Comments on Other Energy Choices and Additional Societal and Institutional Issues

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California Energy Crisis: An Imperfect Storm (or a Cautionary Tale)

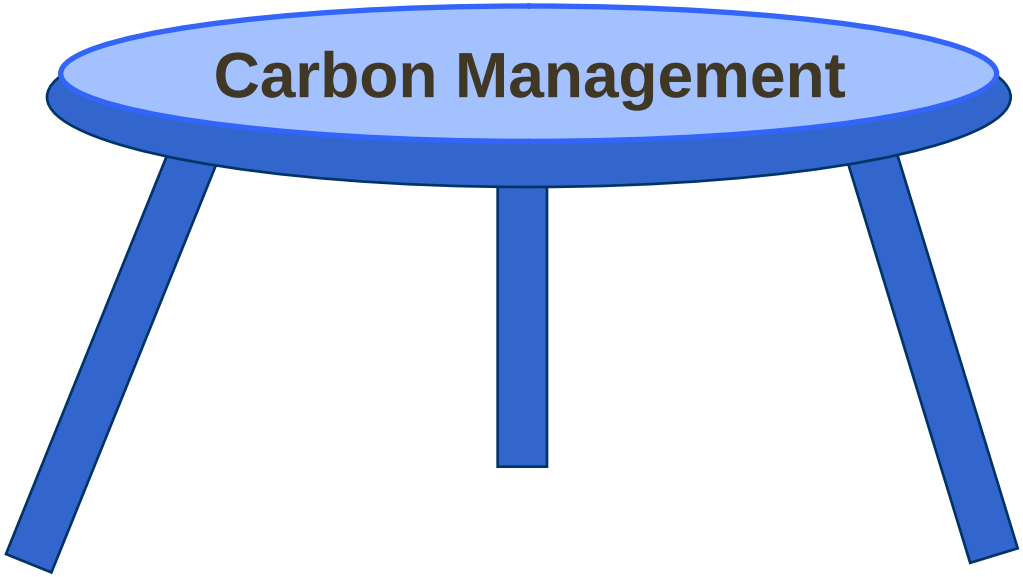
- Flawed 1996 approach to deregulation allowed for significant manipulation of electricity prices
  - Original premise was to create a price cap that allowed IOUs to recover costs on stranded (primarily nuclear) assets
  - SDG&E recovered costs first, with the cap removed (and the assumption that prices would go down), resource costs skyrocketed in summer of 2000
  - California legislative response was to force SDG&E to rescind price increases!!(??)
- 2000/2001 - Low hydro year in California and Pacific Northwest, El Paso natural gas pipeline put out of service
- Good intentions, but bad approach
  - Last “bid in” created market price for all suppliers for that time period
  - Energy marketers took advantage of market imperfections to “game” the system
  - Result - PG&E bankruptcy, lawsuits for everyone!

The New Paradigm: We Can No Longer Ignore the Inter-Relationships

Problem Confluence: Climate Change and Energy Security

- Availability and price pressure on oil prices - disruption of international supply (political unrest) and domestic availability (hurricanes)
- Natural gas – Lots of US shale gas (and fracking) as a new energy paradigm - BUT for how long?
- Nuclear – Benefits to climate, BUT increased concerns for public safety and on-going security concerns over proliferation risks
- Renewable energy resources (use of energy storage) – indigenous resources benefit security, low carbon footprint benefits the climate, BUT at what cost and impact to the grid, logistics (transmission) issues
- Efficiency and demand response – how much can we “squeeze out” over the next century?
- **Coal - domestic supplies lessen security issues, BUT can exacerbate climate issues, geologic carbon sequestration needs to be proven on a large scale**

Carbon Management and Energy Security: A Portfolio Approach



Decarbonization

$< \frac{CO_2}{Btu}$

- Nuclear
- Renewables

Sequestration

$< \frac{CO_2\ atm}{CO_2\ emitted}$

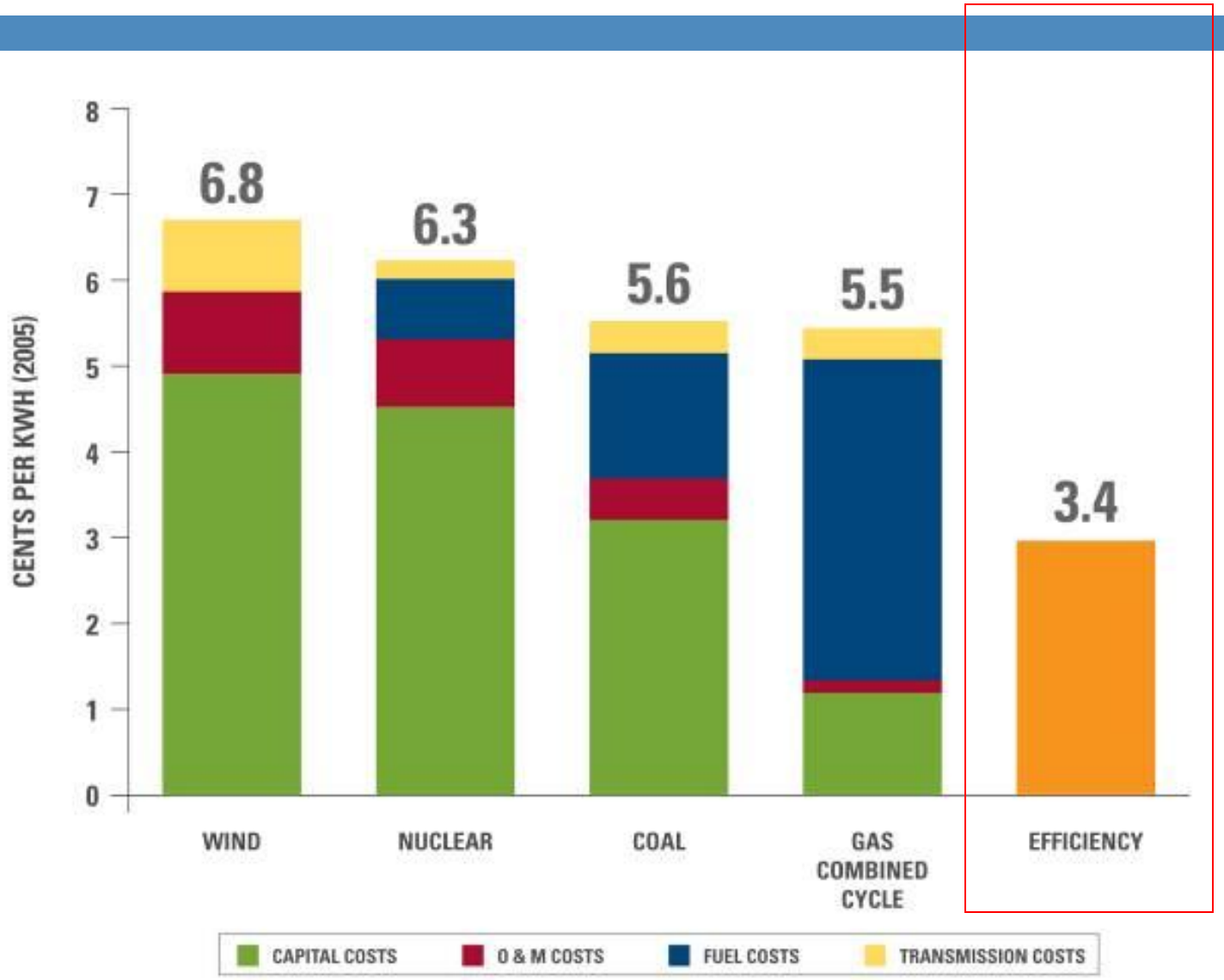
- Regional Partnerships
- Capture/storage

Efficiency

$< \frac{Btu}{GDP}$

- End-use Technologies
- Demand response

Cost of New Generation vs. Efficiency



States (PUCs) Lead in Developing Renewable Policy Instruments

- Renewable Portfolio Standards (RPS) now in over half of the 50 states
- Feed-in Tariffs
- Net metering laws and regulations
- Power Purchase Agreements
  - Under PURPA (now repealed - based on avoided cost)
  - “wind energy windfall” in 2008 for Hawaii IPPs
  - New PPAs must take into account ancillary services - grid stability, reliability, Var support
- Transmission planning, investments, and access
  - renewable resources remote from load centers
  - multiplicity of agencies required for permitting approvals

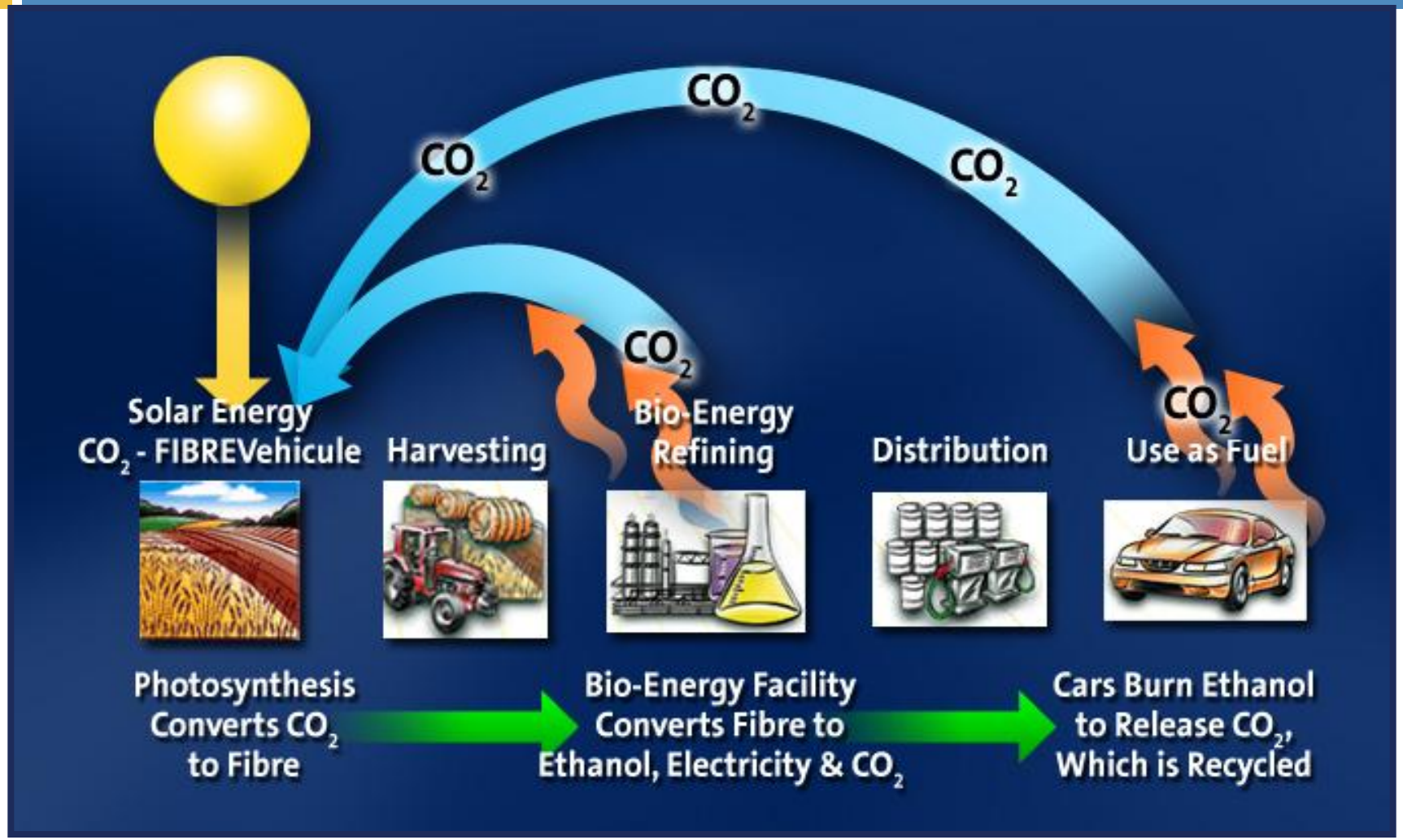
PUC Redux: Transmission Planning Critical for RPS Goals With As-Available Renewable Resources

- Transmission permitting based in state Public Utility Commissions
  - **Major problem** for siting cross-state transmission lines causes delays of up to ten years
  - On-going issues - state regulations can sometimes prevent the implementation of other state goals!
  - California Example: CPUC, CalISO, and CEC, plus IOUs and municipal utilities - multiplicity of permitting agencies even in one state!
- Renewable resources are often remote from load centers
  - Most new renewable generation is purposely built close to existing transmission lines
- Renewable Energy Transmission Initiative (CA)
  - Purpose is to identify competitive renewable energy zones (CREZs) for transmission development – linking load to resource

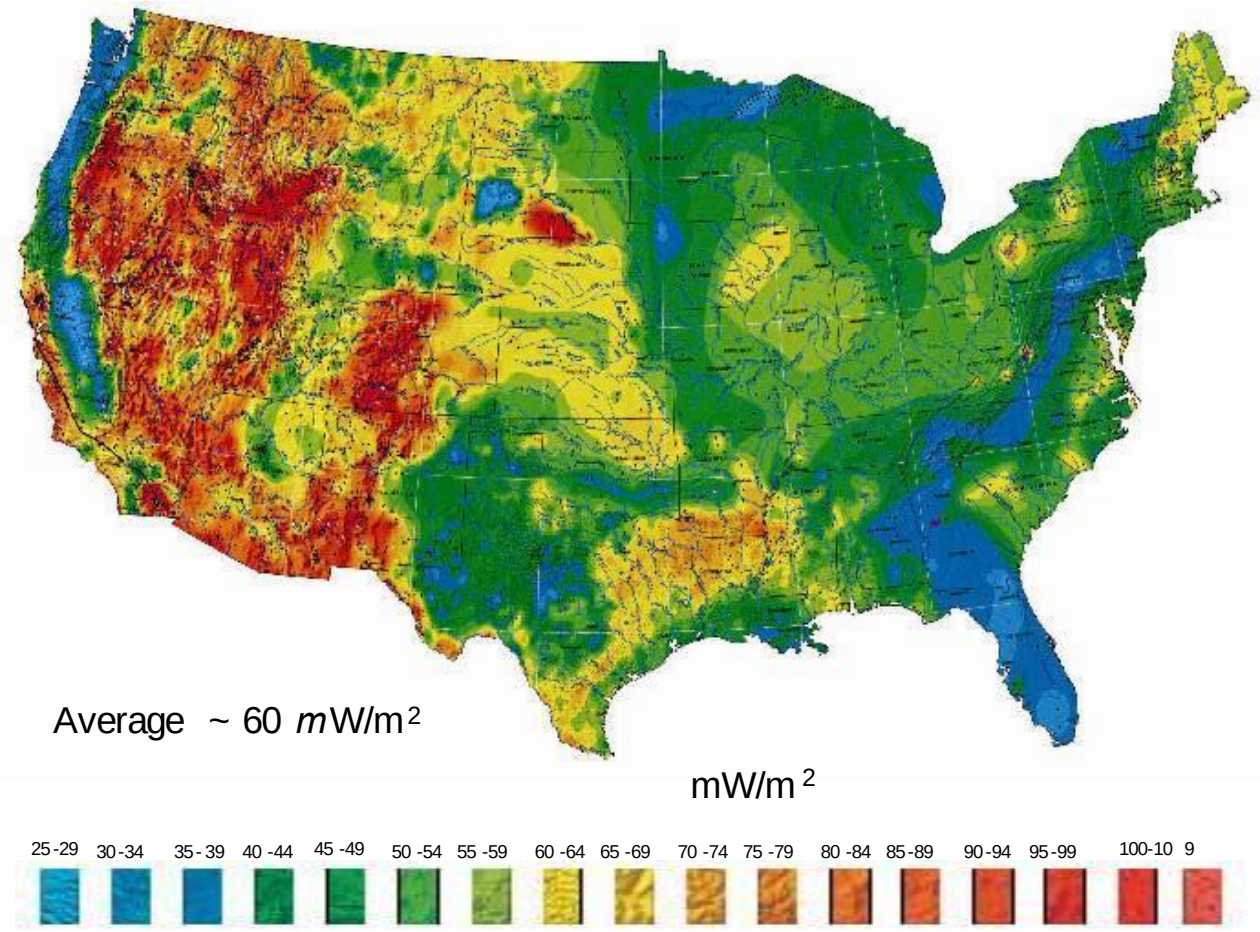
Renewables: Development of Biomass Technology is Not Without Issues

- **Water Use**
  - **Irrigation requires energy**
  - **Water rights will be at issue**
- Fertilizer
  - Many are produced with natural gas feedstocks
  - Run-off causes considerable pollution, ocean dead zones
- **Competition for Food as a Societal Issue**
- Land Availability
  - use of marginal lands can make erosion problems worse
- Contribution to Global Warming
  - Destruction of tropical forests
- Conversion Technologies
  - Problems with developing cost-effective cellulosic conversion systems

Well-to-Wheels Life Cycle Analysis for Carbon



Geothermal Flux – Western Advantages



Geothermal Energy Increasingly Competitive, Particularly in the West

1980: 10-16 cents/kWh

2007:
5-8 cents/kWh

- **Improved technology**
  - **Need for load following systems**
  - **Reduced drilling costs**
- **Expanding resource base**

2011 Goal: Less than 5 cents/kWh (prior to budget reductions)

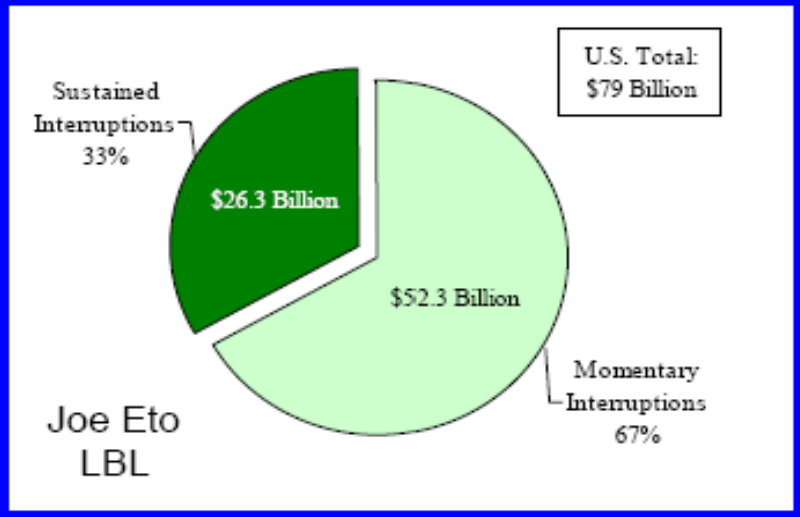
Current Power Purchase Agreements are about 6 to 6.5 ¢/kWh

Intermittent Renewable Energy Issues: Power Quality and Reliability

Outage Costs for U.S. Industry estimated at $79 Billion Annually in a recent study by Joe Eto, LBL

Total U.S. Cost of Electricity $250 Billion Annually

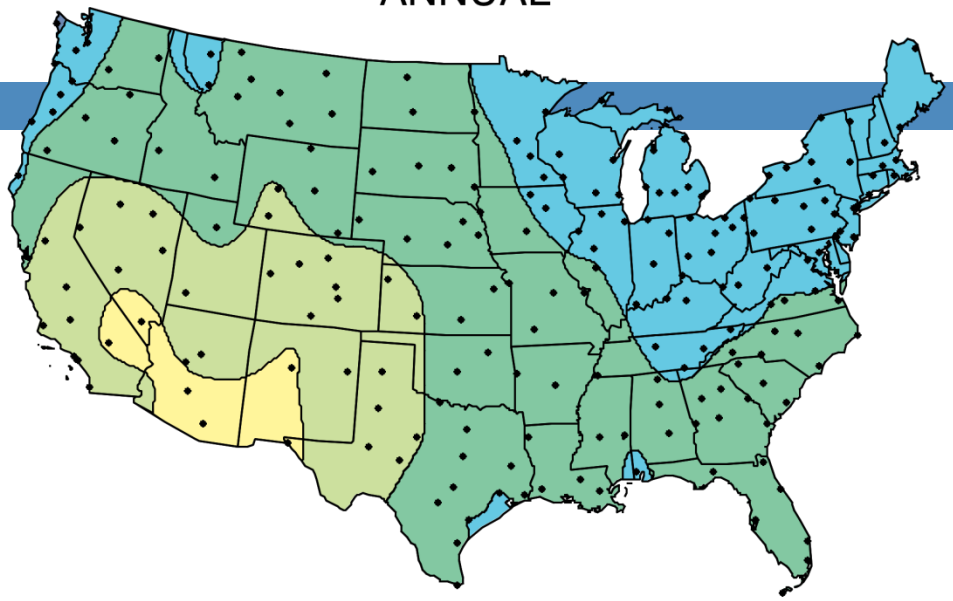
Momentary Interruptions (<5min) are More Costly than Sustained Interruptions



From Imre Gyuk, DOE, 2007

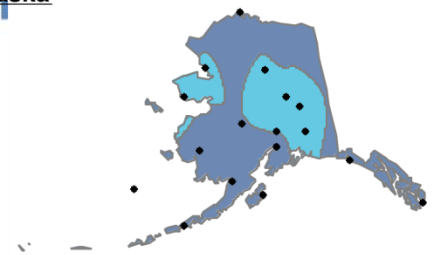
Average Daily Solar Radiation Per Month

ANNUAL

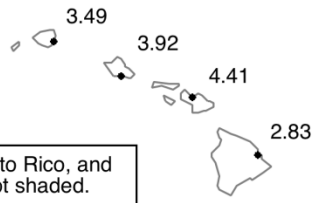


East-West Axis Tracking Concentrator

Alaska

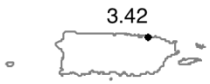


Hawaii



Hawaii, Puerto Rico, and Guam are not shaded.

San Juan, PR



Guam, PI

Collector Orientation

One-axis tracking parabolic trough with a horizontal east-west axis

This map shows the general trends in the amount of solar radiation received in the United States and its territories. It is a spatial interpolation of solar radiation values derived from the 1961-1990 National Solar Radiation Data Base (NSRDB). The dots on the map represent the 239 sites of the NSRDB.

Maps of average values are produced by averaging all 30 years of data for each site. Maps of maximum and minimum values are composites of specific months and years for which each site achieved its maximum or minimum amounts of solar radiation.

Though useful for identifying general trends, this map should be used with caution for site-specific resource evaluations because variations in solar radiation not reflected in the maps can exist, introducing uncertainty into resource estimates.

Maps are not drawn to scale.

*

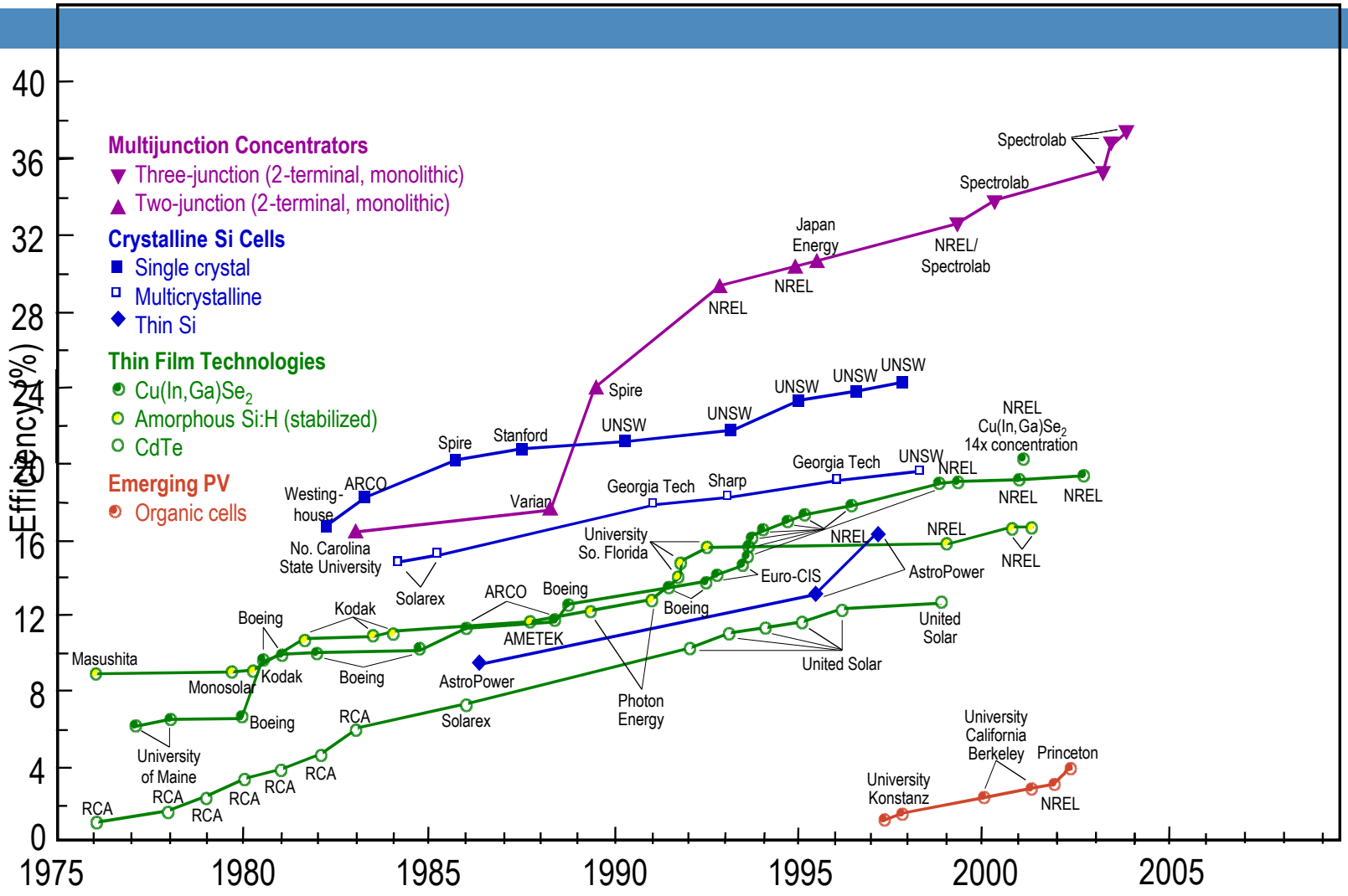
National Renewable Energy Laboratory
Resource Assessment Program

kWh/m^2/day

- 10 to 14
- 8 to 10
- 7 to 8
- 6 to 7
- 5 to 6
- 4 to 5
- 3 to 4
- 2 to 3
- 0 to 2
- none

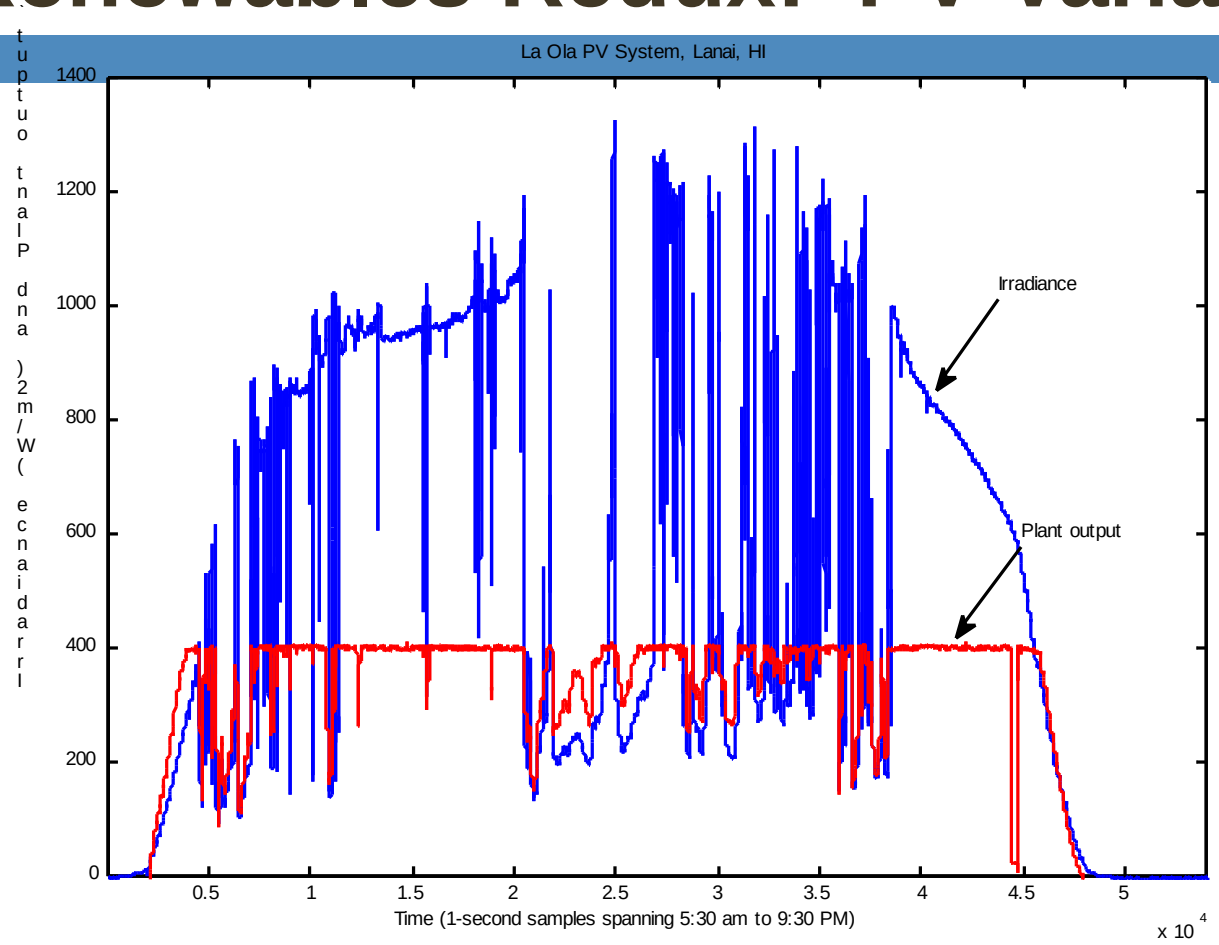
C1XEA13-13

Efficiency of Solar Cells Is Improving



Source: R. King, GCEP Solar Energy Workshop

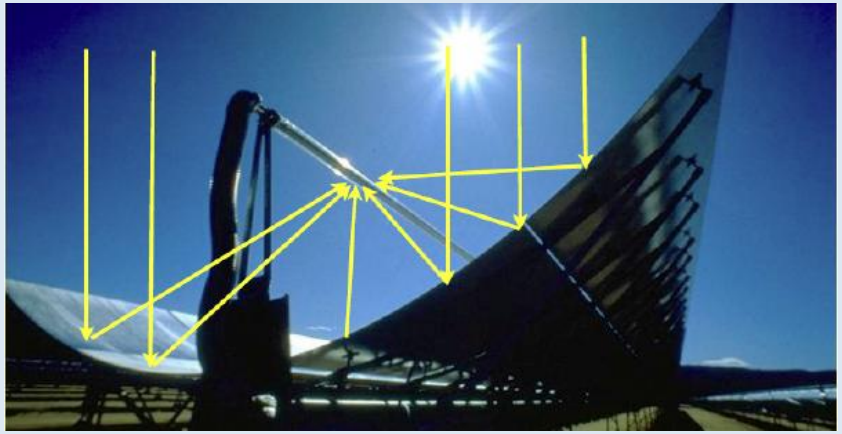
Significant Penetration of Renewables Redux: PV Variability



- Irradiance and PV system ac output A typical partly cloudy day in July
- PV system rating: 1,300 kW ac, presently limited to 400 kW ac (intentionally)

Types of Concentrating Solar Thermal Systems

Concentrate to line



Parabolic trough

Fresnel lens

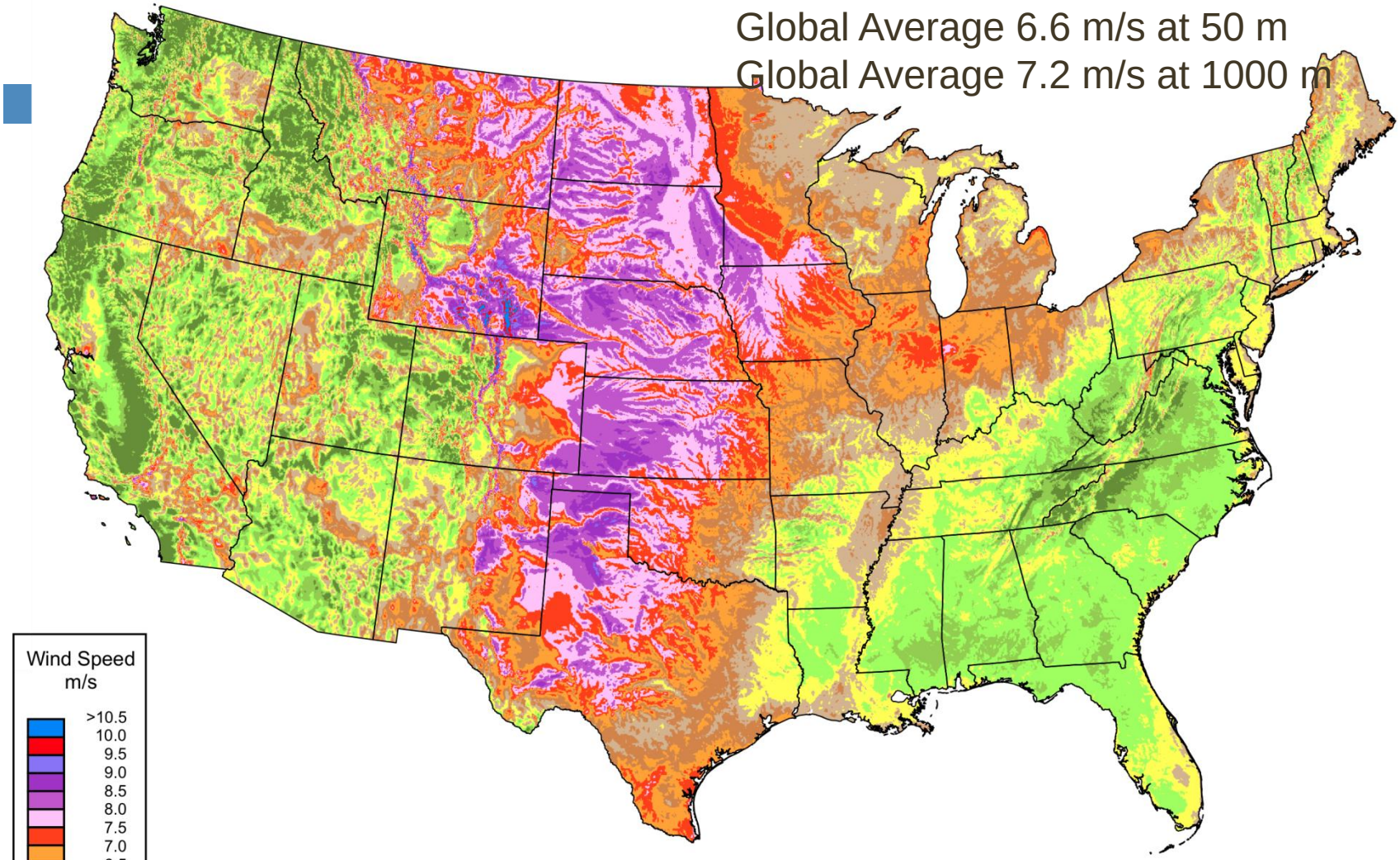
Concentrate to a point

Sterling engine with dish

Power tower

United States - Annual Average Wind Speed at 80 m

Global Average 6.6 m/s at 50 m
Global Average 7.2 m/s at 1000 m



Source: Wind resource estimates developed by AWS Truepower, LLC for windNavigator®. Web: http://www.windnavigator.com | http://www.awstruepower.com. Spatial resolution of wind resource data: 2.5 km. Projection: Albers Equal Area WGS84.

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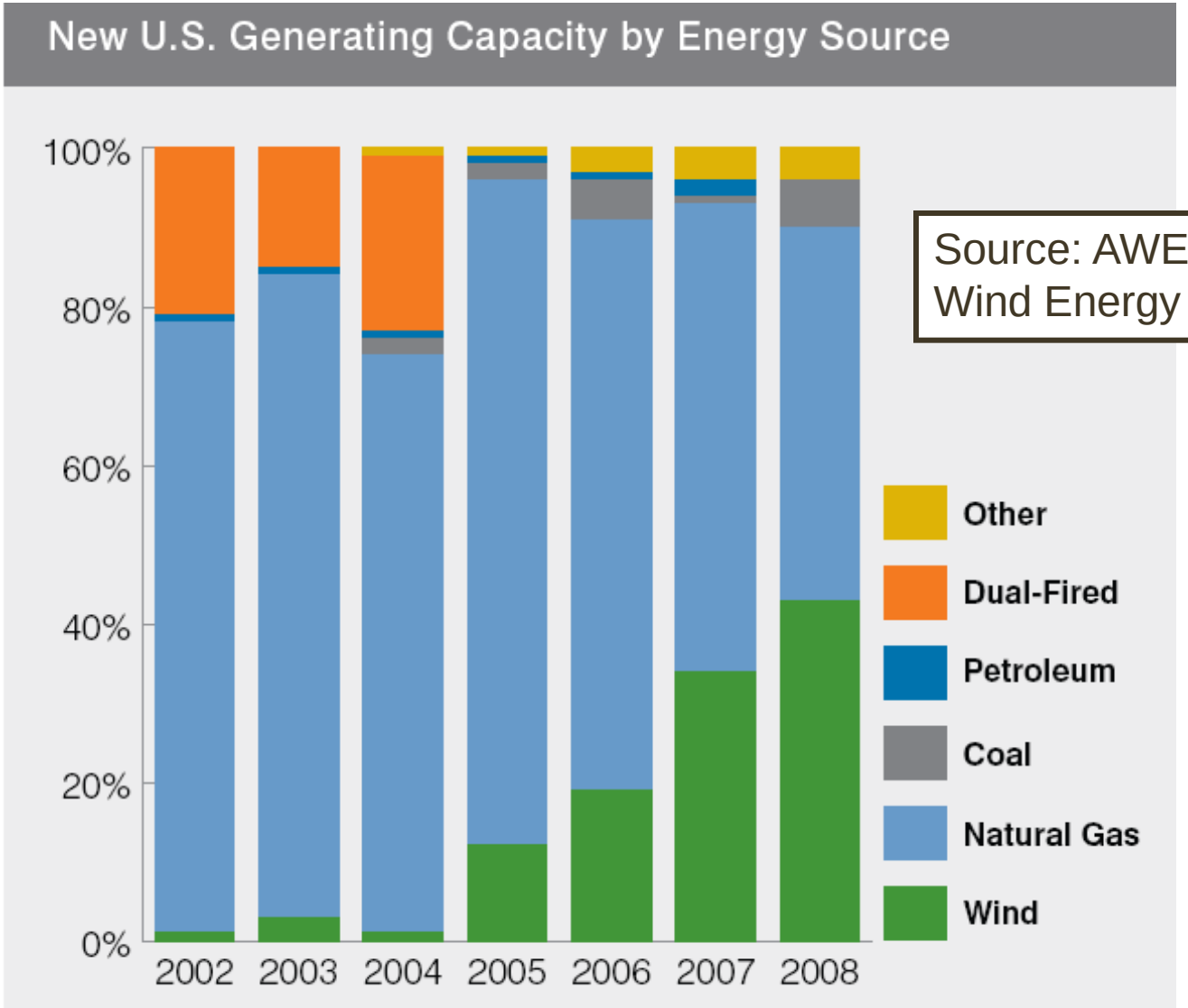
21-SEP-2010 1.1.1

Wind Power Accounted for 40% of New Generation Capacity in 2008

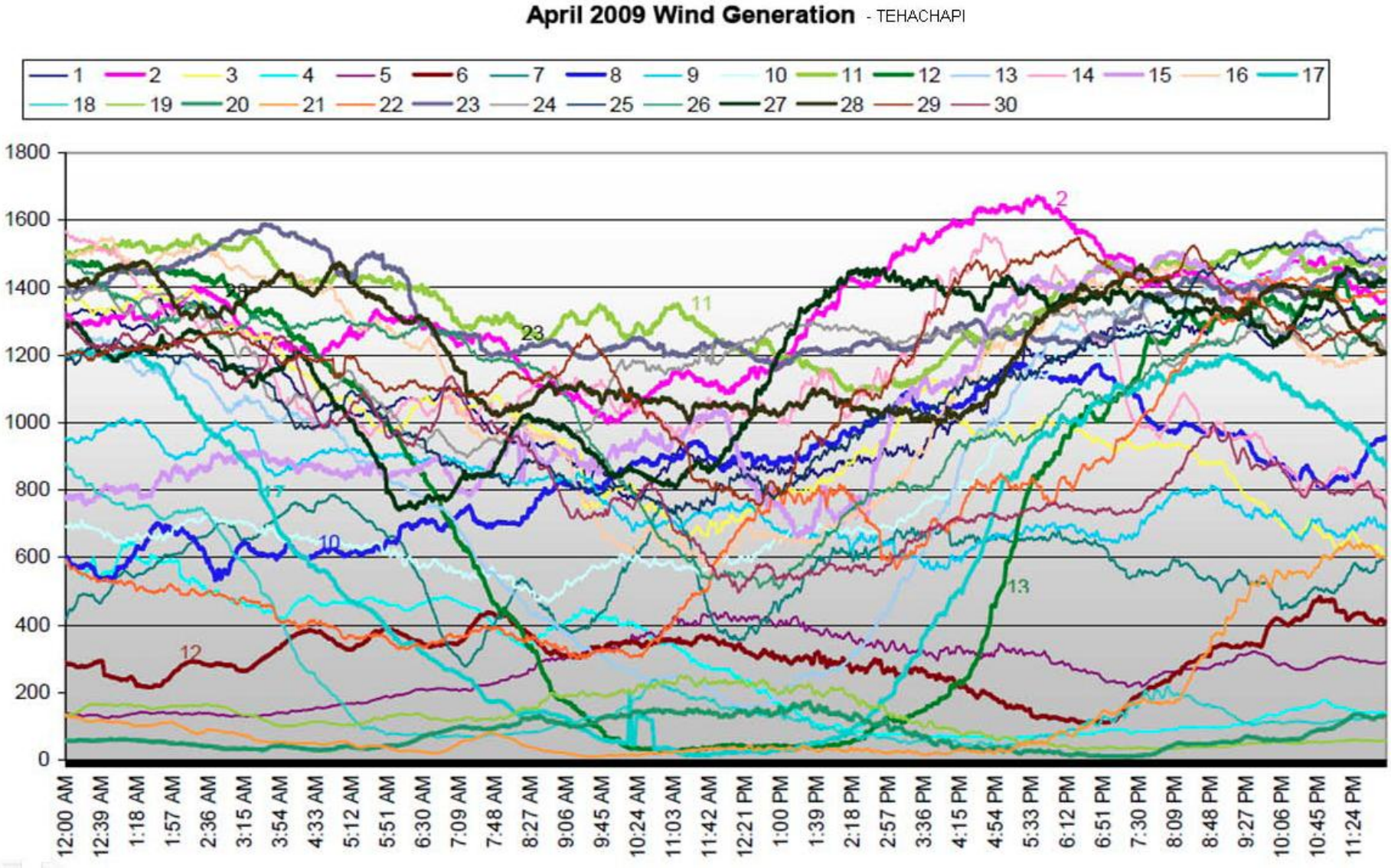


Source: AWEA, 2009 Wind Energy Outlook

Challenges With Wind

- Variable power supply
  - Night time winds
  - High frequency fluctuations
  - Weather related fluctuations
- Capacity factor of about 20-40%
  - Average power generation on 20 to 40% of nameplate capacity
    - 1,000 MW new generating capacity yields and average of 200 to 400 MW per year
- Need for spinning reserve
- Not dispatchable

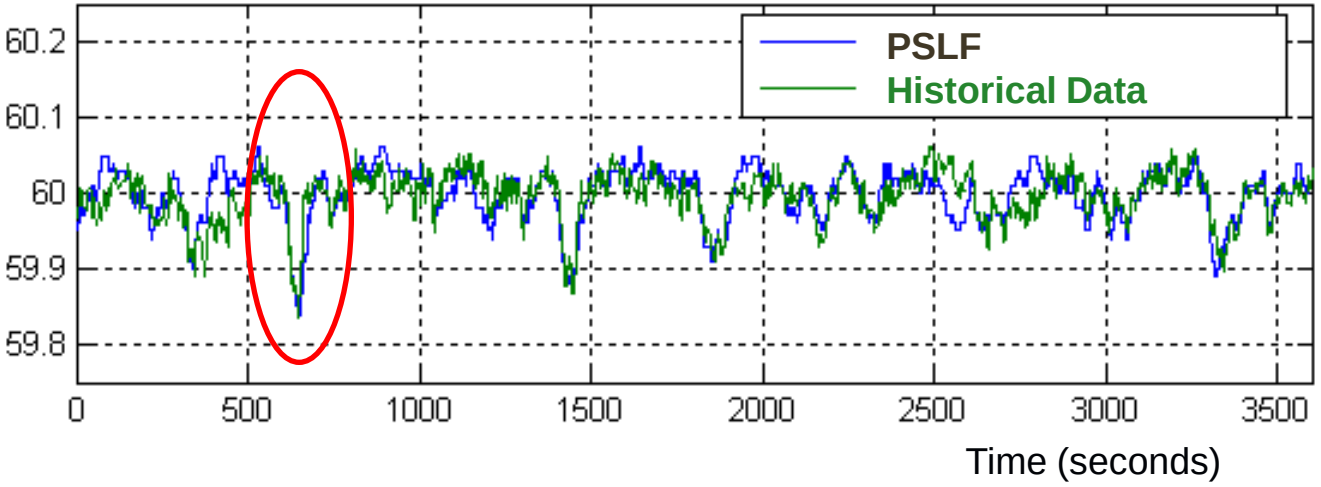
Wind Generation Variability in CA (from CA ISO, Jim Detmers)



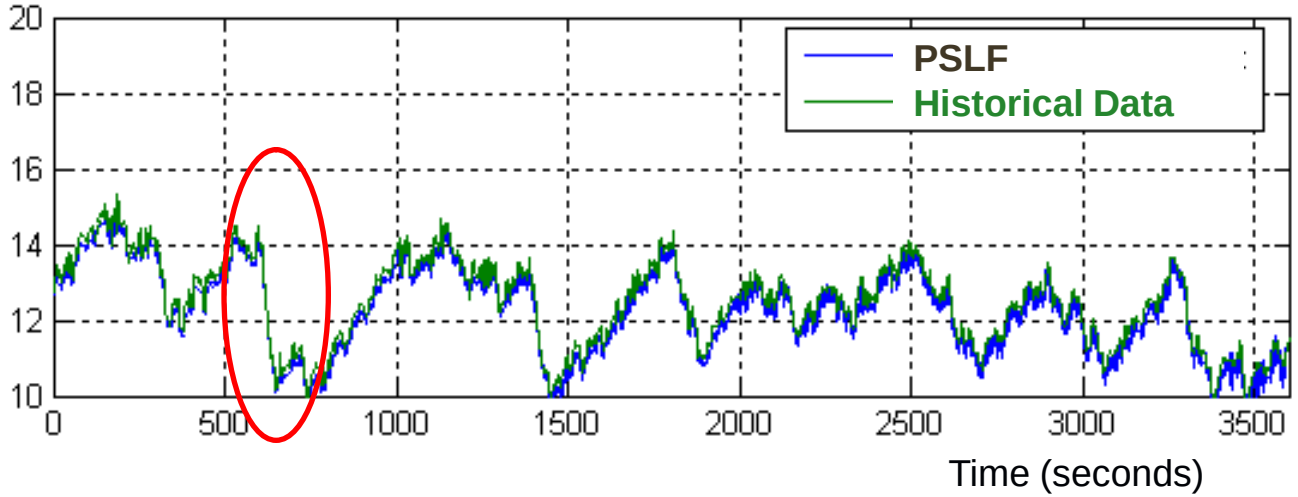
Example of Wind Fluctuations Impacting Grid Performance:
Frequency Sags and Loss of Capacity

Significant Wind Fluctuation (04/03/07)

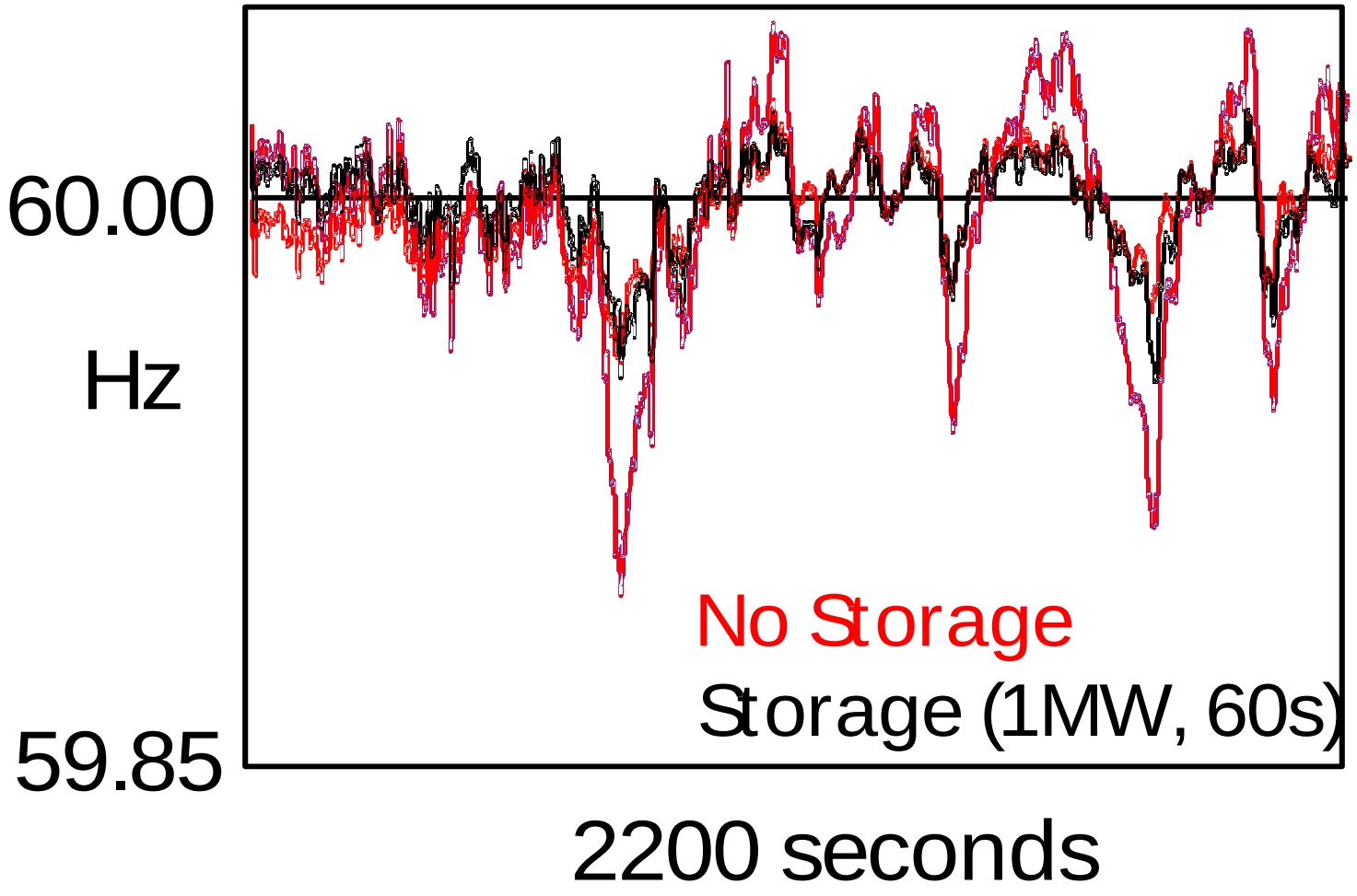
Frequency (Hz)



Apollo Windfarm (MW)



Impact of Storage on Grid Stability

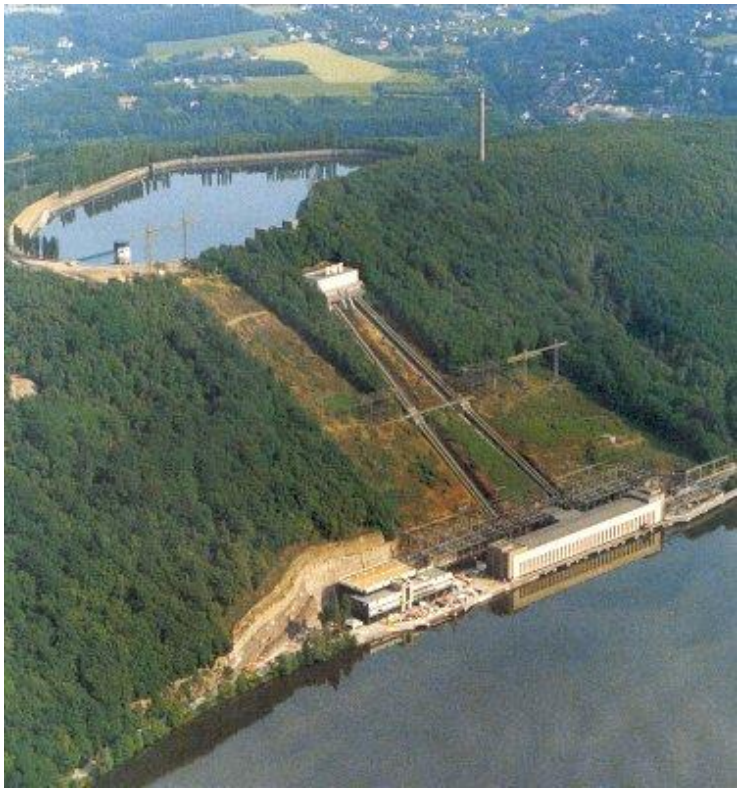


Energy Storage Technologies Needed to Address Renewable Intermittency Issues. but Cost?

Energy

- Pumped Hydro
- Compressed Air Energy Storage (CAES)
- Batteries
  - NAS
  - Flow Batteries
  - Lead Acid
  - Lithium Ion
  - NiMH
  - NiCad
- Flywheels
- Electrochemical Capacitors

Power



Herdecke pumped storage plant
Germany

Fossil-Fired Systems Still Needed in a Renewable Energy Future

- Changes in fossil-fired generation facilities operation and maintenance need to occur to make large-scale, but intermittent, wind a reality.
- Long term operation of multiple facilities at min power raise issues such as how to address ramp rates and how to manage AGC.
- Units might spend much more time at lower loads and equipment changes are needed to improve thermal efficiencies
- Major changes are required to upgrade and/or modify facilities in order to meet new system requirements.
- For the existing fleet, re-evaluation of larger units having distributed and disaggregated responses to address renewable resource variability as this may be most appropriate rather than having one unit address renewable resource variability.
- The utility will need new paradigms for operational procedures from supplying kilowatts to playing significant role of providing ancillary services, such as reactive power. Can ancillary services, such as Var support, be provided on a localized basis?

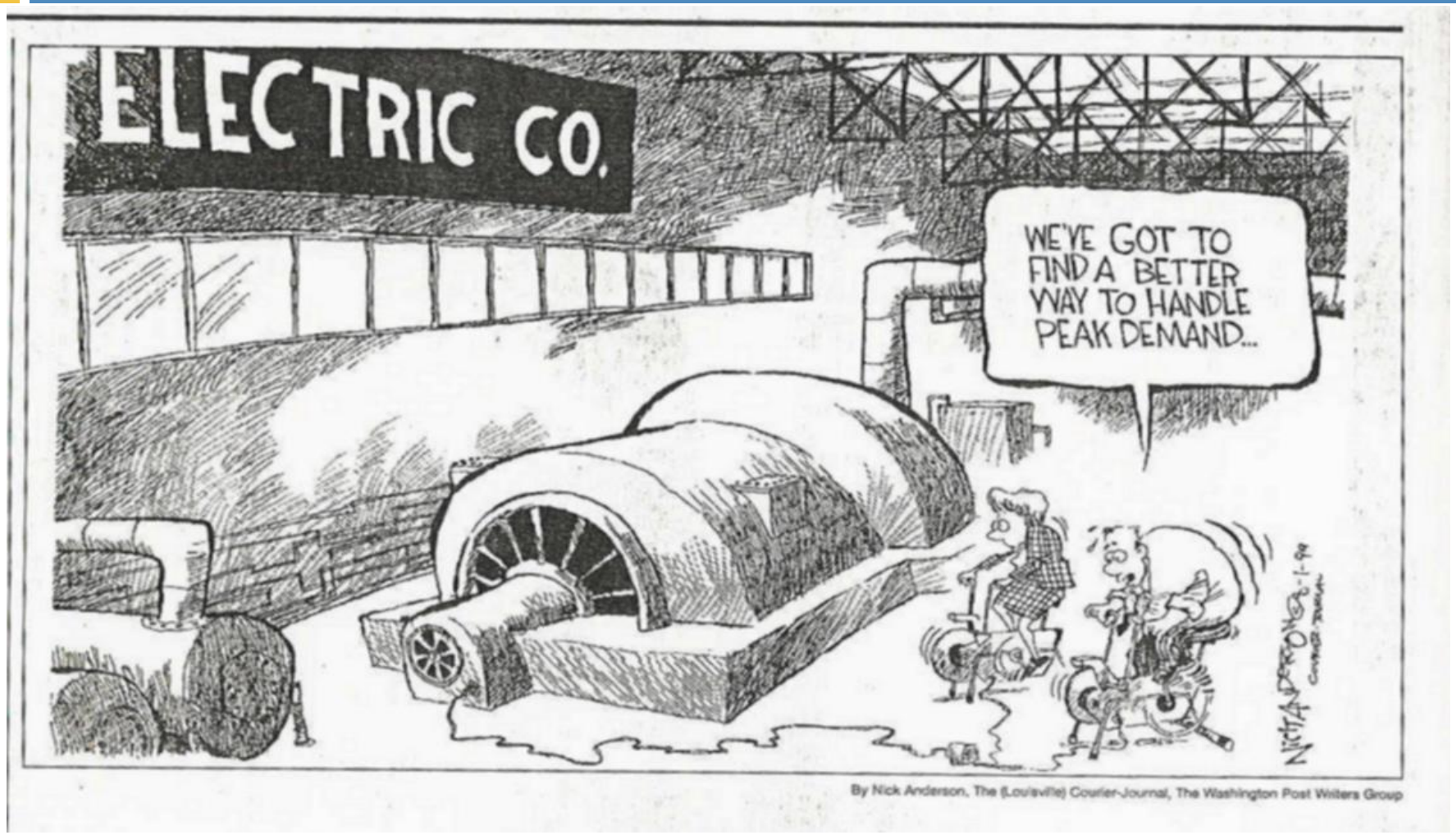
What is the Smart Grid?

What is it now...and for the near future?

- Mainly, “one-way meters” – “Advanced Metering Infrastructure” (AIM)
- Currently, very few truly new and innovative functions
  - “Smart Meters” - automated/remote meter reading
  - Time-differentiated rates – “giving customers a choice” (TOU, real time pricing, peak activated rates)
  - Display energy use and cost information to the consumer
  - Improved reliability - identifying and locating an outage when a meter doesn’t respond
  - Better voltage control – remote capacitor and tap changer controls
  - Integration of “smart” appliances
- **“Idiot savant” grid – being able to do individual, isolated functions better with new technology. The functions are still not being designed to talk to each other**
- **Most of the Smart Grid applications have not been written, or even specified, or even conceived!!!**
- **Problem with incorporation into “legacy” systems**

“Smart Grid” - Linking IT to Electricity: Communications, Control, and Information Systems

- Can take advantage of telecommunications and information technologies developed for exogenous applications
- Resolves issues arising from greater penetration of distributed and renewable energy resources and technologies on grid
- Critical component for more effective and efficient load management, demand response, demand-side management, and power quality
- Major concern is the effective linking of electrical and mechanical engineering skills with information technology profession – need for training!


ELECTRIC CO.
WE'VE GOT TO FIND A BETTER WAY TO HANDLE PEAK DEMAND...
By Nick Anderson, The (Louisville) Courier-Journal, The Washington Post Writers Group

Regional Partnership Program as a Learning Exercise: Its not just about Science and Technology

- **Lessons to be learned addressing institutional, regulatory, and outreach issues**
  - Complexities of land access agreements
  - Mergers and acquisitions
  - Impact of media attention on outreach programs
  - Regulation: multiple permitting agencies
  - Phase III - new policies, regulations, logistics
  - BUT also interest from state regulatory agencies
    - question with regulatory agencies - “What problem are you trying to solve?”

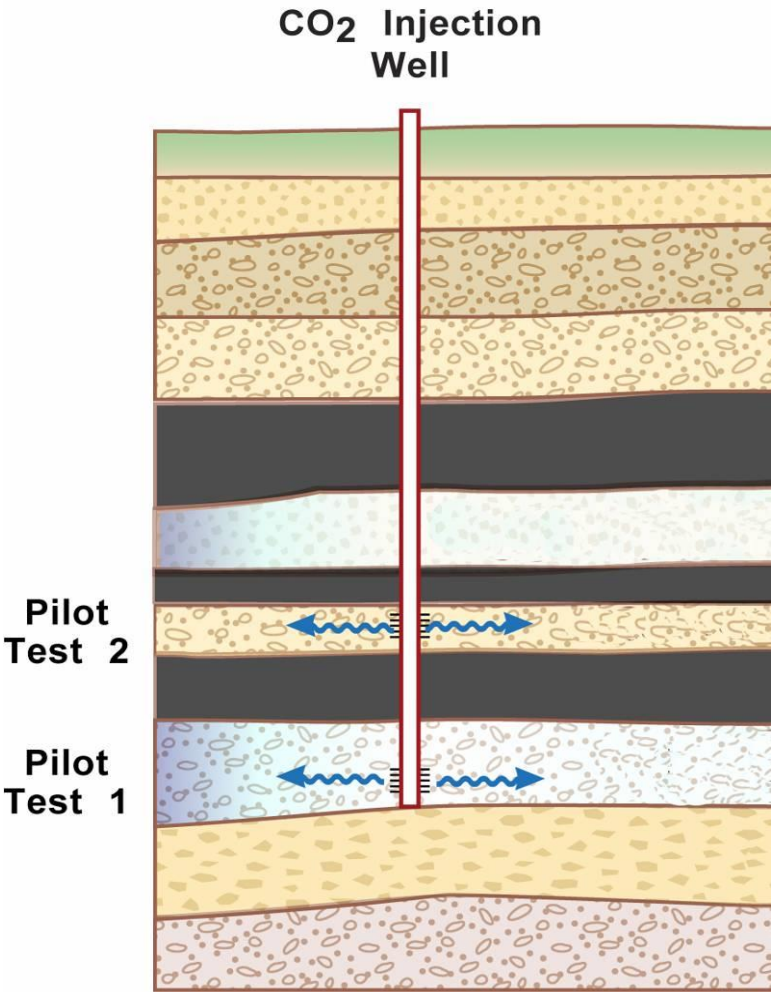
CCS - It's Working in the South, But Elsewhere?

- SECARB (SSEB) is doing an outstanding job in resolving societal issues
- This is not necessarily true in other parts of the country
  - don't overlook state-based issues
  - don't overlook public opposition
  - NEVER presume that NEPA guidelines are as readily met as with SECARB
    - joys of Categorical Exclusions and FONSI
- Some examples will follow

Erroneous Presumption that NEPA Is "pro forma" - Dealing with Permits and NEPA

- Over 40,000 comments on New Production Reactor EIS
- 134 comments on HI Ocean Sequestration EA
- Altamont and avian interactions
- Beserkeley nuclear materials experience
- Poor environmental and security solutions from EIS process- the Barbers Point biofuel - fired 120 MW power plant

Lessons from the Real World: Regulatory One Well; Two Permitting Agencies



- California is a "shared primacy" state

Gas Zone—CA DOGGR (Injectivity Test)

Saline Zone—U.S. EPA Region 9 (UIC)

Objectives of Regulation/Permitting

- Land use
- Water/groundwater protection
- Health and safety
- Mineral rights and mineral resource protection
- Quality of life: traffic, infrastructure impact, etc.
- Air quality
- Greenhouse gas emissions accounting (AB 32 compliance and Low Carbon Fuel Standard in CA)
- Wildlife protection
- Cultural resource protection
- **Environmental Justice**
- Etc., etc., etc.

Agencies That Could Be Involved in Permitting Potential CCS Projects

- **FEDERAL**
  - US EPA Region 9
  - US Army Corps of Engineers
  - US Fish and Wildlife Service
  - US Dept of Transportation
  - US Coast Guard

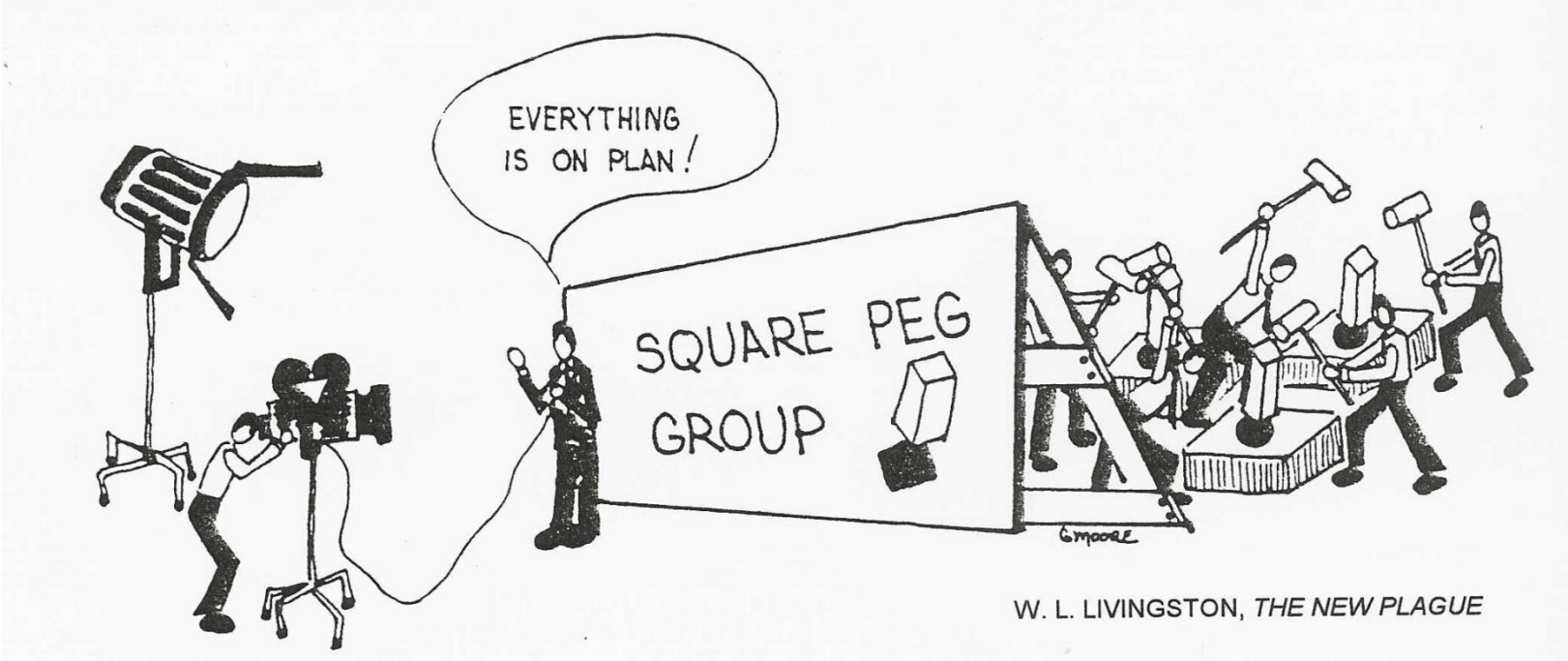
- **STATE**
  - California State Water Resources Board
  - California Dept of Fish and Game
  - Department of Toxic Substances Control
  - California Department of Transportation
  - California Public Utilities Commission
  - California Energy Commission
  - California Department of Conservation (DOGGR)
  - California Air Resources Board

- **REGIONAL**
  - Area Air Quality Management Districts
  - Bay Conservation and Development Commission
  - Regional Water Quality Management District

- **LOCAL**
  - City or County Planning Commissions
  - Other county/city departments

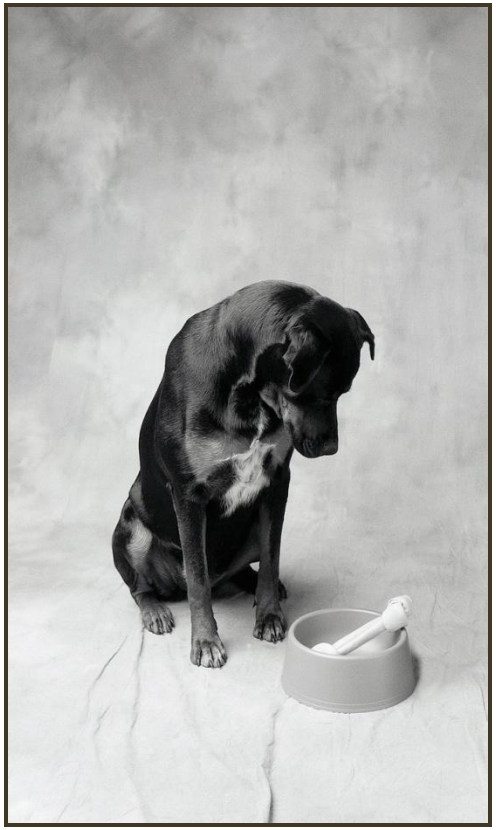
Current Regulatory Approach

Or, “I Heard It Through the Grapevine” - G. Knight



California Required Better Direction on Regulatory and Institutional Issues for CCS

- Regional Partnerships program required that institutional and regulatory barriers be addressed in addition to technical aspects of sequestration
- Clear direction for AB1925/AB32 was needed versus dog's breakfast in the current California regulatory and policy environment
- Three state agencies (CEC, ARB, and CPUC) came together and appointed an independent review panel
- In additional to policy and technical experts,the environmental justice community was included



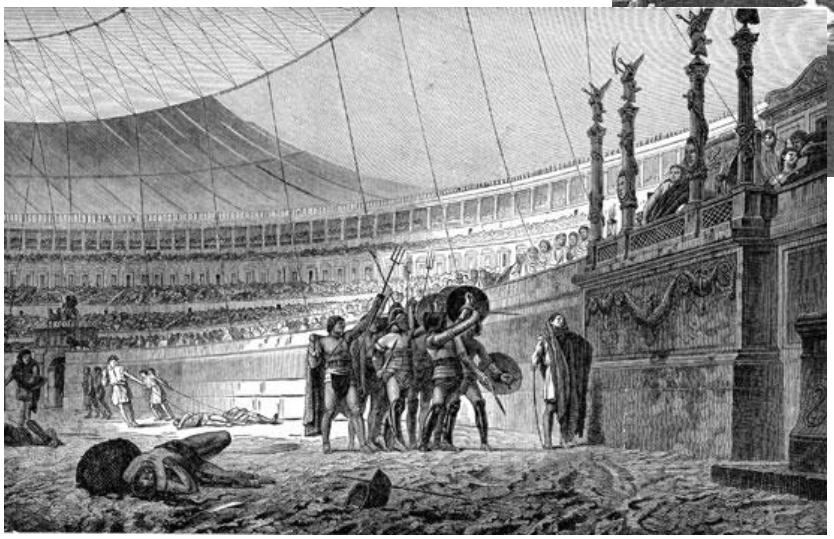
California Assembled Blue Ribbon Panel to Address Institutional and Regulatory Issues

- Nationally respected lawyers, scientists, engineers, legislators from academia, utilities, environmental groups, and industry
- Assess issues, ask probing questions, and recommend what California ought to consider (and not to consider)
- Context of dynamic California policy milieu with a more heterogeneous geological environment than most other CCS states
- Technical Advisory Team to “frame the debate”
- Important that there was some distance between agencies and the Panel, due to state legal issues
- Cost to the state was $300K.

Evolution of Technical Advisory Team

Project team - 2003

Final Project Team



Presentation to the Panel

Blue Ribbon Panel in California Endorses CCS

- Can help California meet 2050 80% emission goals reduction
  - CCS a significant tool and public benefit for compliance with AB32.
  - Sequestered CO2 not to be defined as emitted
  - Consider adoption of offset protocols for CCS projects
- Streamline/coordinate regulatory & permitting processes
  - Lead state agency (CEC) for CCS projects, working with state agencies per their expertise (ARB, DWR, DOGGR, Fire Marshall)
- Resolve key legal uncertainties
  - Industry-funded trust fund for post-closure stewardship
  - Develop procedures for defining, aggregating, adjudicating, and compensating for pore space ownership
  - Legislation for CPUC to extend CO2 transportation infrastructure for CCS projects similar to the rights of way acquisition for natural gas storage
- Ensure safe, equitable, & economic use of CCS in California
  - Burdens and benefits of CCS should be borne equally across state
  - Need for broad and effective outreach program on CCS

Blue Ribbon Recommendations - continued

- Resolve key legal uncertainties
  - Create industry-funded trust fund for post-closure stewardship
  - Surface owner should be pore space owner
  - Develop procedures for aggregating, adjudicating, and compensating for pore space ownership
  - Consider legislation for CPUC to extend CO2 transportation infrastructure for CCS projects similar to the rights of way acquisition given to natural gas storage projects
- Ensure safe, equitable, & economic use of CCS in California
  - Burdens and benefits of CCS should be borne equally by all Californians
  - Need for broad and effective outreach program on CCS
  - Cost allocation mechanisms should be spread broadly across all Californians
  - Evaluate different incentives for early CCS projects.

An Integrated Approach is Required