Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy

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The Inspirations:
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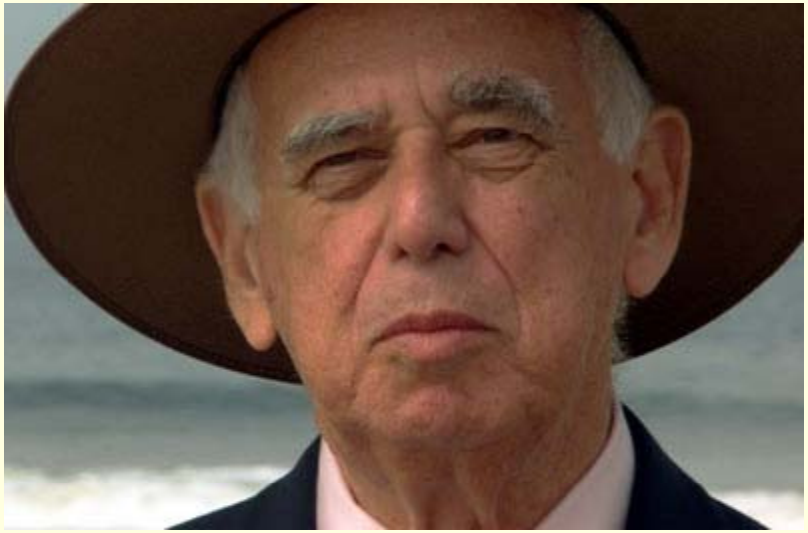


Four Crises: Climate, oil insecurity, nuclear insecurity, food insecurity

Ansgar Walk (http://commons.wikimedia.org/wiki/Image:15_Walross_2001.jpg)

www.andysinger.com

NRC / PPL Susquehanna

Illustration by Victor Juhasz for ROLLING STONE MAGAZINE

Great Arctic Ice Melt of 2007

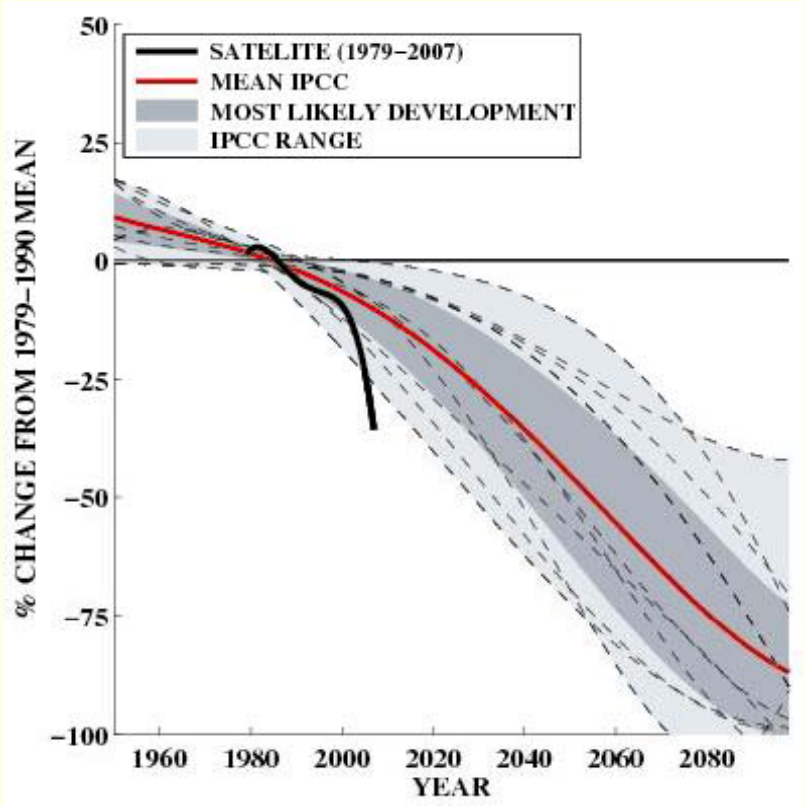
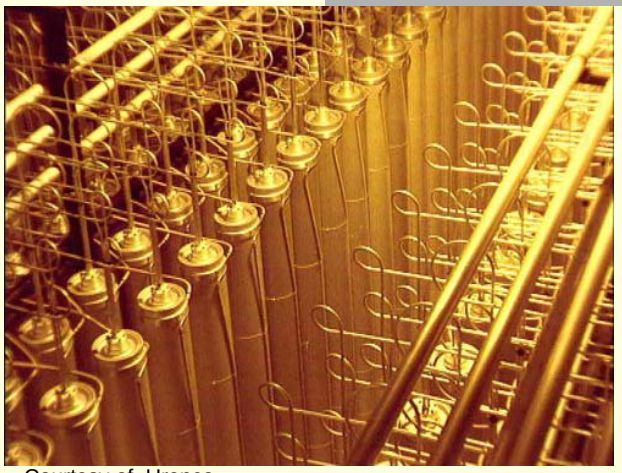


Chart courtesy of Dr. A. Sorteberg, Bjerknes Centre for Climate Research, University of Bergen, Norway.

- Dramatic change in worst case scenario
- Previously 2070
- Now 2010 or 2015 (Louis Fortier, Scientific Director, ArcticNet, Canada)

Nuclear reactors – proliferation

- Need 3,000 reactors – one a week
- 2 to 3 uranium enrichment plants per year (one proposed for Idaho, 50 miles from Jackson Hole)
- Annual global spent fuel: contain 90,000 bombs worth of plutonium per year if separated (separation research in Idaho)



Courtesy of Urenco

Photo courtesy of the U.S. Department of Energy. Image ID 2000033

Proliferation statements: Oppenheimer 1946; Gulf Coop. Council 2007; El Baradei, 2008

- 1946, Oppenheimer: “We know very well what we would do if we signed such a [nuclear weapons] convention: we would not make atomic weapons, at least not to start with, but we would build enormous plants, and we would call them power plants….we would design these plants in such a way that they could be converted with the maximum ease and the minimum time delay to the production of atomic weapons…”

Source: J. Robert Oppenheimer, "International Control of Atomic Energy," in Morton Grodzins and Eugene Rabinowitch, eds., *The Atomic Age: Scientists in National and World Affairs,* (New York: Basic Books, 1963), p. 55.

- 2006, Al Faisal, Saudi Foreign Minister: “It is not a threat. …We are doing it [nuclear power] openly. We want no bombs. Our policy is to have a region free of weapons of mass destruction. This is why we call on Israel to renounce [nuclear weapons].”

Source: as quoted in Raid Qusti. “GCC to Develop Civilian Nuclear Energy.” *Arab News*, 11 December 2006, reprinted in Saudi-US Information Service

- 2008, El Baradei on “latent” capability: "You don't really even need to have a nuclear weapon. It's enough to buy yourself an insurance policy by developing the capability, and then sit on it. Let's not kid ourselves: Ninety percent of it is insurance, a deterrence.”

Source: As quoted in Joby Warrick, “Spread of Nuclear Weapons Is Feared,” *Washington Post*, May 12, 2008, p. A1.

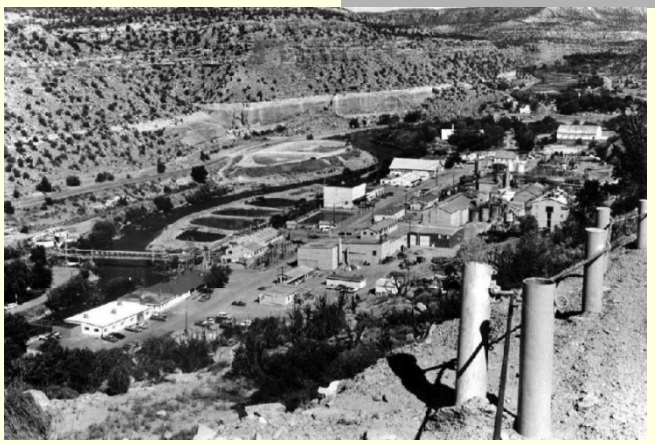
Yucca Mountain for nuclear waste? Pomegranates: 20 miles away

Photo courtesy of the U.S. Department of Energy.
(http://ocrwm.doe.gov/info_library/newsroom/photos/images/ym_1883_72dpi.jpg)

Fir0002 (www.commons.wikimedia.org/wiki/Image:Pomegranate_fruit.jpg)

Other issues: Mining waste & mill tailings (250 mn tons each in US), water (10 to 20 mn gal/day/reactor evaporative consumption), other radioactive waste (DU shown here). Uncertain water supply in a warming world could make nuclear reactors less reliable

U.S. Dept. of the Interior (www.osmre/oversight/wyomingaml03.pdf & http://commons.wikimedia.org/wiki/Image:Sunset_Uranium_Mine_Wyoming.JPG)



Credit: EPA (http://www.epa.gov/Region8/superfund/co/uravan)

Credit: NRC / Exelon Nuclear - Braidwood

Photo courtesy of the U.S. Department of Energy. Image ID-2010822

How about France? The waste story

- 75-80 percent nuclear electricity
- Reuse some Pu as fuel
- Pay more
- 10,000 bombs equivalent surplus Pu
- 100 million gallons of liquid radioactive waste into English Channel per year
- 12 of 15 OSPAR government parties want it stopped
- ~99 percent waste content of spent fuel piling up – no repository yet and much opposition
- Increase in repository waste volume – HLW plus GTCC

Truzguiladh, released under cc-by-sa-2.5, on Wiki Commons. (http://en.wikipedia.org/wiki/File:UsineHague.jpg)

Gavin Newman / Greenpeace (http://archive.greenpeace.org/nuclear/pics/pipe2b.jpg)

New nuclear power is costly, too slow and too financially risky

- $5,000 to $10,000 per kilowatt, 10 to over 20 cents per kWh
- Wall Street does not want to finance it
- Industry seeking 100% federal loan guarantees for 80 percent of capital cost
- Nuclear investments likely to go sour (ratepayers, taxpayers, and/or investors will likely wind up holding the bag)
- In the last energy crisis, none of the reactors ordered after October 1973 were completed – overestimation of demand and underestimation of efficiency and cost
- Same may happen this time with so-called “nuclear renaissance”
- Only 4 to 8 can be built in the next ten years. Too little, too slow for getting to other side of CO_2 peak emissions.
- In crisis should build shorter lead time projects – efficiency, CHP, renewables.
- Can do much more electricity generation with renewables in the same time.

The Web President (http://commons.wikimedia.org/wiki/Image:NYSE-NYX.jpg)

Nuclear: Opportunity Cost Perspectives for reducing CO_2 emissions

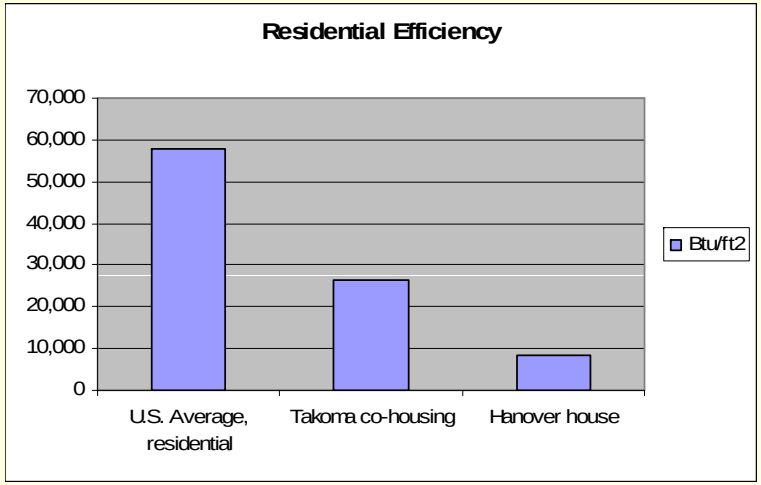
- Investment in efficiency, smart grid, ice energy, CSP, makes nuclear investments uneconomical: San Antonio example: combination saves $1.4 billion to $3.1 billion relative to new nuclear investment.
- According to industry: 4 to 8 new nuclear plants can be built in 10 years. Too slow.
- Ten times or more the above level of generation can be achieved with wind and solar in ten years, with intermediate CO_2 displacement Added cumulative CO_2 emissions will be hundreds of millions of metric tons of CO_2 over ten years. Additional emissions in the nuclear case will continue for years.
- At $50 per metric ton, cost of CO_2 emissions due to emission reduction delay will be in the tens of billions in the first ten years alone.
- GE CEO: Gas and wind are better. "I don't have to bet my company on any of this stuff. You would never do nuclear. The economics are overwhelming." *Financial Times*, Nov. 2007
- Water use a huge issue: 10 to 20 million gallons per day per 1000 MW.

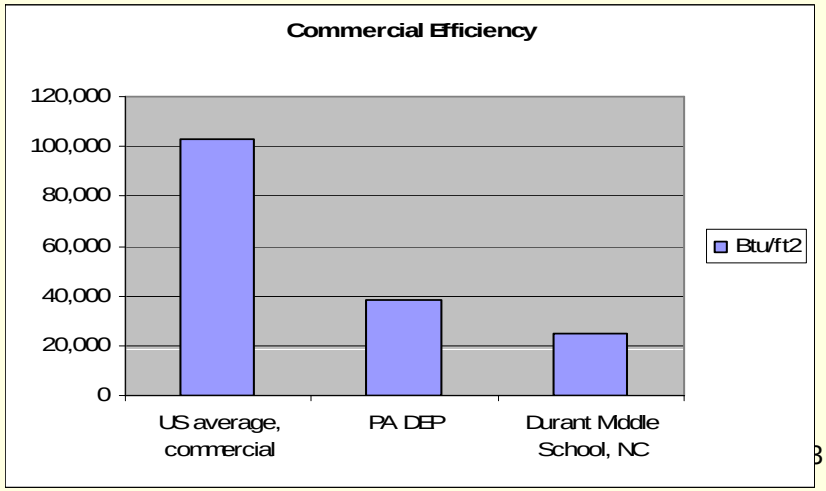
Cost comparisons - new low to zero CO_2 electricity sources per kWh

- Nuclear: 10 to more than 20 cents (plus water uncertainty and cost, plus long lead time risk)
- Wind: 8 to 12 cents
- Solar thermal: ~12 to 15 cents and coming down (dry cooling now commercial – SCE 1.3 GW order Feb. 09 dry cooling power tower technology)
- Solar PV: 20 cents large scale, 25 cents intermediate scale (~1 MW). Equivalent since no T&D in intermediate scale
- PV expected to be 10 cents or less in five years

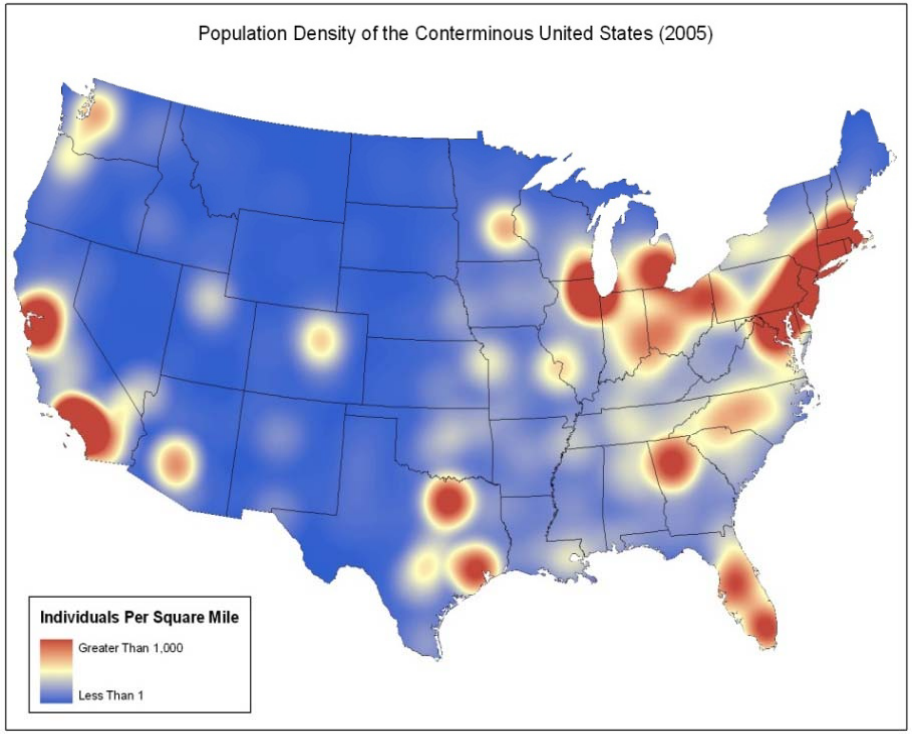
Residential and Commercial Efficiency Examples

- Efficiency improvement of 3 to 7 times is possible per square foot
- Existing homes more costly to backfit but much is still economical
- Standards at the local and state level are needed
- Zero net CO2 new buildings and communities by 2020 or 2025 can be mandated

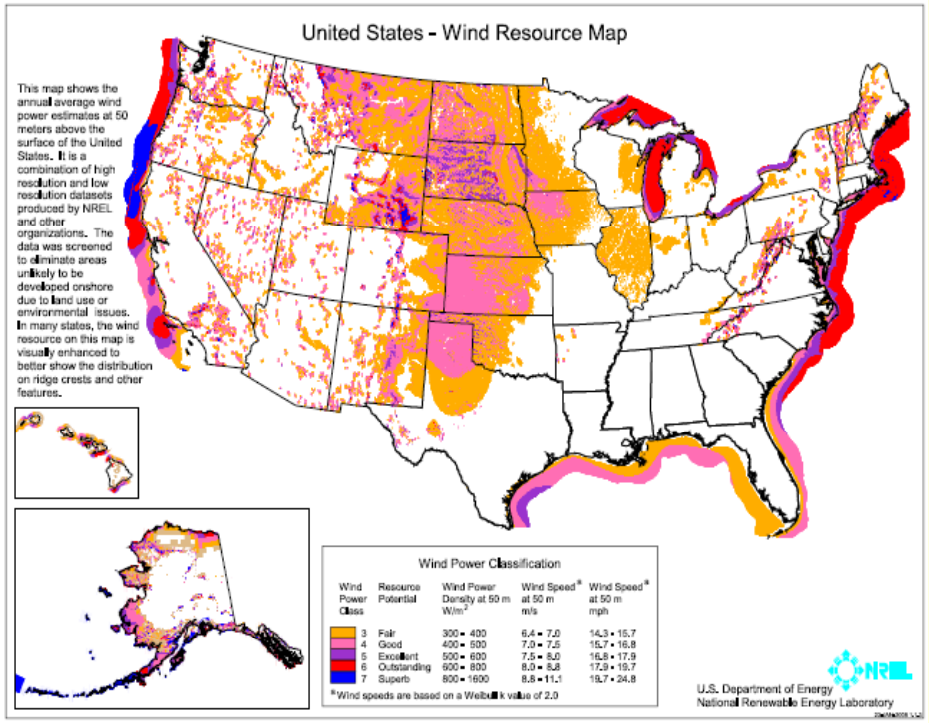




Wind total resource more ~3x U.S. electricity generation (on shore and offshore), excludes non-usable lands



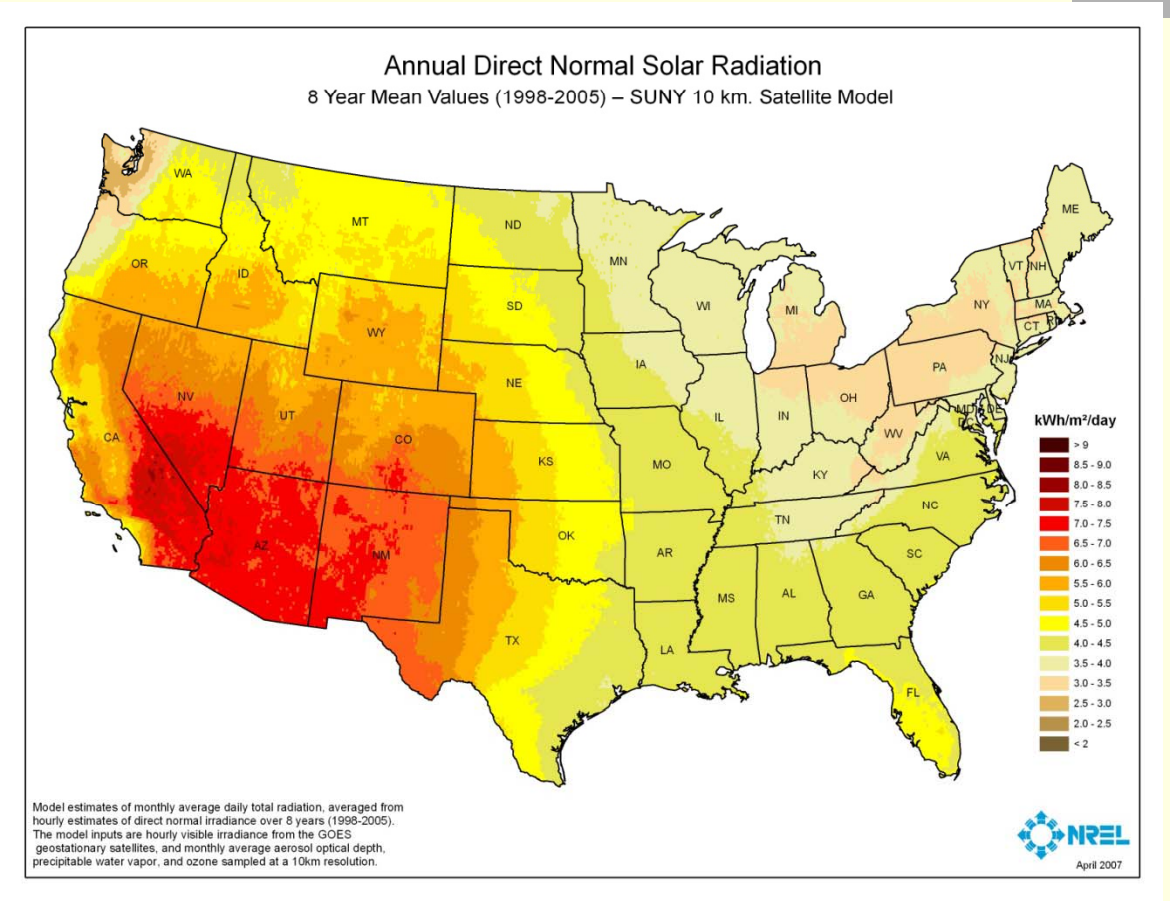
Courtesy of AWS Truewind, LLC



Provided by National Renewable Energy Laboratory

The idea of how to illustrate this problem comes from Walt Musial.

Solar geography



Provided by National Renewable Energy Laboratory

750 kW US Navy San Diego Parking Lot

Courtesy of SunPower Corporation

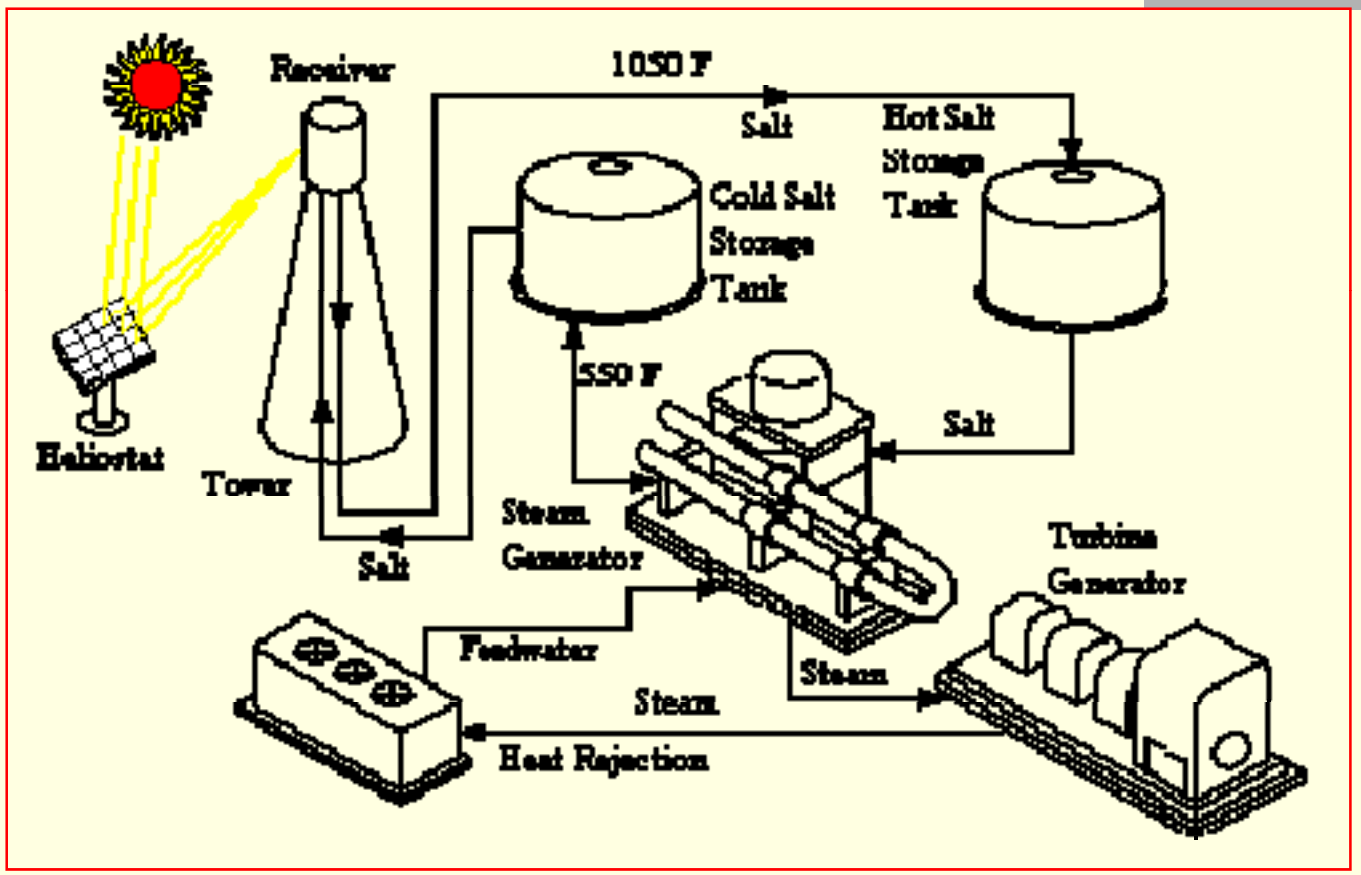
Dealing with intermittency

- Smart grid: consuming devices talk to producing devices; storage devices, smart meters, mediate conversation.
- Store heat while the sun shines.
- Store cold while the wind blows.
- Solar and wind integration
- Existing hydro backup
- Existing natural gas standby (U.S. has enormous surplus capacity), long-term: replace fuel with biogas (use aquatic plants, such as microalgae, as feedstock)
- IGCC solid biomass (e.g., algae), geothermal, CHP
- Other storage elements, medium- to long-term (compressed air, including, vehicle-to-grid, dispatchable wind – produce compressed air instead of electricity at the turbine and generate electricity when needed, e.g., General Compression http://www.generalcompression.com

Solar thermal power

Courtesy of BrightSource Energy. Its Solar Energy Development Center in Israel shown. (http://www.brightsourceenergy.com/news/media_center)

Storing heat – solar power at night



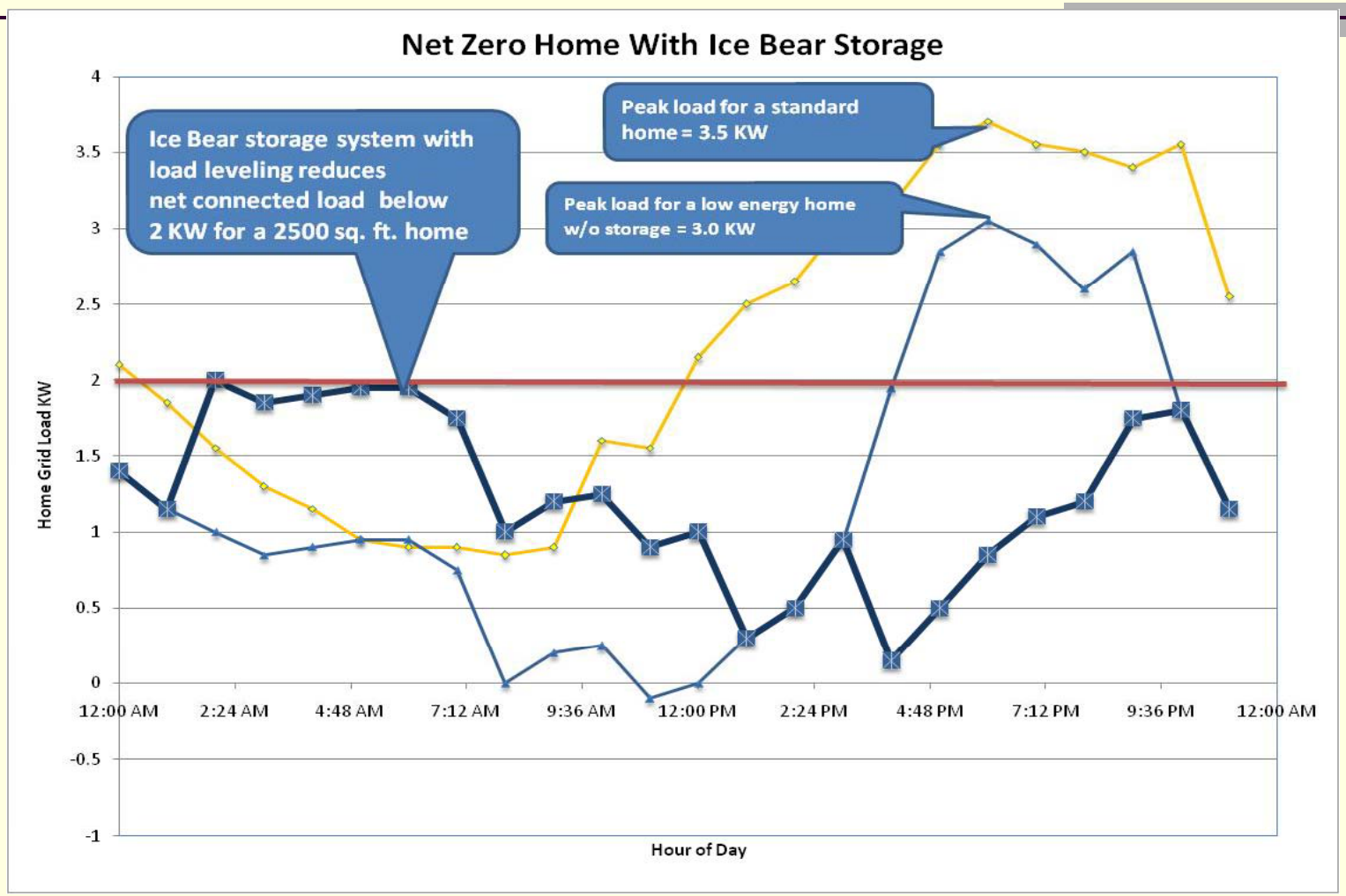
Credit: Sandia National Laboratories

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

SMUD ZEH with Energy Storage – courtesy Ice Energy



ZEH w/ Ice Bear 70% peak reduction

Smart parking meter – V2G infrastructure

Courtesy of EDF Energy (UK)

Electric vehicle: 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

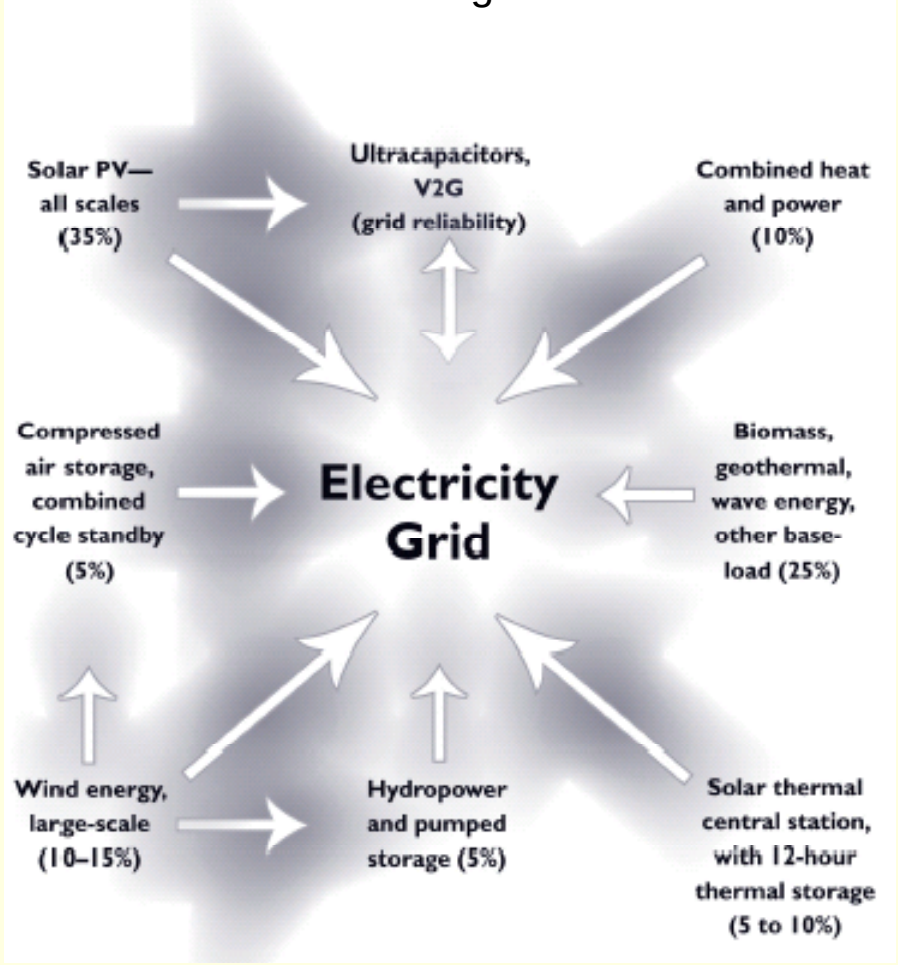
Courtesy of Phoenix Motorcars

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

A renewable, distributed electricity grid configuration

One Possible Future U.S. Electric Grid Configuration Without Coal or Nuclear Power in the Year 2050



Some observations for PRCs and utilities

- 80% reduction of GHG below 1990 by 2050 is now a near certain. IRP should be based on this rather than scenarios for CO_2 cost. Set a target for reduction, set reliability goals, and minimize cost of CO_2.
- Water is a critical concern. Existing infrastructure reliability could go down.
- Efficiency standards for buildings, cars, trucks
- Large-scale government performance-based purchases of renewable fuels and electricity
- Make plug-in hybrid the standard government car by 2015; mandate zero-energy government buildings by 2020, backfit existing govt. buildings
- State contracting preferences for low-CO_2 corporations

End note

Slides are primarily a summary of

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

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