NOAA's Potential to Support Renewable Energy

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My ESRL Colleagues

Jim Wilczak, Robert Banta, Stan Benjamin, John Brown, Ellsworth Dutton, Rich Lataitis, John McGinley, Alexander E. MacDonald, Joe Michalsky, Yelena Pichugina, John Schneider, Betsy Weatherhead, Klaus Wolter

Main Message

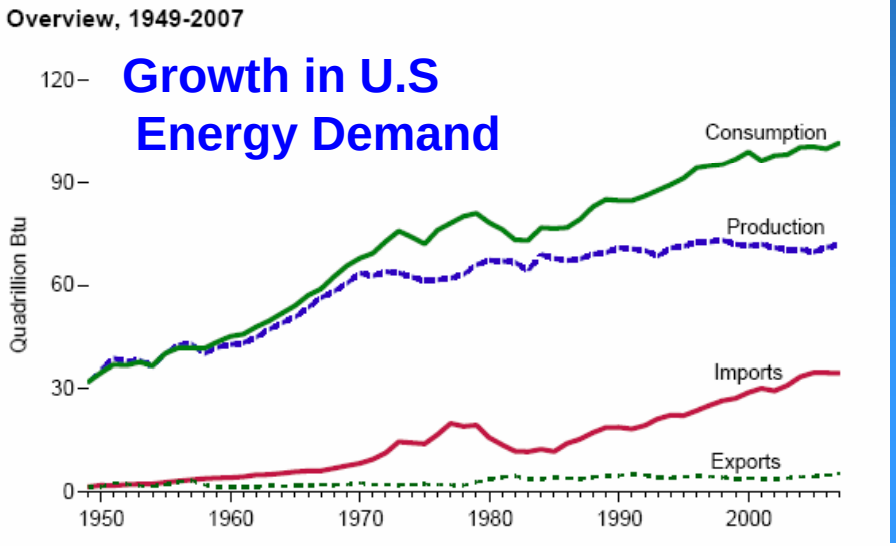
Photo courtesy of NREL, Dave Mooney

NOAA could provide the missing observations, weather forecasts & climate information that are required to allow for large amounts of renewable energy to be incorporated into the U.S. energy system.

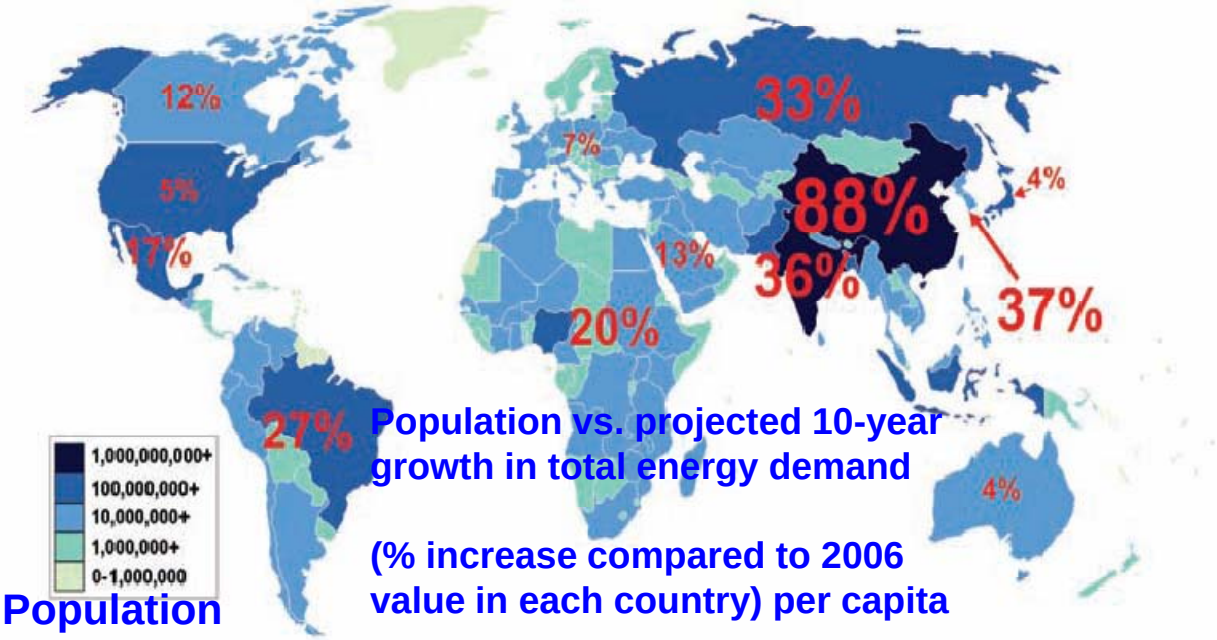
Outline

- Current vs. future energy system
- Wind
- Solar
- Possible ocean energy in the future
- Water issues
- Climate and environmental factors
- Economic benefits of REs
- NOAA's energy partners

U.S. and Global Energy Demands Continue to Rise



Growth in Global Energy Demand

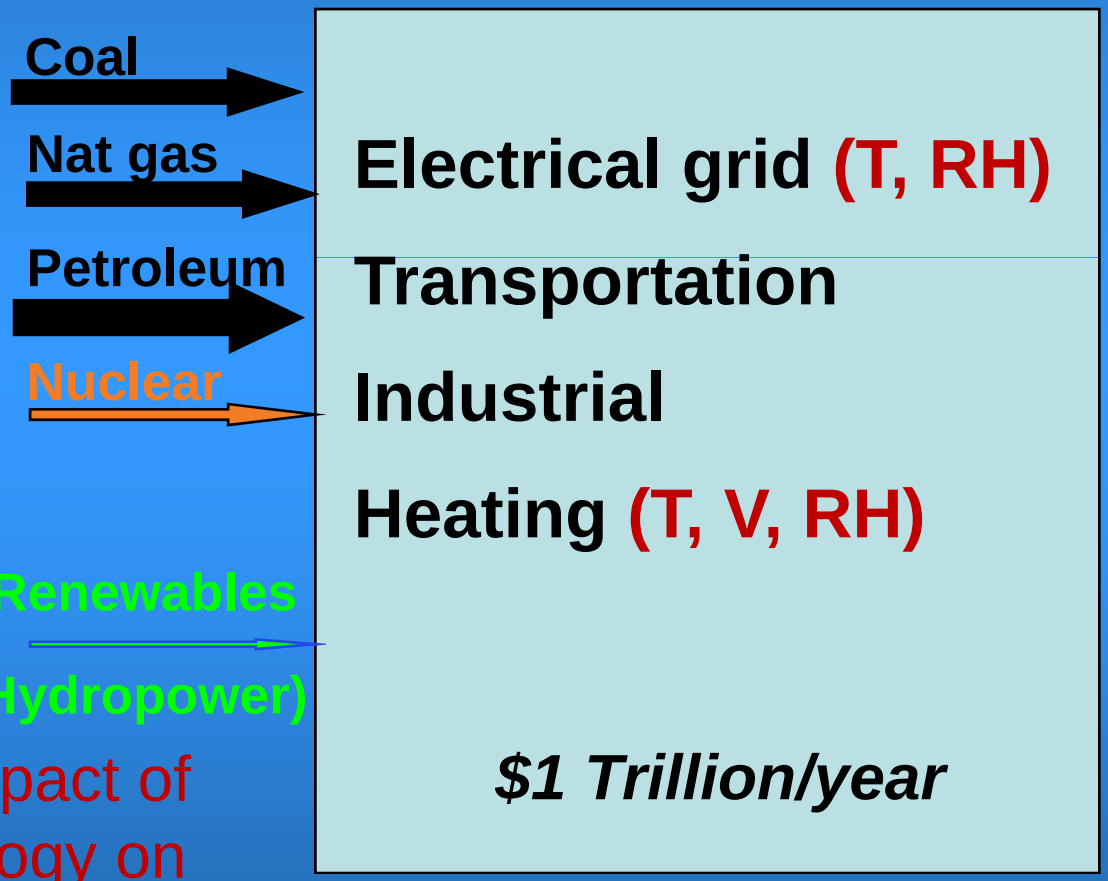


Population vs. projected 10-year growth in total energy demand

(% increase compared to 2006 value in each country) per capita

Current vs. Future Energy System

Current Energy System



Modest impacts of meteorology on demand:

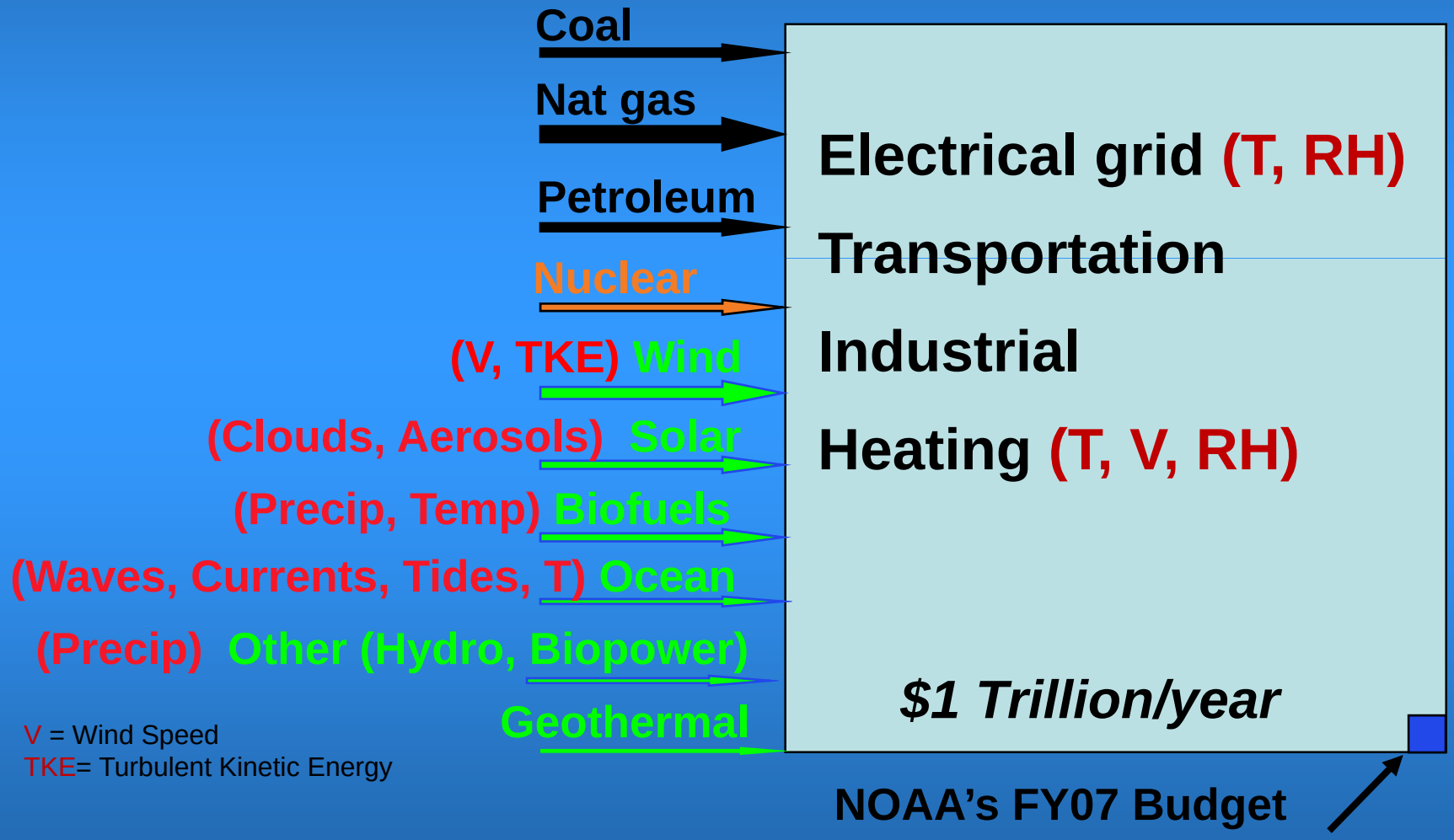
T=Temp

RH= Relative Humidity

Trivial impact of meteorology on supply side.

Current vs. Future Energy System

2030 US Energy Flows?

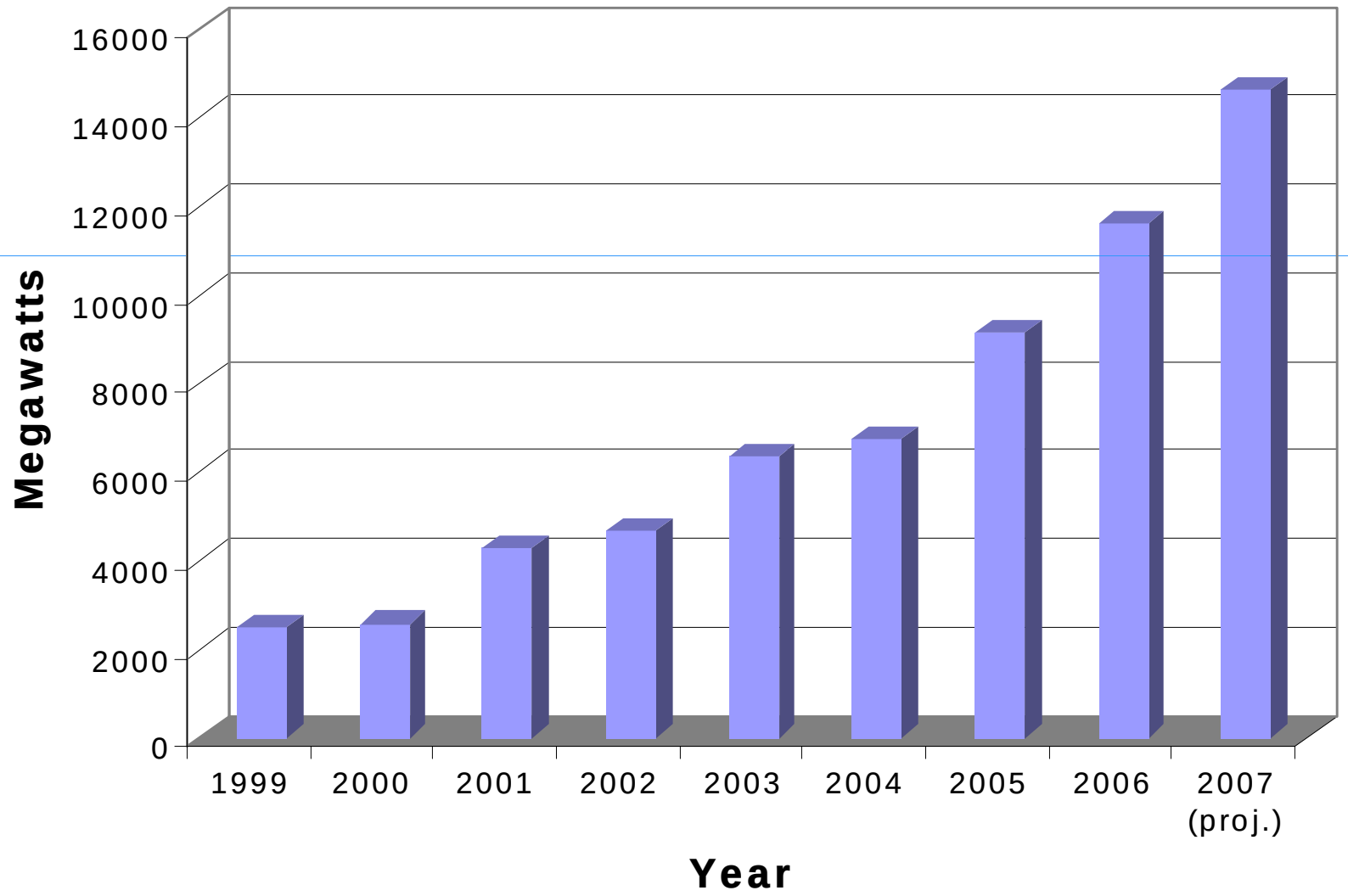


V = Wind Speed
TKE= Turbulent Kinetic Energy

Significant impacts of weather and climate on supply.

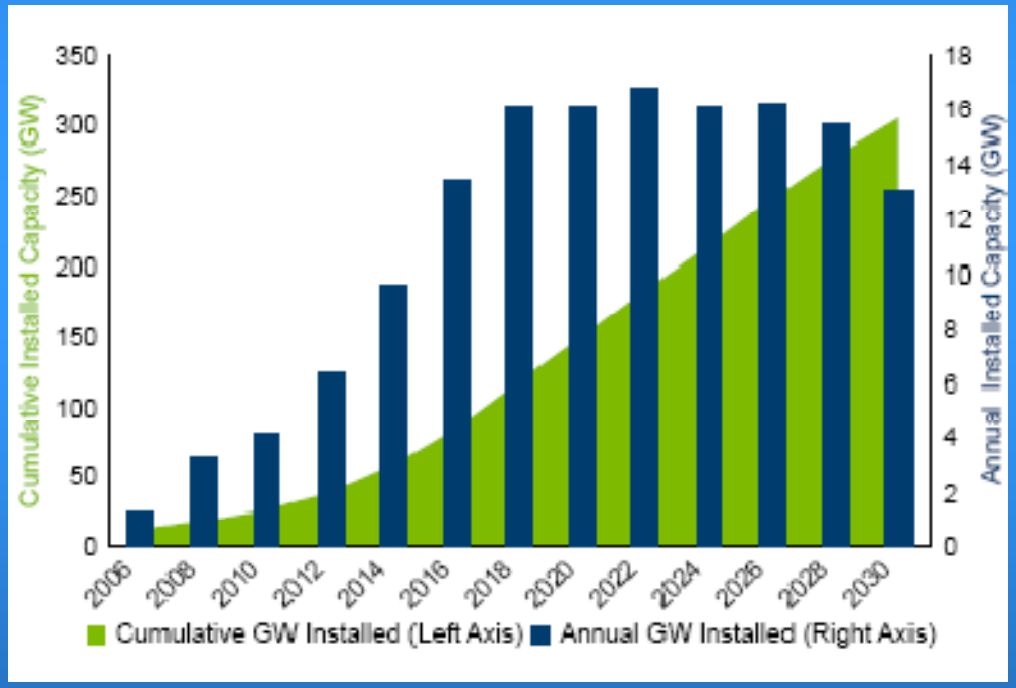
Wind

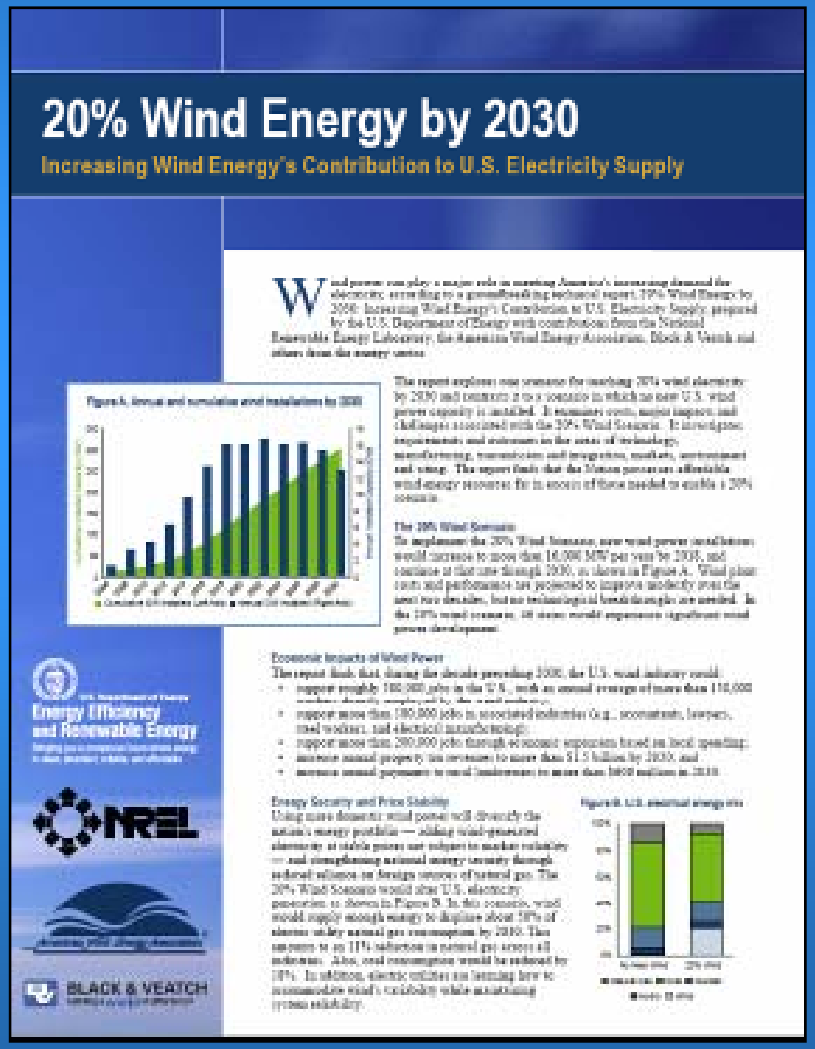
U.S. Installed Wind Energy Capacity



Slide courtesy of Chuck Kutscher, NREL

DOE's Vision: 20% Wind Energy by 2030

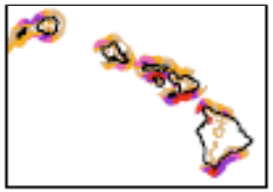


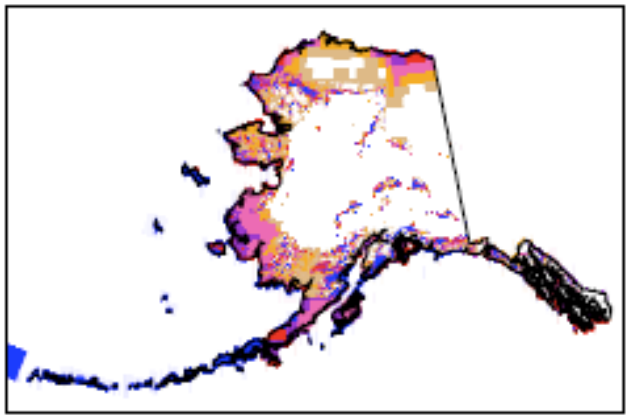


http://www.20percentwind.org/

United States - Wind Resource Map

This map shows the annual average wind power estimates at 50 meters above the surface of the United States. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.





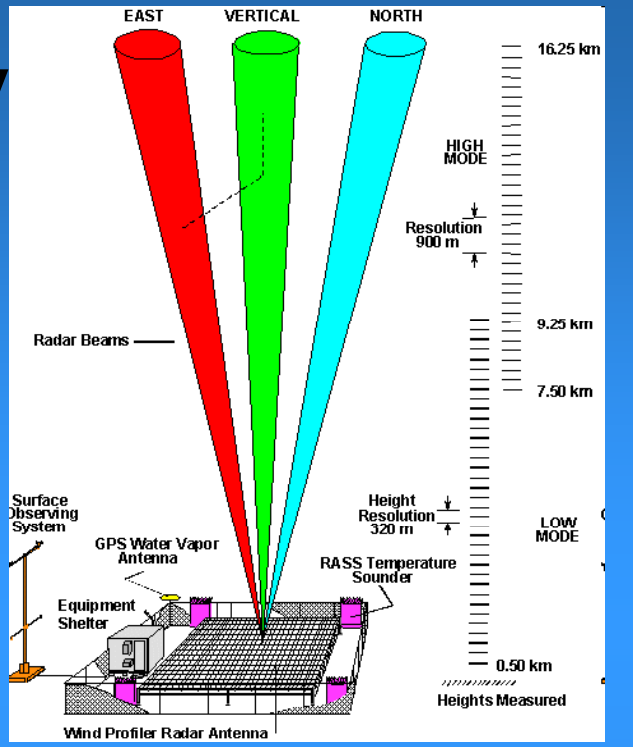
Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

[a] Wind speeds are based on a Weibull k value of 2.0

U.S. Department of Energy
National Renewable Energy Laboratory

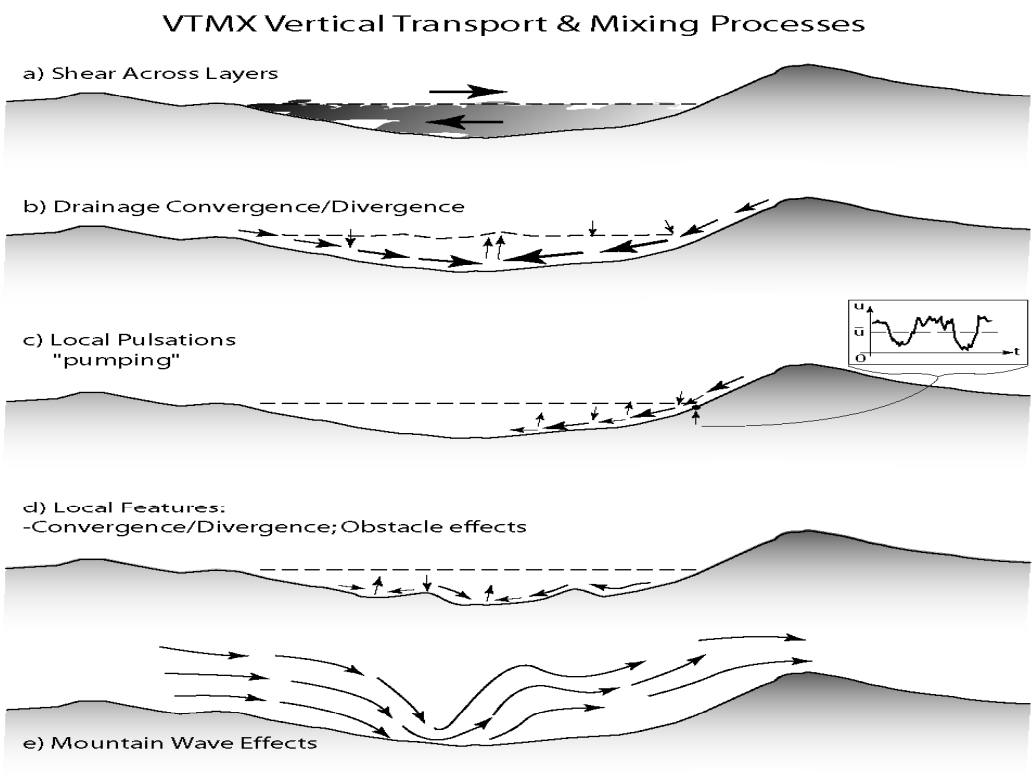
Wind Energy



NOAA Profiler Network

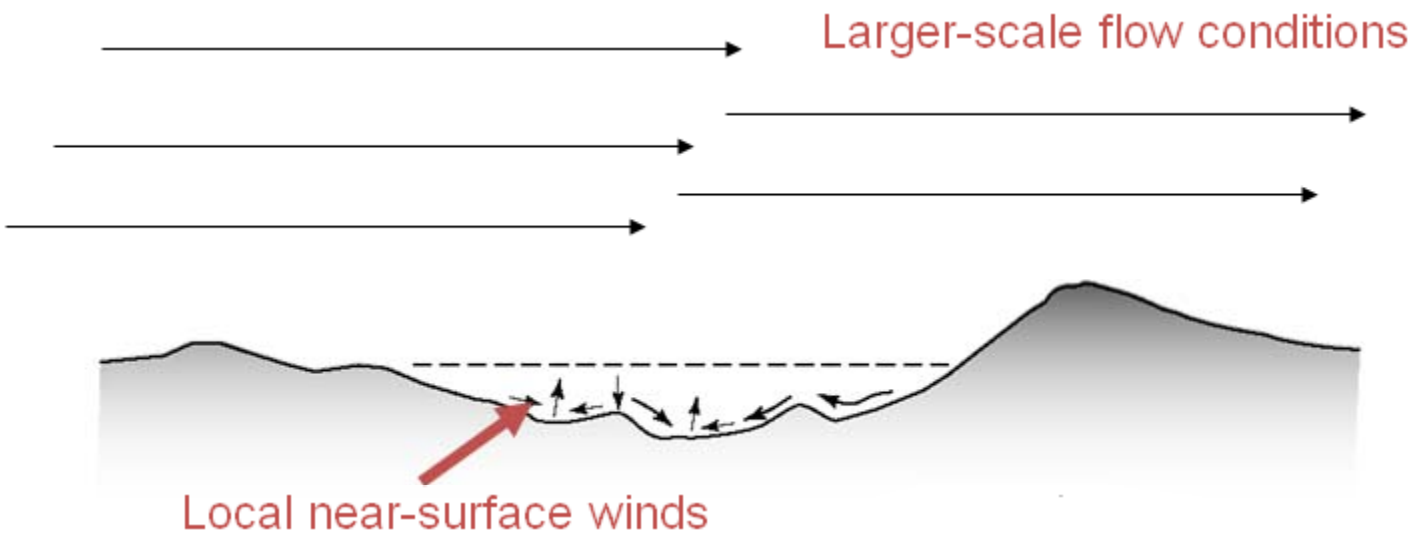
- Relevant observations of wind speed are needed.
- Improved forecasts of wind are needed.

Complex Terrain



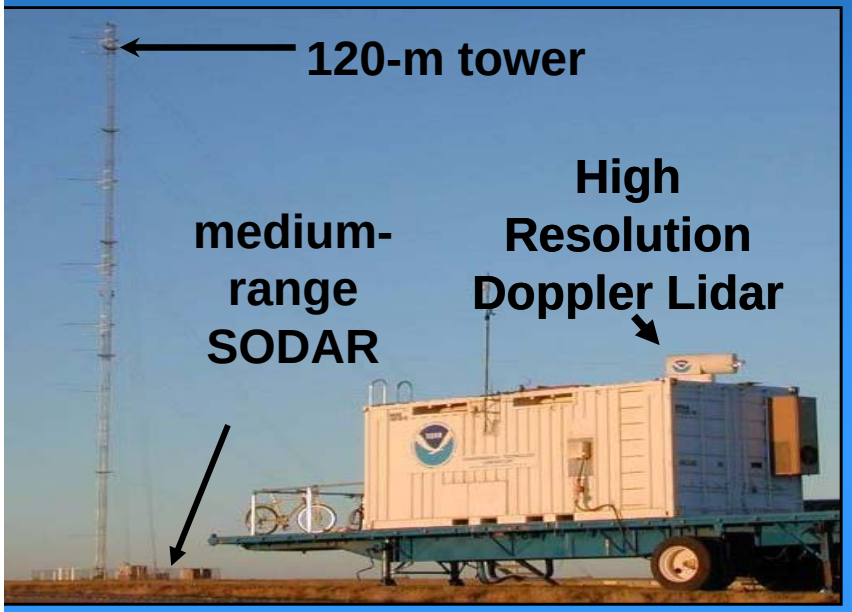
Complex terrain:

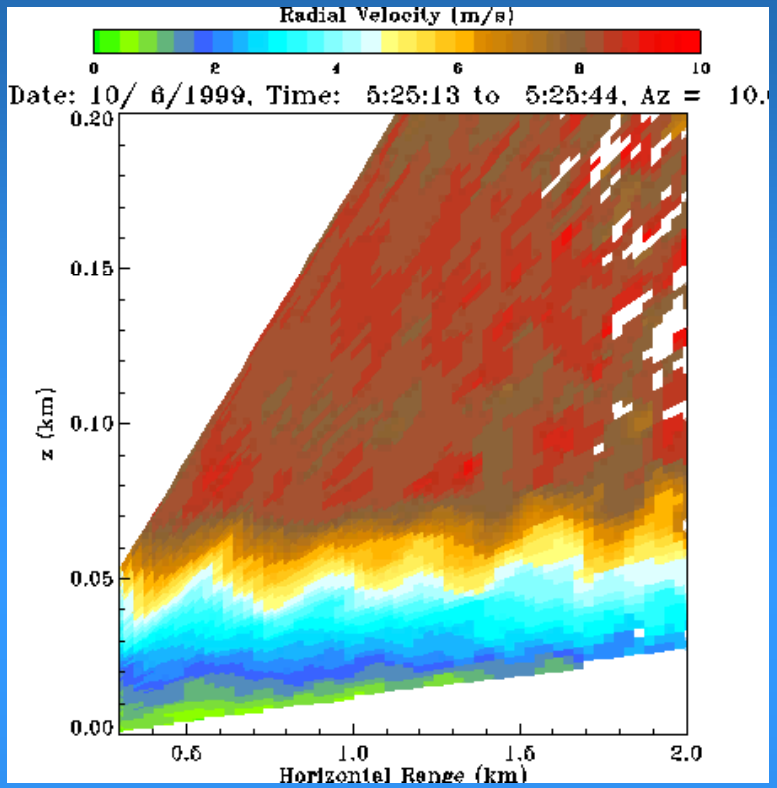
Near-surface winds = interaction between large-scale and topographic effects



Large-scale conditions (wind, temperature, pressure, distributions) addressable using satellite information ??

NOAA has Specialized Instruments for Studying Wind

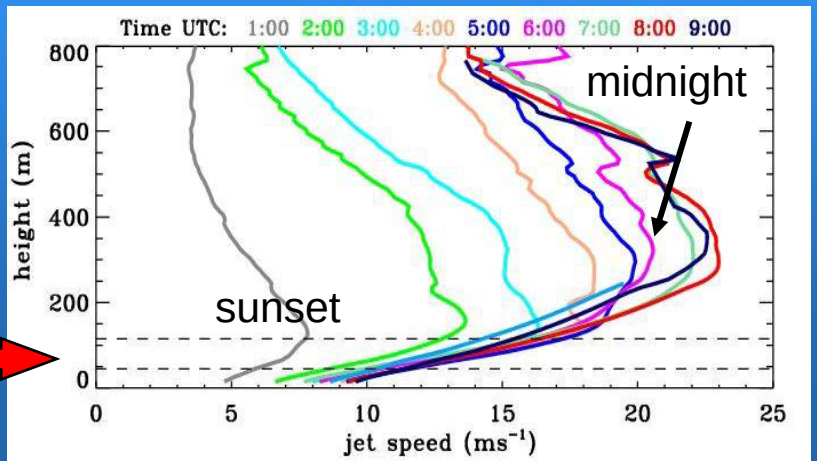




Neil Kelly (NREL) & Bob Banta, Yelena Pichugina (NOAA), Lamar, Sept. 2003. Studied Low-Level Jet.

ESRL could expand and refine this research.

Turbine blades at this height



NOAA - Relevant Issues for Wind

- Insufficient observations of wind at the height of wind turbines (20 -200 m)

- Need improved understanding of:
  - mesoscale processes
  - planetary boundary layer
  - complex terrain effects
  - upwind turbine effects

- Need improved weather forecasts

- Need to explore co-variability of wind power potential across grid, in particular for extremely low and high tails of the distribution

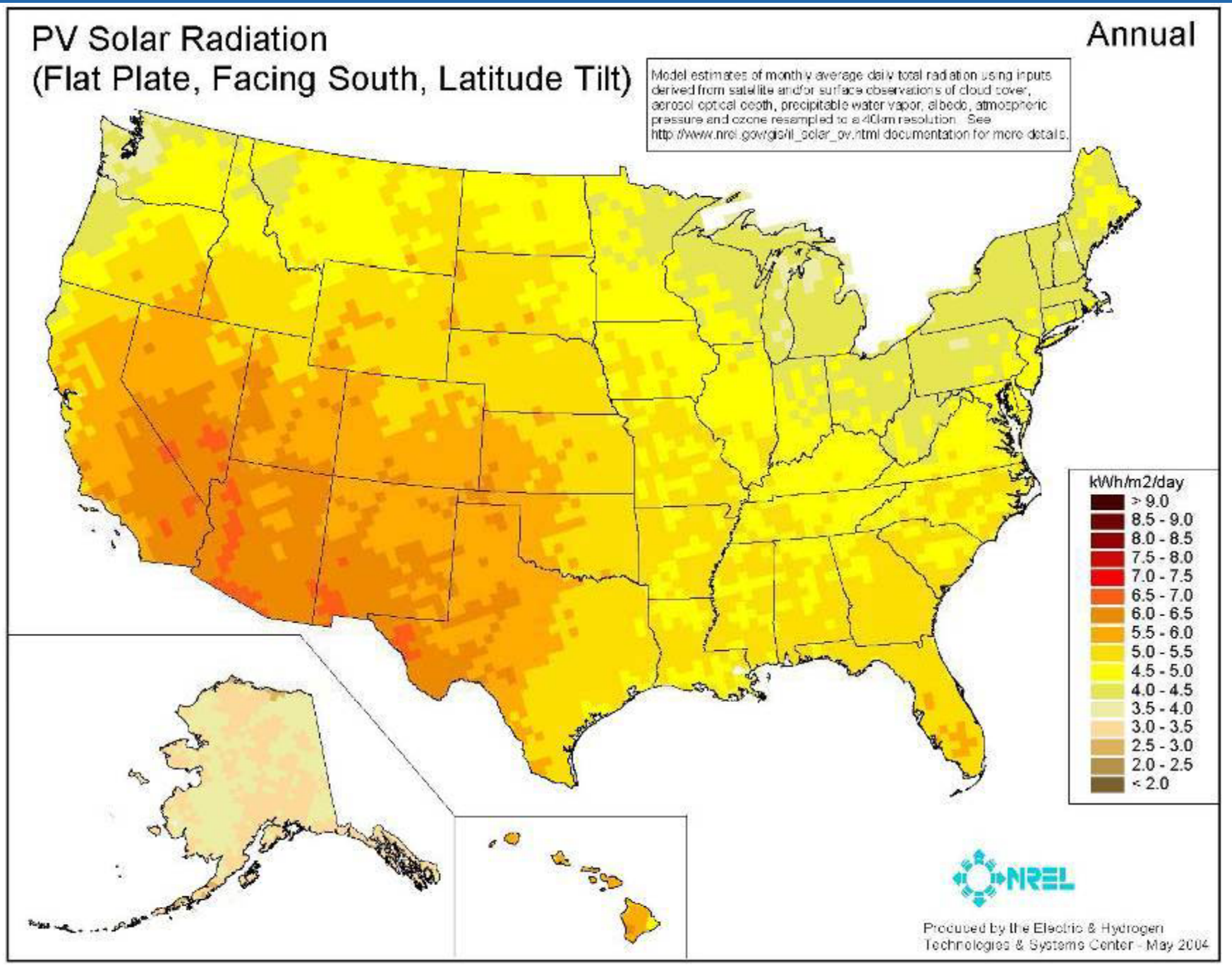
- NOAA holds the expertise to do this work

- To realize CO_2 savings, grid operators must have confidence in wind forecasts to offset fossil fuel plants

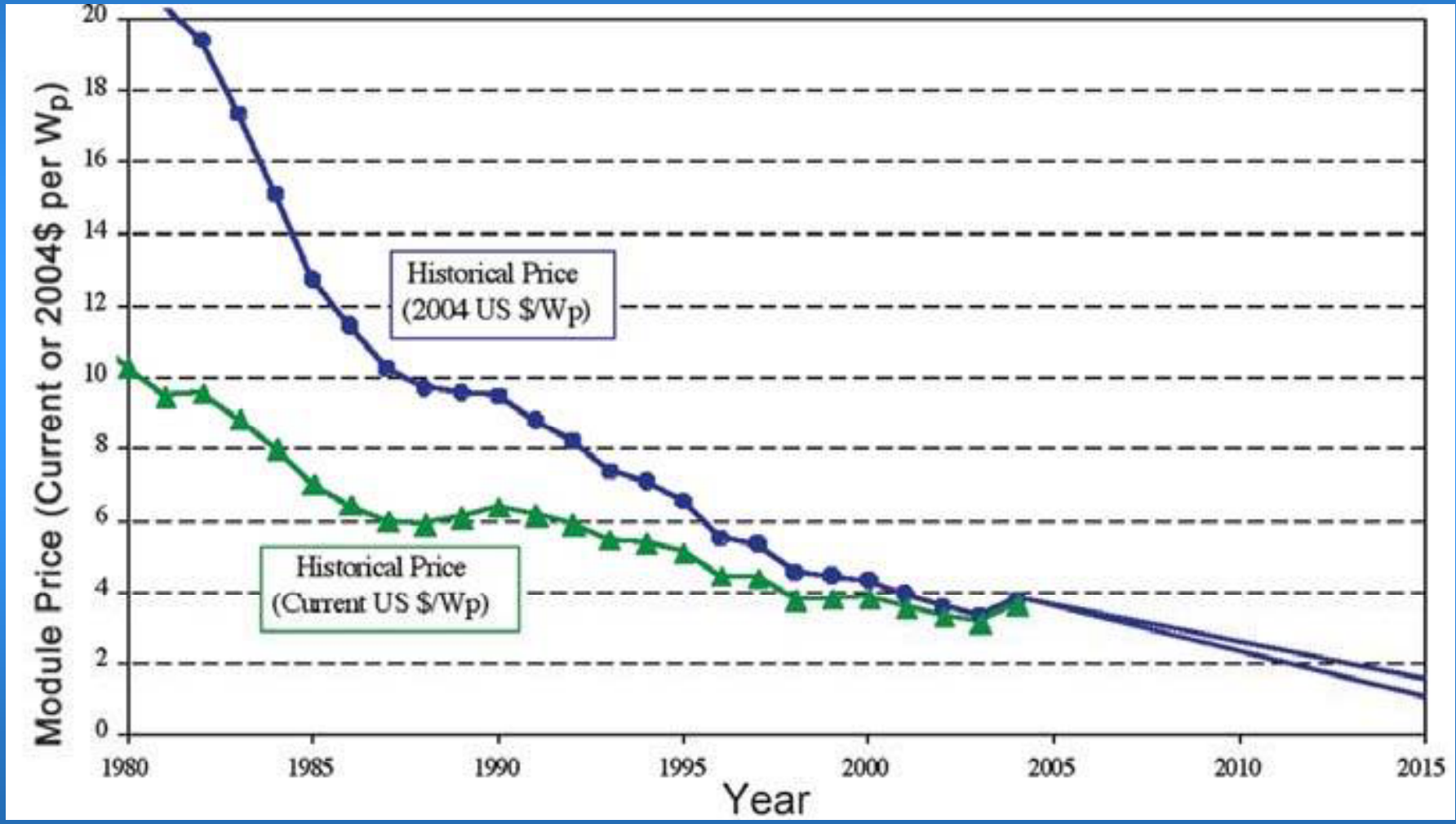
Example Targets of Support NOAA Could Offer for Wind Energy

- Develop 1-km National Weather Models with Hourly Updating as a Backbone to RE Guidance Infrastructure
- Develop wind-energy testbeds to improve fundamental understanding of mesoscale and local flows that have proved critical to wind-energy operations.
- Improve quantitative forecast skill for mesoscale and local flows in NWP models by improving representation of physical processes at wind-turbine heights
- Create a national reference data base with historical and real-time data, the latter including data at the relevant turbine hub height
- Develop and deploy new instruments and observational strategies, and data distribution and visualization tools
- Develop seasonal forecasts products that address regional wind energy potential in the U.S.
- Improve understanding of the impacts of wind farms on the environment, weather and climate across a range of spatial and temporal scales.

Photovoltaics (PV)

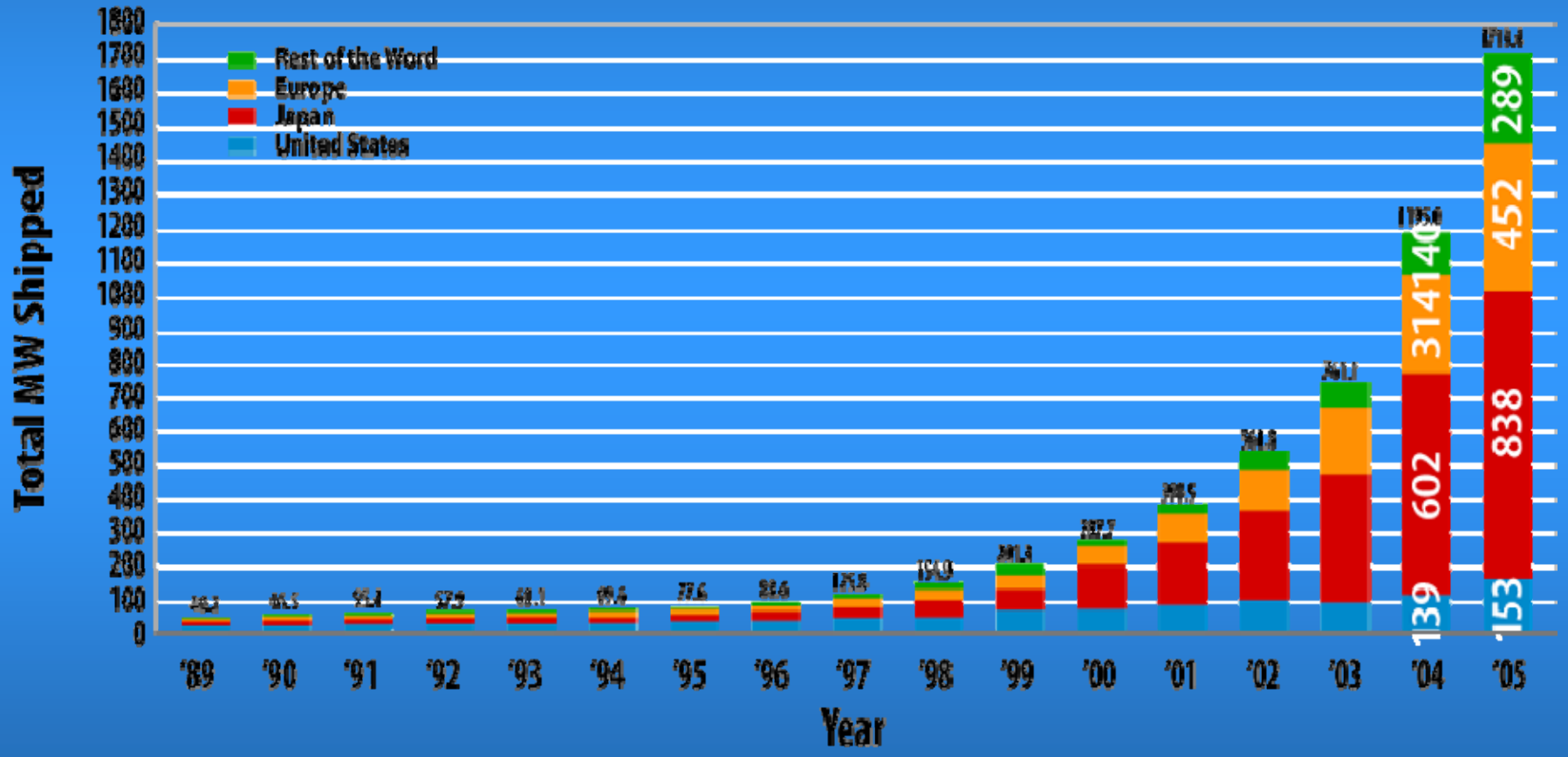

PV Solar Radiation
(Flat Plate, Facing South, Latitude Tilt)
Annual
Model estimates of monthly average daily total radiation using inputs derived from satellite and/or surface observations of cloud cover, aerosol optical depth, precipitable water vapor, albedo, atmospheric pressure and ozone resampled to a 40km resolution. See http://www.nrel.gov/gis/pv_solar_pv.html documentation for more details.
kWh/m2/day
> 9.0
8.5 - 9.0
8.0 - 8.5
7.5 - 8.0
7.0 - 7.5
6.5 - 7.0
6.0 - 6.5
5.5 - 6.0
5.0 - 5.5
4.5 - 5.0
4.0 - 4.5
3.5 - 4.0
3.0 - 3.5
2.5 - 3.0
2.0 - 2.5
< 2.0
NREL
Produced by the Electric & Hydrogen Technologies & Systems Center - May 2004

PV Module Prices



Slide courtesy of Chuck Kutscher, NREL

Worldwide PV Cell Shipments



Slide courtesy of Chuck Kutscher, NREL

Concentrating Solar Power

354 MW Solar Electric Generating Systems (SEGS)

Concentrating Solar Power (CSP): The Other Solar Energy

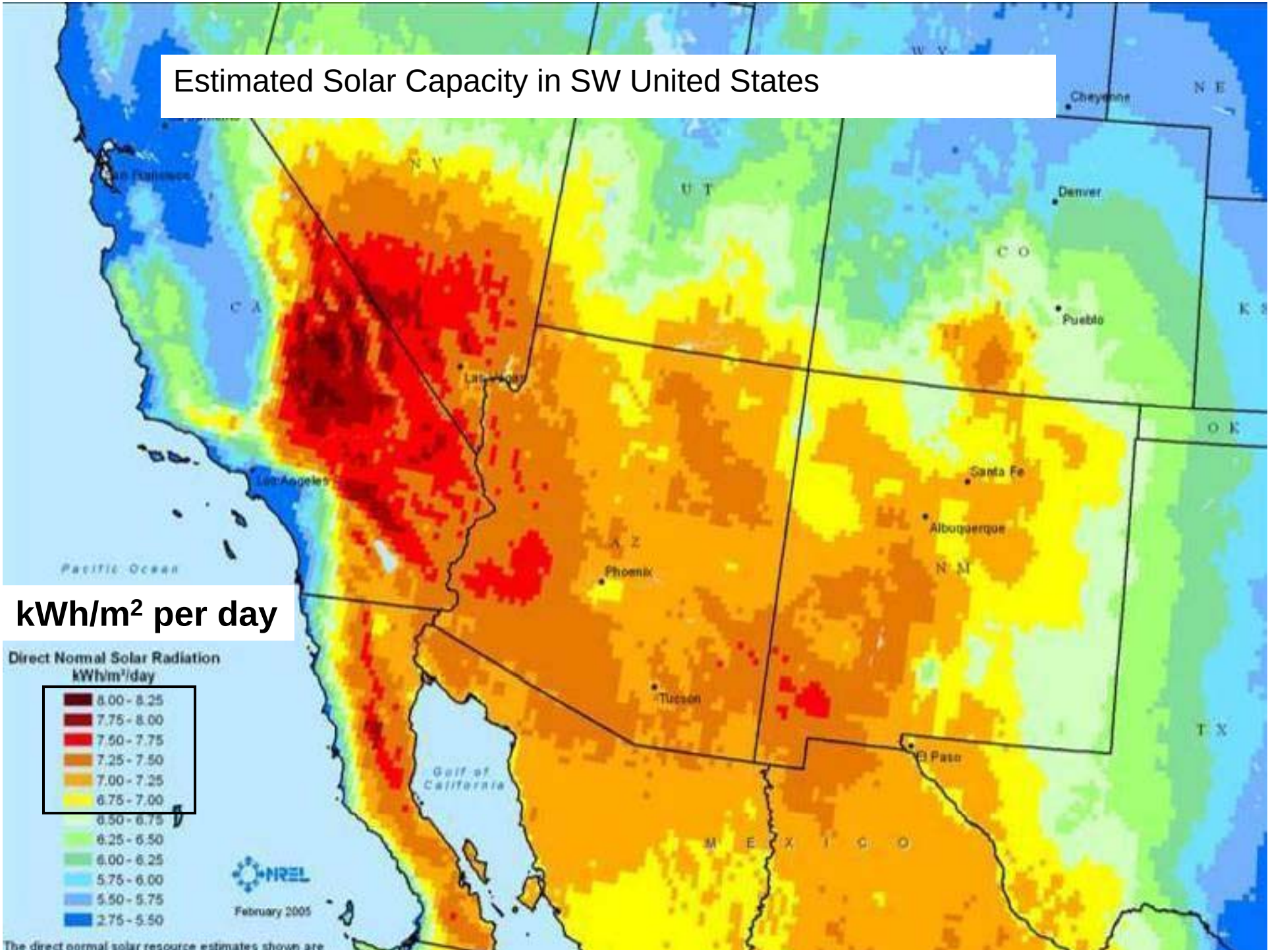
Parabolic trough

Linear Fresnel

Power tower

Dish-Stirling

Estimated Solar Capacity in SW United States

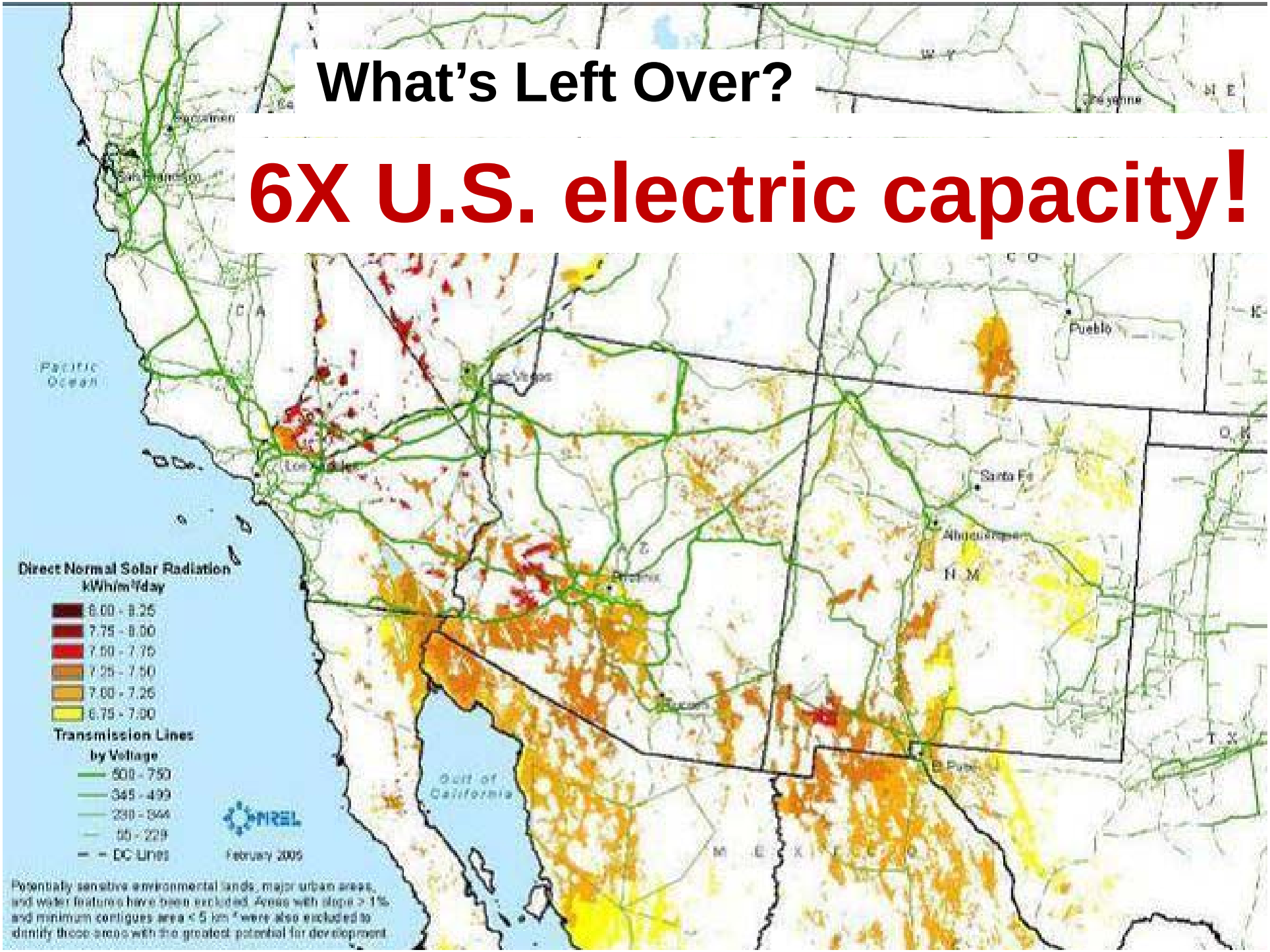


If the Following Areas are Excluded:

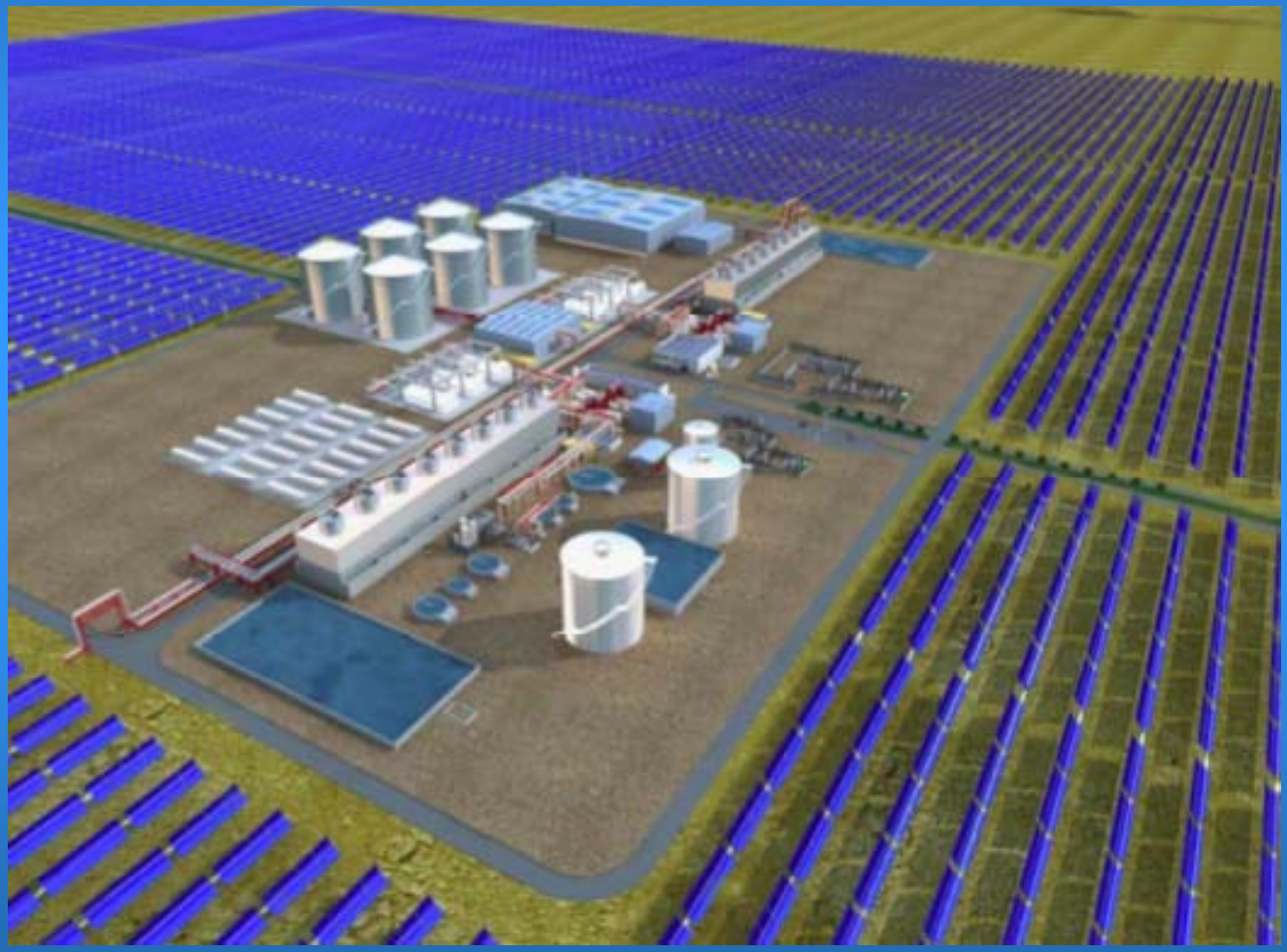
- **Solar < 6.75 kWh/m2 per day**
- **Used and sensitive land**
- **Ground slope > 1%**

What's Left Over?

6X U.S. electric capacity!



Planned 280 MW Solana Plant with 6 hrs Thermal Storage



1500 construction jobs over two years

85 permanent jobs

APS Renewable Energy

(Artist Rendition)

Slide courtesy of Chuck Kutscher, NREL

Solar Energy

Photovoltaics

Concentrating Solar Power

- Few observations of solar radiation. Fewer of direct beam component.
- More observations are needed.
- Improved forecasts of clouds and aerosols are needed.

Photos courtesy of NREL, Dave Mooney, Chuck Kutscher.

Current Solar Capabilities

SURFRAD

Seven CONUS background surface sites measuring solar diffuse, direct, and total irradiance as well as surface reflectivity.

8 Global background sites

Run by the ESRL-GMD-Radiation group, measure downward solar diffuse, direct, and total first 8 sites listed). One-minute averages. Unedited data available next day edited within 2 weeks.

Climate Reference Network (CRN)

Run by NESDIS/NCDC, measures total downwelling solar irradiance (spectrally restricted to silicon detector range); 5-minute resolution at about 140 sites in CONUS with additional sites outside CONUS; in near real time (up to one hour delay).

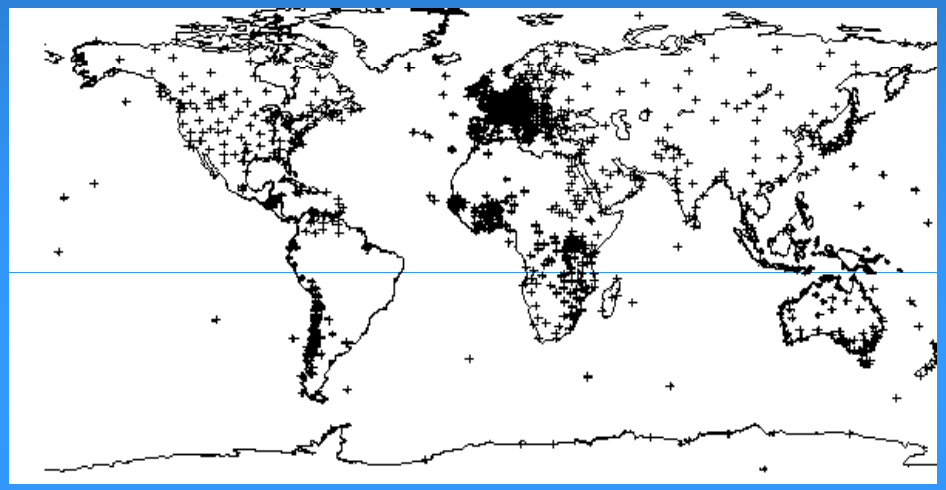
NESDIS GOE Surface and Insolation Product (GSIP)

GSIP has provided operationally-retrieved total surface solar radiation from GOES for the contiguous US (CONUS) since July 2000. The retrievals are every hour on a spatial resolution of 0.5 x 0.5 degrees (~50 km). A higher spatial resolution version of the above product, the full-disk GSIP (GSIP-fd), is expected to become operational in May 2009ISIS is a network of eight CONUS urban sites, operated by ESRL GMD and measures downward solar diffuse, direct and total irradiance; three-minute resolution. Not currently funded.

NOAA National Climatic Data Center (NCDC)

The NCDC accepts and distributes a variety of surface solar radiation observational data from all (including non-NOAA) US sources.

Solar Networks

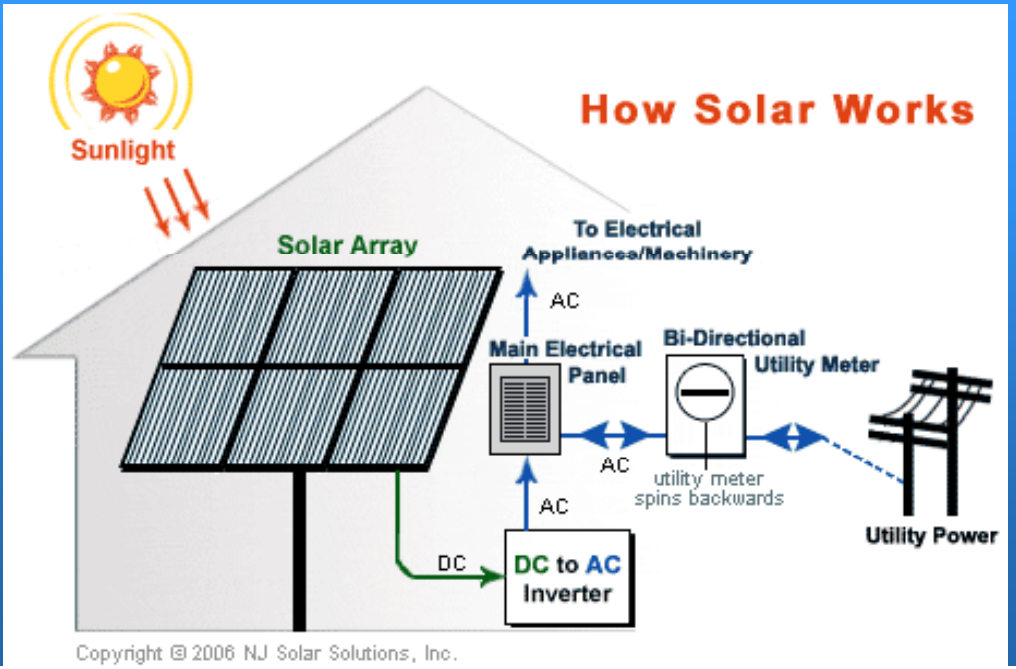


Surface solar radiation sites between 1964 and 1993. By 1993 most U.S. sites were inactive.
Reviving these U.S. sites quickly would be very helpful for supporting solar energy development.

NOAA solar network sites supported as of 2008. The new Surface Radiation Budget network started in 1995 with three sites.

NOAA-Relevant Issues for PV and CSP

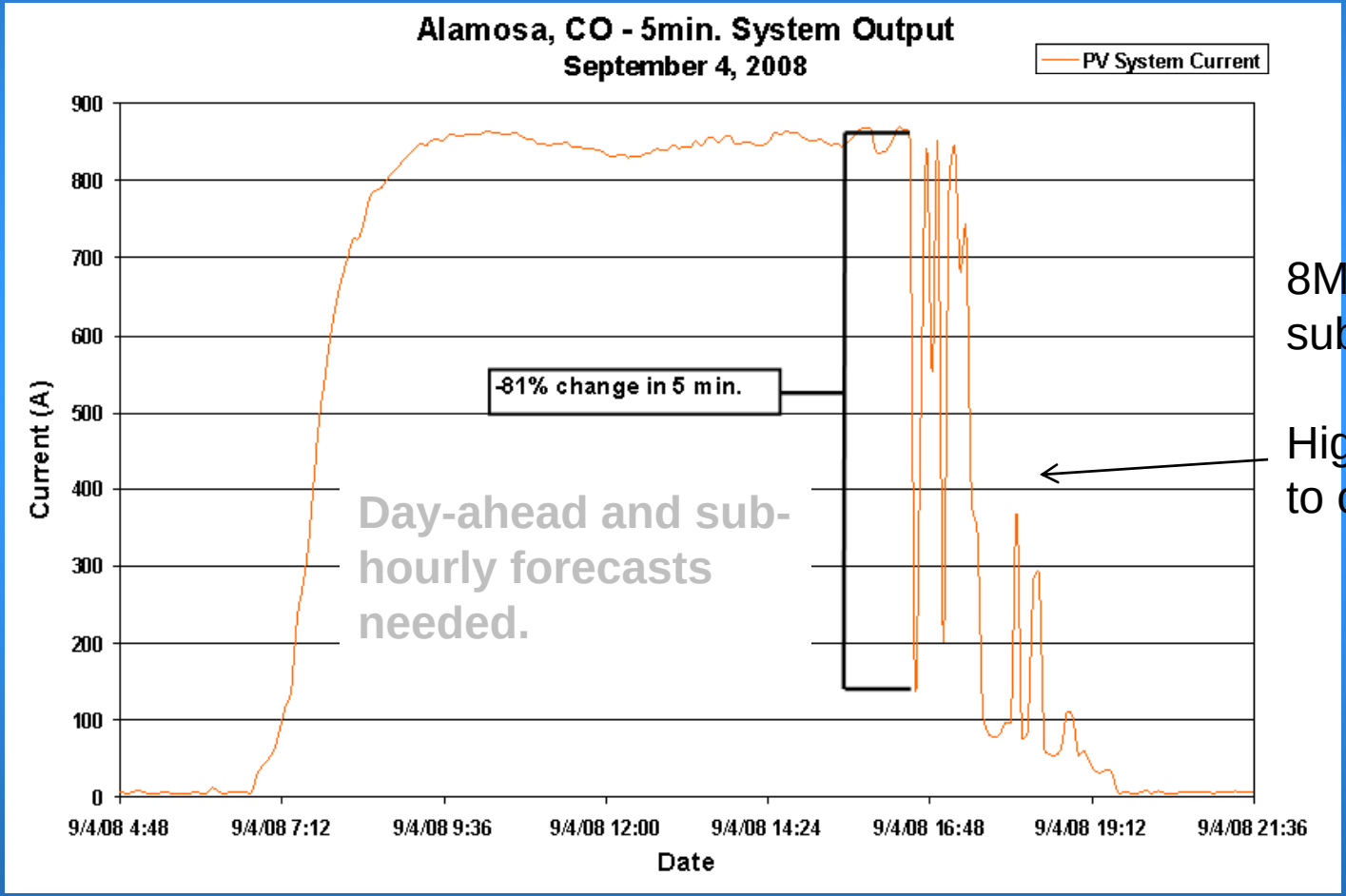
- Insufficient observations of solar radiation (direct and total)
- Need improved forecasts across a range of time scales of sun (clouds & aerosols) to help integrate CSP into grid (balance supply with demand)
- Need to know co-variability of wind and solar energy
- NOAA has the expertise to do this work



Solar Industry Requirements

- Both direct (for CSP) and total irradiance measurements required
- Data for spectral as well as broadband devices are needed
- Aerosol optical depth is important for CSP (0.10 AOD is considered clean, but this is still a 10% loss of direct beam energy for high sun)
- Space and time resolution (1/2-hour data from GOES may not suffice; extreme is needed for 1-sec sampling with 100-m resolution for PV arrays)
- Accuracy (Consider an investment if return were estimated at 10% with uncertainty of 10%; a lot of marginal data exist)

Example of the Need for Improved Weather Forecasts



8MW connected to substation

High Variability due to clouds

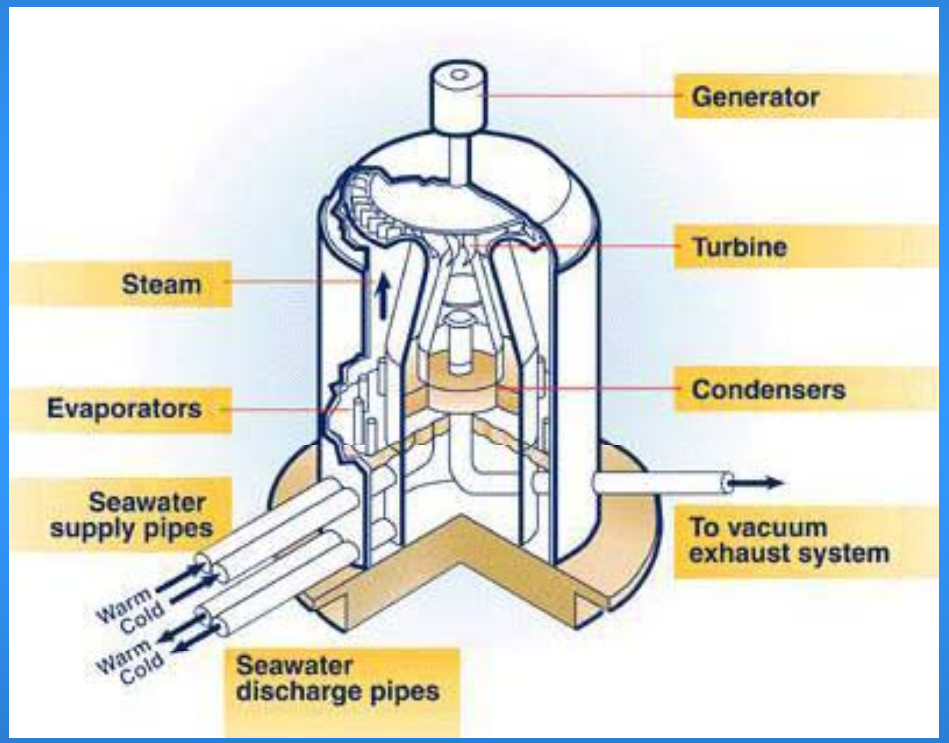
Slide courtesy of NREL, Dave Mooney

Examples for Support NOAA Could Offer for Solar Energy

- Acquire enhanced solar observational database (total and direct) to help evaluate current and future solar resource for spatial and temporal variability.
- Solar testbeds and observations network.
- Enhance ability to infer direct solar radiation at the surface from satellite data using these validation datasets.
- Improve cloud forecasts in models and fundamental understanding of clouds, including improved assimilation of cloud observations in NWP models.
- Develop and validate surface solar radiation forecast products (direct and total).
- Assimilate current aerosol and albedo data into forecast models.
- Develop seasonal forecasts products that address regional solar energy potential in the U.S.
- Develop data distribution and visualization tools.
- Improve understanding of the impacts of CSP farms on the environment, weather and climate across a range of spatial and temporal scales.

Possible Ocean Energy in Future

Hydrokinetics (wave, currents, tides)



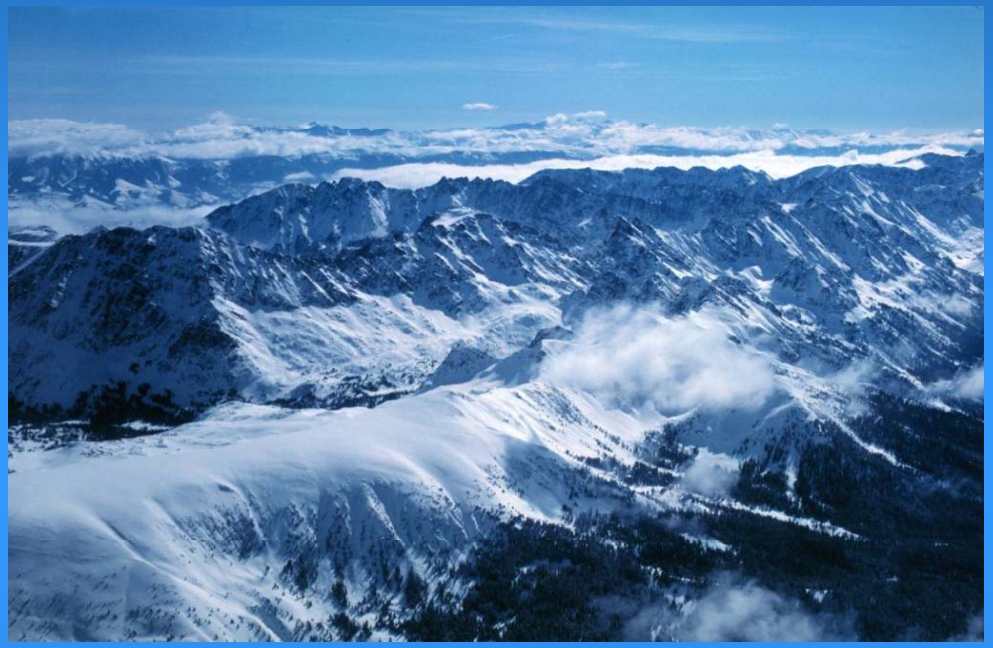
Ocean Thermal Energy Conversion

Diagram courtesy of NREL

Water Issues

- Hydropower makes up majority of current renewable energy.
- Must consider need for water in production of energy.

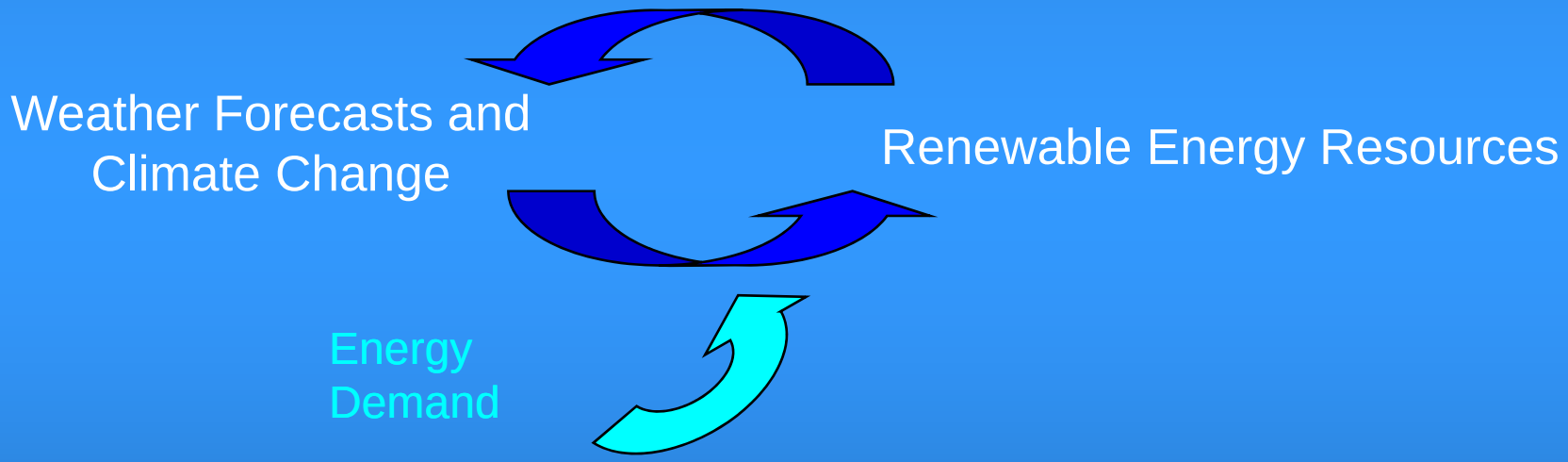
Environmental Factors



Climate Issues

Ecosystems Impacts

NOAA's Capabilities to Advance Renewable Energy: Improve understanding of Climate Issues



Reciprocal Relationship of RE and Climate

- Improving understanding of climatic variability of RE resources (wind, solar, precipitation) using historical data.
- Improving understanding of remote forcing mechanisms, such as ENSO, PDO, AMO, etc., and whether they are linked to climatic variability of RE resources.
- Determining if climate models have skill at addressing long term projections of RE resources, and recommending potential model improvements that would yield higher accuracy at simulating RE resources.
- Assessing skill of weather models at forecasting RE resources out to Week-Two time scales.

Climate and RE continued

- Assessing the ability of climate models (e.g. CFS) to be skillful at simulating and predicting RE resources over seasonal time scales, in conjunction with our understanding of the impact of remote forcing mechanisms such as ENSO.
- Assessing the impacts of deploying of massive RE projects on a national or regional basis.
- Developing and testing of better model physical parameterization schemes for weather and climate models, especially their representation of PBL structure and clouds.
- Providing information about future impacts of climate change on renewable energy systems, to optimize the operational effectiveness of these energy production systems.

20% Wind Energy by 2030: Economic Benefits

- Report finds that, during the decade preceding 2030, the U.S. wind industry would create many good jobs.
- Support ~ 500,000 jobs in the U.S.
  - >150,000 workers employed directly by wind industry
  - >100,000 jobs in associated industries, e.g., accountants, lawyers, steel workers, electrical manufacturing
  - >200,000 jobs through economic expansion based on local spending;
  - Increase annual property tax revenues to more than $1.5 billion by 2030
  - Increase annual payments to rural landowners to > $600 million in 2030.

NOAA's Mission

To understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental needs.

Multiple Federal Agencies Will Have to Cooperate to Solve the Energy-Climate-Economic Crisis

- **Department of Energy**
- **Environmental Protection Agency**
- **Federal Energy Regulatory Commission**
- **Department of the Interior**
- **U.S.G.S**
- **NOAA's mission is to *predict and understand changes in Earth's environment* and conserve and manage coastal and marine resources to *meet our nation's economic, social and environmental needs*.**

Summary of Opportunities

NOAA could provide the missing observations, weather forecasts & climate inform that are required to allow for large amounts of renewable energy to be incorporated into the U.S. energy system.

Cooperative Agreement between NOAA ESRL & NREL

Seminar brings us into contact with private companies, universities, and others in renewable energy.

Letter of Intent

Sandy MacDonald, Director of NOAA ESRL;

Andy Karsner, DOE DUS for Renewable Energy;

Dan Arvizu, CEO of NREL.
July 31, 2008.

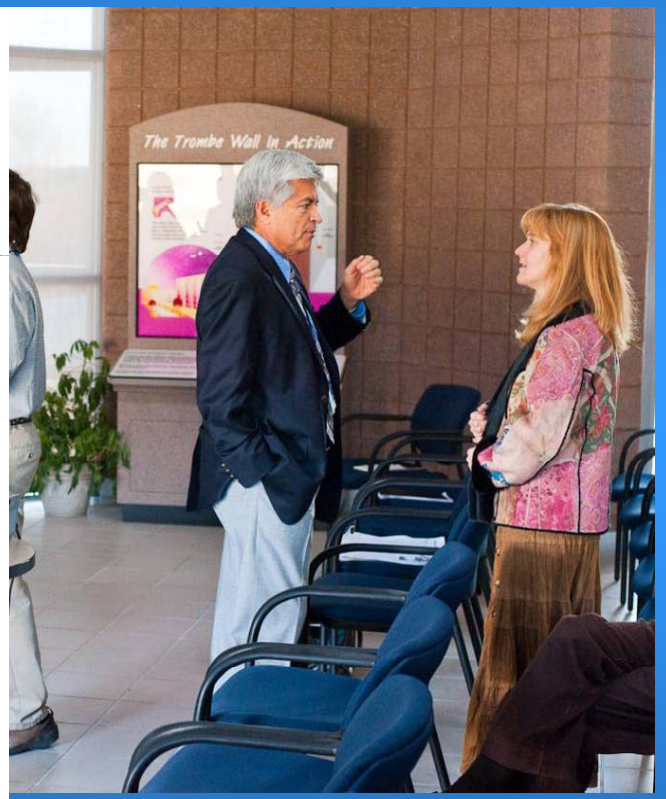
Monthly seminar hosted by NOAA ESRL
and DOE NREL

"Sustainable Energy and Atmospheric Sciences"

Diverse audience, e.g., academia, private industry, public

June 16 seminar will address SmartGrid technology

Let me know if you would like to be added to our seminar email list



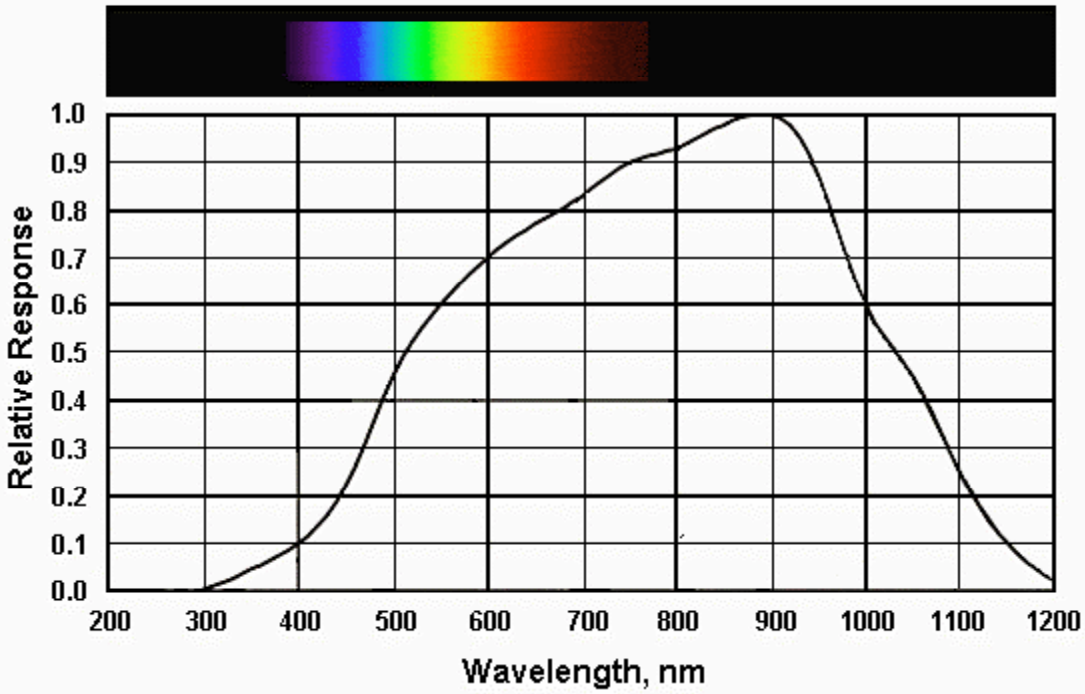
Feb. 2 SEAS seminar at NREL:
NREL Director Dan Arvizu and Melinda Marquis

www.esrl.noaa.gov/research/events/seas

Thank you

- For more info, see:
  www.esrl.noaa.gov/research/renewable_energy/
- Monthly Sustainable Energy and Atmospheric Sciences seminar, co-hosted by DOE NREL and NOAA ESRL
  www.esrl.noaa.gov/research/events/seas/

Back-Up Slides



Typical Silicon Photodiode Spectral Response

1. **Solar Data Archives and Monitoring Network (1976-1982)**

The need for improved solar and meteorological data in response to the 1973 oil embargo, resulted in the joint effort by DOE (then ERDA) and NOAA to rehabilitate available historical data and address the development of a national Solar Monitoring Network. ERDA/DOE, NOAA, academia, and industry worked jointly during this period to produce the SOLMET data archive based primarily on models that produced hourly solar irradiances from cloud observations at NWS stations. In 1976, DOE also provided funding to re-instrument the solar monitoring network (I recall funding was at the $1M level). Beginning in 1978, DOE/SERI staff worked closely with NOAA staff in Boulder (then assigned to Global Monitoring for Climatic Change - GMCC) to characterize radiometers, develop procedures for the operation and maintenance of the new 38-station network, assess the measured data for quality, develop improved methods for estimating solar resources from surface meteorological observations, and archive the resulting data at NOAA's National Climatic Data Center. This effort produced the SOLMET data base with hourly solar and meteorological data from 1952-1975 for 248 locations in the U.S. These data supported renewable energy R&D and technology deployment for several years. Measurements of solar irradiance from the 38-station network gradually stopped from the majority of stations in about 1982 after funding was eliminated in 1980 and the network operations began to degrade due to lack of maintenance. To this day, the solar irradiance data from the 38-station "New NOAA Network" remain as the best national spatial coverage of measured solar and meteorological information available for renewable energy R&D.

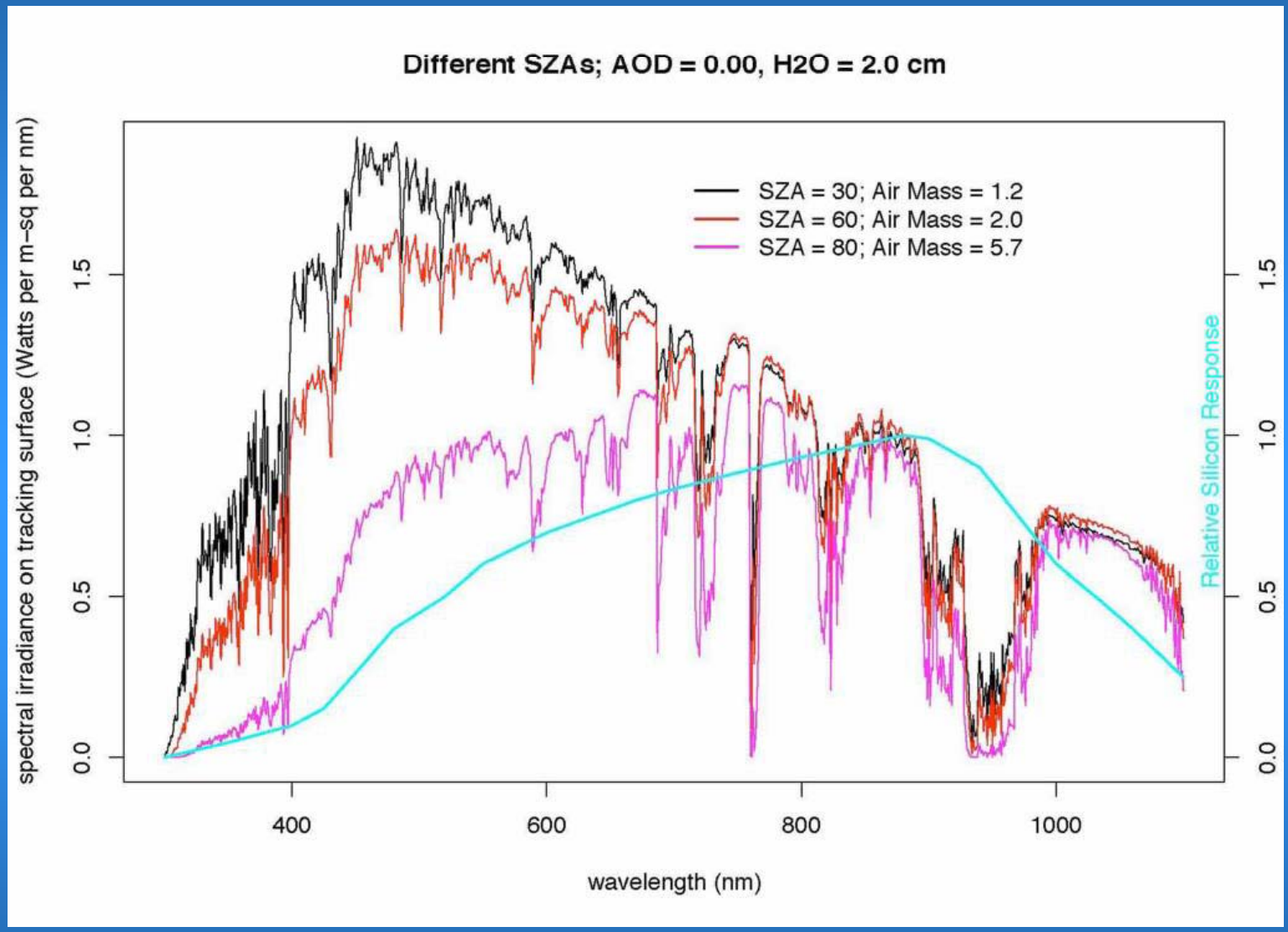
2. **National Solar Atlas (1981)**

Based on the above "rehabilitated" SOLMET data, several data products were made by NOAA and SERI to provide policy makers, developers, engineers, and scientists with useful summary information about the spatial and temporal distributions of solar resources. The *Solar Radiation Energy Resource Atlas of the United States* (SERI/SP-642-1037) is one example.

Continued, informal collaborations with NOAA/GMCC, NOAA/CMDL and now NOAA/GMD have helped us to produce several improved versions of this information. See http://www.nrel.gov/gis for examples of our Geographic Information System (GIS) products.

3. **National Solar Radiation Database (1961-1990) and Update (1991-2005)**

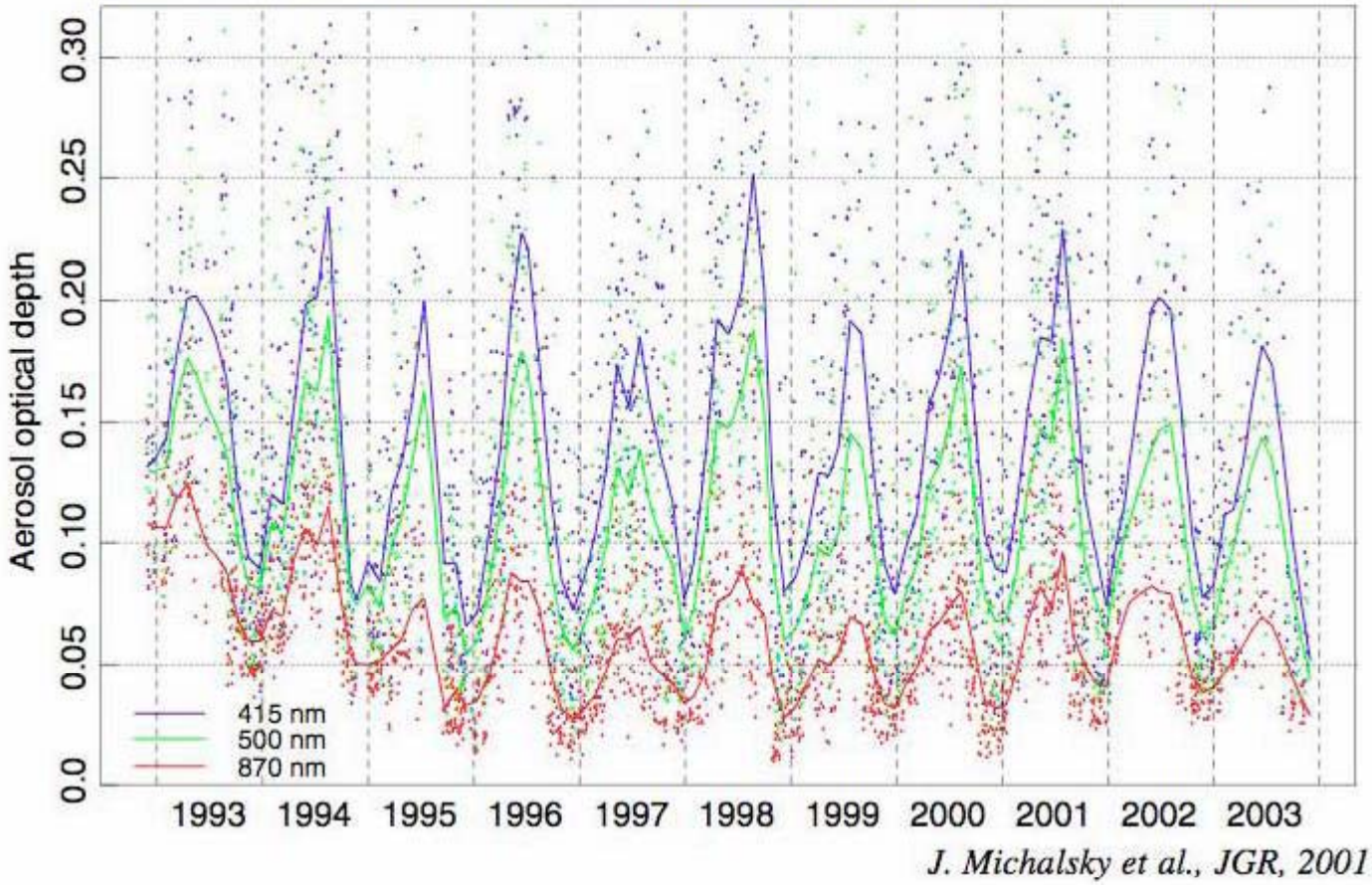
The need continues for high-quality solar and meteorological data to support renewable energy R&D and deployment. Since 1995, NREL and NOAA have produced two editions of the National Solar Radiation Database (NSRDB) to meet the needs for information with greater spatial and temporal resolution. The full NSRDB data files are available from the National Climatic Data Center. Steve Wilcox lead the NSRDB project team and more information about this work is available from our Renewable Resource Data Center at http://rredc.nrel.gov/rredc/solar_data.html.


Different SZAs; AOD = 0.00, H2O = 2.0 cm
SZA = 30; Air Mass = 1.2
SZA = 60; Air Mass = 2.0
SZA = 80; Air Mass = 5.7
spectral irradiance on tracking surface (Watts per m−sq per nm)
Relative Silicon Response
wavelength (nm)
0.0
0.5
1.0
1.5
400
600
800
1000

AEROSOL OPTICAL DEPTH

Determined by sunphotometry

North central Oklahoma - Daily average at three wavelengths

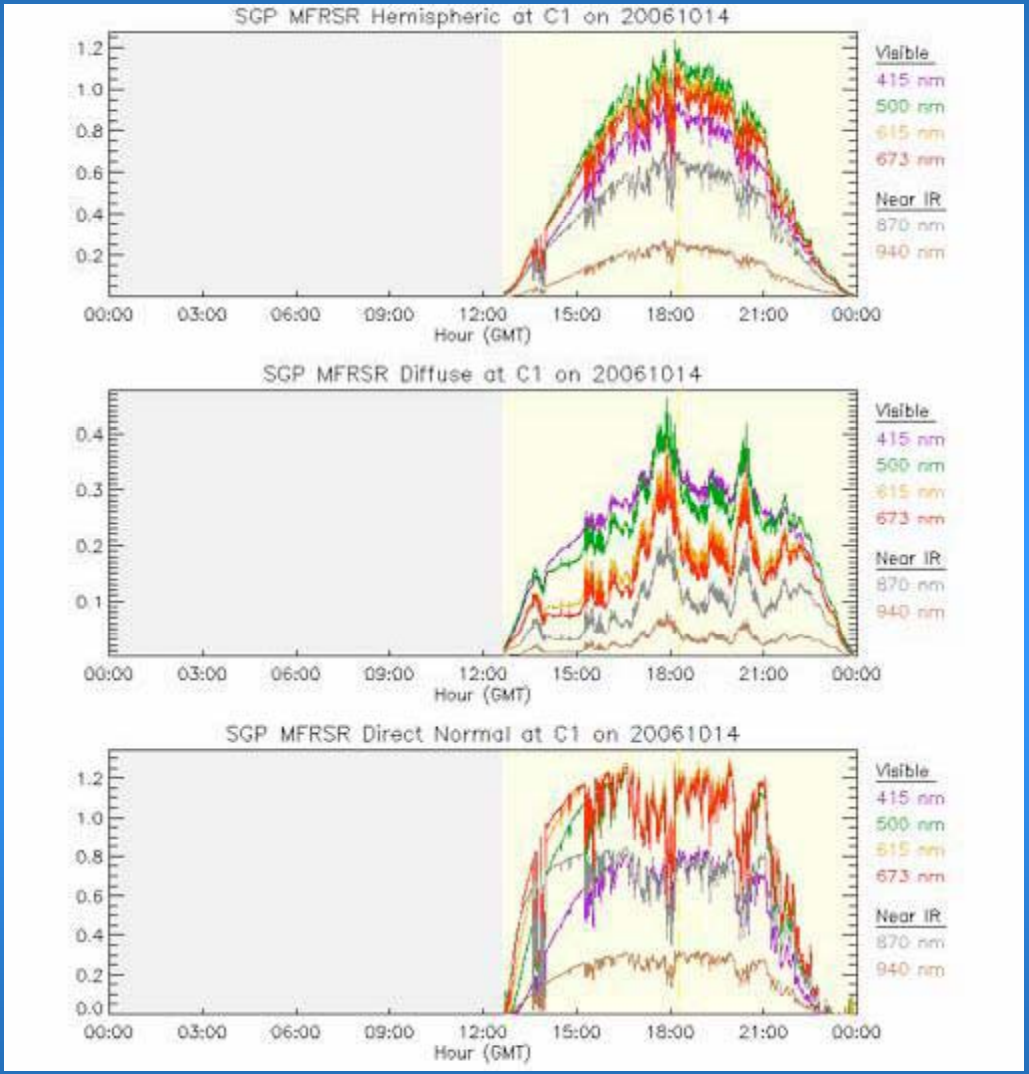


J. Michalsky et al., JGR, 2001

CIRRUS

Total and Diffuse on Horizontal

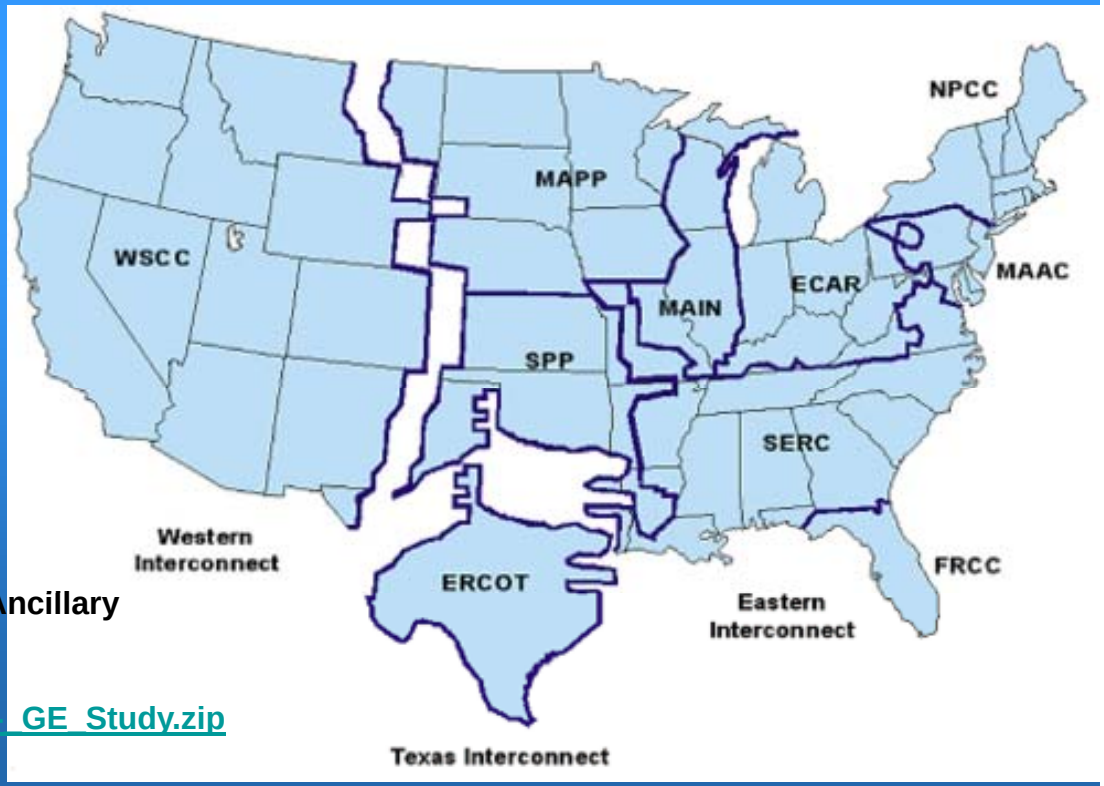
Direct Normal



Impacts of Wind Forecasts on Electricity Generation

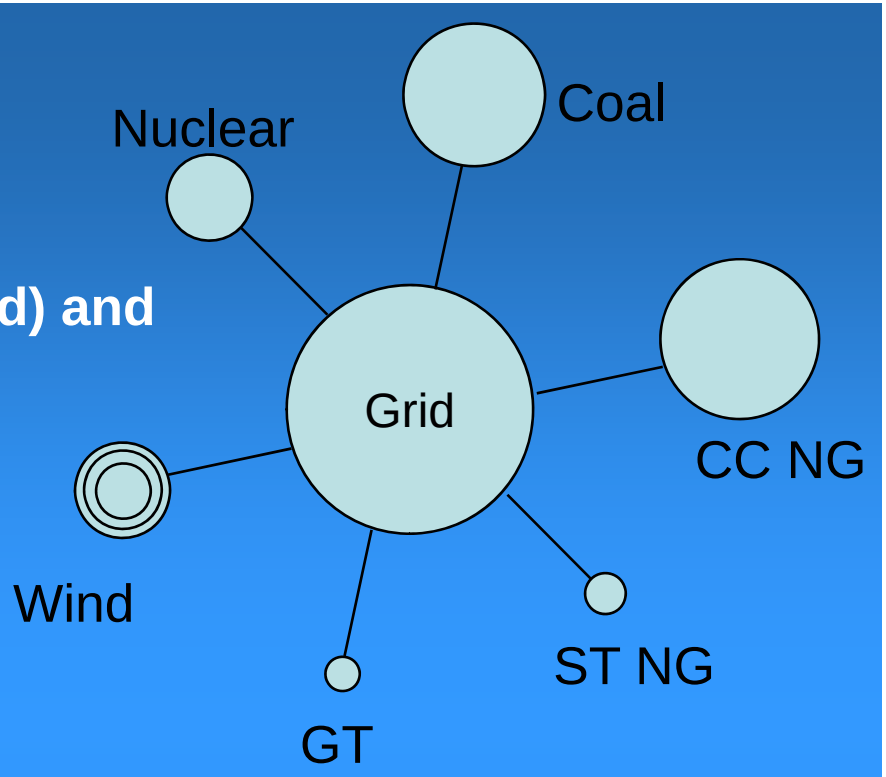
Can one estimate the energy, dollar, & carbon value of improved atmospheric and oceanic info for renewable energy?

- GE Study for the ERCOT (2008)[1]
- GE Analysis "Impact of Wind Forecasting", Gary Jordan, Utility Wind Integration Group presentation, October, 2008



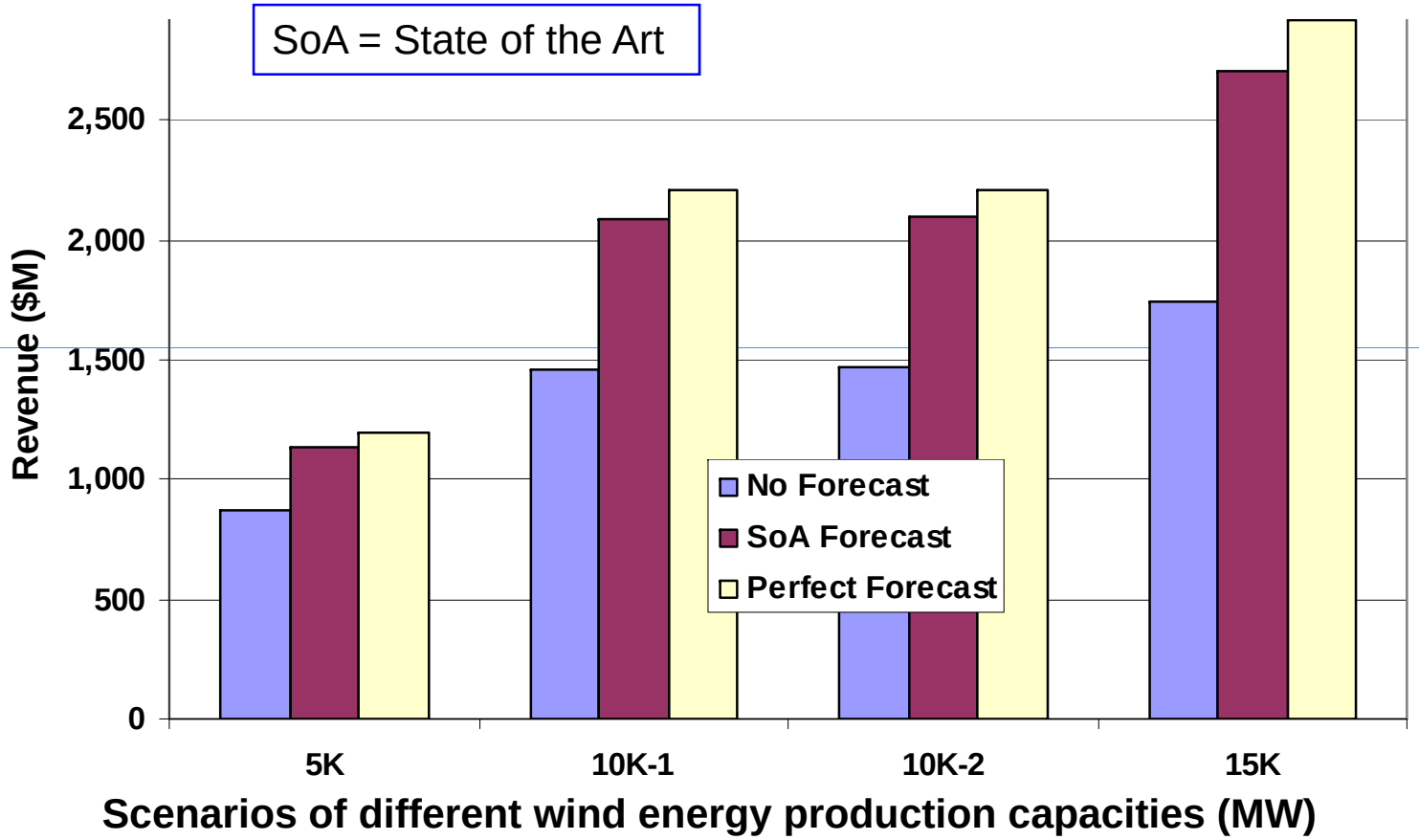
[1]"Analysis of Wind Generation Impact on ERCOT Ancillary Services Requirements" (March, 2008) Available: http://www.ercot.com/news/presentations/2008/Wind_Generation_Impact_on_Ancillary_Services_-_GE_Study.zip

Issues



- Grid operators keep demand (load) and generation closely balanced
- Balancing is done by
  1) reducing output levels from plants, or
  2) shutting plants off
- Plants operating at reduced capacity are less efficient (~30 % lower efficiency for CC, 15 % for coal)
- Because of start-up costs, don't want to turn off plants for short periods of time:
  - Nuclear: weeks
  - Coal and Steam Gas: 24 h,
  - Combined Cycle: 8 h,
  - Gas Turbine: minutes.

Wind Generation Revenue ($M)



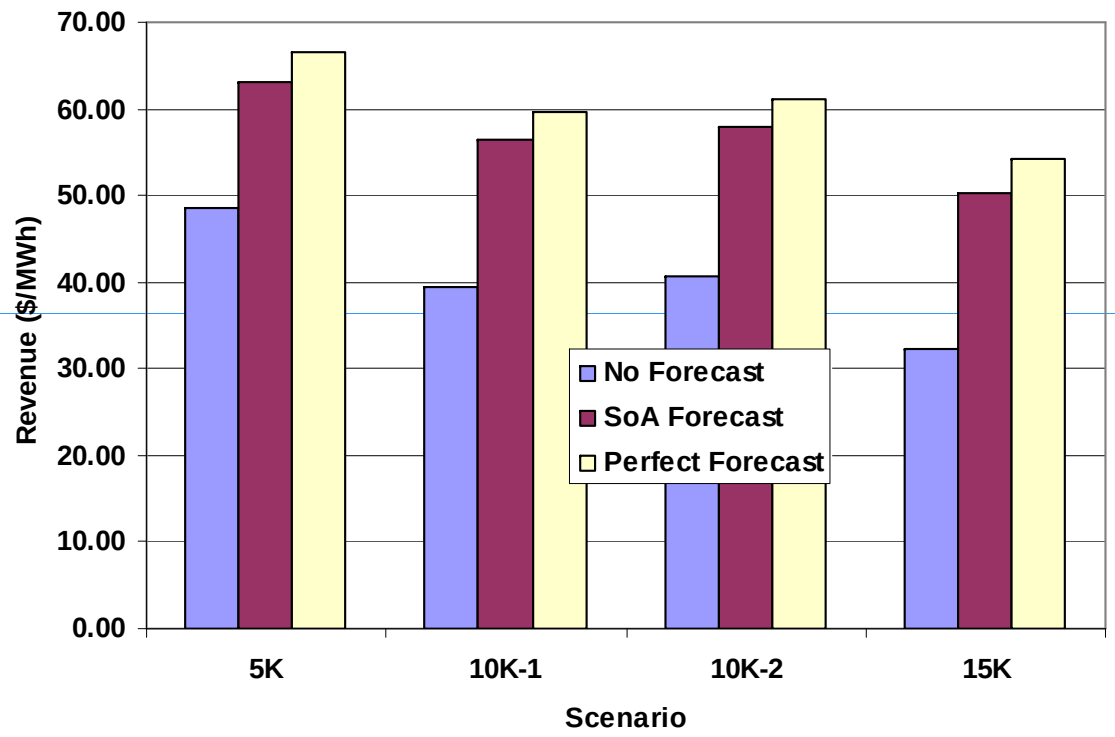
The impact of wind forecasting on electricity production in a study by General Electric for ERCOT.

On the x-axis are shown several scenarios of different wind energy production capacities that range from the present 5K MW to 15,000 MW of wind capacity (~17% penetration). There are two 10,000 MW scenarios, one (1) in the Texas Panhandle and the other (2) in South Texas near the Gulf of Mexico.

Gary Jordan, GE ERCOT Study

Impact of Forecasting on Wind Generation

Revenue ($/MWh of wind energy)

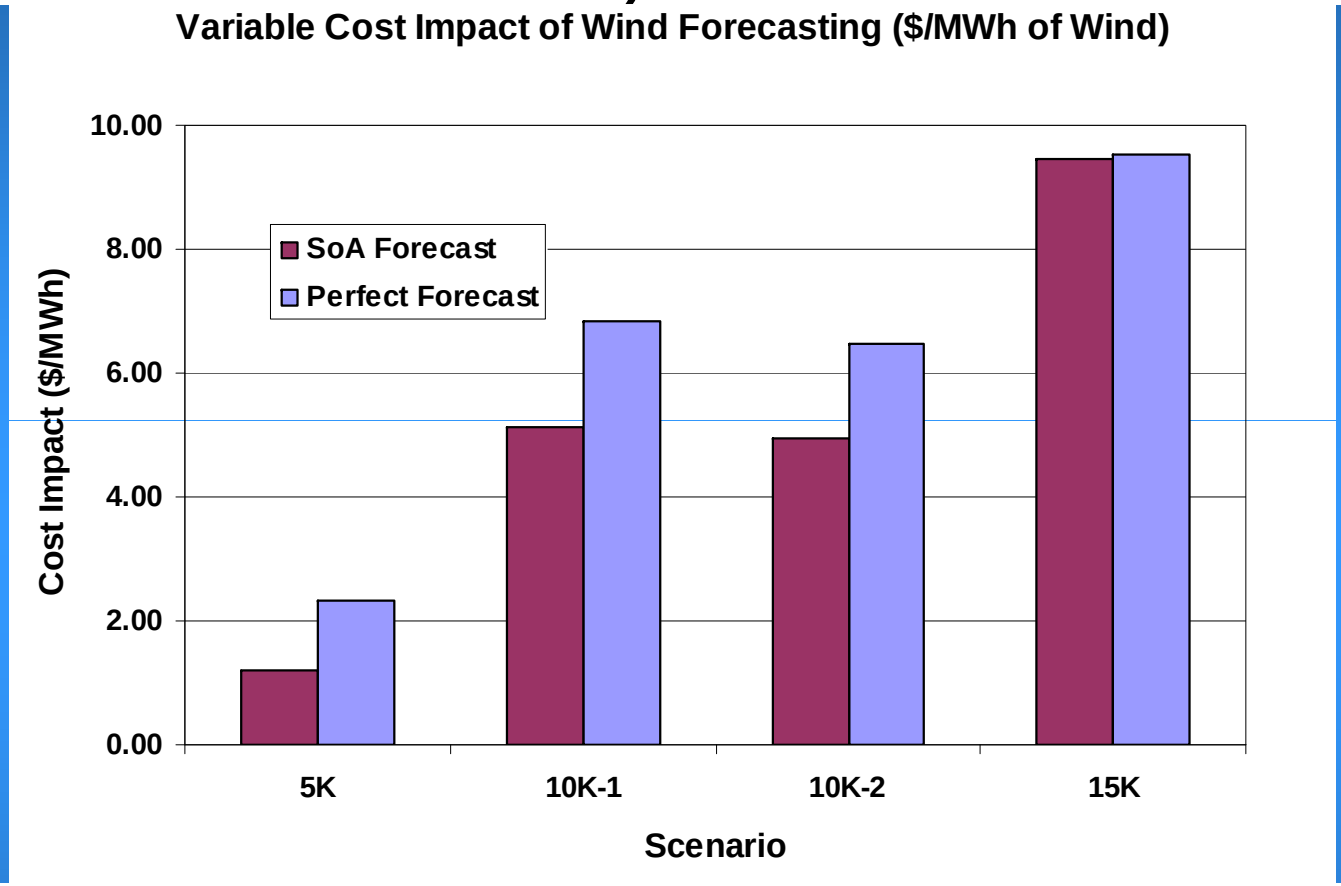


Extrapolating GE ERCOT results to 20% US electricity production by wind in 2030:

Value of SOA forecast: ~$16/MWh x 800 TWh = $13 B/year

Value of improving from SOA to perfect forecast: ~$2.4 B/year

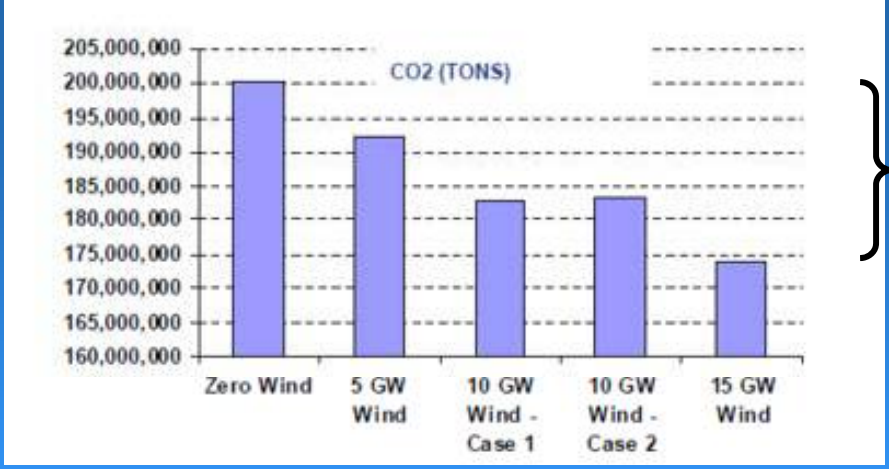
Impact of Wind Forecasting on Fuel and Plant Costs ($/MWh of Wind Generation)



Extrapolating GE ERCOT results to 20% US electricity production by wind in 2030:

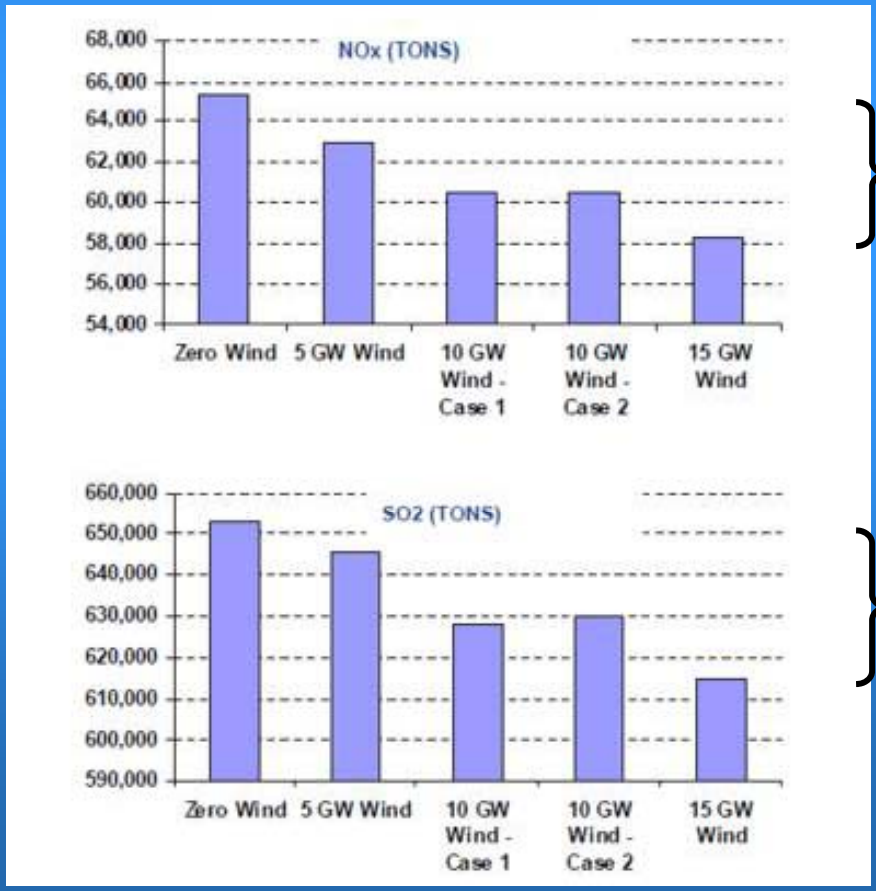
Value of SOA forecast: ~$5/MWh x 800 TWh = $4 B/year

Value of improving from SOA to perfect forecast: ~$800 M/year



13% CO_2 reduction

Reductions in CO_2 and key pollutants with SOA wind forecasts.

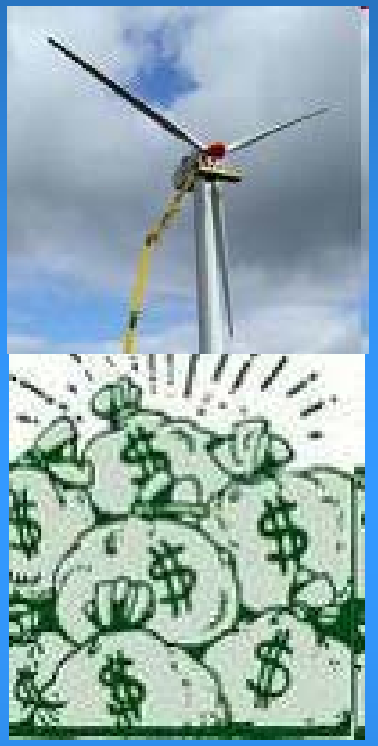


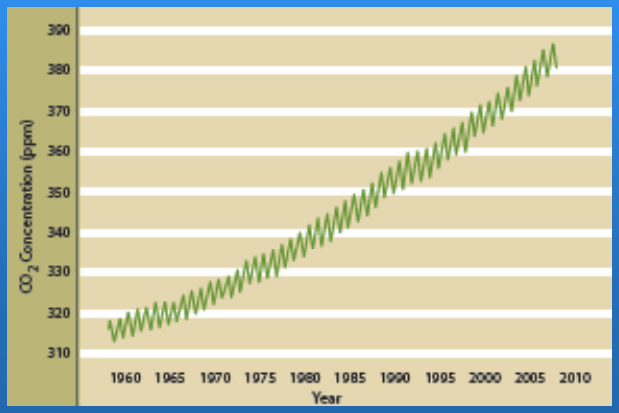
11% NOx reduction

6% SO_2 reduction

GE Texas Study Summary

- With good wind forecasts, wind can be integrated into the (Texas) grid, despite its inherent difficulty
- The dollar savings are enormous, even for this small piece of the renewable energy pie
- Using good wind forecasts saves energy, money, CO_2 emissions





Person	Affiliation	Program	Date	Content
Joe Michalsky	ESRL	Climate COM	May 6	SURFRAD, rotating shadowbands, SEBN, etc.
Arlyn Andrews	ESRL			Obtain high quality meteorological measurements from the NOAA/ESRL Tall Tower network.
Ed Kearns	NCDC	Climate COM	May 7	ISCCP B1 cloud products (from GOES imager - Knapp lead).
Fuzhong Weng	NESDIS JCSDA		May 7	4D-var assimilation for new analysis in supporting solar and wind energy forecasting; Community Radiative Transfer Model for UV/Visible radiance assimilation.
Richard Patchen	NOS/OCS and NOS/CO-OPS		May 7	Hydrokinetic and OTC RE Support
Steve Fine & Melissa Fine	ARL	Climate CRM	May 7	Winds Dust Clouds RE resources est'd w/cc
Bob Banta	ESRL		May 14	The establishment of the instrument arrays will involve assessing current lidar, sodar, profiler, and in-situ sensors, making decisions about the appropriate mix of different types of sensors for this application using testbeds to test the effectiveness of various mixes, and design, location, and siting of instrument arrays. Model improvement will have dual goals using long-term testbed deployments along with more intensive deployments of specialized instrumentation of assessing model skill and limitations in the 30-300m atmospheric layer using the testbeds and arrays, and developing new representation of physical processes in the models by using the data from the instrumentation deployments in process studies.
Ralph Lopez	NMFA/OHC	Ecosytems Habitat, Eco Research	May 7	Current research activities focus on understanding formation and dissociation of gas hydrates, ice-like crystalline structures that encapsulate methane gas molecules. Hydrates are present world-wide in seafloor sediments, may impact seafloor stability and climate change through gas release, and have potential for development as a vast energy resource. To carry out this investigation, OER - through its National Institute for Undersea Science and Technology (NIUST) is engaged in the science-driven design and deployment of a seafloor observatory in the Gulf of Mexico.
Tim Owen	NCDC	COM	May 11	NCDC will continuously highlight current NCDC products (including collaborative efforts with DOE) for renewable energy applications. Such products include: • On-line wind energy data summaries (frequency distributions) • Wind speed/direction data summaries • U.S. GIS map-based summaries and thematic overlays related to wind and solar energy (in collaboration with DOE/NREL and NCDC/Scientific Services Division) Advanced cloud/solar climatologies using historical GOES data (1995-present; in collaboration with DOE/NREL and NCDC/Remote Sensing and Applications Division)

Current Solar Capabilities

SURFRAD

Seven CONUS background surface sites measuring solar diffuse, direct, and total irradiance as well as surface reflectivity.

8 Global background sites

Run by the ESRL-GMD-Radiation group, measure downward solar diffuse, direct, and total first 8 sites listed). One-minute averages. Unedited data available next day edited within 2 weeks.

Climate Reference Network (CRN)

Run by NESDIS/NCDC, measures total downwelling solar irradiance (spectrally restricted to silicon detector range); 5-minute resolution at about 140 sites in CONUS with additional sites outside CONUS; in near real time (up to one hour delay).

NESDIS GOE Surface and Insolation Product (GSIP)

GSIP has provided operationally-retrieved total surface solar radiation from GOES for the contiguous US (CONUS) since July 2000. The retrievals are every hour on a spatial resolution of 0.5 x 0.5 degrees (~50 km). A higher spatial resolution version of the above product, the full-disk GSIP (GSIP-fd), is expected to become operational in May 2009. The spatial resolution of GSIP-fd is 1/8 x 1/8 degrees (~14 km). Data are produced from both the east and the west GOES satellites every hour for the Extended Northern Hemispheres, and every three hours for the full disks.

ISIS

ISIS is a network of eight CONUS urban sites, operated by ESRL GMD and measures downward solar diffuse, direct and total irradiance; three-minute resolution. Not currently funded, but is prime for revival with minimal funding. The data collection/retrieval/processing system is still functional, but the data are withheld pending QA.

NOAA National Climatic Data Center (NCDC)

- The NCDC accepts and distributes a variety of surface solar radiation observational data from all (including non-NOAA) US sources. Data are typically submitted by the data originator in monthly files of hourly averages. The basic components of direct, diffuse, and total are accepted but are site by site dependent as to which components are included. Access to the data appears to require a data order to NCDC since access through the web site, http://www.ncdc.noaa.gov/oa/land.html#dandp, is not readily provided. NCDC also archives the DOE/NREL product known as the National Solar Radiation Database, NSRDB. The NSRDB (two products covering 1961-1990 and 1991

Current Solar Products

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- Data are typically submitted by the data originator in monthly files of hourly averages.
- The basic components of direct, diffuse, and total are accepted but are site by site dependent as to which components are included.
- NCDC also archives the DOE/NREL product known as the National Solar Radiation Database, NSRDB. The NSRDB (two products covering 1961-1990 and 1991-2005) provides data for over 1100 sites across the US, but is comprised primarily (97%) of model generated values. The database was developed and substantiated using scant observational data, 35% of which was from the NOAA SURFRAD and ISIS programs.

- Some non-NOAA groups that are currently providing solar data include: Colorado State University's UV-B Monitoring and Research Program that measures solar and ultraviolet (UV) radiation at more than 30 sites; the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) program, the University of Oregon's Pacific Northwest network; and a private company that assembles and distributes solar data taken by those interested in agricultural uses,

Solar Resource Assessment

- Reliable, sub-hourly data sets (sub-minute?), from obs or model outputs representing response time of solar PV, esp. over compact service territories
  - Use in load-control and load-following studies under high penetration scenarios w/no storage.
  - Only a few obs stations in the U.S. provide these data and all of the NSRDB (model output) are hourly values.

Solar Resource Assessment

- Improved spatial resolution of data sets
- Solar resource forecasting capabilities over a range of time scales: 1-3 hour for load dispatching, day-ahead for system ops, and seasonal and interannual for long-term planning and cash-flow analyses

NREL Tech. Report NREL/TP-581-42301
D. Renne', R. George, W. Wilcox, T. Stoffel, D. Myers, and D. Heimiller

- **Magnuson-Stevens Fishery Conservation and Management Act (MSA):** Pursuant to the MSA, NOAA is responsible for the conservation and management of marine fishery resources and their habitats. The MSA requires federal agencies to consult with NOAA with respect to any agency action that may adversely affect essential fish habitat. In response, NOAA provides formal recommendations as to ways that the agency can reduce or eliminate the effects of the action. Depending on the degree and type of habitat impact, compensatory mitigation may be necessary to offset permanent and temporary effects of the project.
- **Endangered Species Act (ESA):** The purpose of the ESA is to provide a means whereby ecosystems upon which endangered and threatened species depend may be conserved, and to provide a program for the conservation of such listed species. The ESA prohibits the "take" of endangered or threatened species. Section 7 of the ESA requires Federal agencies to consult with NOAA to insure that any action authorized, funded, or carried out by such agencies is not likely to jeopardize the continued existence of any endangered species or threatened species or adversely modify or destroy designated critical habitat.
- **Marine Mammal Protection Act (MMPA):** Pursuant to the MMPA, it is generally illegal to "take" a marine mammal without prior authorization from NOAA. Under the MMPA, NOAA, authorizes the take of small numbers of marine mammals incidental to otherwise lawful activities (except commercial fishing), provided that the takings would have no more than a negligible impact on those marine mammal species, and would not have an unmitigable adverse impact on the availability of those species for subsistence uses. In the event that any aspect of a proposed energy activity will result in a "take" of a marine mammal, the project applicant, or the lead agency acting on behalf of the applicant, would be required to obtain an incidental take authorization in advance from NOAA.
- **National Marine Sanctuaries Act (NMSA):** The NMSA and implementing regulations regulate certain activities within sanctuaries that might cause adverse impacts on sanctuary resources. In addition, pursuant to NMSA section 304(d), any federal agency action inside or outside the boundaries of a sanctuary, including issuance of a license or permit that is likely to injure the resources of a sanctuary, must provide NOAA with a written statement describing the action and its potential effect on sanctuary resources. NOAA may recommend reasonable and prudent alternatives to the proposed action, which may include choosing an alternative location for the federal activity or federally permitted activity.
- **Coastal Zone Management Act (CZMA):** The CZMA encourages states to preserve, protect, develop, and where possible, restore and enhance natural coastal resources. NOAA administers the CZMA and facilitates cooperation between states, federal agencies and others. Federal actions having reasonably foreseeable effects on any land or water use, or natural resource of a state's coastal zone must be consistent with a state's federally-approved CZMA enforceable policies. On appeal by a non-Federal applicant, the Secretary of Commerce may override a state's CZMA objection to a federal authorization or funding application.

- **National Environmental Policy Act (NEPA):** NEPA requires Federal agencies to prepare Environmental Impact Statements (EIS) for major Federal actions that significantly affect the quality of the human environment. NOAA maintains jurisdiction and special expertise over marine resources as contemplated by the NEPA implementing regulations. As a result, NOAA is required to comment on environmental impact statements within its jurisdiction, expertise, or authority.
- **Fish and Wildlife Coordination Act (FWCA):** The FWCA requires Federal departments and agencies that undertake an action or issue a Federal permit or license that proposes to modify any stream or other body of water to first consult with the U.S. Fish and Wildlife Service, NOAA, and appropriate state fish and wildlife agencies. NOAA responds with comments and recommendations to conserve the fish and their habitat.
- **Ocean Thermal Energy Conversion Act (OTECA):** Under OTECA, no person may construct or operate an ocean thermal energy conversion facility located within the territorial sea of the United States, except pursuant to a license issued by the NOAA Administrator.
- **Federal Power Act (FPA):** Pursuant to Sections 10(a) and 10(j) of the FPA, NOAA has authority to recommend that the Federal Energy Regulatory Commission (FERC) include measures in hydroelectric power project licenses for the protection, mitigation, and enhancement of fish and wildlife and their habitats. Under FPA section 18, NOAA has authority to issue mandatory prescriptions for “fishways” to ensure the safe, timely and effective passage of fish past hydroelectric power projects. NOAA may also issue mandatory conditions for the adequate protection of a federal “reservation” under Section 4(e) of the Act.
- **Oil Pollution Act of 1990 (OPA90):** OPA90 greatly increased federal oversight of maritime oil transportation, and improved the nation’s ability to prevent and respond to oil spills, including contingency planning requirements for both government and industry. It created a comprehensive prevention, response, liability, and compensation regime to deal with vessel and facility-caused oil pollution to U.S. navigable waters. OPA90 also created the Oil Spill Liability Trust Fund, which is available to pay response costs and claims for damages resulting from spills. Under OPA90, NOAA and other Federal and state agencies and Indian tribes act as Trustees on behalf of the public to assess the injuries to natural resources from spills, scale restoration to compensate for those injuries, and implement restoration.
- **National Contingency Plan (NCP):** The National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan (NCP), is the federal government's blueprint for responding to both oil spills and hazardous substance releases. NOAA expertise on the National Response Team and 13 Regional Response Teams is critical to mitigate harm, provide critical information for allocation of response assets, restore adverse effects on natural resources, aid planning and response decision-making, and document damages.