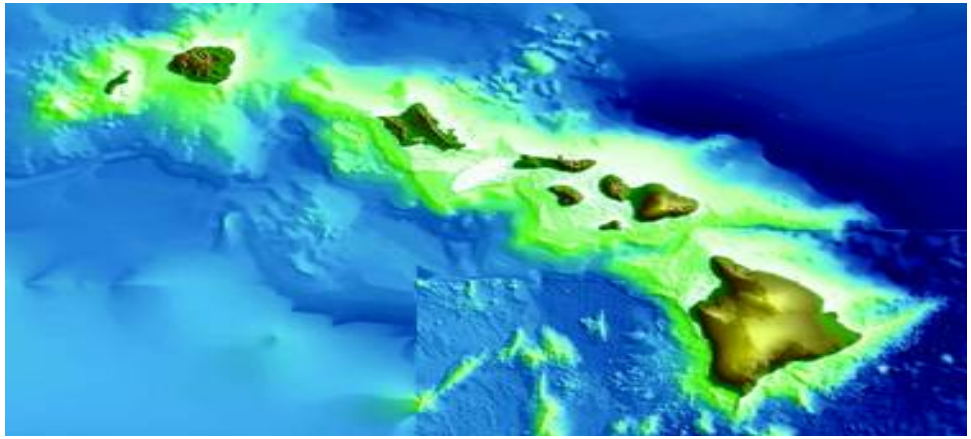
Comments on Recent US Renewable and Ancillary Energy Services Activities



EGNET - 41

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Pacific Northwest National Laboratory

October 17, 2013

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Nature of Politics in DC: Big Four and the Impact on Energy and Economy

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Political Phenomenon: the Tea Party in the House of Representatives

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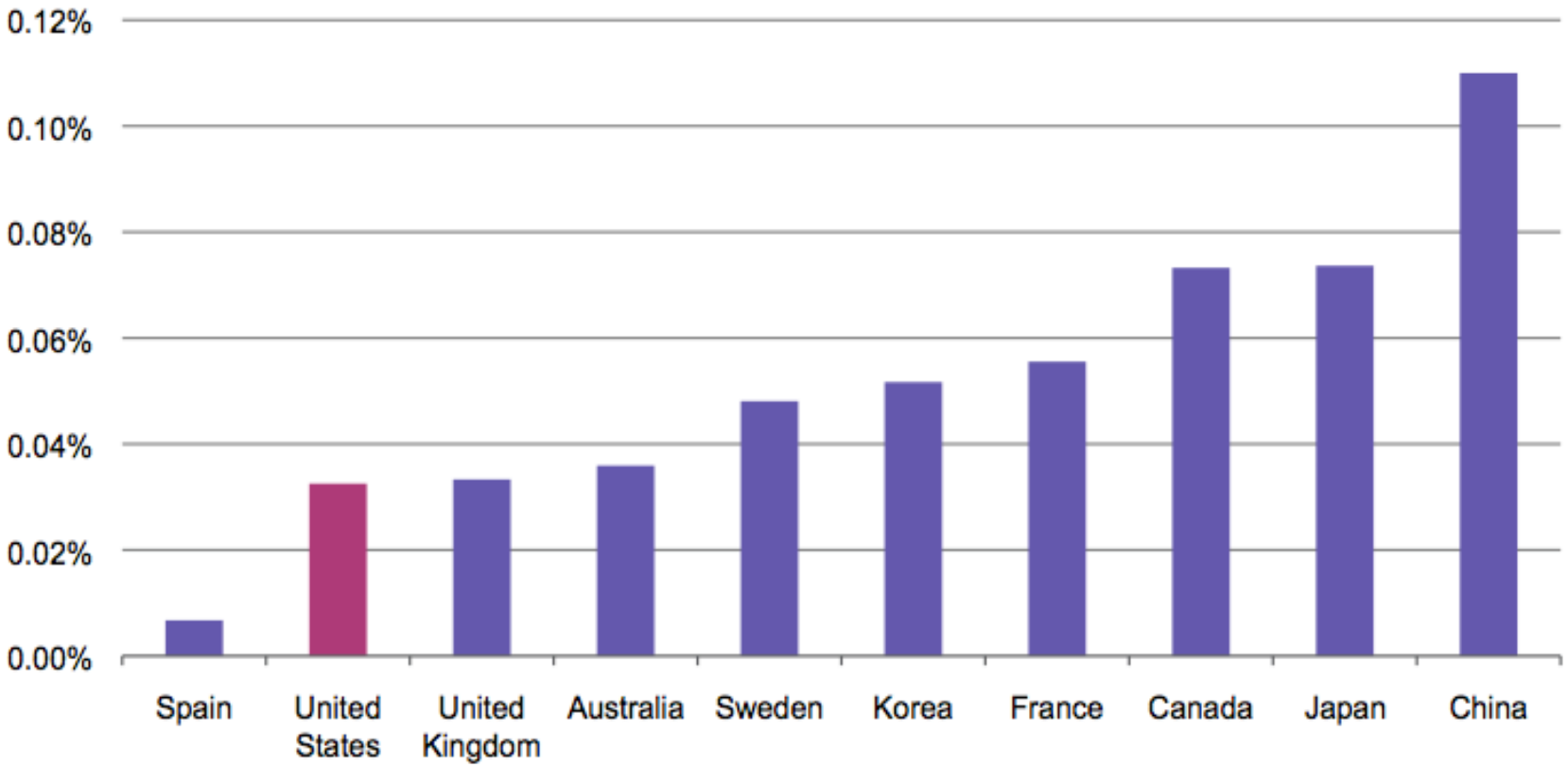
2013/10/24

Public Energy R&D Spending as % of GDP, 2010



ice data is 2009; China data is 2008.
ternational Energy Agency, "Energy Technology RD&D 2012 edition (free access)," http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx?CS_referer=&CS_ChosenLa
telligence Agency, "The World Fact Book," https://www.cia.gov/library/publications/the-world-factbook/.

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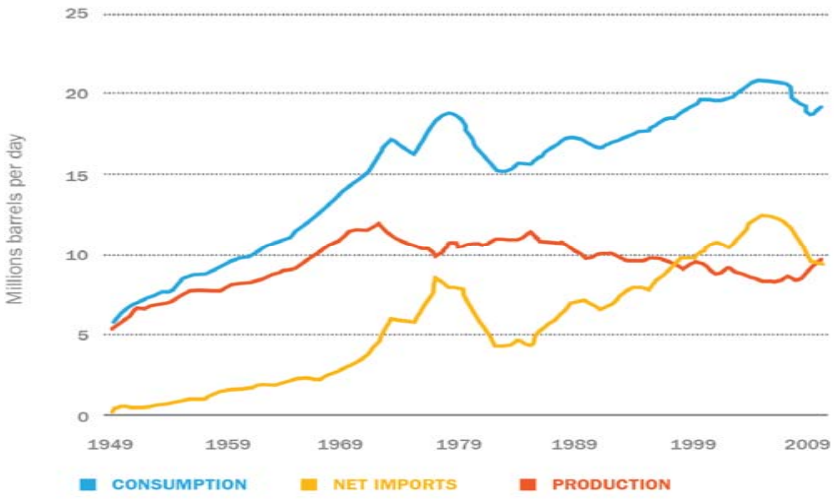
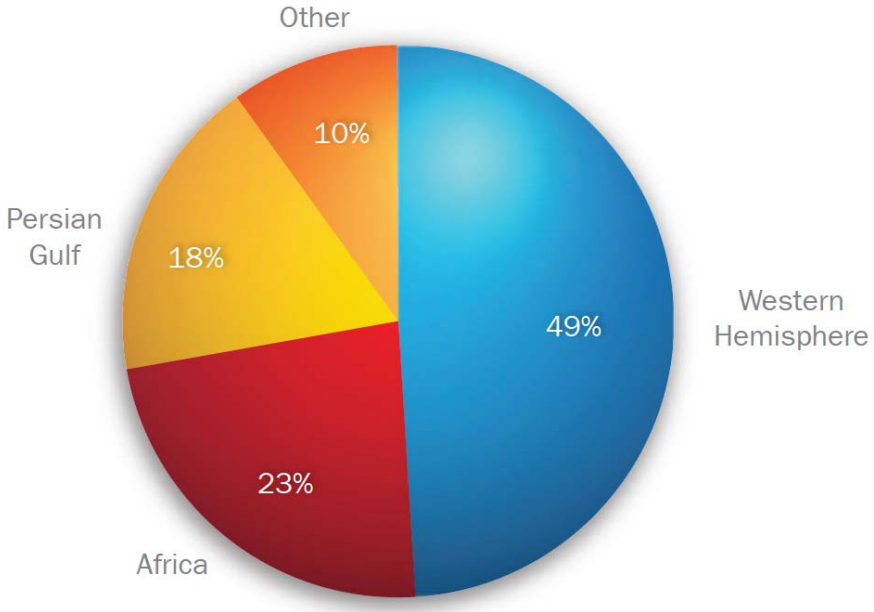
Sources of Liquid Fuels

Trends in US Consumption, Production, and Import of Liquid Fuels - 2011



Sources of US Petroleum, 2010



- Due to Bakken and recession, less than 50% of liquid fuels in US are imported - lowest since 1995
- Import of liquid fuels responsible for 70% of national trade deficit (~$1 billion per day)
- Almost 50% from Canada, but Keystone Pipeline issues

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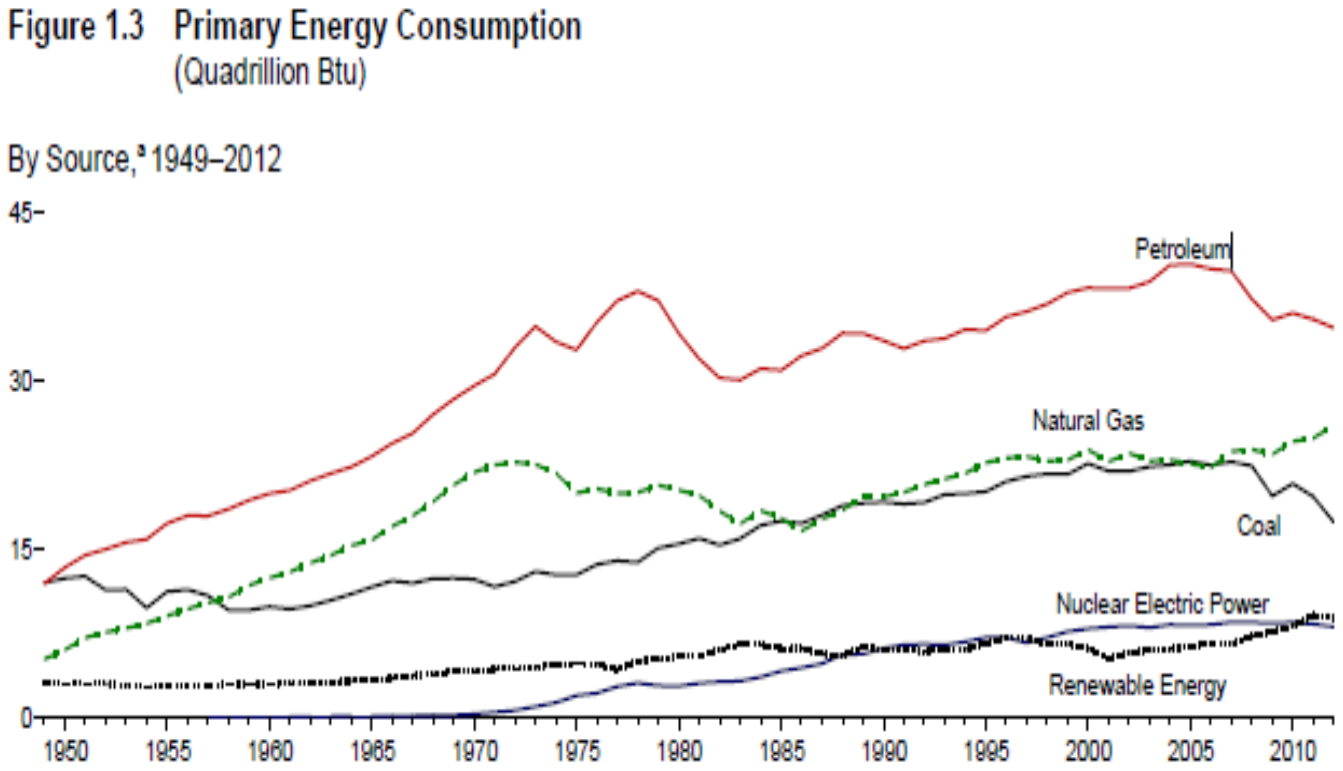
From 2011 DOE QTR

US Primary Energy Consumption: Fracking Wins and Reduction in Oil Use/Imports

(http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf)

Report Released: September 25, 2013



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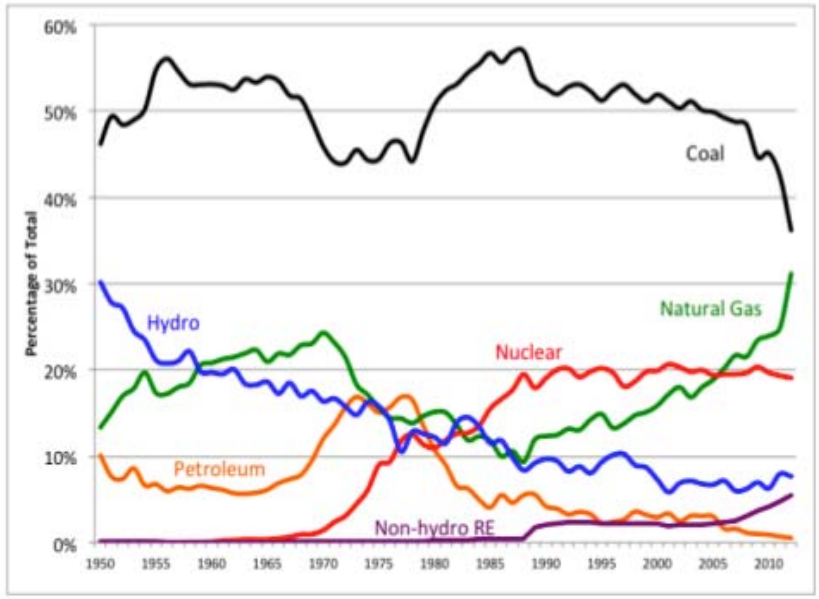
Natural Gas Is on Course to Displace Coal and Compete with Renewable Capacity Deployment

- For the US, in April 2012, natural gas-fired facilities produced 95.9 MMWH vs. 96 MMWH for coal
- Shale gas is one-third of delivered gas for the US - a percentage that will increase over the near term
  - One issue for fracking is concern of water contamination and seismic events - some states (MD, NY) have ban on fracking
- Since there is 50% less carbon from NGCC compared to coal, this "fuel-switching" is seen as an answer to climate issues
  - However, CCS will eventually be required for NGCC as well



ure 4. Coal-fired electricity generation is declining rapidly as the use of natural gas and renewable energy expand

EIA, "Annual Energy Review," September 27, 2012; EIA "Electric Power Monthly," October 31, ata for 2012 includes generation through August only.

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Renewable (and Gas) Opportunity: New Regulations May Lead to Closure of 30GW of Coal-fired Capacity

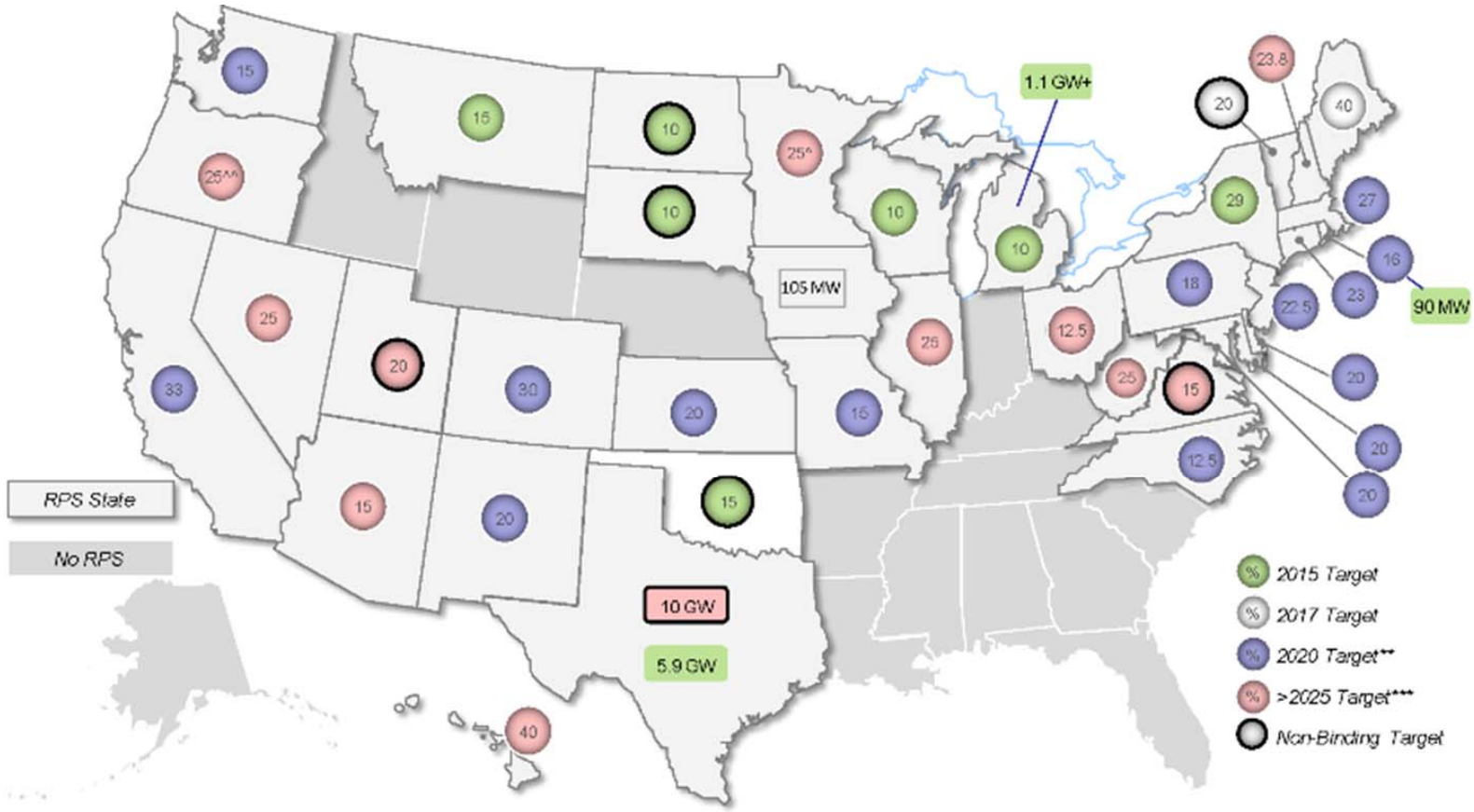
	Affected Units	Regulatory	Quantity, MW
Air Toxics Hg, Ni, V particulates	Principally coal and oil units	MACT	410,000+ coal, oil
CSAPR/ NAAQS	All fossil units	CAA	Complex-Need unit data, operating conditions, etc.
CCP	Coal Only	RCRA	330,000 (utility) Thousands? Industrial
Water OTC/316B	Most thermal plants, including nuclear	CWA	247,000
Regional Haze	All units, but largest burden falls on coal fleet	CAA	15% of coal?
GHG	1st source with a GHG "BACT" is an NGCC	CAA	800,000+

States More Effective than Federal Government in Developing New Policies and Programs

- US energy policy is effectively to not have an energy policy due to political issues and issue-specific legislation
- Energy Efficiency and Demand Side Management Standards and Goals
  - Standards developed for building codes and appliances
  - PUCs now denying most coal-fired applications based on future carbon prices
- Renewable Portfolio Standards (RPS) now in 34 of 50 states, plus DC
  - Feed-in tariffs (with an eye towards grid stability)
  - Net metering laws and regulations
- Power Purchase Agreements - national law
  - Under PURPA (now repealed) - based on avoided cost
  - New PPAs must (and generally do) take into account ancillary services - grid stability, reliability, Var support from fossil-fired systems
- T&D investments, access and interconnection - “Dueling laws”
  - BUT, various public (ISOs, state EPA) and private intervenors can drag out interconnection time and increase costs for any IPP

State RPS Map

RPS – Renewable Portfolio Standard

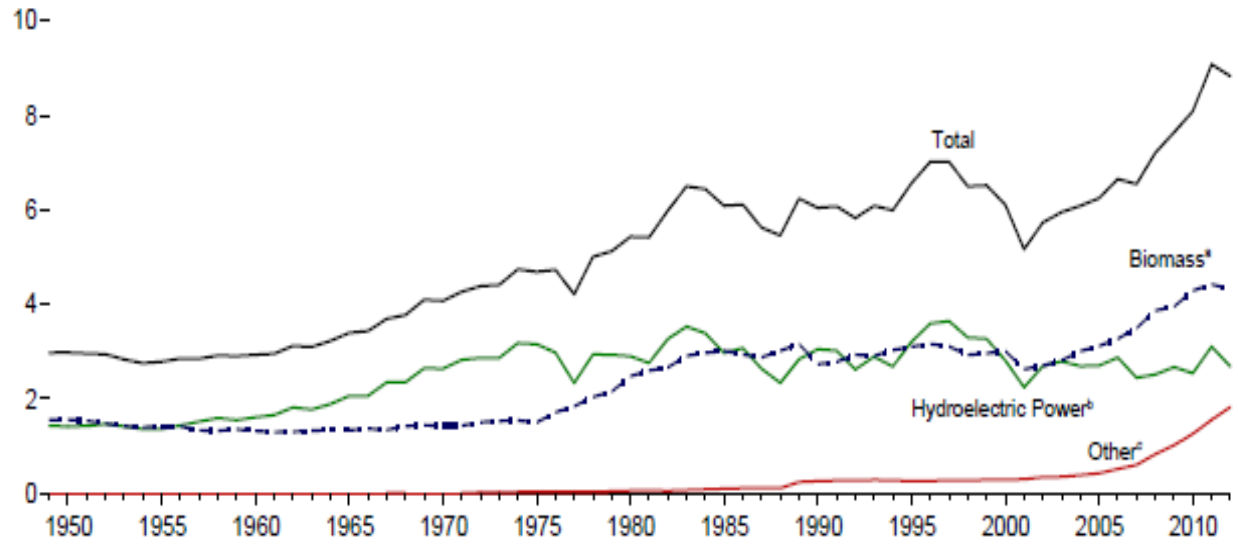


Note: *Includes states with installed capacity >1 MW. **Includes targets for 2019 (RI), 2021(MO, NC), and 2022 (MD). ***Includes Hawaii, with target date of 2030. ^Separate target for Xcel Energy at 30% by 2020. ^^By 2025: 25% (large utilities), 10% (small); 5% (smallest)
Source: IHS Emerging Energy Research

Renewable Energy Consumption - note hydro decrease in 2012 due to extensive drought

Figure 10.1 Renewable Energy Consumption
(Quadrillion Btu)

Total and Major Sources, 1949–2012



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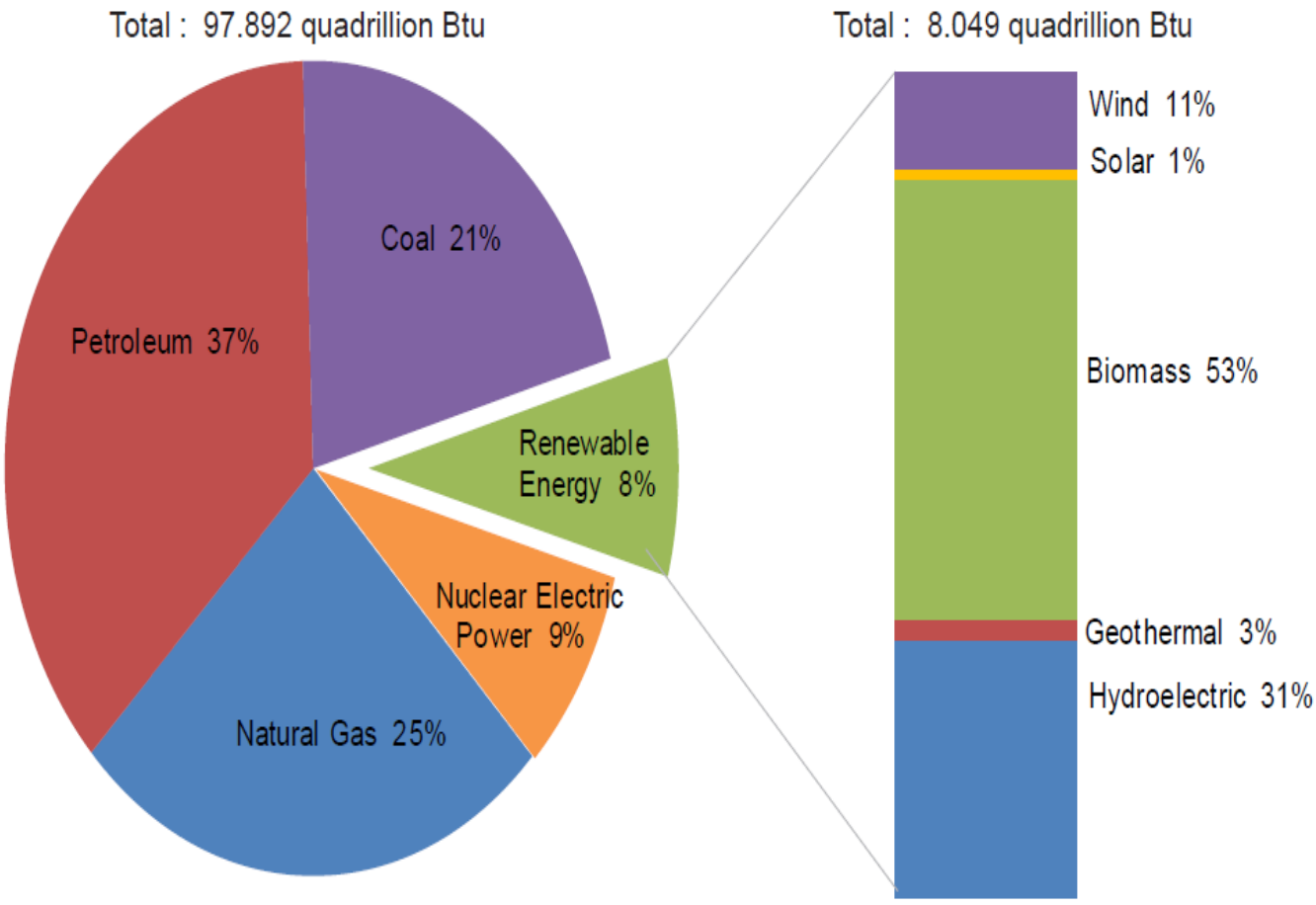
US Renewable Energy Consumption in 2010



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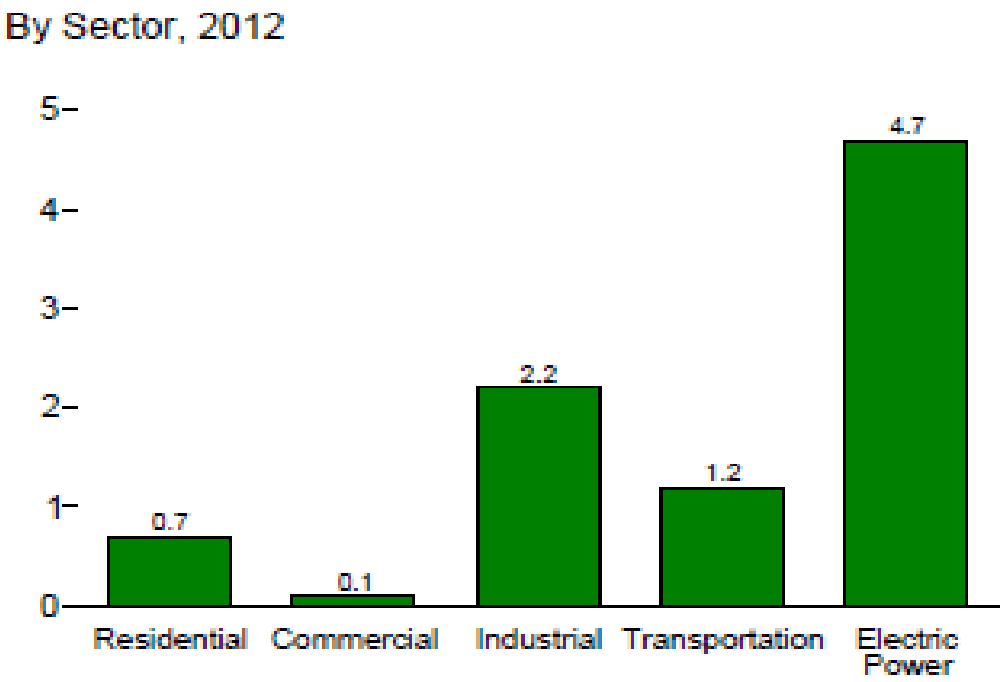
Renewable Energy by Sector, 2012 (Quadrillion Btu)



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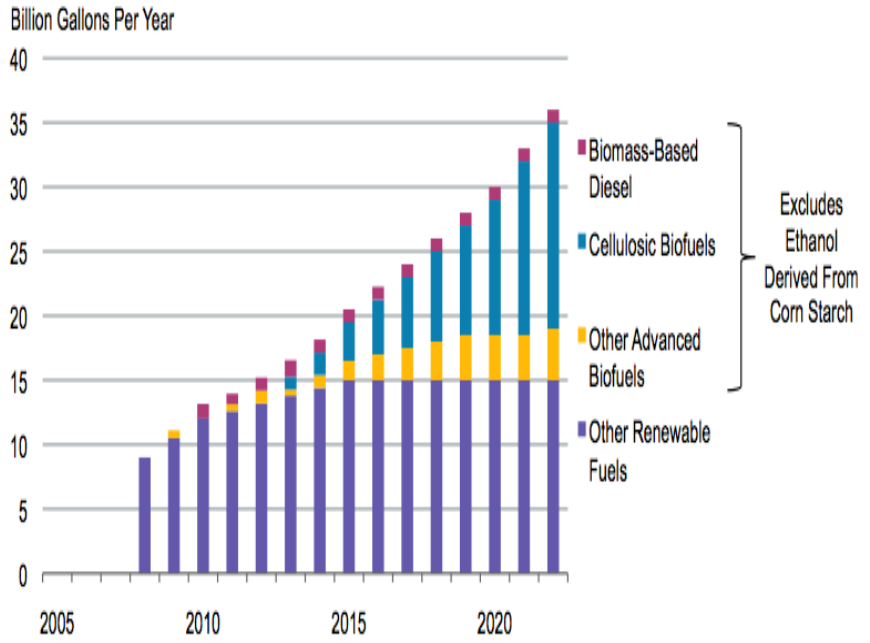
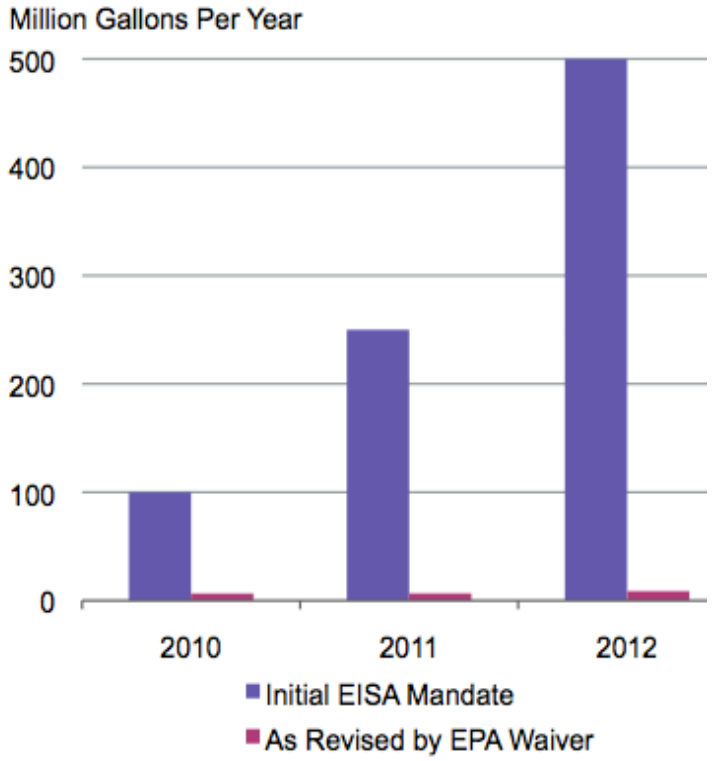
Serious Shortfall in Cellulosic Production for Liquid Fuels Vs. Stated Mandates

Figure 2-21: Renewable Fuel Standard (RFS2) Volume Requirements



Source: Randy Schnepf and Brent D. Yacobucci, Congressional Research Service, *Renewable Fuel Standard (RFS): Overview and Issues*, January 2012, R40155, 3, http://www.fas.org/sgp/crs/misc/R40155.pdf.



Source: Randy Schnepf and Brent D. Yacobucci, Congressional Research Service, *Renewable Fuel Standard (RFS): Overview and Issues*, January 2012, R40155, 3, http://www.fas.org/sgp/crs/misc/R40155.pdf.

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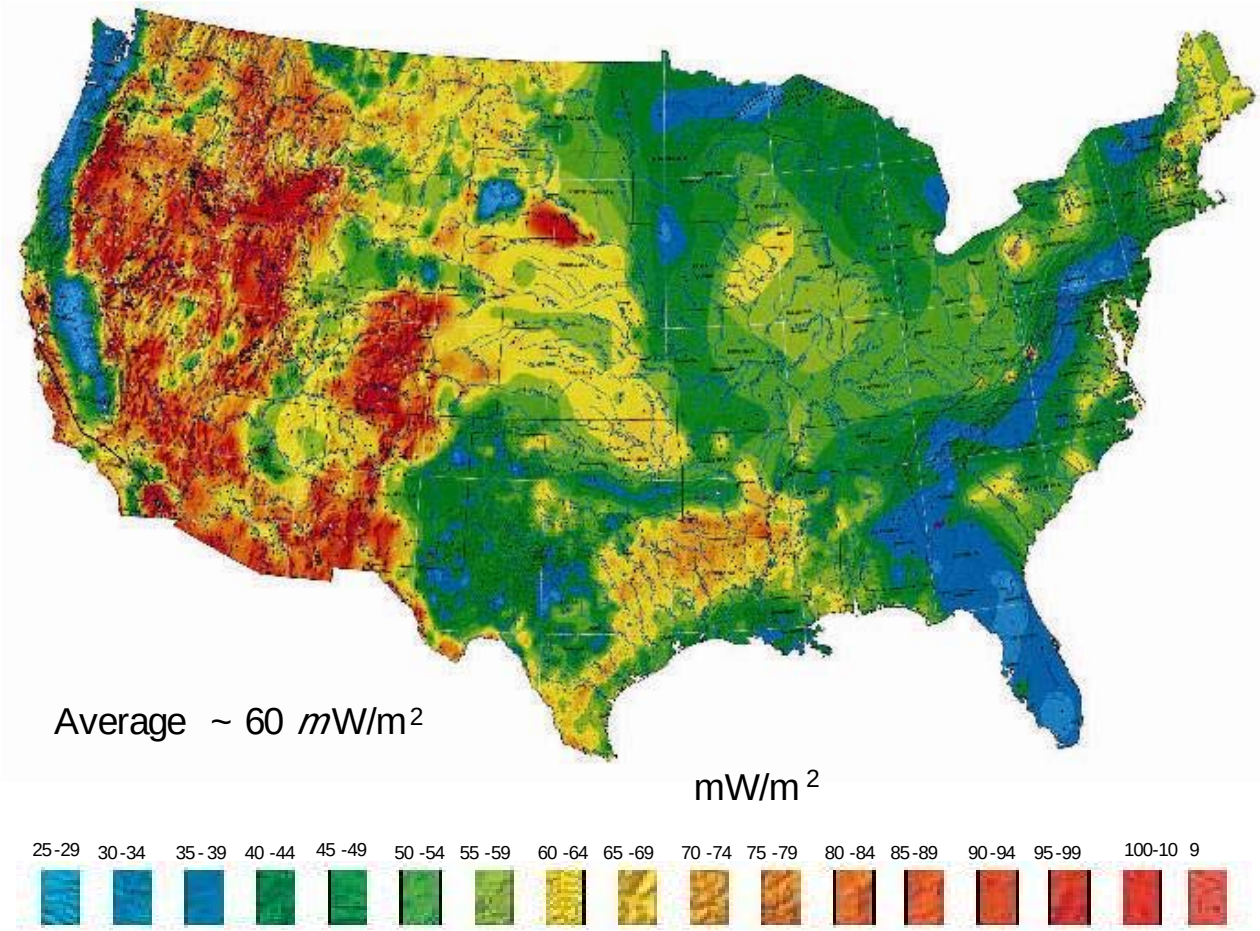
More than 100 GW of Estimated Undeveloped Geothermal in US: Issues Are Lack of Transmission, Remote from Load Centers, Interstate Commerce



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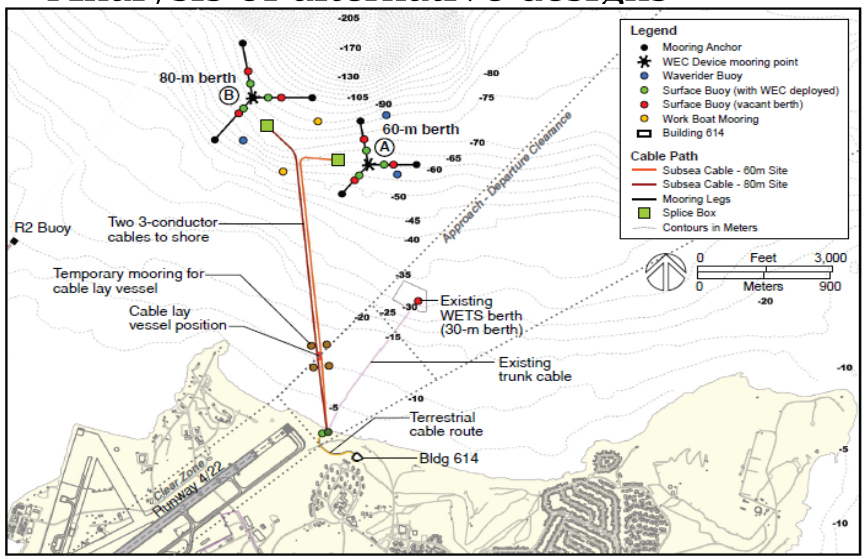
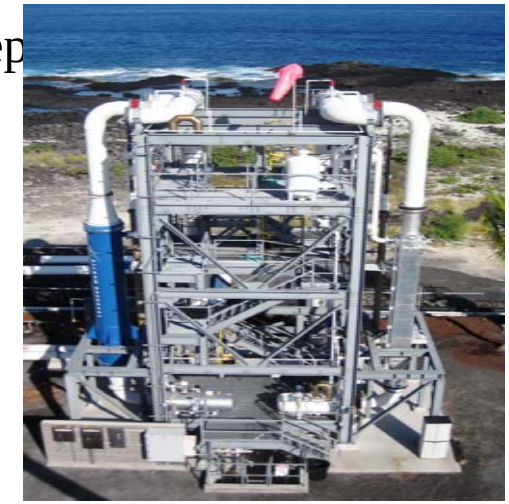
Ocean Resources Are Not Ready for Prime Time

- **Hawaii National Marine Renewable Energy Center - US DOE funding to:**
  - Facilitate commercial development of wave energy conversion devices
  - Reduce technology risk for ocean thermal energy conversion (OTEC)
  - Oregon State University is the other Center
- **Sea Water Air Conditioning (cost reduction)**
  - Plume modeling to characterize impacts of discharge dep
  - Environmental monitoring to verify performance
  - Analysis of alternative designs



Kaneohe Bay - WETS



Makai OTEC Test Facility

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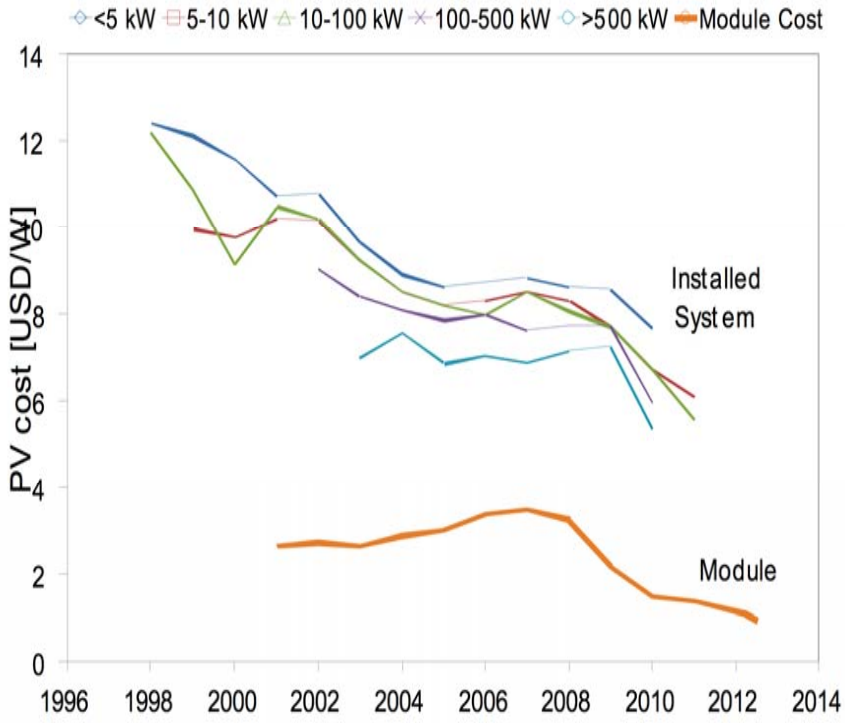
Trends for Photovoltaic Systems Are Encouraging

- Installed costs have declined to $6.2/watt in 2010 (with California Solar Initiative at $5.7/watt in 2011)
  - 3.313 GW of PV added in 2012
  - Attributable to falling module costs as well as reduced installation costs
- Increase in installation due to emergence of third party ownership
  - third party installs and then charges a set rate for the electricity produced
  - Solar City had a very successful IPO
- Crystalline module installed costs remain cheaper than thin-film
- Tracking costs are greater by $1.0/W.
  - Larger facilities, such as Sempra in Nevada, find it cheaper to not use these due to capital and O&M costs that outweigh production increases
- Utility sector costs range from $3.8 to $4.4/W



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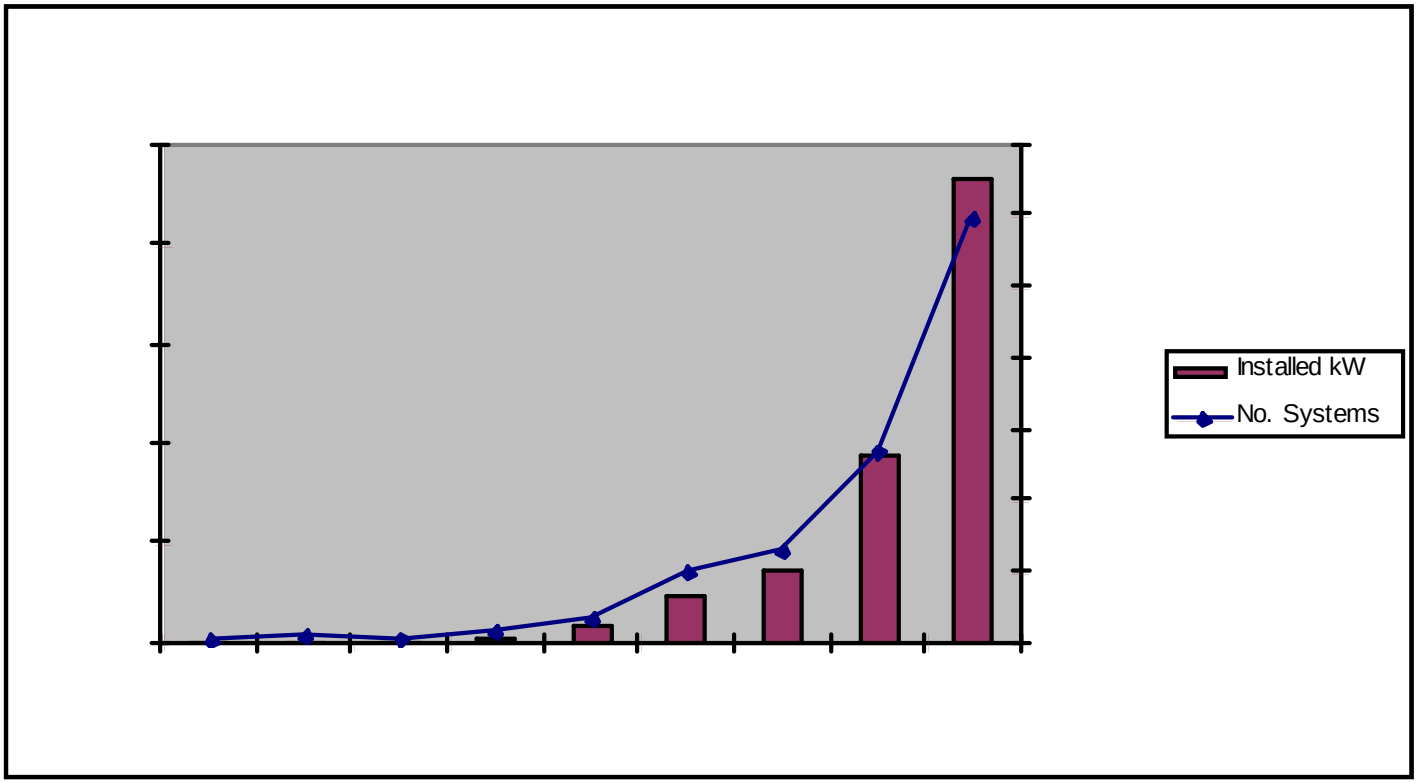
Post Fukushima, High Cost of Petroleum ($135/bbl LSFO) Drives Electricity Prices ($0.45/kwh) - Leads to Maui PV Deployment - 25 MW in 2012 out of peak of 200 MW

In 2013 some feeder lines on the Big Island and Maui are now at 100% peak load for PV



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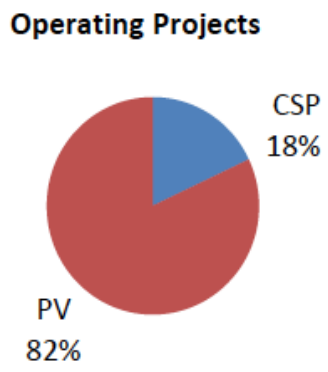
Utility Scale Solar Pipeline in the United States

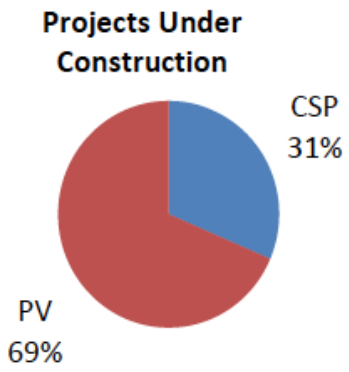
Utility-Scale Solar Projects in the United States
Operating, Under Construction, or Under Development

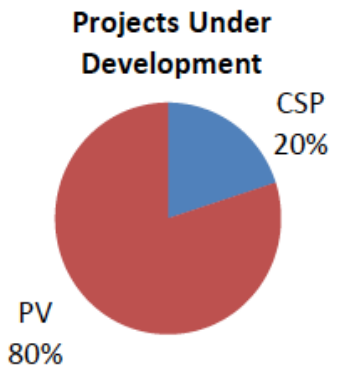
Updated February 11, 2013

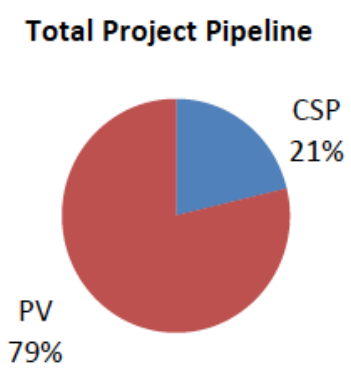
SEIA Solar Energy Industries Association®

Utility-Scale Project Capacity by Technology and Completion Status (MW)				
Technology	Operating	Under Construction	Under Development	Total
CSP	523	1,317	5,244	7,084
PV	2,387	2,870	20,981	26,239
Total	**2,910**	**4,187**	**26,225**	**33,323**









Installed Capacity:
California (1,049 MW) >> Nevada (332 MW) ~ Arizona (586 MW)

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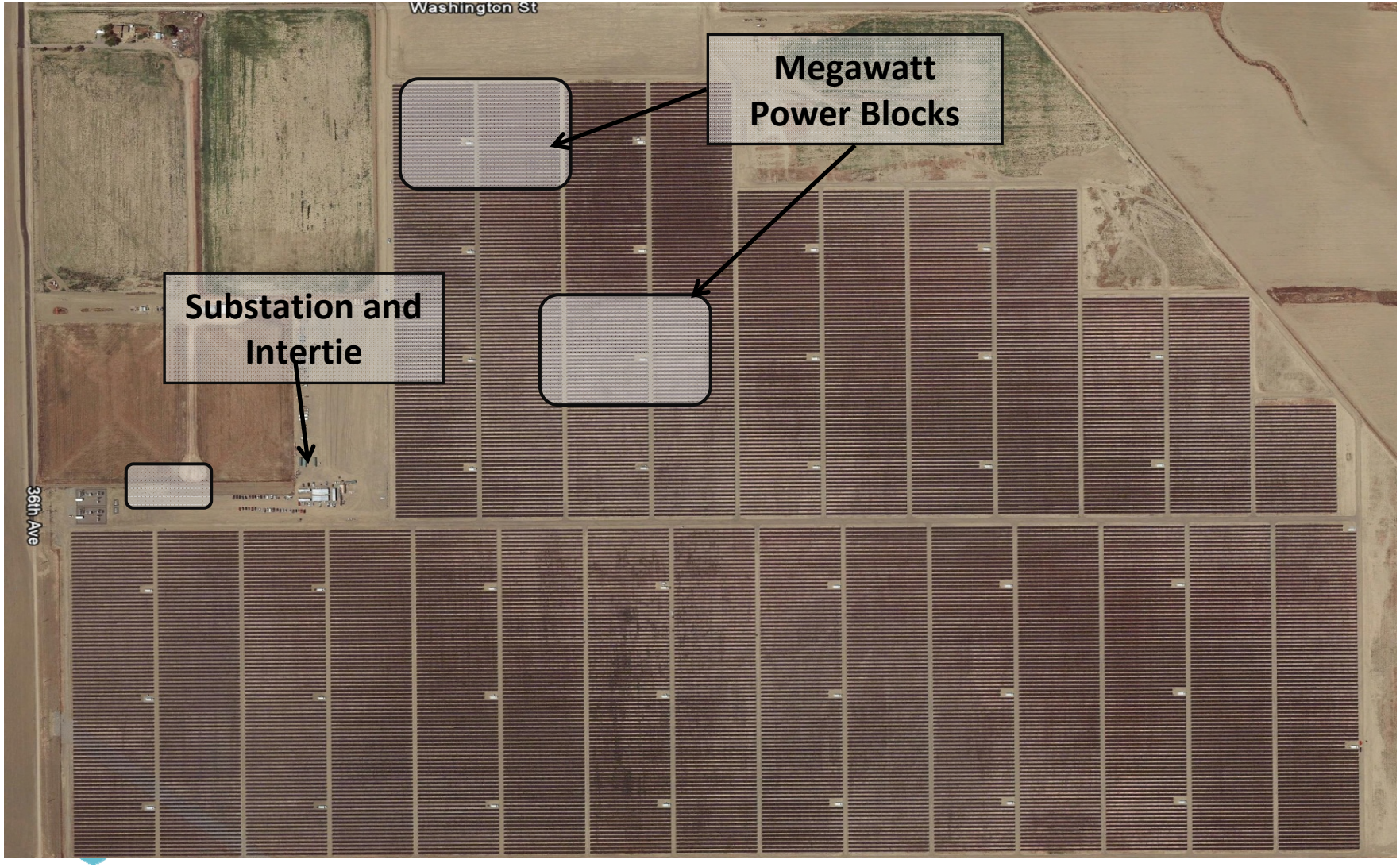
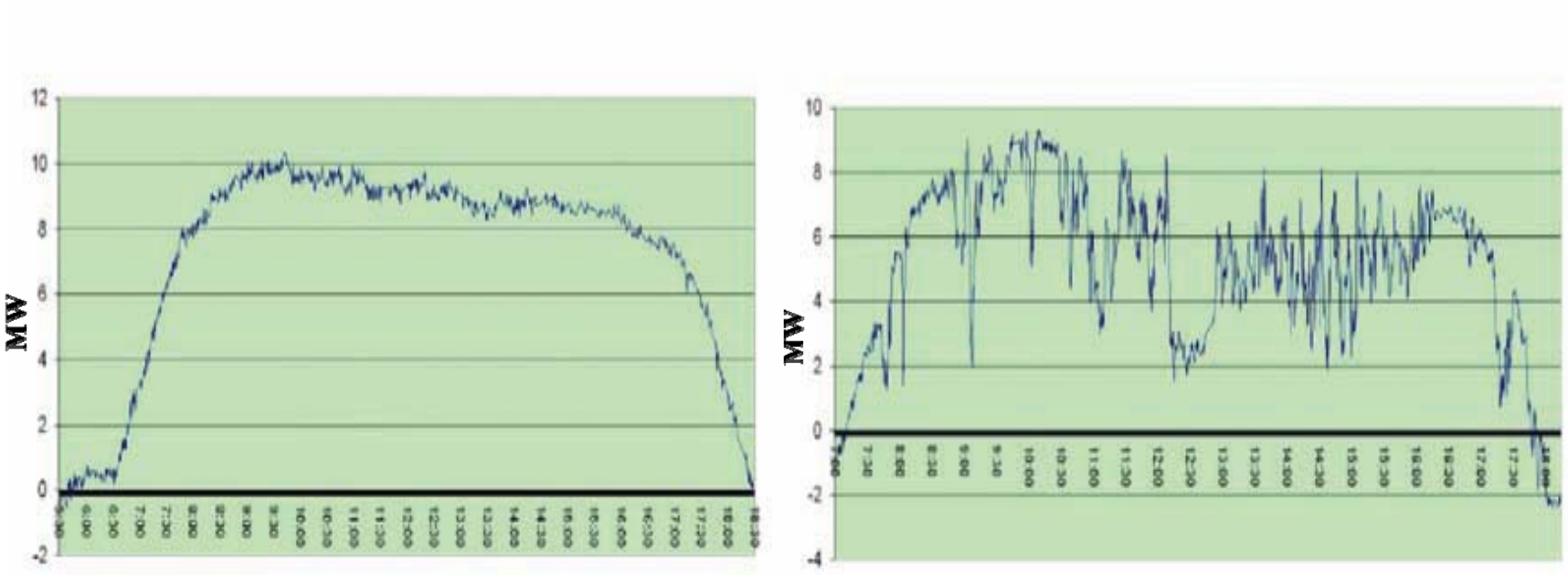
Utility Scale System:
One MW = six acres

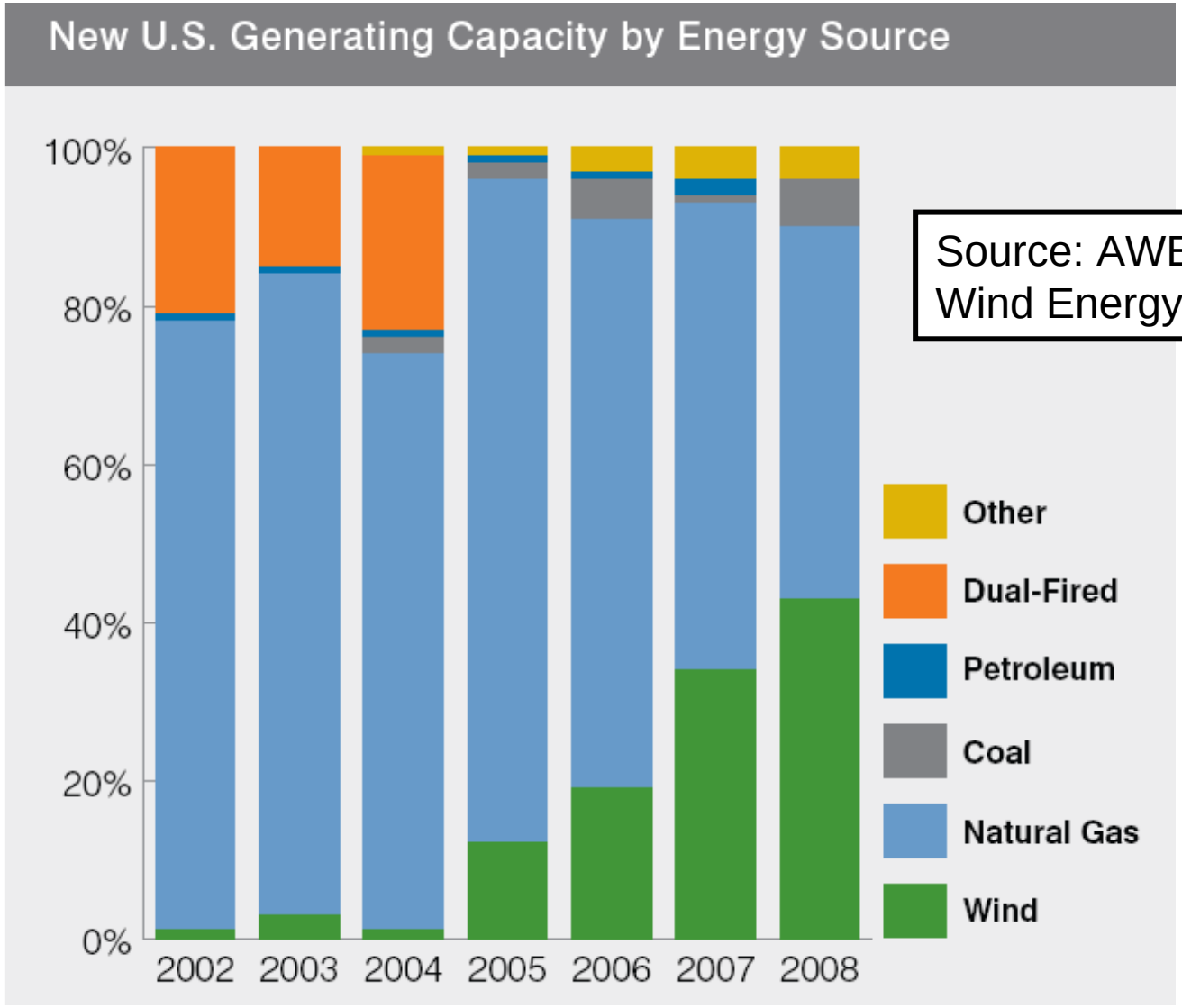


Nevada Solar Photovoltaic (PV) Plant Output on a Sunny Day (Left) and a Partly Cloudy Day (Right) in 2008



Source: North American Electric Reliability Corporation, *Accommodating High Levels of Variable Generation* (Princeton, NJ, 2009).

Wind Power Accounted for 40% of New Generation Capacity in 2008, % Now Lower Due to NG Development



Source: AWEA, 2009 Wind Energy Outlook

Wind Power Capacity: Improved, But Still a Need for Spinning Reserve

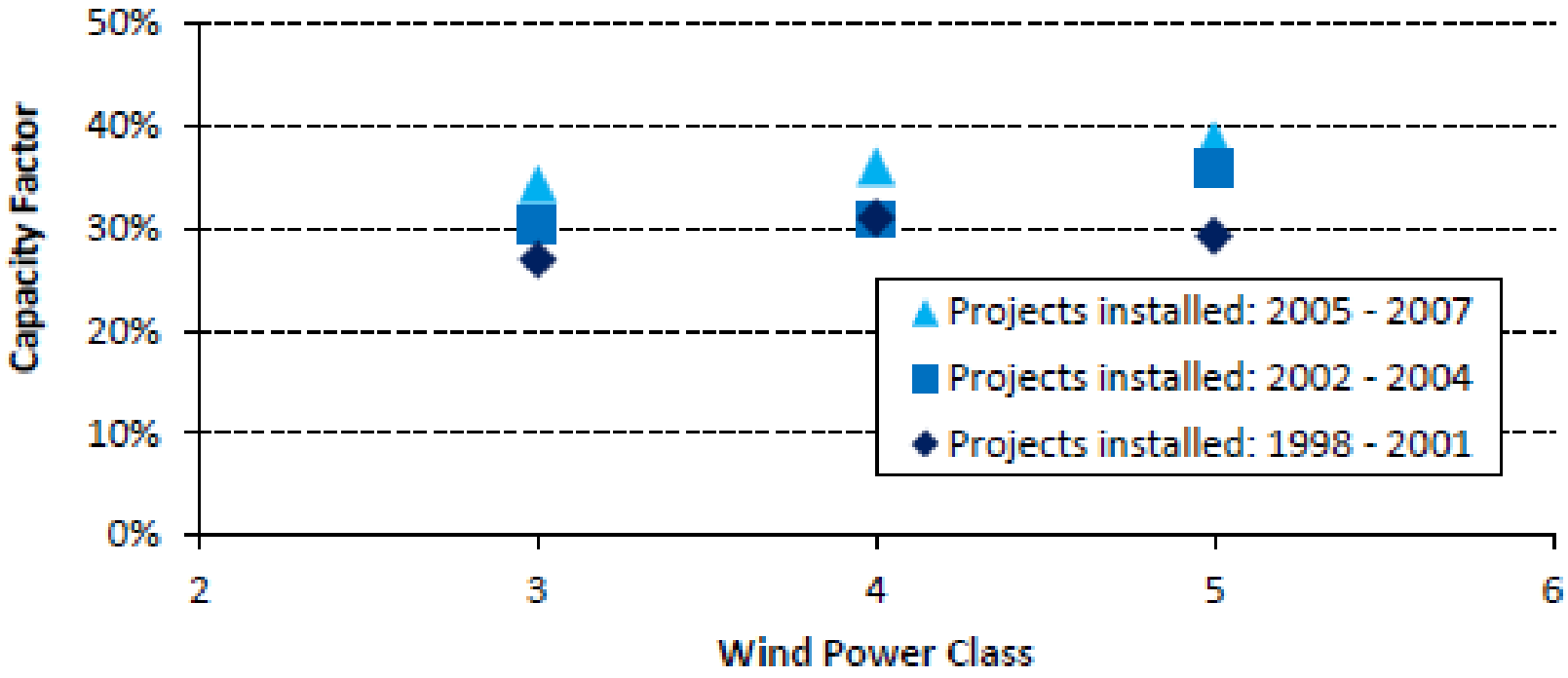


Figure 6. U.S. project capacity factors by vintage and wind power class

Source: Wiser 2010

Wind Turbine Pricing: Location Is Important in Pricing

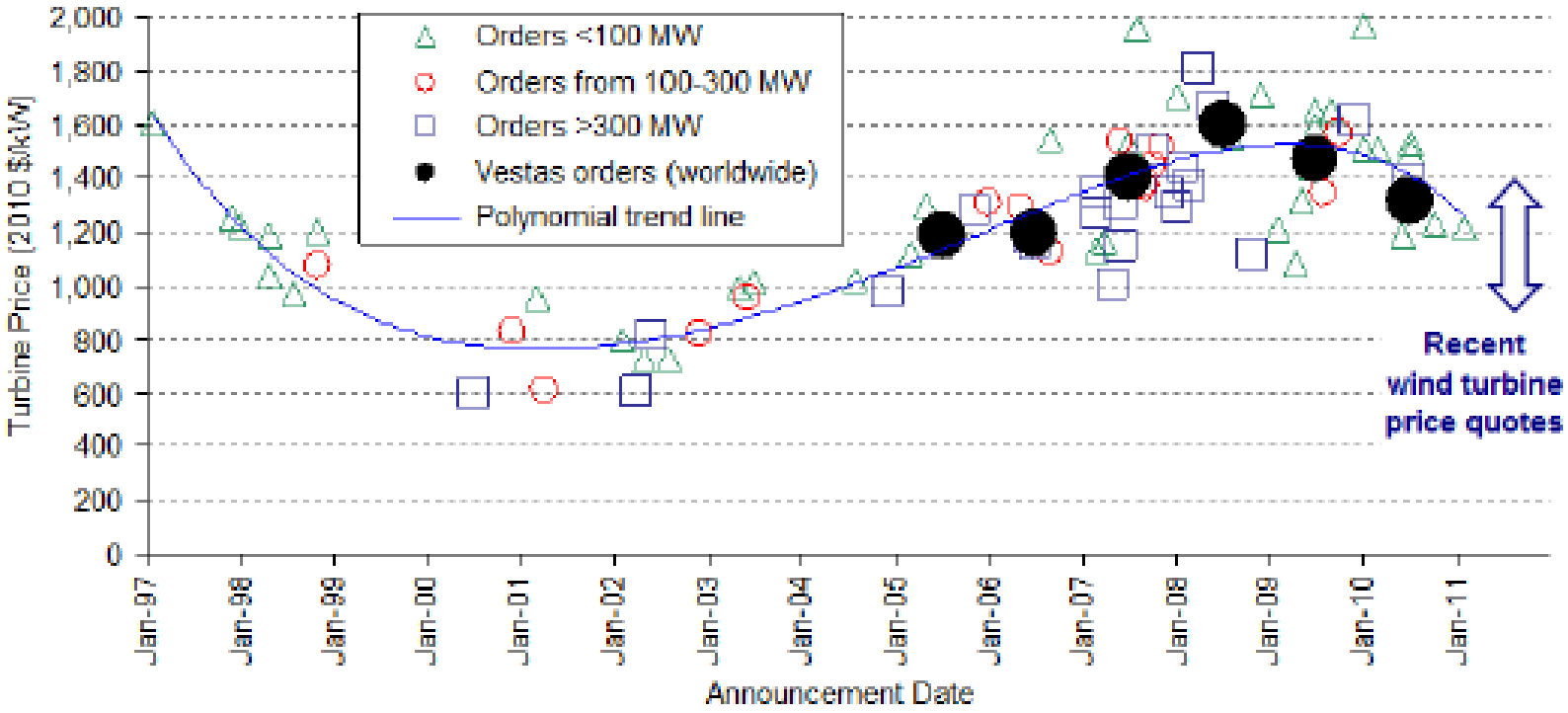
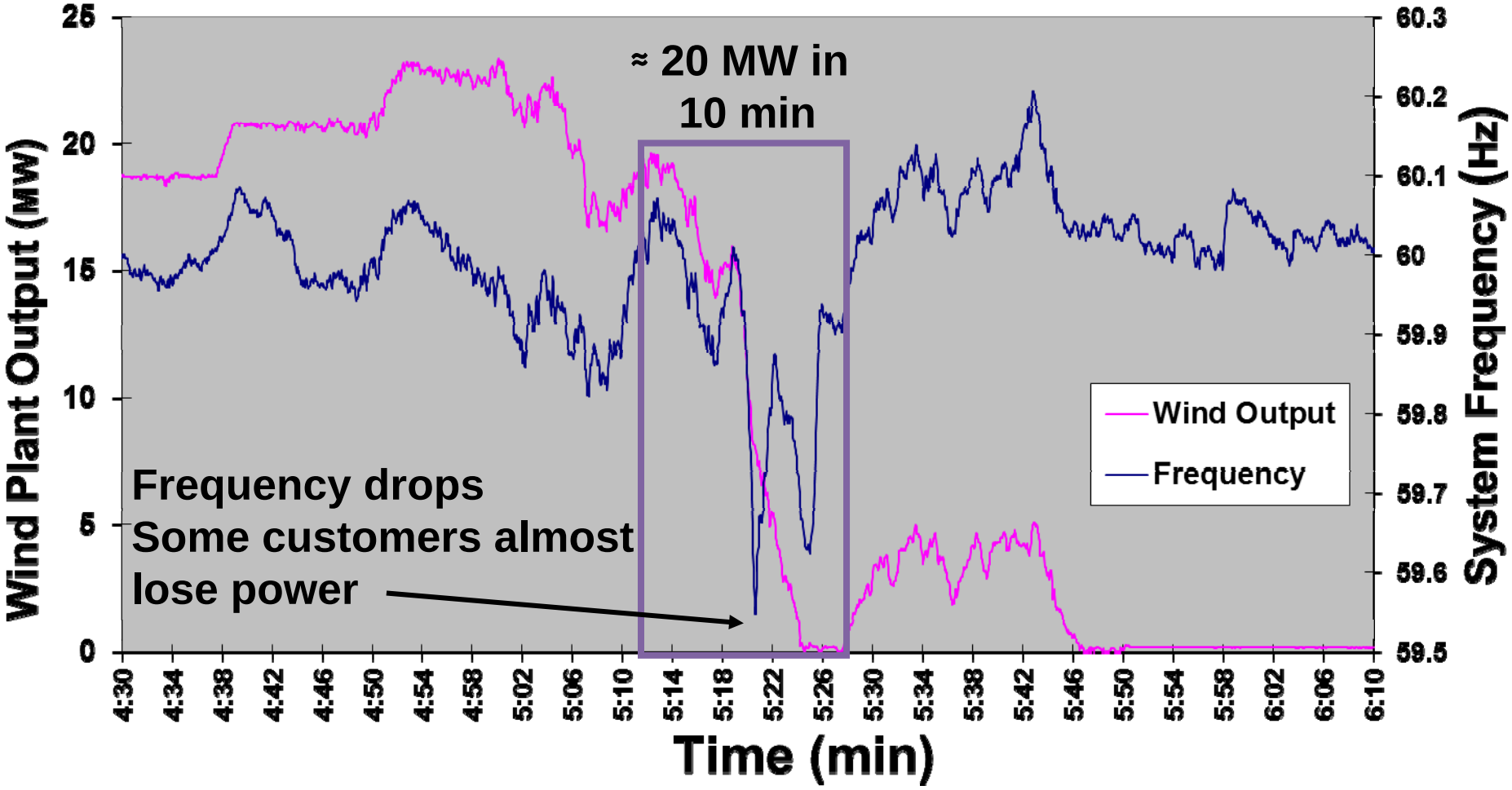


Figure 3. Wind turbine prices in the United States

Sources: Wiser and Bolinger 2011, Vestas (2011a, 2011, 2011c), and BNEF (2011a)

Example of Key Integration Challenge

Managing Large Wind Ramp on Maui



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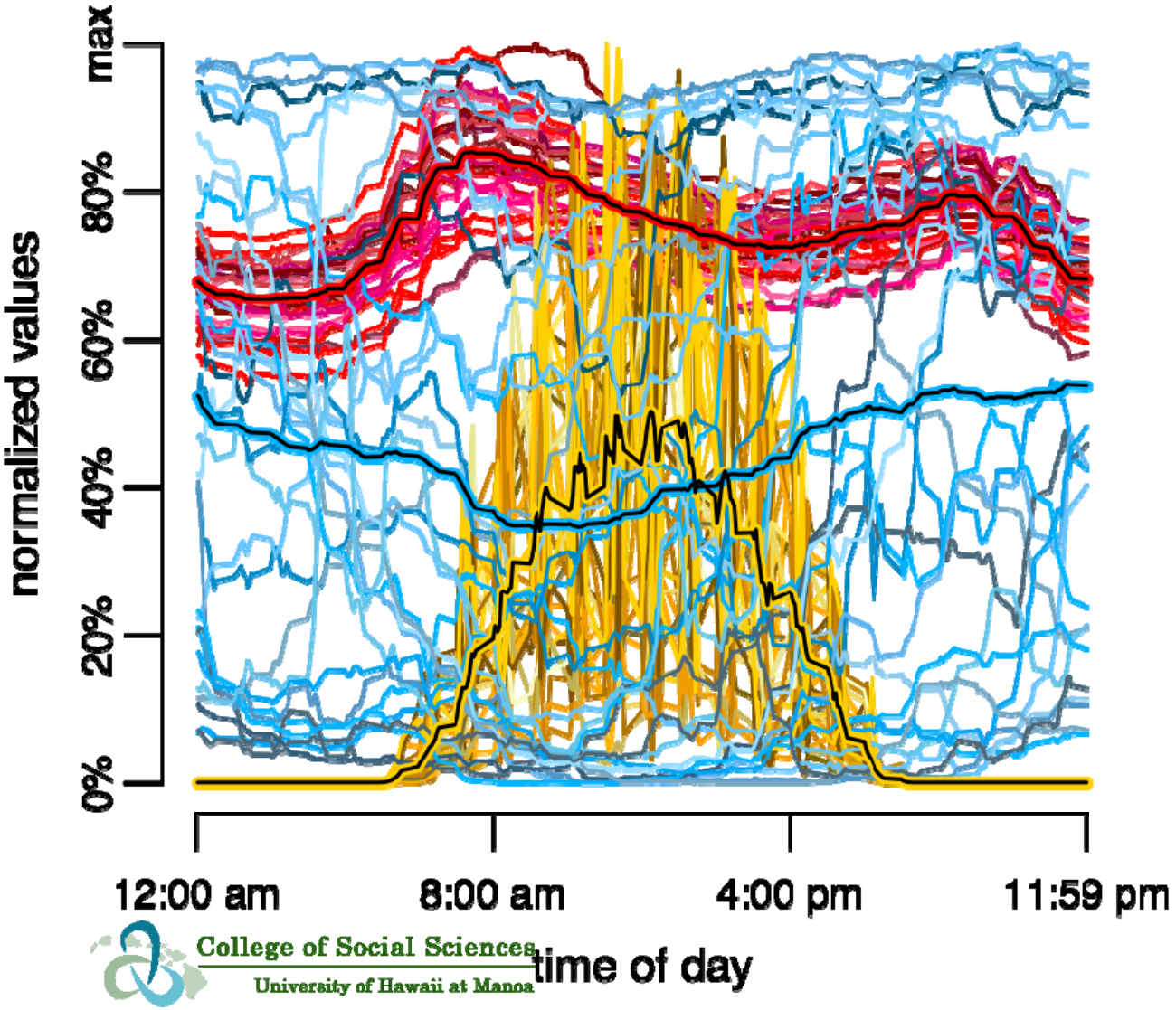
Actual event from February 29, 2008

Source: Maui Electric Co.

Wind and Solar Resources are Variable



Consequences

- Curtailment
- Grid instability
- Large spinning reserves
- Rapid ramping

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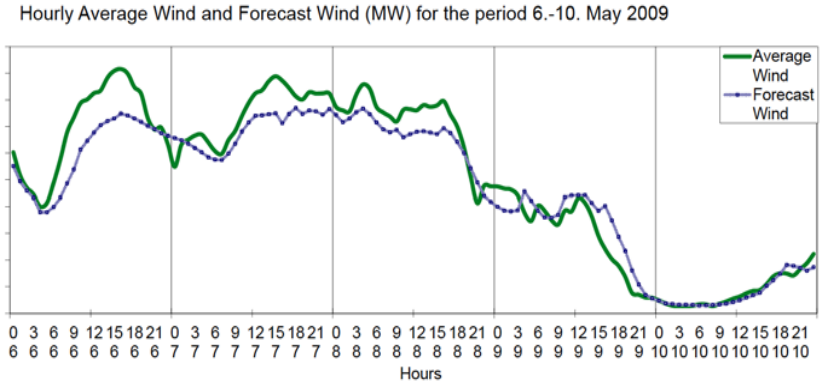
timeseries data obtained from Bonneville Power Administration

plot concept motivated by Hawkins, 2005

New Technologies Must Be Utilized to Increase Flexibility in Power Supply and Delivery



Improved Forecasting

Wider Area Aggregation (Transmission) and Use of Baseload for Ancillary Services

Flexible Dispatchable Generation and Use of Load as a Resource (Demand Response Technologies)

Energy Storage

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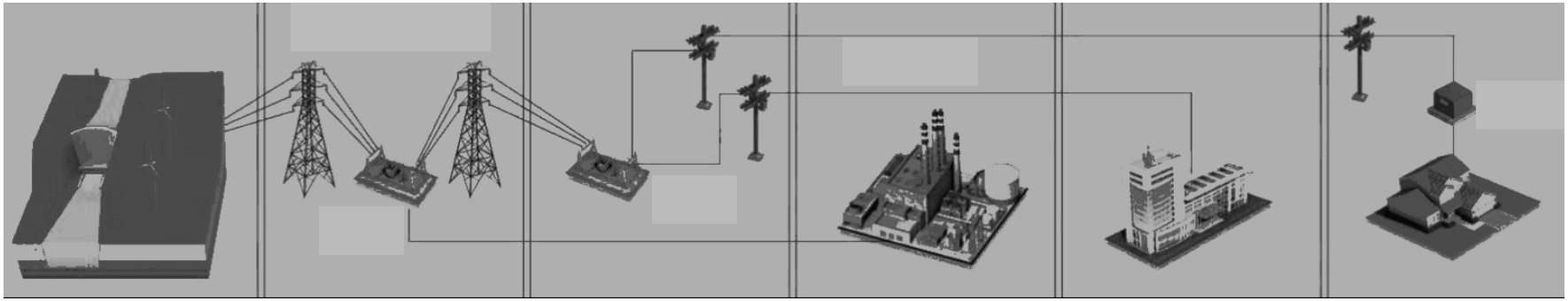
Smart Grid Opportunities

Generation | Transmission | Distribution | Industrial | Commercial | Residential



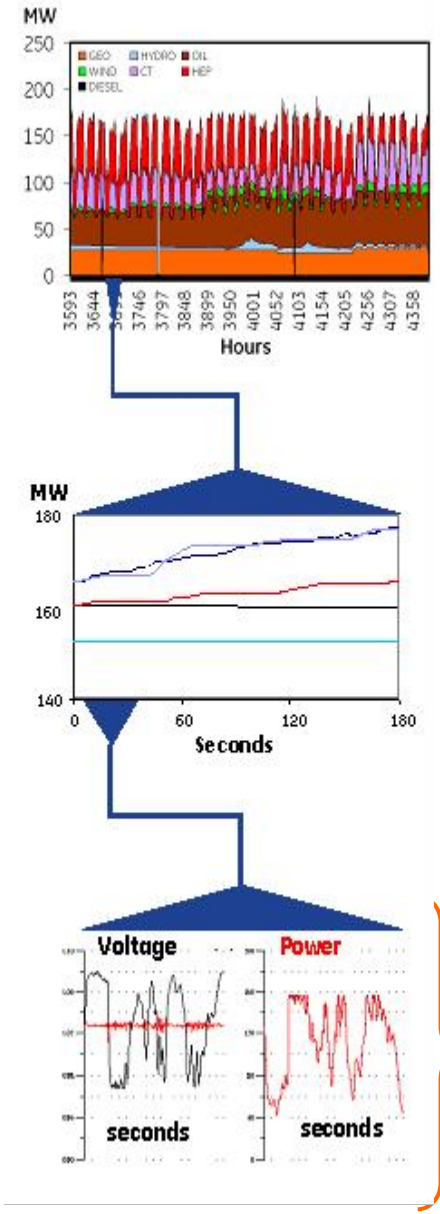
- Renewable Energy
- Integrating Renewables
- Distributed Generation
- Electric Vehicle Integration
- Flexible Generation
- Cyber Security
- Energy Storage
- Demand Response
- Dynamic Reactive Power
- Wireless Comms
- Distribution Automation
- Smart Meters
- Flexible Transmission
- Wide Area Measurements
- Substation Automation
- Home Energy Monitoring

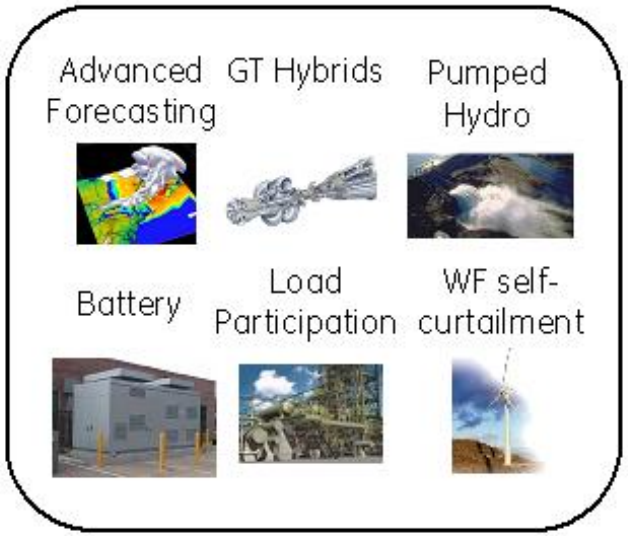
Energy Storage: Mitigation for Higher Penetration

“Hours”
Spinning reserve & day-ahead scheduling

“Minutes”
Load-following

“Seconds”
Faster than AGC

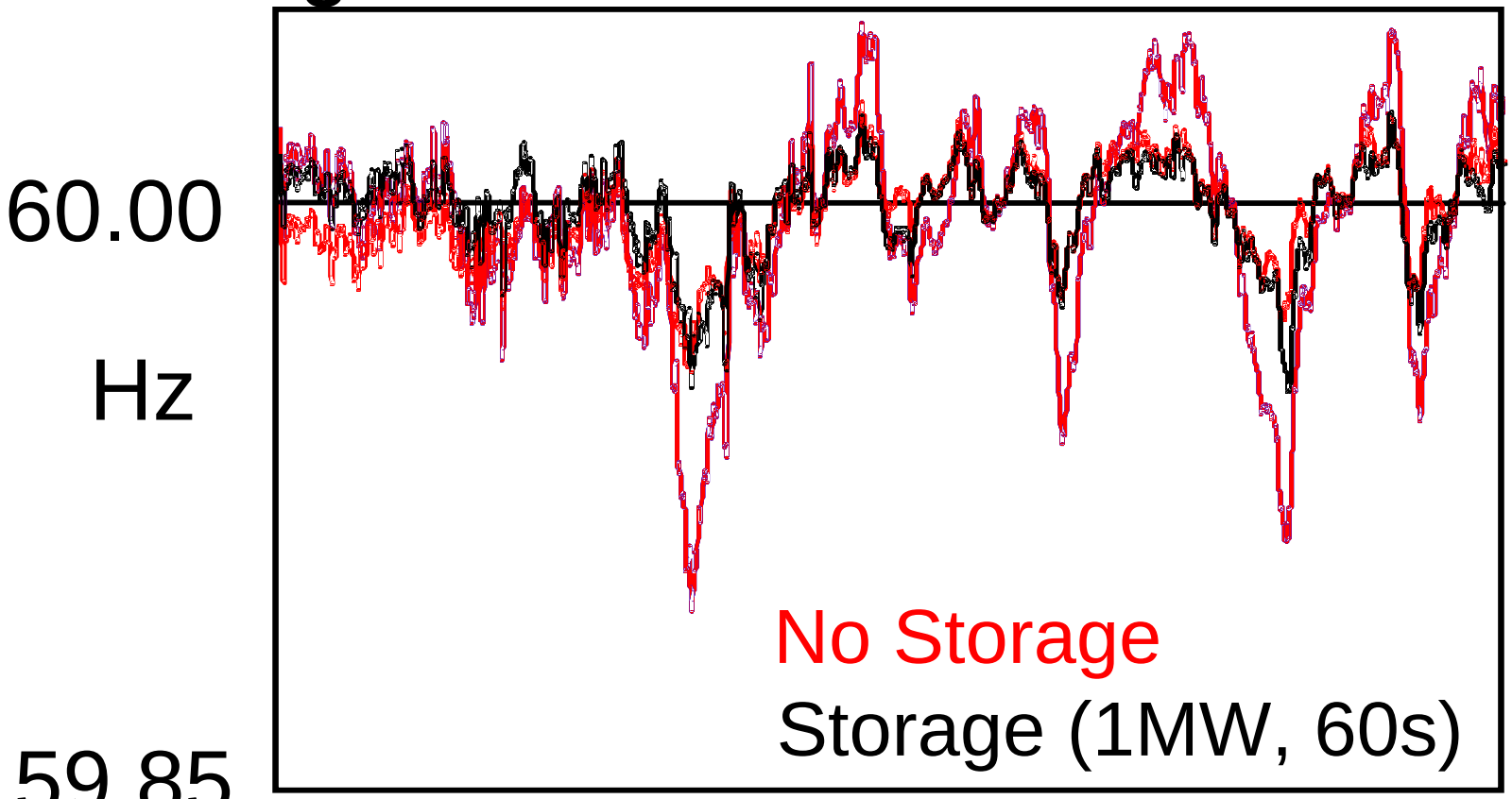




Possible Program

- Quantify performance of mitigation technologies, including energy storage, in each timescale, using Hawaii models.
- Develop battery storage & controls for ramp rate relief
- Explore partnerships to demonstrate performance of battery storage and controls solutions

Modeling Impact of Storage on Grid Stability Using Lithium Titanate Batteries



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Testing and Evaluation of BESS for Grid Support

Hawi 10 MW Wind farm at Upolu Point Hawaii Island

- 1MW, 250kW-hr Li-ion titanate at wind/utility interface
- Frequency regulation, wind smoothing, power quality

HECO feeder with high penetration (>1 MW Distributed PV)

- 1MW, 250 kW-hr Li-ion titanate at substation
- Voltage, VAR, Frequency regulation, power quality

Molokai Secure Renewable Microgrid

- 2MW, 375kW-hr Li-ion titanate, ~100kW community BESS,
- Operating reserves, frequency regulation, smoothing, peak shifting.

MECO 20 MWh at substation

Address ramping, load shifting, and large percetages of residential and commercial PV

Kauai Waste Water Treatment Facility

- ~1MW, 2MW-hr integrated into MW PV system
- PV smoothing, energy storage/load shifting
- Grid independent operation

Grid-scale Energy Storage – photos courtesy of Altairnano

Examples of new U.S. renewable energy initiatives (1)

- **Advanced Research Projects Agency-Energy (ARPA-E) Awards $66 Million for Transformational Technologies**
  - **On September 19, 2013 DOE announced awards to 33 projects under two areas:**
    - Recycling metals for lightweight vehicles, and the other to develop
    - Biological technologies to convert biogas to liquids for transportation fuels

Examples of new U.S. renewable energy initiatives (2)

- **On July 16, 2013, ARPA-E Announces $30 Million for Full-Spectrum Solar (July 16, 2013)**
  - Full-Spectrum Optimized Conversion and Utilization of Sunlight (FOCUS), seeks to develop two distinct technology options to deliver low-cost, high-efficiency solar energy on demand:
    - New hybrid solar energy converters
    - New hybrid energy storage systems

Summary

1. Renewable energy resources are enormous
2. Solar and wind industries are growing at double digit rates
3. Harvesting decades of innovation in PV and wind technology
4. Costs for renewable energy have dropped dramatically in the past decade
5. Renewable energy innovation pipeline is full and growing
6. Natural gas is a partner for renewables, along with Demand Response and Demand Side Management
7. New regulations will limit future coal use - lead to increased exports
8. Ancillary and Smart Grid systems will continue to change the nature of the electric utility industry