: 100 – 42 GW
 36-41% Capacity Factor: 2 – 0 GW
Total: 102 – 42 GW

Indiana - 100 m Wind Speed

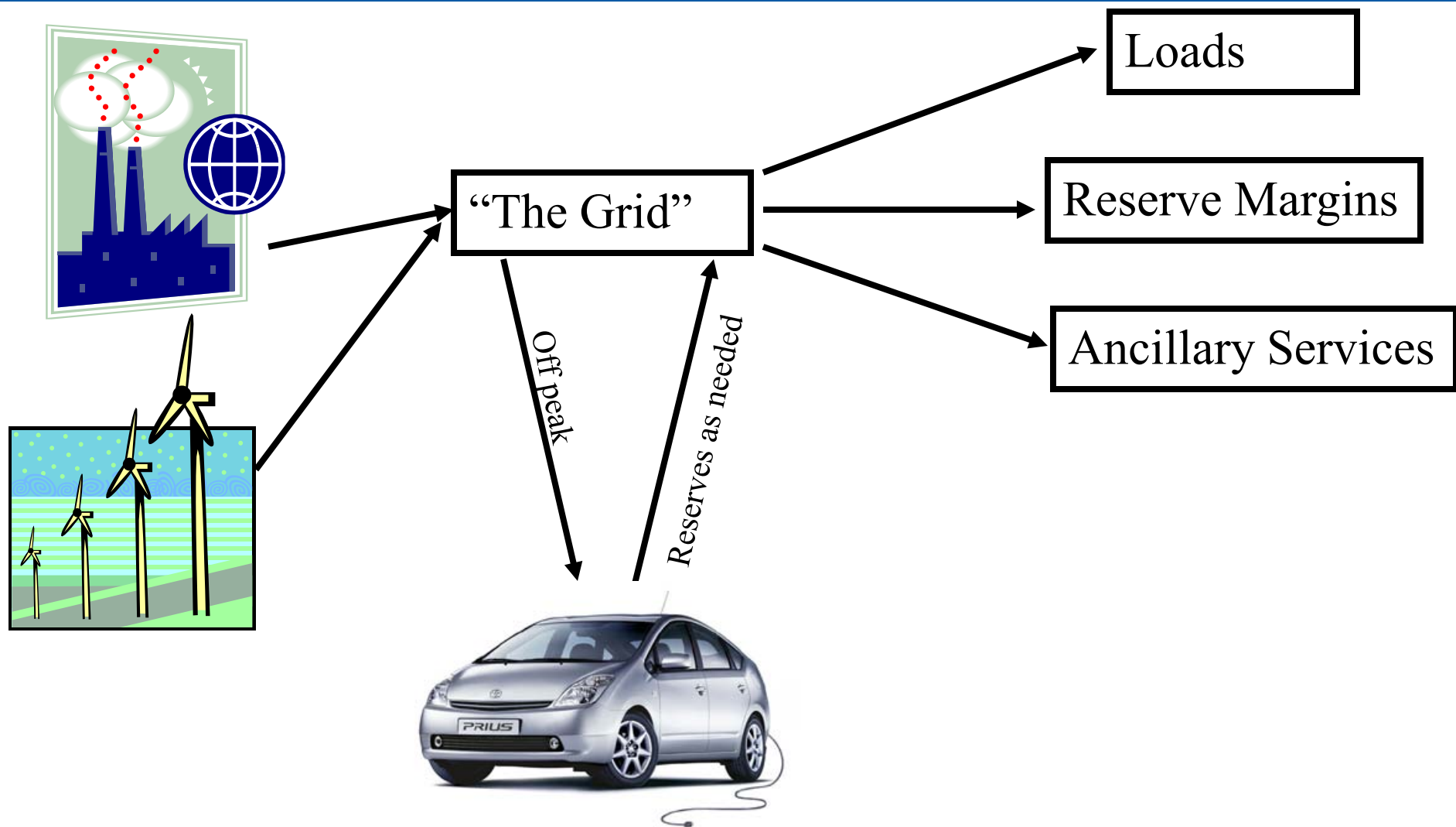


Wind Potential (8-12% Losses)
 30-36% Capacity Factor: 123 – 161 GW
 36-41% Capacity Factor: 99 – 37 GW
 42-46% Capacity Factor: 1 – 0 GW
Total: 223 – 198 GW

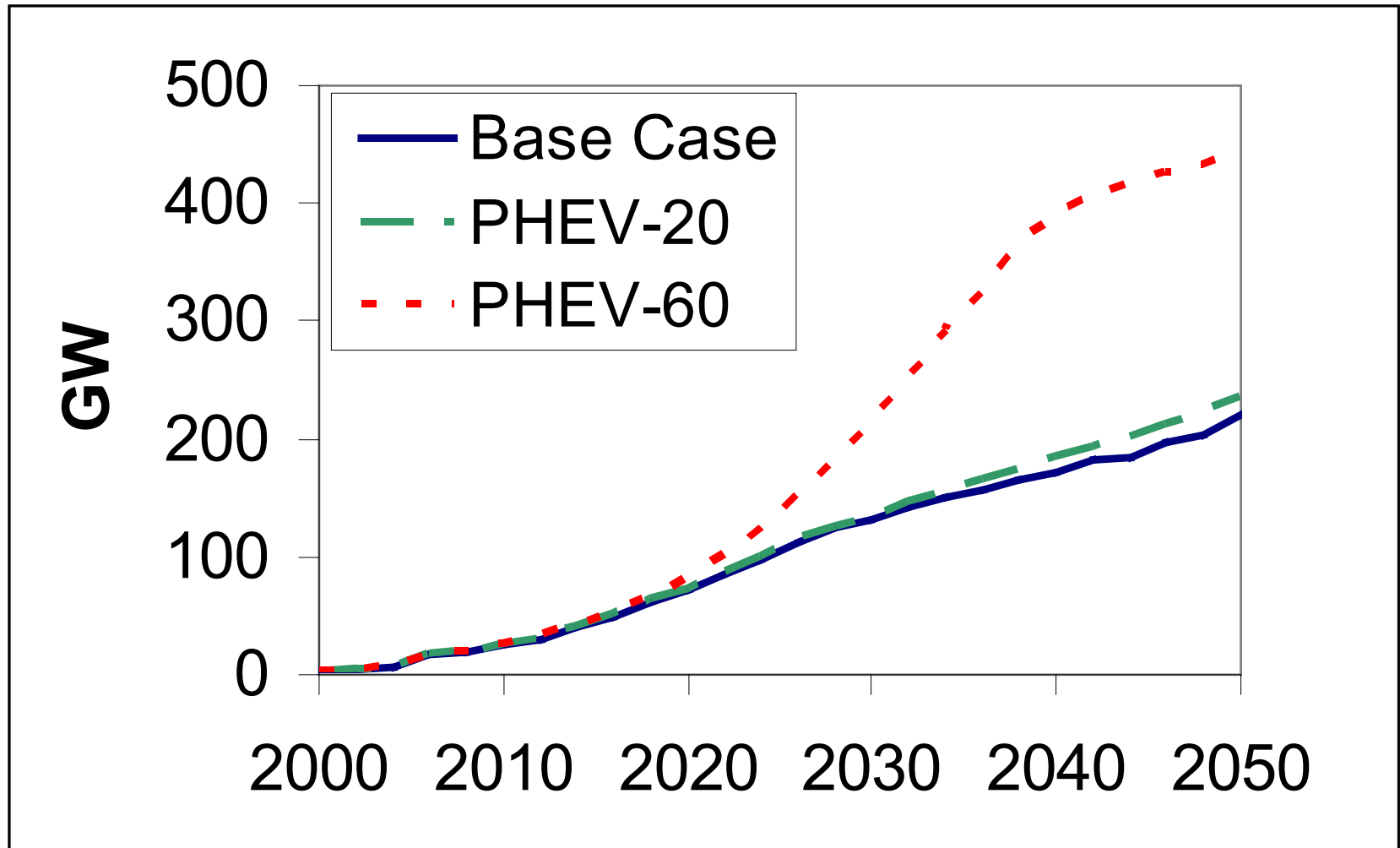
Evolution of Electric Generation under Carbon Constraint



Plug-in Hybrid Electric Vehicle Modeling

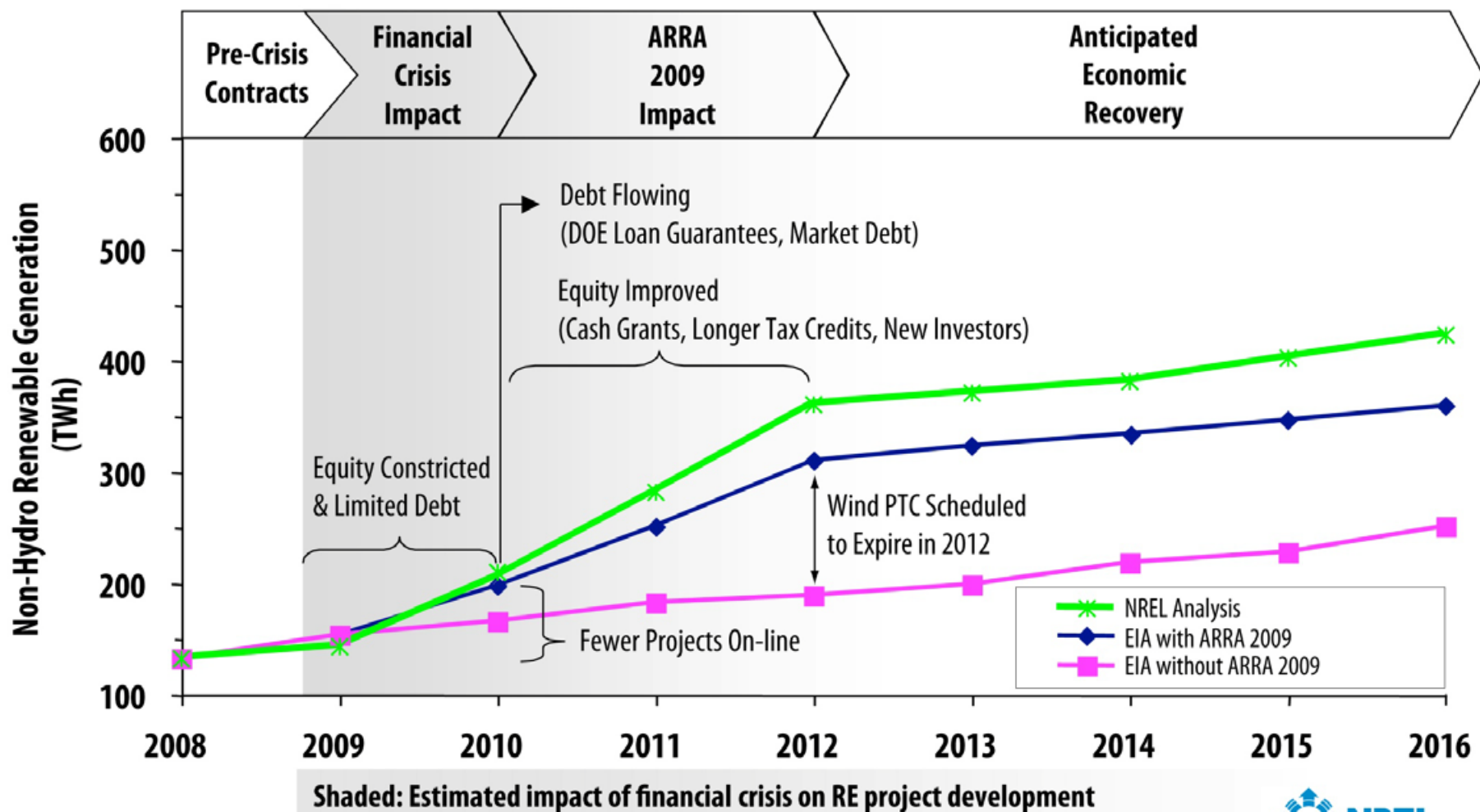


PHEVs* Can Increase Wind Penetration



* Assumes 50% PHEV-V2G penetration by 2050

Federal Stimulus Impact on Renewables

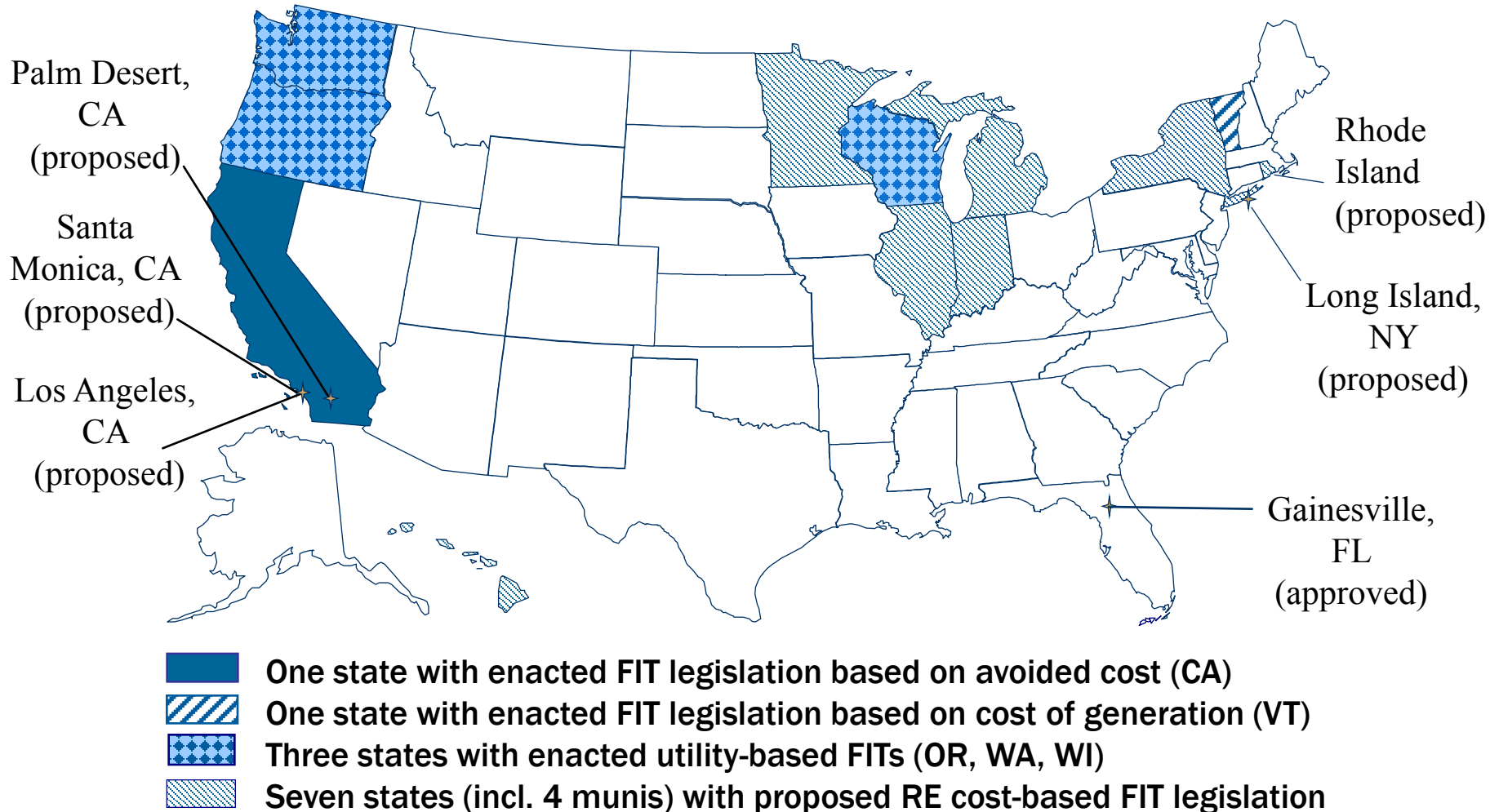


Source: EIA - 2009 Updated Annual Energy Outlook Reference Case

NREL - Comparative Analysis of Three Proposed Renewable Electricity Standards

Feed-in Tariffs in the U.S.

Note: Gainesville Regional Utilities, has approved the first U.S. cost-based FIT for solar PV. In May 2009, Vermont enacted the first statewide FIT policy based on the RE project cost.



Source: NREL June 2009

Recent Publications

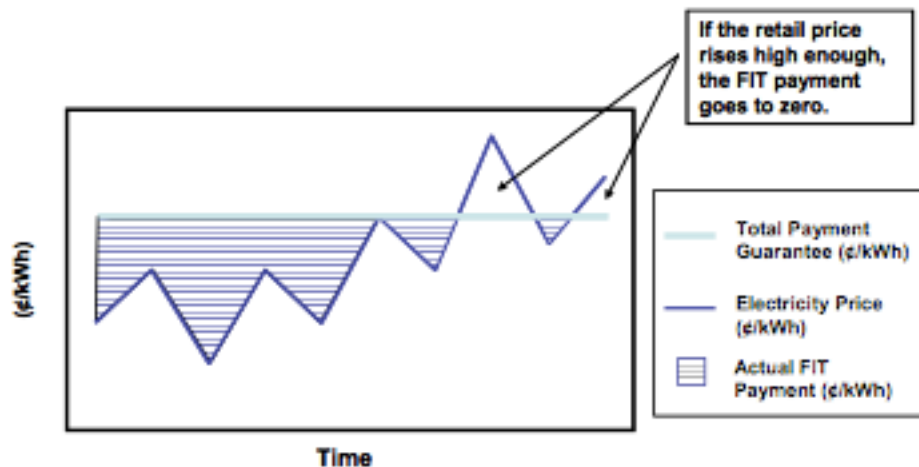
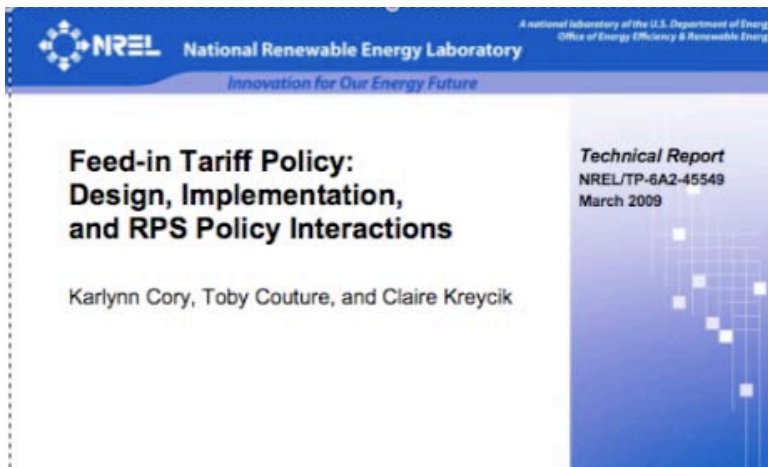


Figure 3. The Netherlands' premium-price FIT (Spot-Market Gap Model)



ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

LBNL-1642E



National Renewable Energy Laboratory

NREL/TP-6A2-45359

PTC, ITC, or Cash Grant? An Analysis of the Choice Facing Renewable Power Projects in the United States

Mark Bolinger and Ryan Wiser
Lawrence Berkeley National Laboratory

Karlynn Cory and Ted James
National Renewable Energy Laboratory

Environmental Energy
Technologies Division

March 2009



National Renewable Energy Laboratory
Innovation for Our Energy Future

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

Comparative Analysis of Three Proposed Federal Renewable Electricity Standards

Patrick Sullivan, Jeffrey Logan, Lori Bird, and
Walter Short

Technical Report
NREL/TP-6A2-45877
May 2009



Insights & Opportunities

- Technology, Policy and Business Model Innovations will drive opportunity
- System Solutions hold high promise.
 - IT Enabled: Smart Grid...
 - Geospatial Diversity
 - Interactions of Technologies
 - Cross Sector Opportunities: Transport & Power
 - Load Shifting & Storage