Moving Towards a Renewable Electricity System: Roles of the Smart Grid and Energy Storage

Alternative Energy for New Jersey
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The Inspirations:
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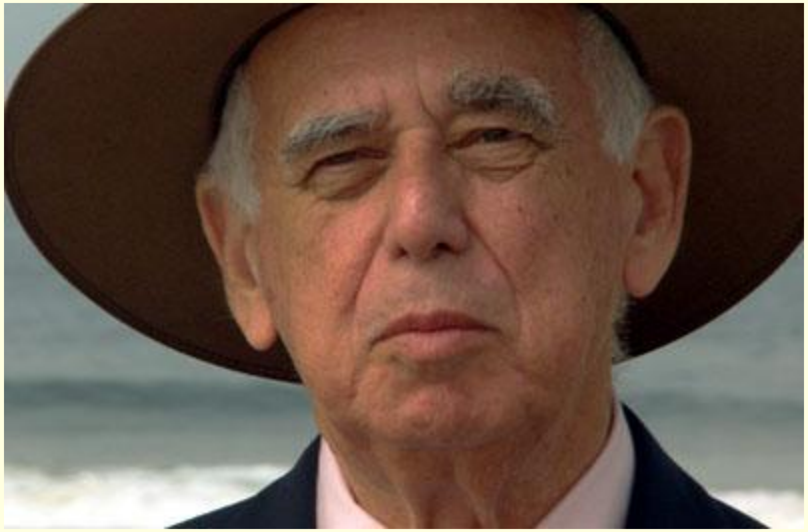
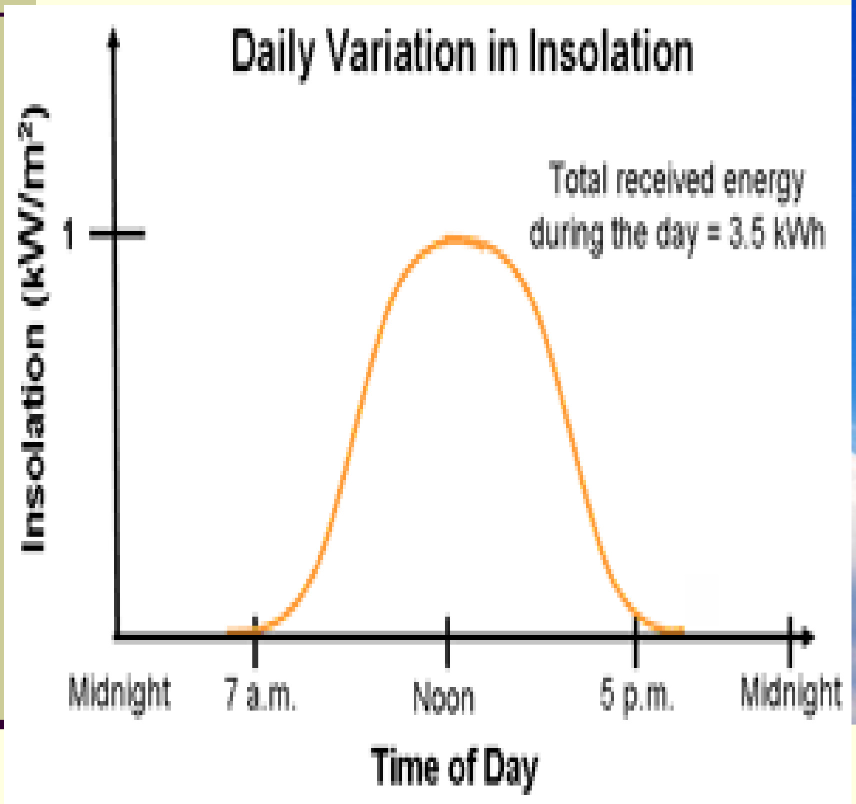


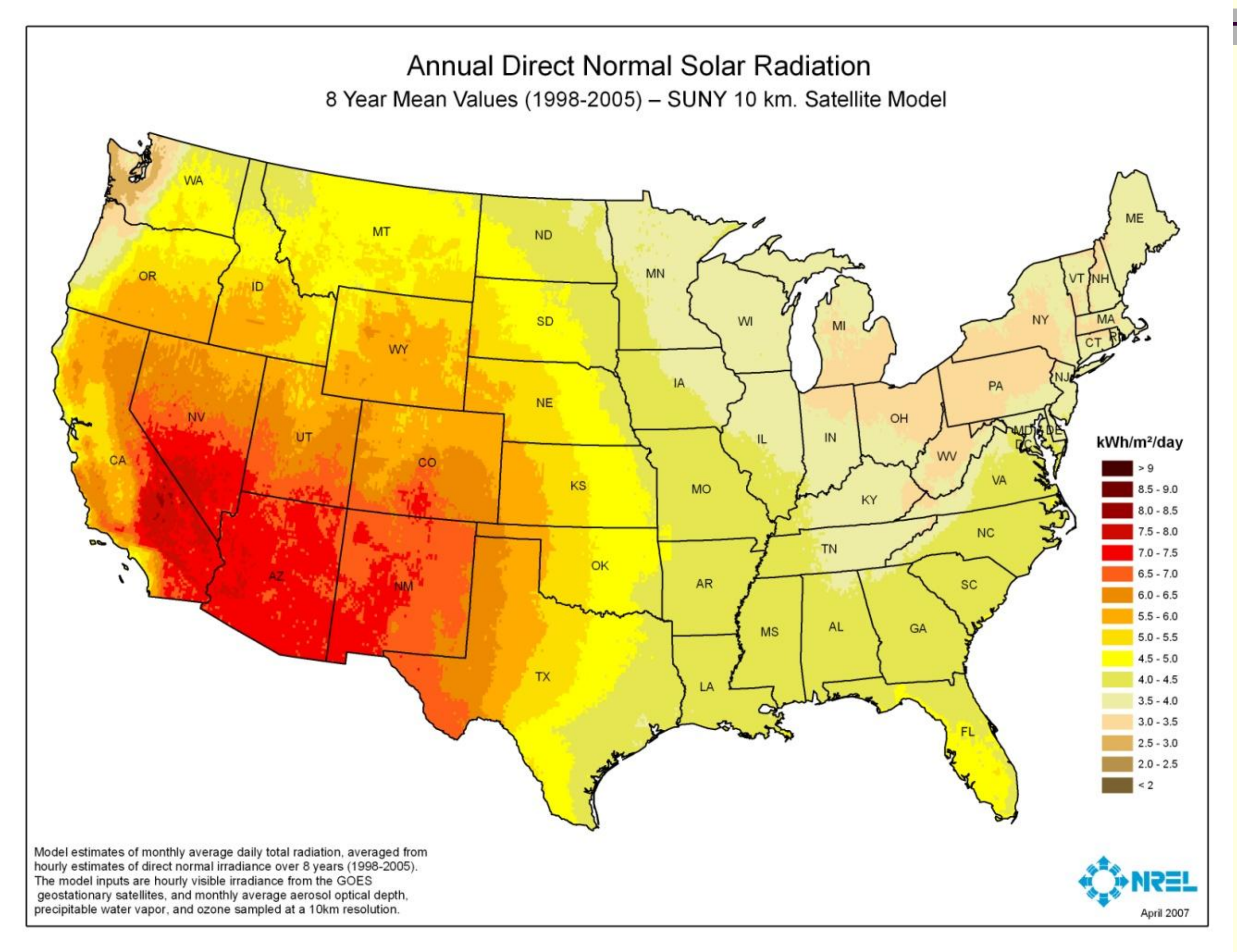
Bright day, looming clouds



Credit: Avesun | Dreamstime.com

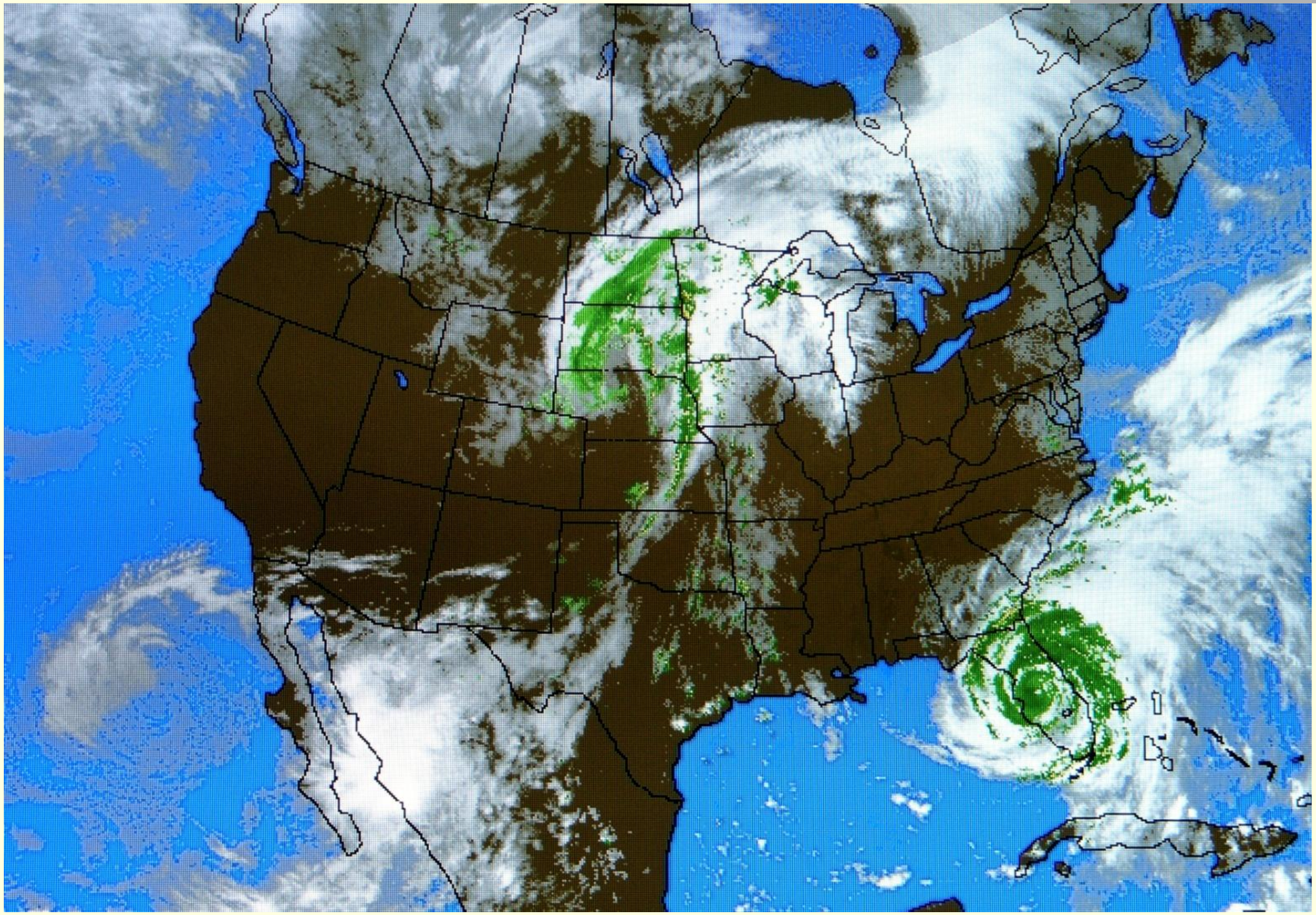
Source: www.mpoweruk.com

Solar geography



Provided by National Renewable Energy Laboratory

Geographic diversity -- solar

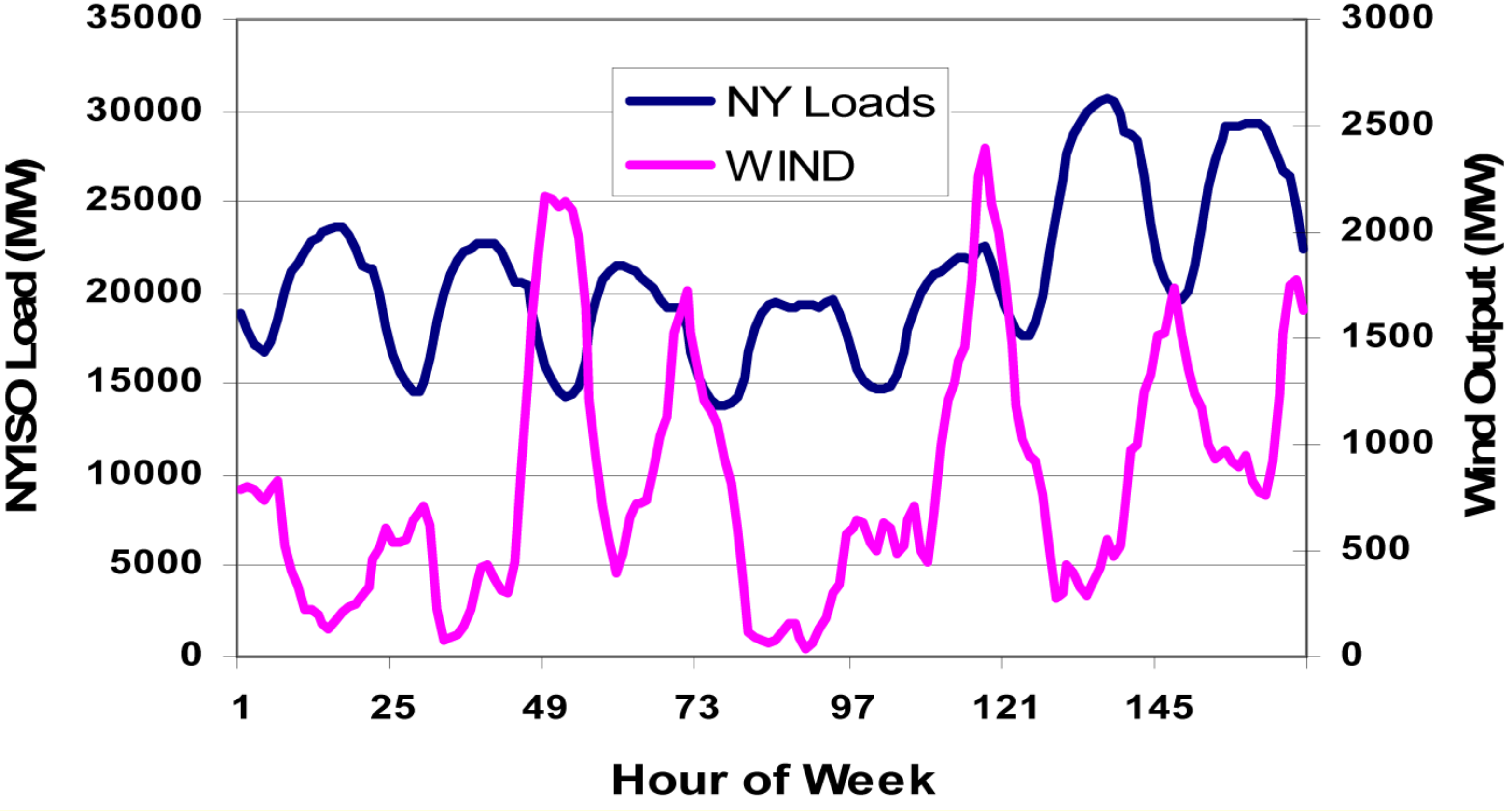


Credit: Carolina K. Smith, M.D. (Shutterstock.com image 403008)

750 kW US Navy San Diego Parking Lot

Courtesy of PowerLight Corporation

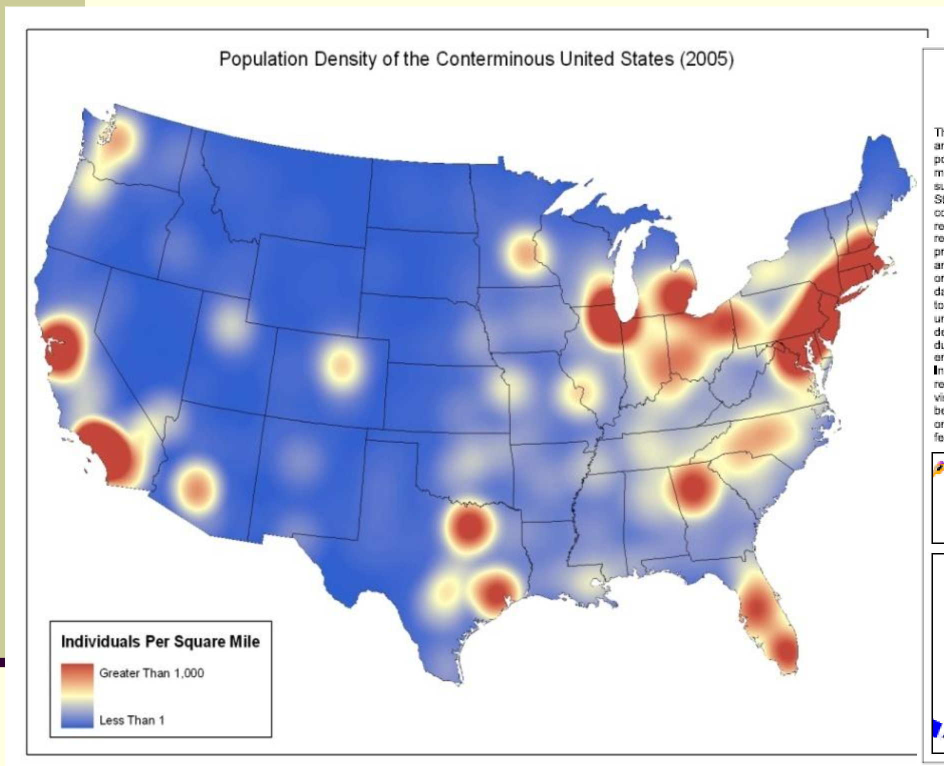
Typical wind supply pattern



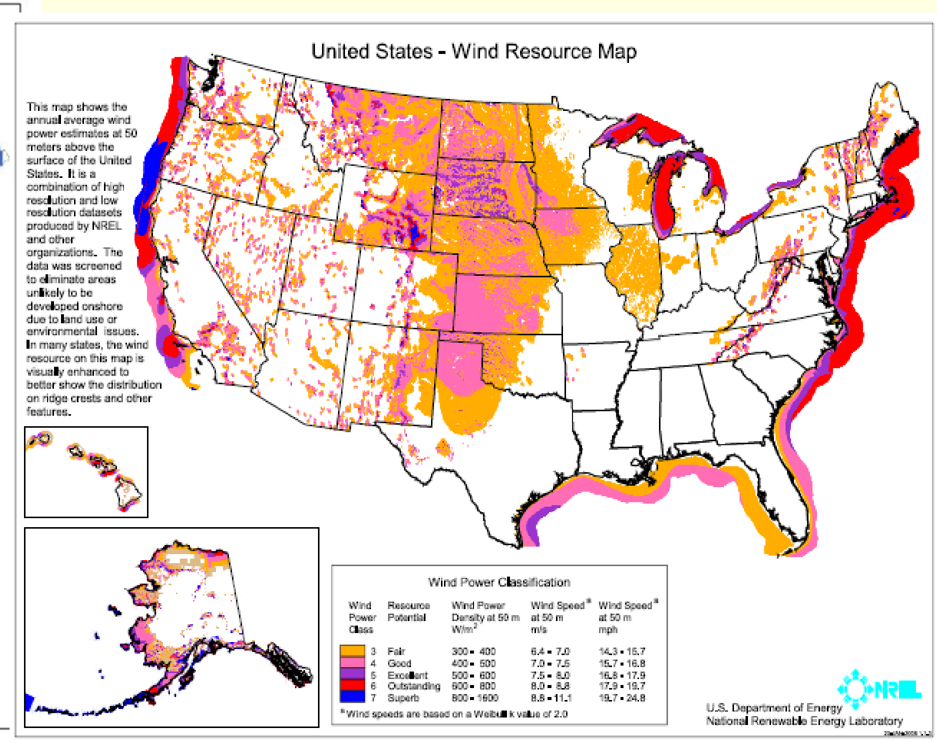
Provided by the U.S. Department of Energy. Source: Parsons et al. 2006 Figure 5 (page 7)

Note: The wind capacity is shown on the right hand scale and does not contribute more than 10% of demand at the highest wind generation.

Wind total resource more ~3x U.S. electricity generation (on shore and offshore), excludes non-usable lands



Provided by AWS Truewind, LLC



Provided by National Renewable Energy Laboratory

Geographic diversity -- wind

- Minnesota Reserve Requirements at Various Levels of Wind Generation

Reserve Category	Base		15% Wind		20% Wind		25% Wind	
	MW	%	MW	%	MW	%	MW	%
Regulating	137	0.65	149	0.71	153	0.73	157	0.75
Spinning	330	1.57	330	1.57	330	1.57	330	1.57
Non-Spin	330	1.57	330	1.57	330	1.57	330	1.57
Load Following	100	0.48	110	0.52	114	0.54	124	0.59
Operating Reserve Margin	152	0.73	310	1.48	408	1.94	538	2.56
Total Operating Reserves	**1049**	**5.00**	**1229**	**5.86**	**1335**	**6.36**	**1479**	**7.05**

Source: EnerNex 2006 Table 1 (page xvii)

Jon Wellinghof, Chairman FERC

Saying we need baseload power it is

"like people saying we need more computing power, we need mainframes. We don't need mainframes, we have distributed computing."

-- Chairman,

Federal Energy Regulatory Commission

Smart grid goals

- Better quality power and performance for consumer – e.g. fewer outages and shorter outage time
- Efficiency of grid operation (transmission and distribution)
- Advanced consuming devices using smart outlets and smart appliances
- Price, carbon, grid status, and other information to consumer
- EFFICIENT Integration of large amounts of distributed generation from very local, household level to multi-megawatt solar PV
- Integrating storage at all scales

Smart grid elements

- Two grids: one for power and one for communications
- Communications are multi-level:
- Within a building from devices (local generation and use) to the consumer web portal
- From devices and building to utility
- Consumer preferences to utility (how much temperature variation can you tolerate)
- From utility to consumer – state of generation, prices, carbon footprint
- From substation to utility
- State of large-scale and intermediate-scale storage devices to utility
- From distributed generation of various scales to utility

The Ice Bear - Designed for building controls, reliability and serviceability – courtesy Ice Energy, www.ice-energy.com

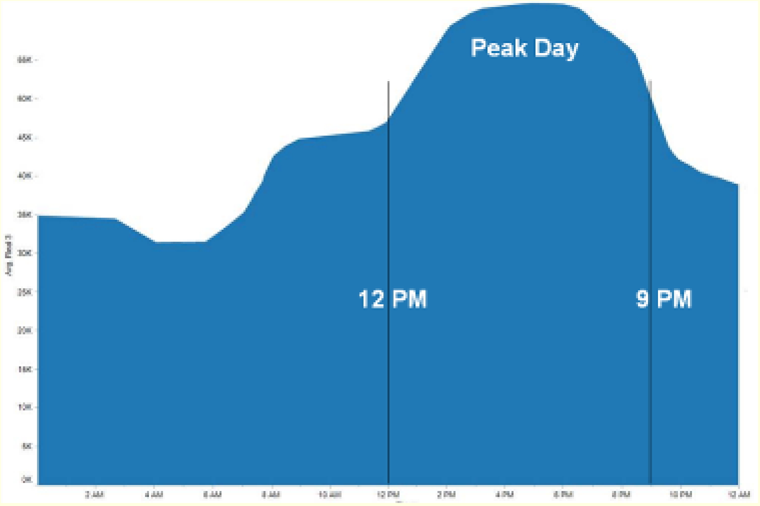
- **Hinge with positive stop and "latch"**
- **Door on opposite side for access to compressor and water pump**
- **Compressor location**
- **30" door swing**
- **magnetic "catch" in open position**
- **CoolData Controller™**
- **Refrigerant pump uses 100 W on peak**

CoolData™ Controller is designed to monitor and control up to 200 building data points, serve as FDD and communicate with Ethernet

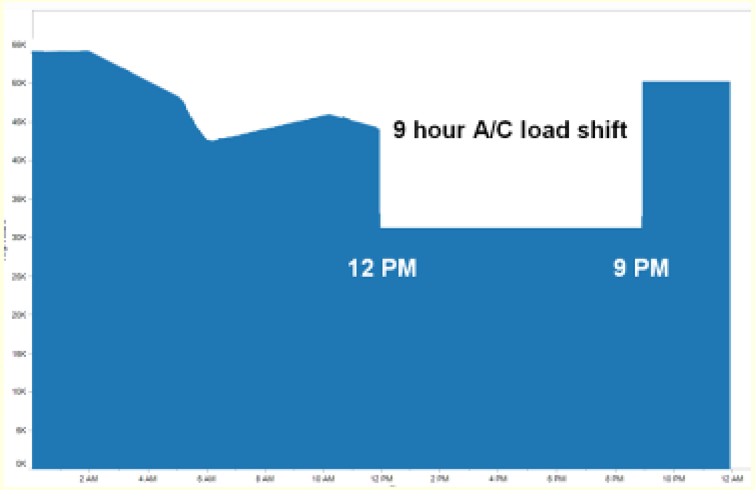
Load Shifting – courtesy of Ice Energy – www.ice-energy.com

Electric Utility Meter Load Profile (inclusive of all loads)

Before

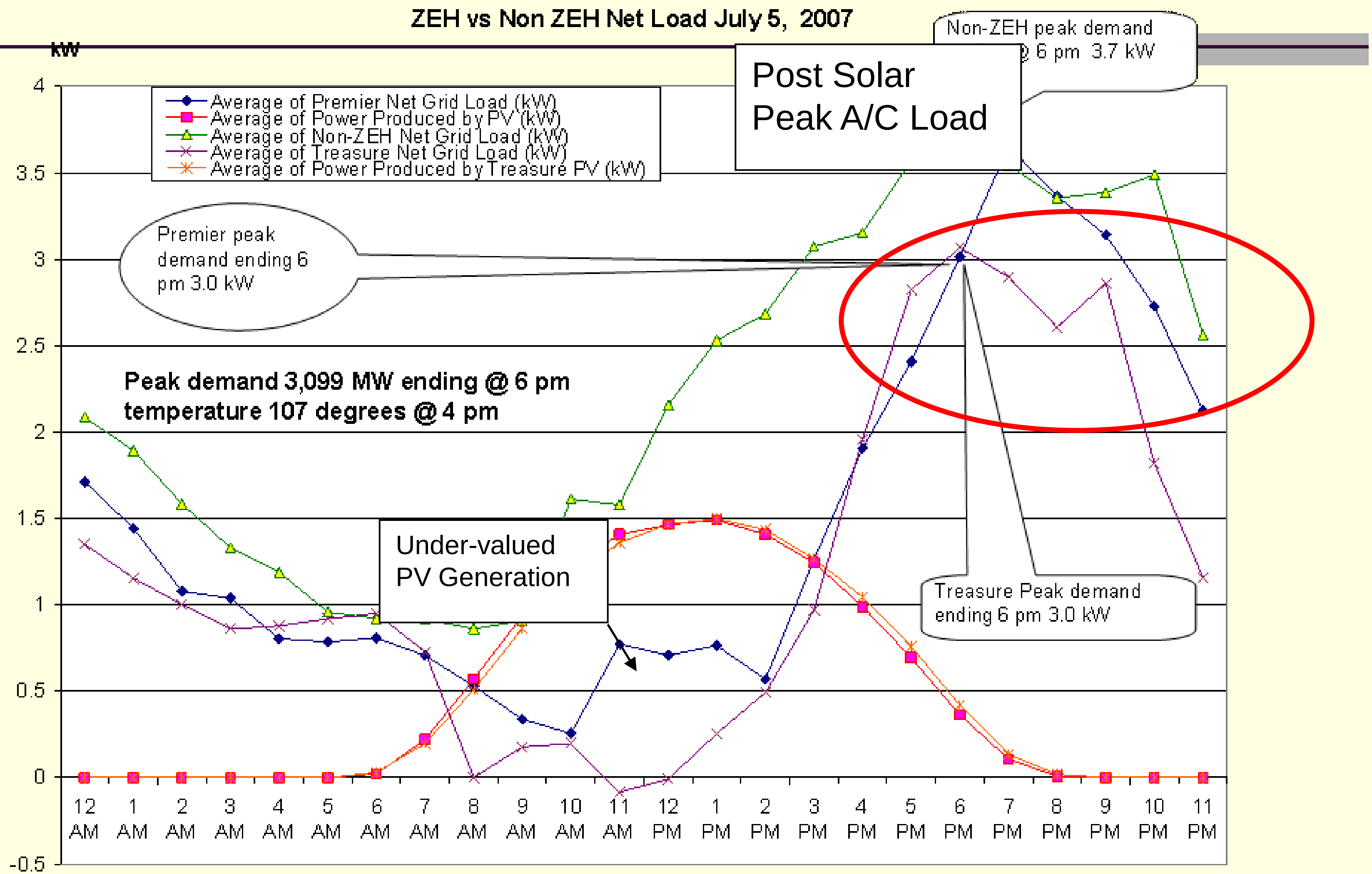


After



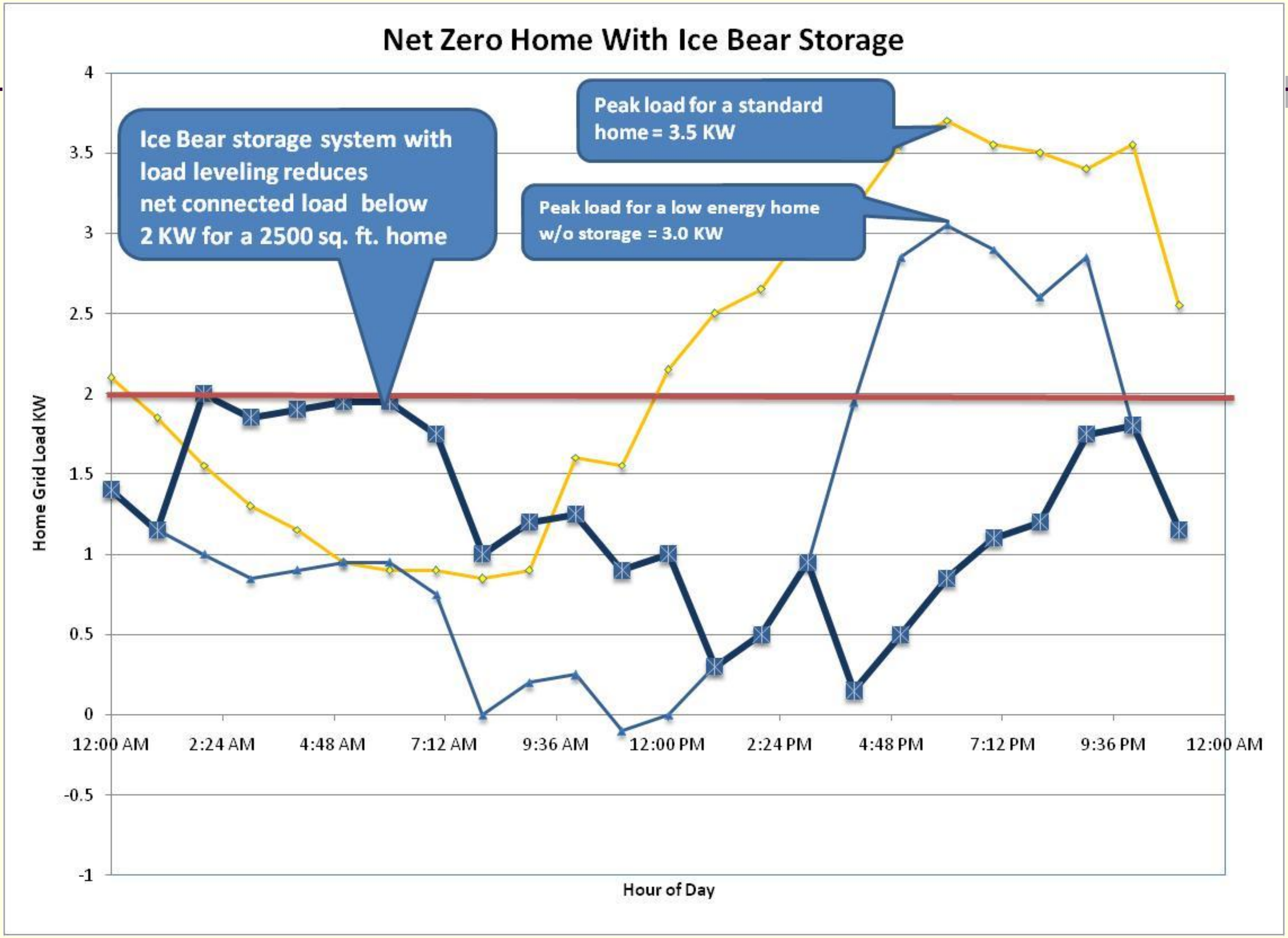
- 45 kW peak day demand reduction
- 300 kWh load shifting per day (on peak to off peak)
- 105% high desert round trip storage efficiency (saves site energy)
- 6 hour storage per day summer

NREL – SMUD Building America Program Study



ZEH 15% peak reduction

SMUD ZEH with Energy Storage, Courtesy Ice Energy



ZEH w/ Ice Bear 70% peak reduction

NaS Batteries, 34 MW, 245 MWh

Courtesy of NGK Insulators

Electric car: Phoenix Motorcars Pickup - this type of battery useful for vehicle to grid

- All electric: Range 130 miles, about one-third kWh per mile

Altairnano batteries can be:

- charged in 10 minutes with special equipment
- Retain 85% capacity after over 10,000 charging and discharging cycles
- Suitable for vehicle to grid applications
- There are other similar lithium-ion batteries from other manufacturers now coming on the market
- Cost reduction needed – appears to be occurring rapidly

Tesla: 0 to 60 in 4 secs. (goal) 200 mile range 0.2 kWh/mile; off-the-shelf lithium-ion batteries combined in special battery pack

Courtesy of Tesla Motors

Smart parking meter – V2G infrastructure

Courtesy of EDF Energy (UK)

Baseload output from wind (2,000 MW) + CAES (900 MW), CO2 emissions, ~50 gm/kWh

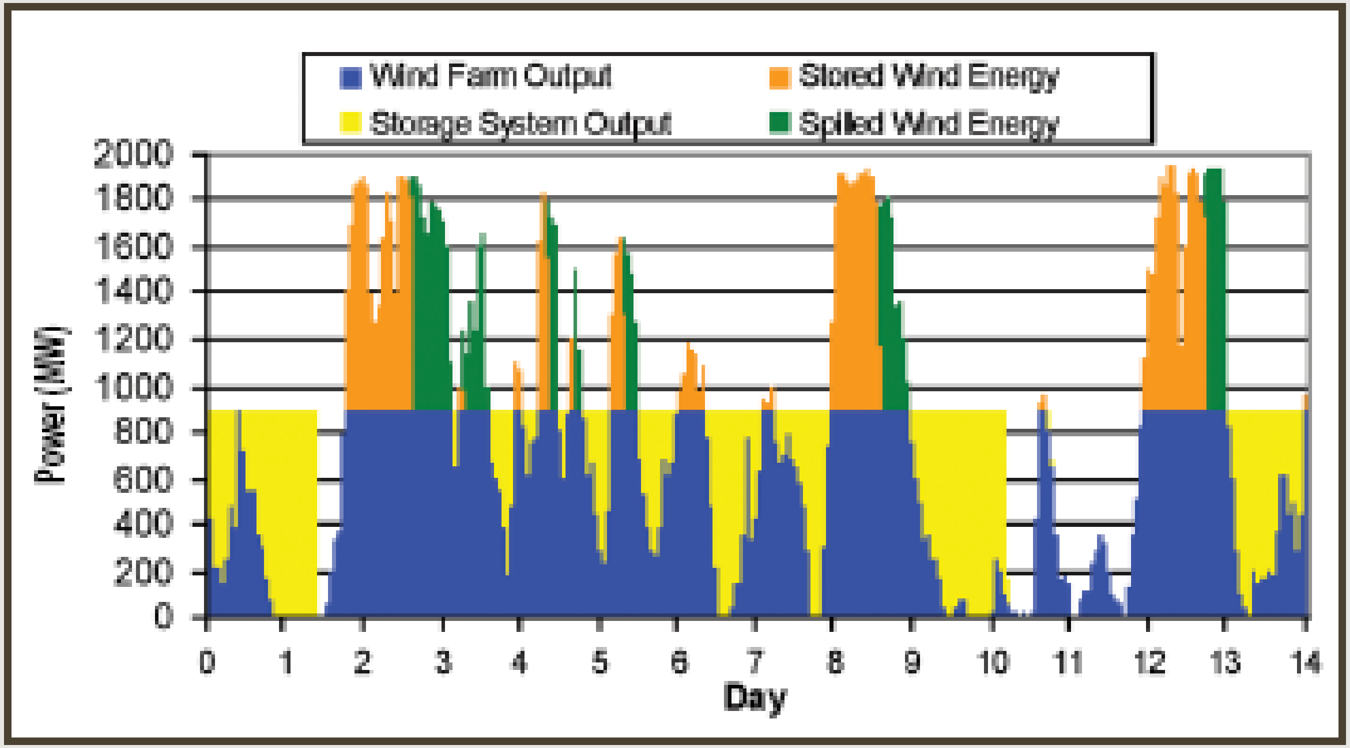


Figure 3. Sample Baseload Wind Generator Output (Target Output = 900 MW)

This figure was developed by the National Renewable Energy Laboratory for the U.S. Department of Energy. Credit :Paul Denholm. http://ei.colorado.edu/pdf/denholm_poster.pdf.

Baseload wind – Source NREL

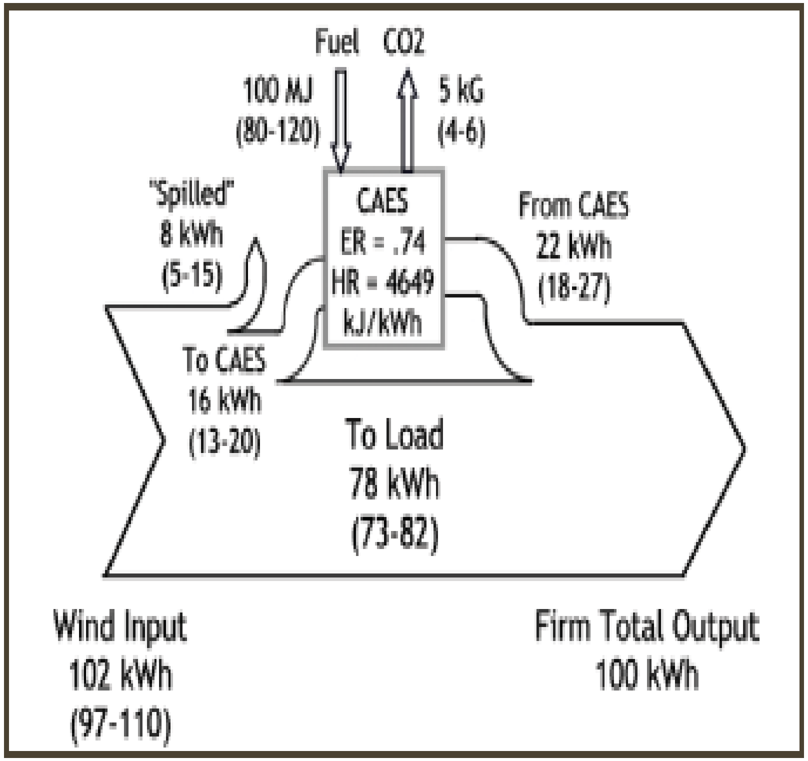


Figure 4: Energy Flow through a Baseload Wind Power Plant

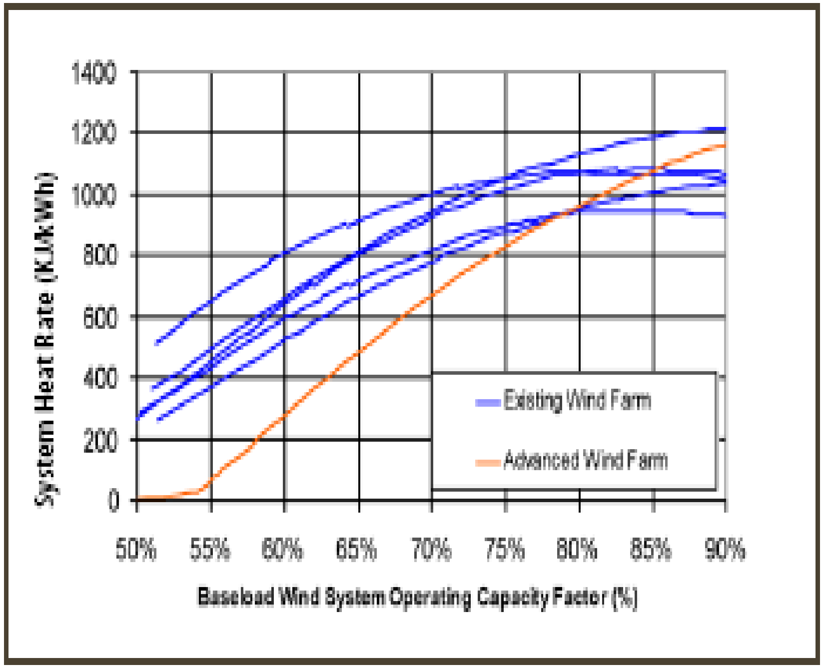
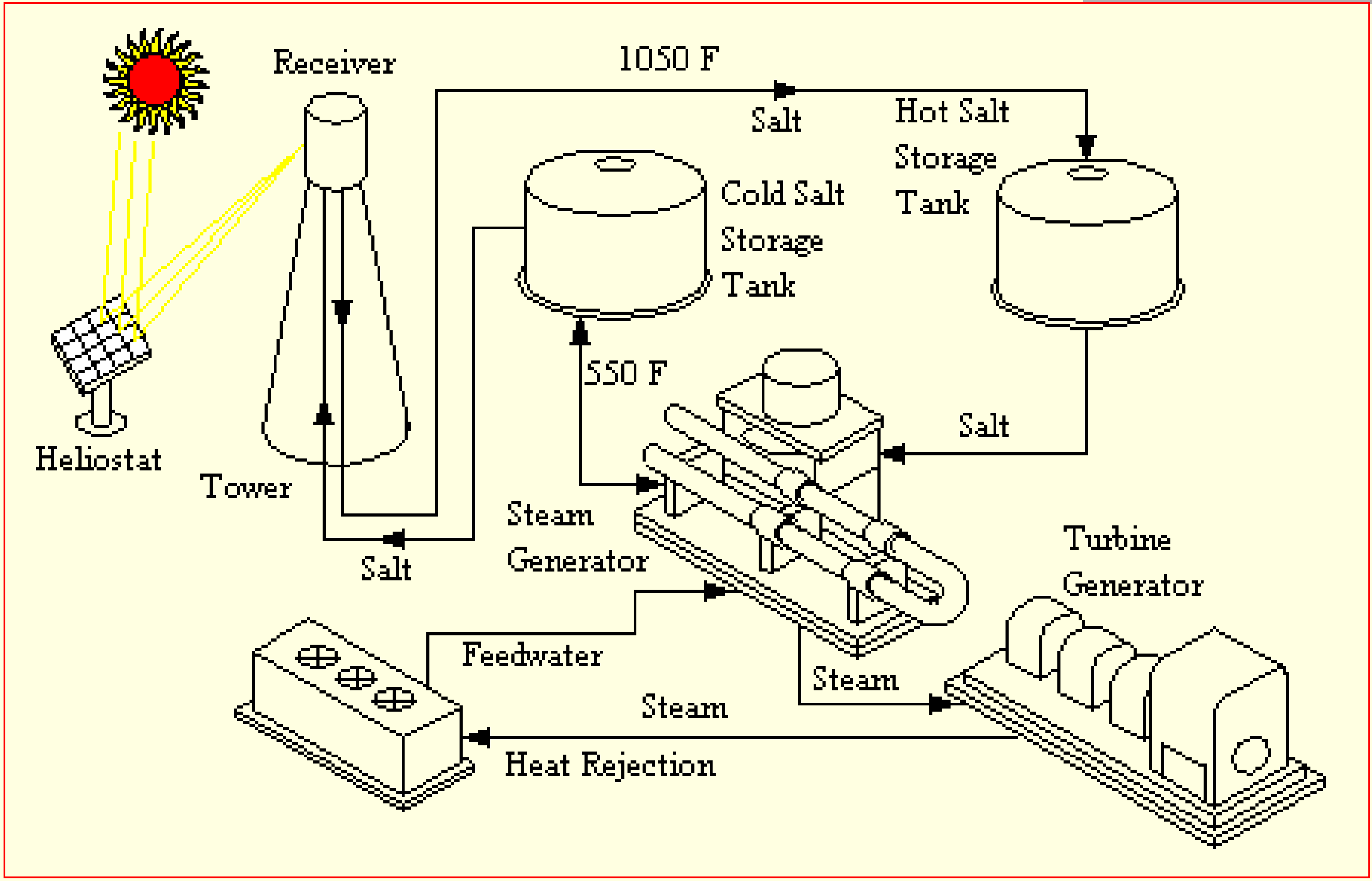


Figure 5: Baseload Wind Plant Fuel Requirements

These figures were developed by the National Renewable Energy Laboratory for the U.S. Department of Energy. Credit :Paul Denholm. http://ei.colorado.edu/pdf/denholm_poster.pdf.

Storing heat – solar power at night



Credit: Sandia National Laboratories

Dealing with intermittency – 2010-2020

- Redeploy existing natural gas and, as feasible, hydro, to provide reserve capacity for renewables (2008 NG capacity factor = 25%)
- Coordinate wind and solar
- Add first smart grid elements
- Systematic integration of CHP
- Solar thermal power with storage
- Deploy first large scale baseload renewables: IGCC with biomass, hot rock geothermal
- Deploy first large scale CAES with wind
- Can take it to ~30 percent renewables (Denmark has 20 percent wind without solar diversity and just fossil fuel reserve capacity)

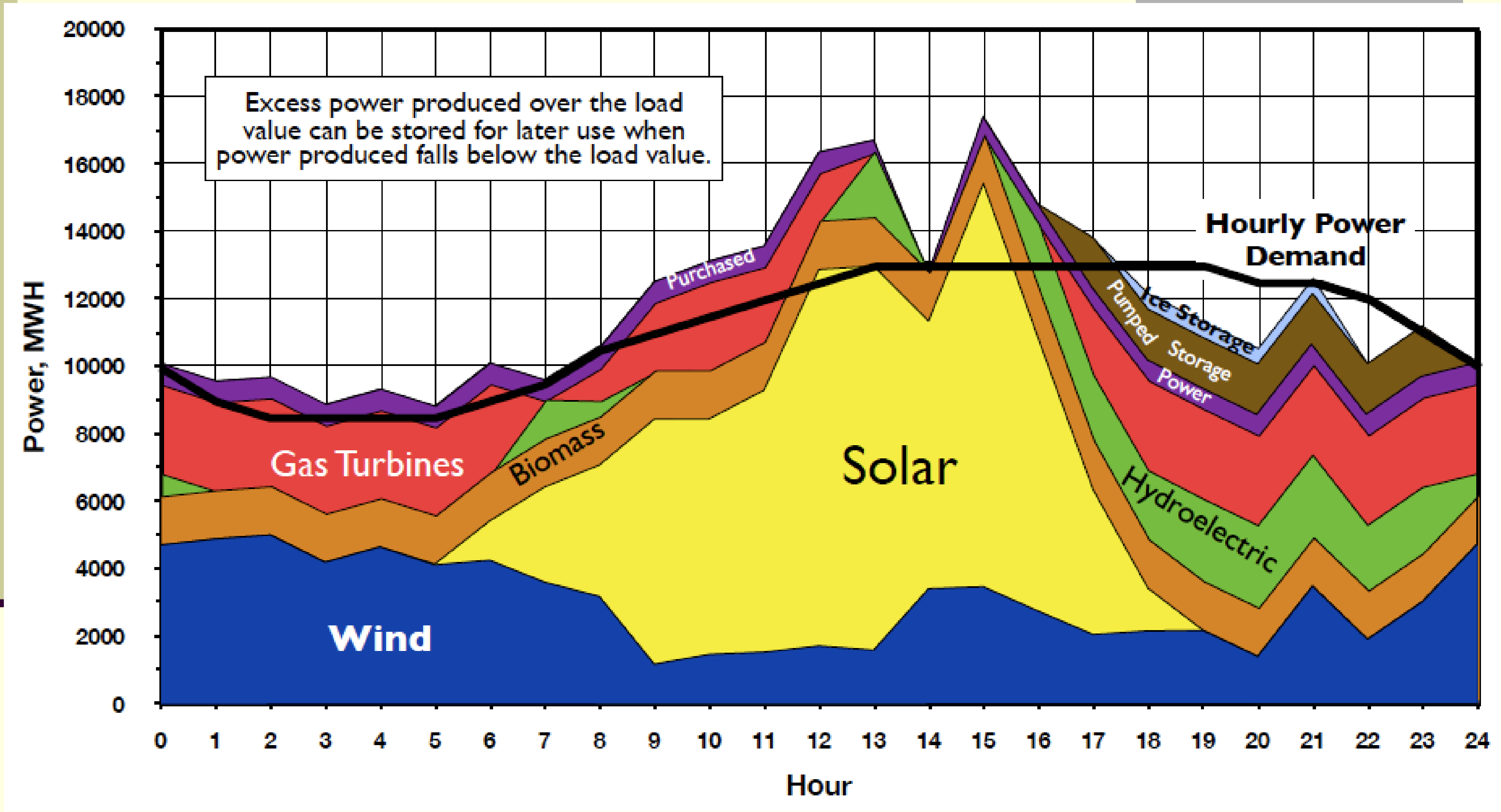
30 or 40% renewables

- Smart grid – intermediate level – state of grid information to consuming devices
- Load tailored to renewable energy availability to the extent feasible (e.g. ice-energy storage), using dishwaters and washing machines when renewable plus storage is plentiful
- Increased scale deployment of CAES
- Wind geographic diversity
- Some regulation storage components, such as flywheels
- Some battery storage components (stationary and/or mobile)
- Fuel cells with electrolytic hydrogen from wind energy?

~100 percent renewables ~2040

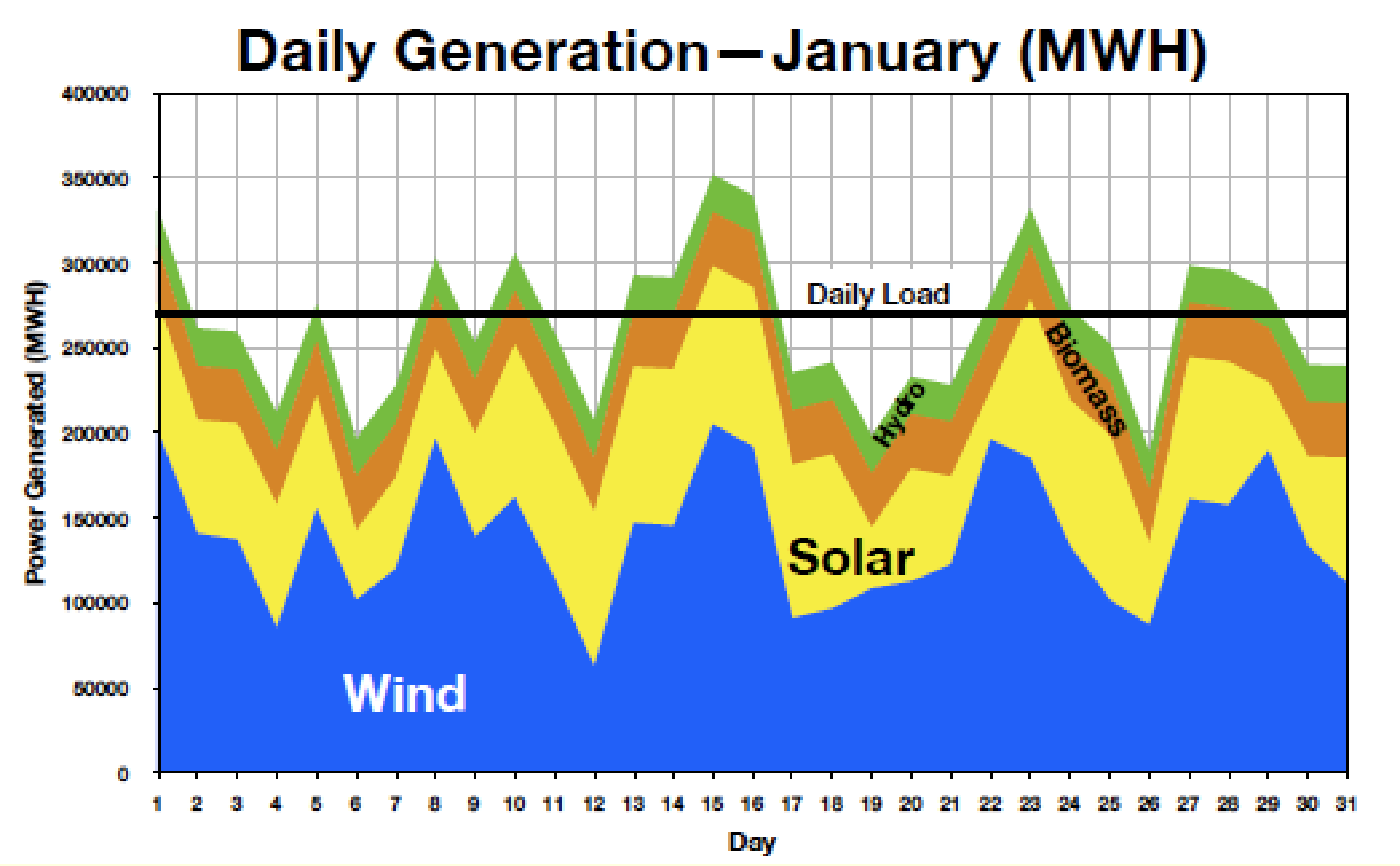
- Full smart grid implementation – i.e., fully integrated communications and power grids – and smart devices, in home and in-building web portals, etc.
- Distributed generation – all levels from very local to large-scale
- Sufficient regional and possibly national grid to take advantage of geographic diversity without creating security vulnerabilities
- Storage at all levels, from local to regional.

Sample day in July – North Carolina



Source: http://www.ieer.org/reports/NC-Wind-Solar.pdf

North Carolina Wind and Solar Template



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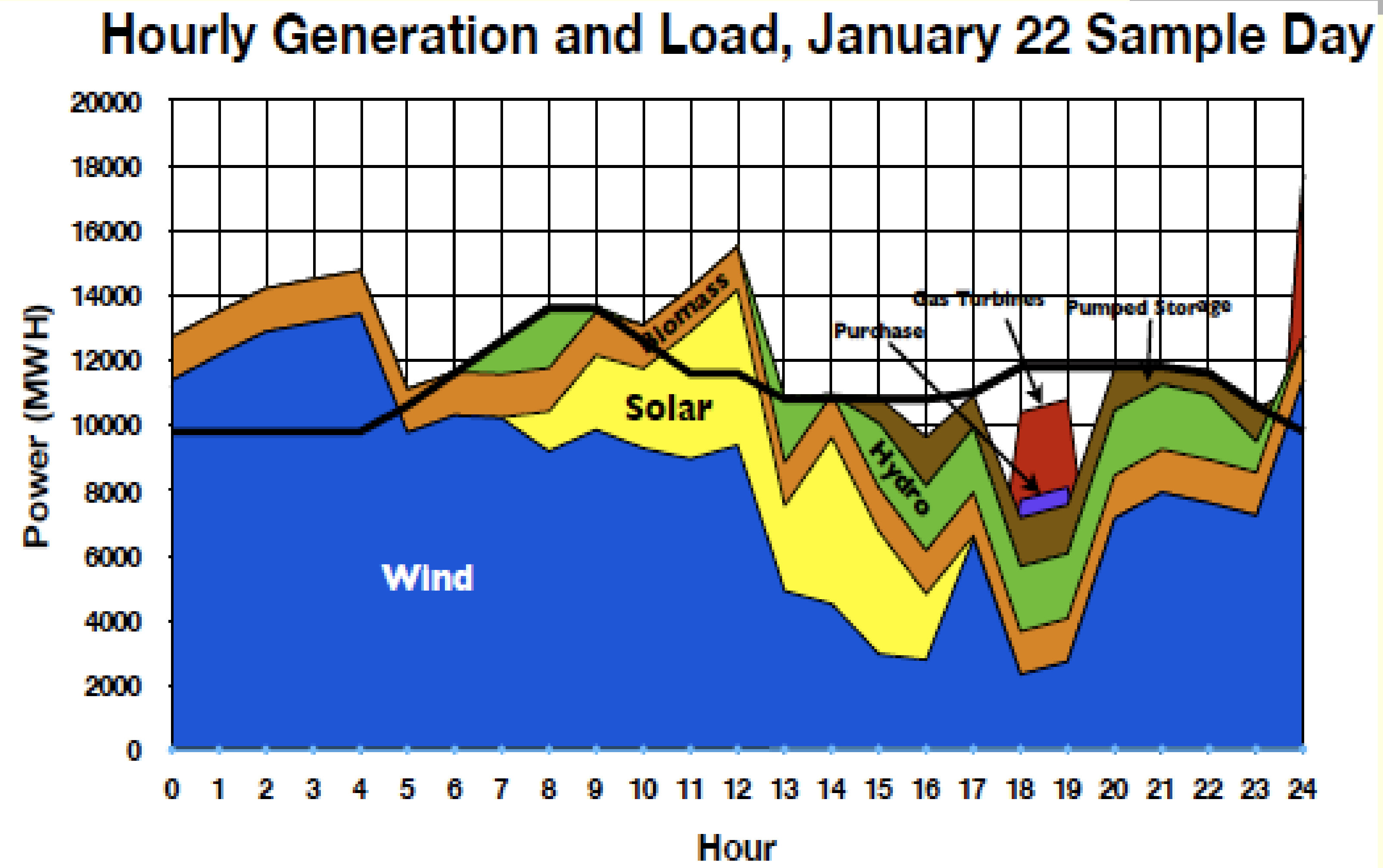
January day – North Carolina



Source: http://www.ieer.org/reports/NC-Wind-Solar.pdf

IEER Plans

- May 2010: Publish a 100 percent renewable electricity scenario for Minnesota with 8760 hour modeling and economic data
- Fall: Publish a 100 percent renewable electricity plan for Utah
- Caution against smorgasbord approach to electricity planning

New Jersey notes

- Start a couple of Smart Grid Projects à la Boulder CO in New Jersey
- NJ is already a leader in technical education and these elements will consolidate that role and carry it forward.
- NJ has the resources – wind offshore
- Establish a mid-Atlantic Renewable Electricity Commission in the PJM Grid region
- 100 percent renewable electricity system for NJ study anyone?

End note

Carbon-Free and Nuclear-Free: A Road Map for U.S. Energy Policy **by Arjun Makhijani**

Find the many source citations in the downloadable version of the book, available at no cost, on the Web at

http://www.ieer.org/carbonfree/CarbonFreeNuclearFree.pdf

or contact IEER.

The book can be purchased in hard copy at www.rdrbooks.com or www.ieer.org.