

Recent Developments in Hawaii and California – A Look at Successes and Future Challenges



Terry Surles
terry.surles@uc-ciee.org

And
surles@hawaii.edu

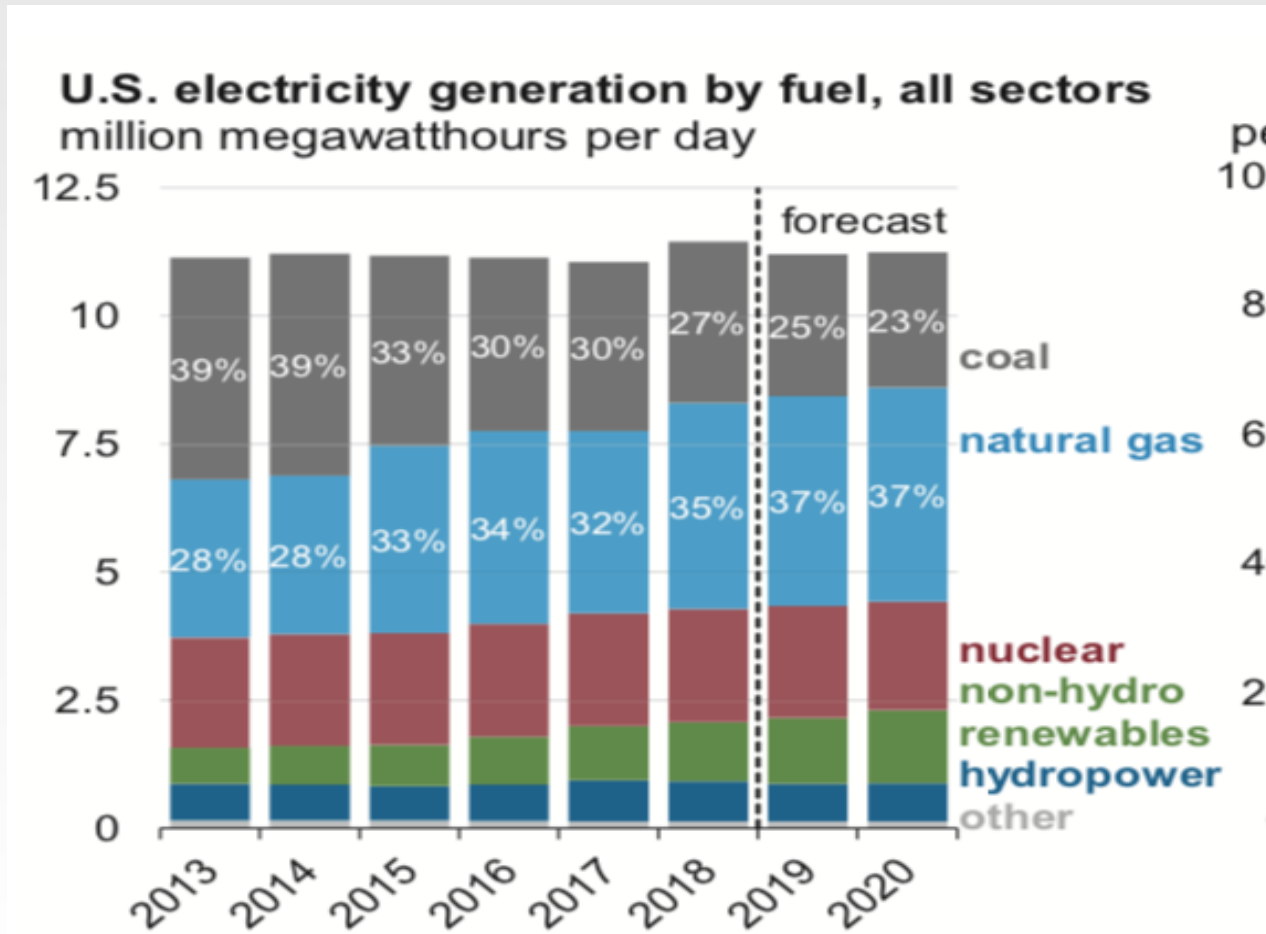
New Zealand Wind
Energy Association
Conference

May 1, 2019

A President “so untethered to reality” - LA Times – The Paris Accord Withdrawal Pep Rally

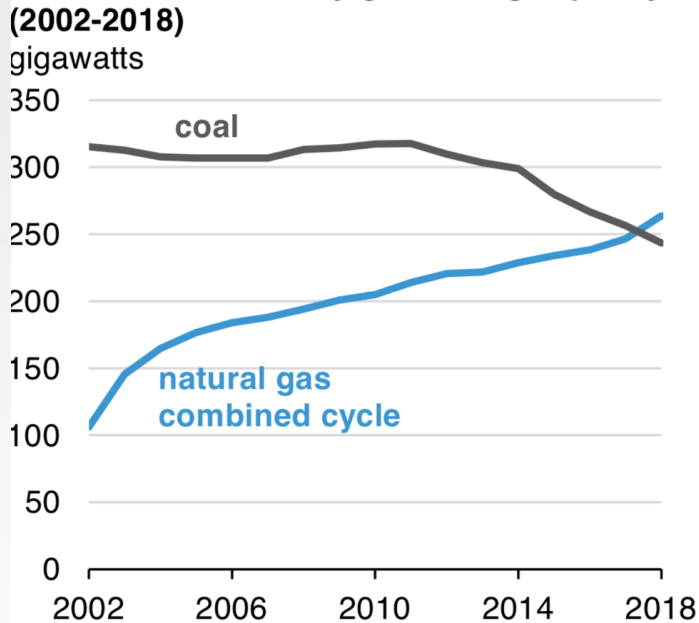


Early 2018 Data on US Electricity Generation by Resource – Over 1/3 by Natural Gas

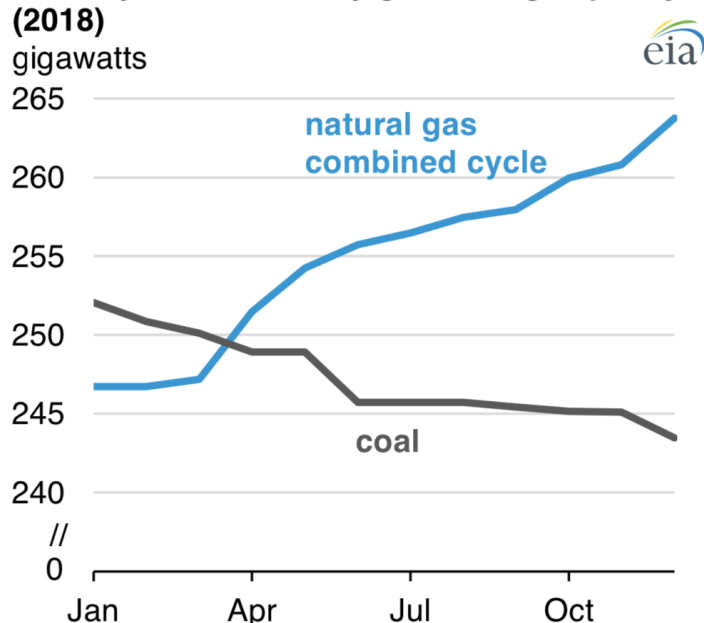


Decline of Coal Versus Natural Gas – But NG Use Requires CCS with New Bills (40Q) in Congress

Annual U.S. electricity generating capacity (2002-2018)



Monthly U.S. electricity generating capacity (2018)

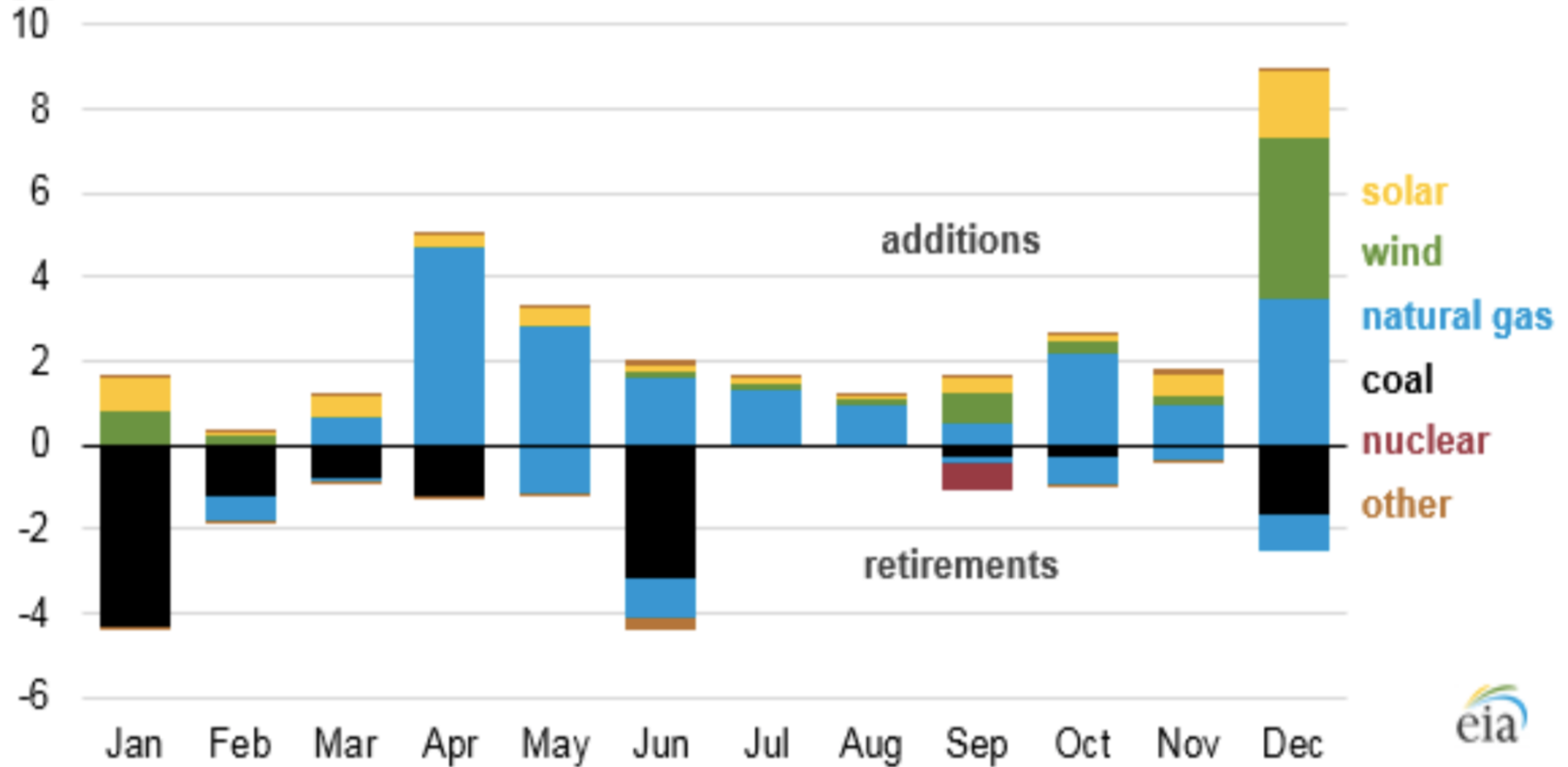


Source: U.S. Energy Information Administration, [Annual Electric Generator Report](#) and [Preliminary Monthly Electric Generator Inventory](#)

The amount of generating capacity from natural gas-fired combined cycle (NGCC) plants has grown steadily over time, and in 2018

Capacity Additions in 2018 (62% NGCC and 21% wind)– Continued Retirement of Coal (69%) and Natural Gas Peakers (25%)

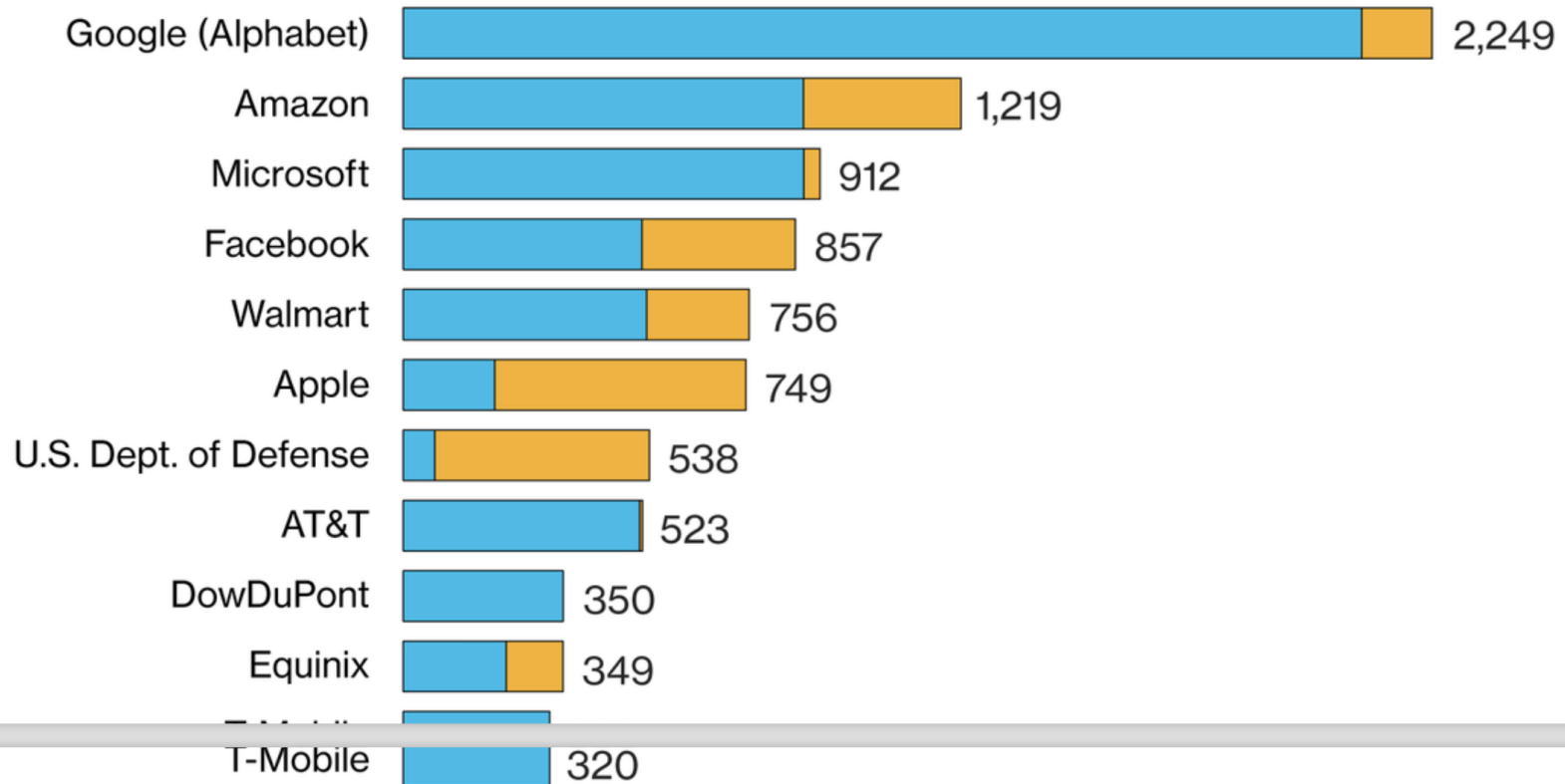
U.S. utility-scale electric generating capacity additions and retirements by month, 2018
gigawatts



Source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*

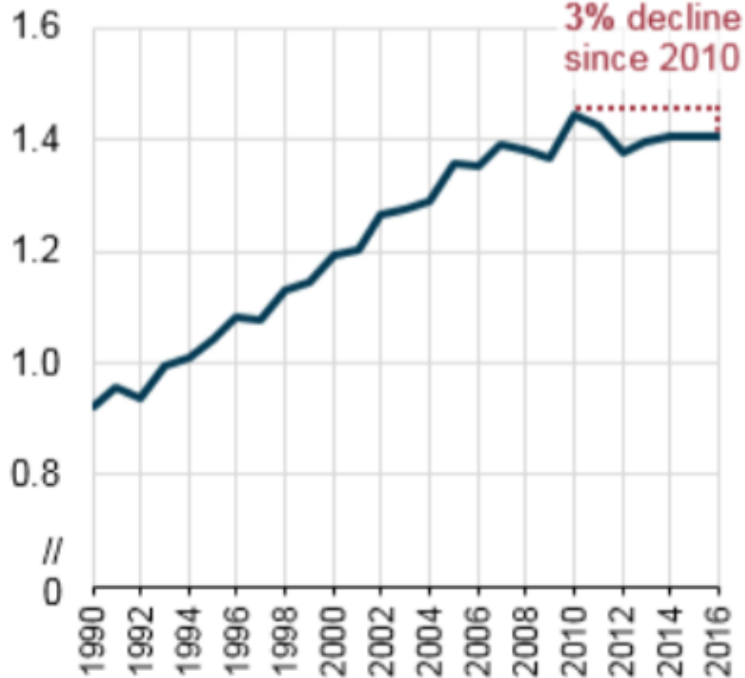
Companies Are Ignoring Trump Pronouncements – Smaller Wind Is Now Preferred

Total capacity (in megawatts): Wind Solar

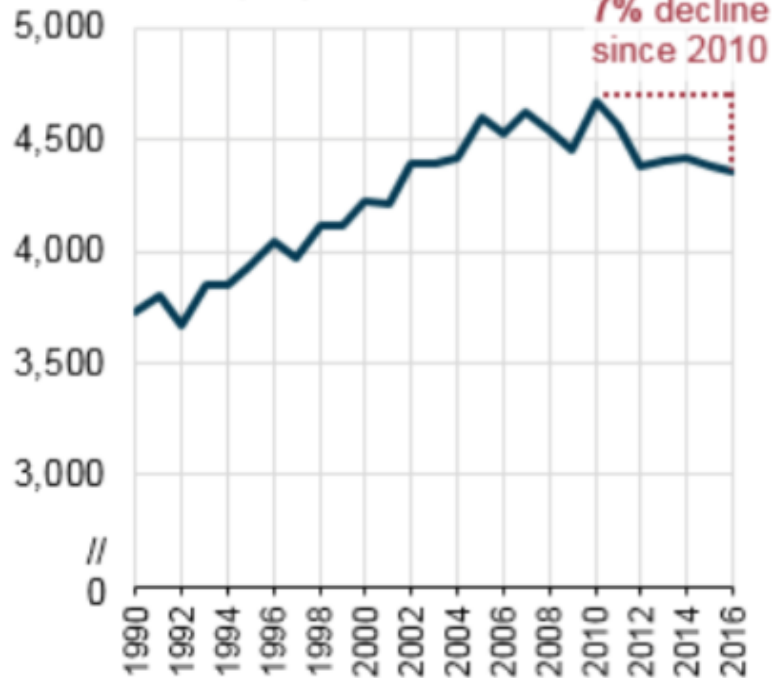


Efficiency and BTM Generation Drive Electricity Sales Down, Can Impact Funding for New Systems – DOE, 2017

U.S. annual residential electricity sales
trillion kilowatthours



Residential electricity sales per capita
kilowatthours per person

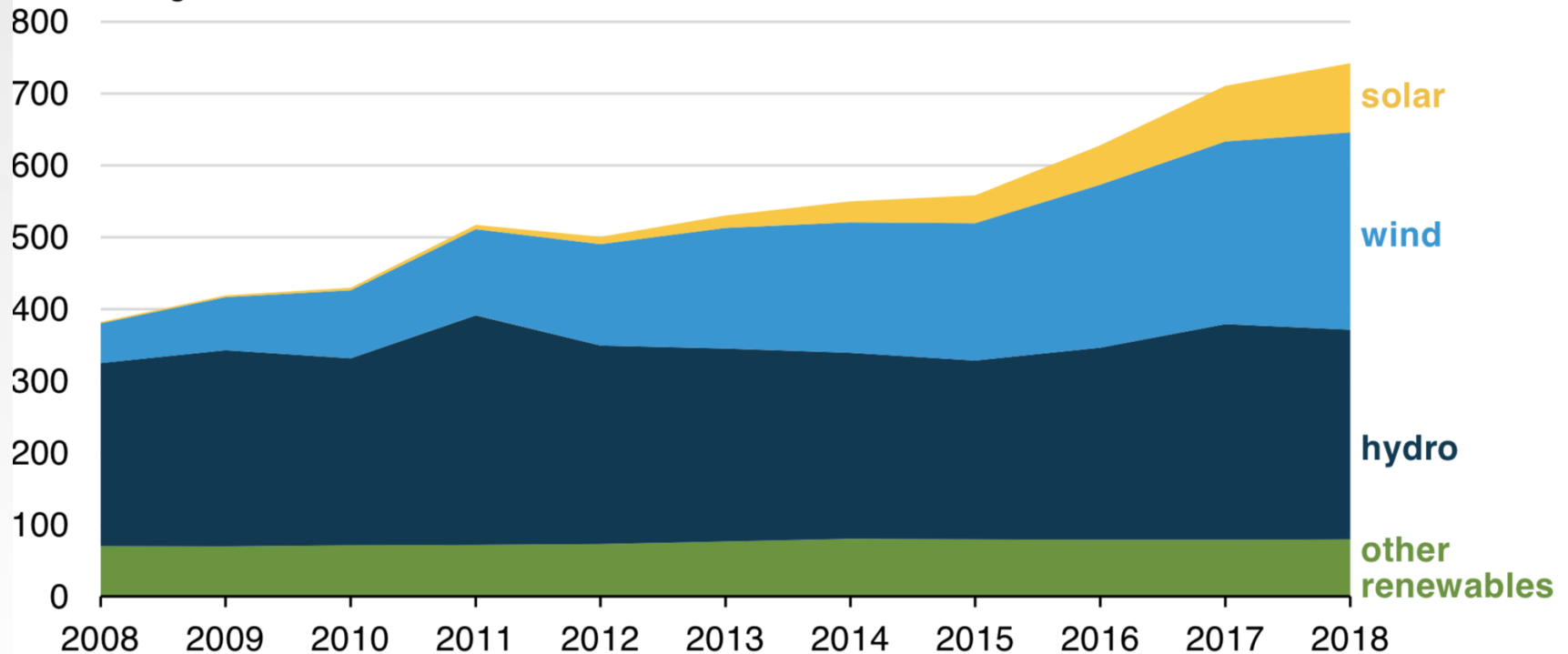


Source: U.S. Energy Information Administration, *Electric Power Annual* and U.S. Census Bureau *Population estimates*

Intermittent Renewable Generation Has Grown to 742 Twh for 2018: with majority of growth from wind

U.S. annual renewable generation, by fuel type

million megawatthours



Source: U.S. Energy Information Administration, *Electric Power Monthly*



States and Utilities Are “Racing to the Top”

- States with 100% renewable goals
 - Hawaii, California, New York
 - Over 20 states now part of Climate Action Network
- Utilities with 100% non-fossil goals
 - HECO, Idaho Power, Xcel, PSNM, Nevada Energy
- Other entities addressing carbon management
 - PJM considering carbon price in dispatch
 - Serves 61M, manages delivery of 800Twh, 21% of US GDP
 - NY, NJ, IL will subsidize their nuclear power as a carbon management tool

U.S. 2nd in Wind Capacity Additions in 2018 – also with a look at off-shore development (Energy Insider)

1. China – 21,200 MW
2. USA – 7,588 MW
3. Germany – 2,402 MW
4. India – 2,191 MW
5. Brazil – 1,939 MW
6. France – 1,563 MW

7. Mexico – 929 MW
8. Sweden – 717 MW
9. United Kingdom – 589 MW
10. Canada – 566 MW

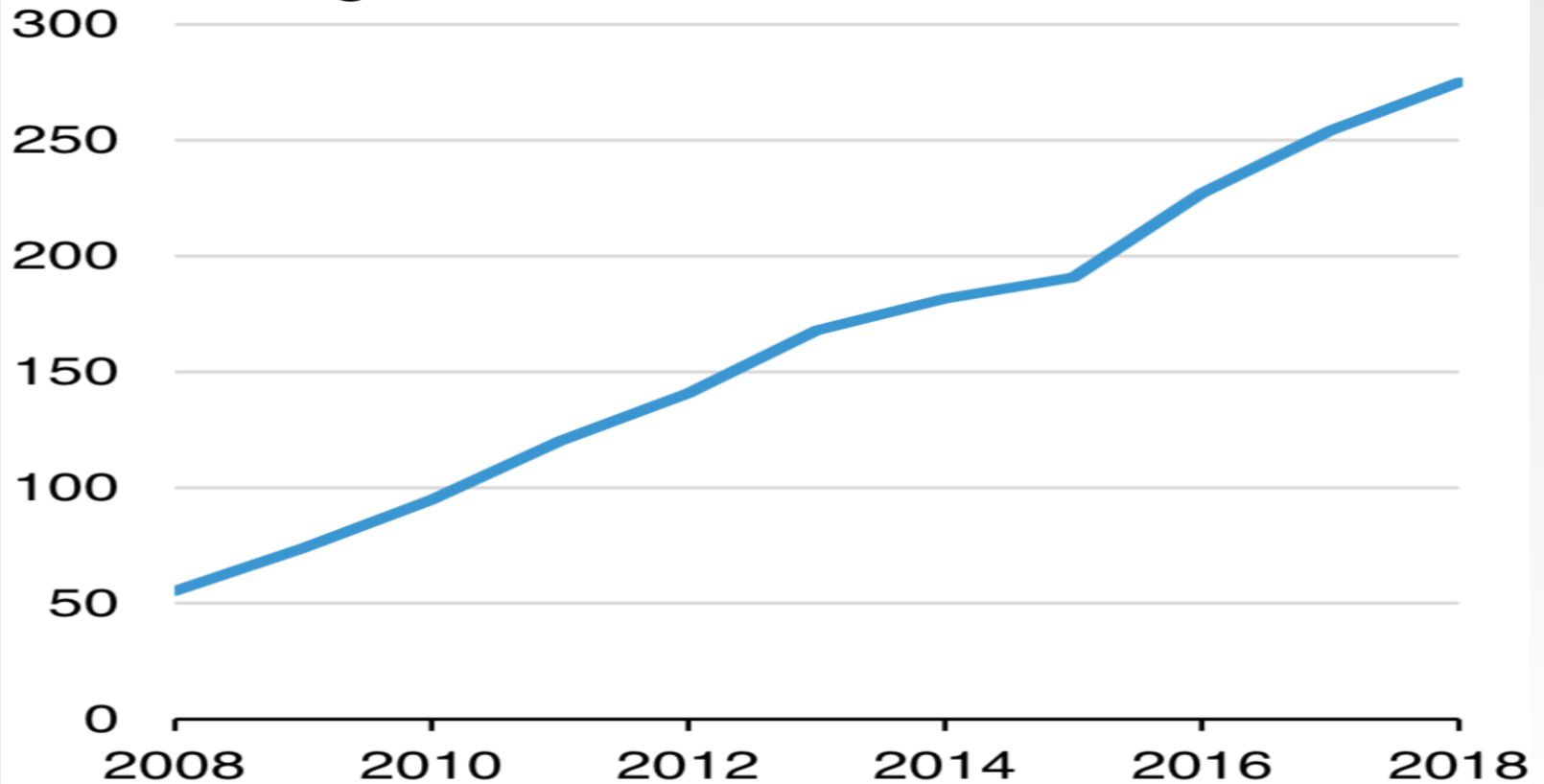
Top offshore markets in 2018:

1. China – 1,800 MW
2. United Kingdom – 1,312 MW
3. Germany – 969 MW
4. Belgium – 309 MW
5. Denmark – 61 MW

Wind Capacity Has Grown from 25GW in 2008 to 94 GW at the end of 2018

U.S. annual net generation, wind

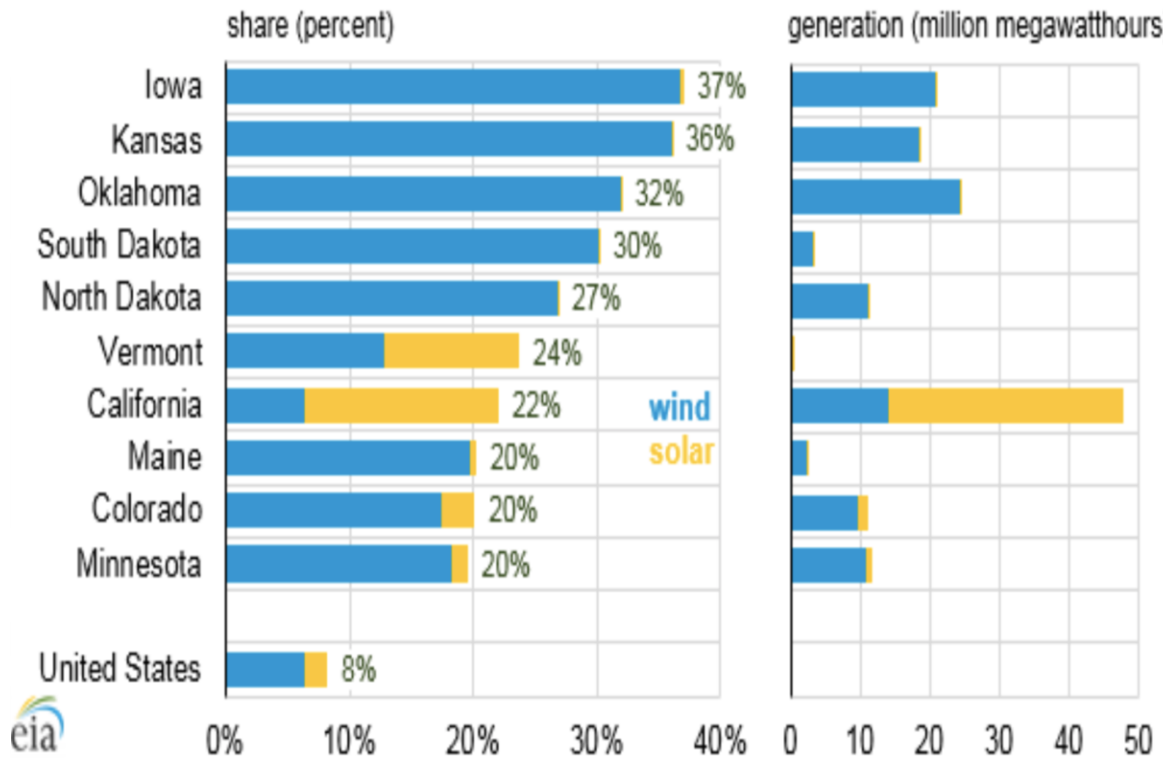
million megawatthours



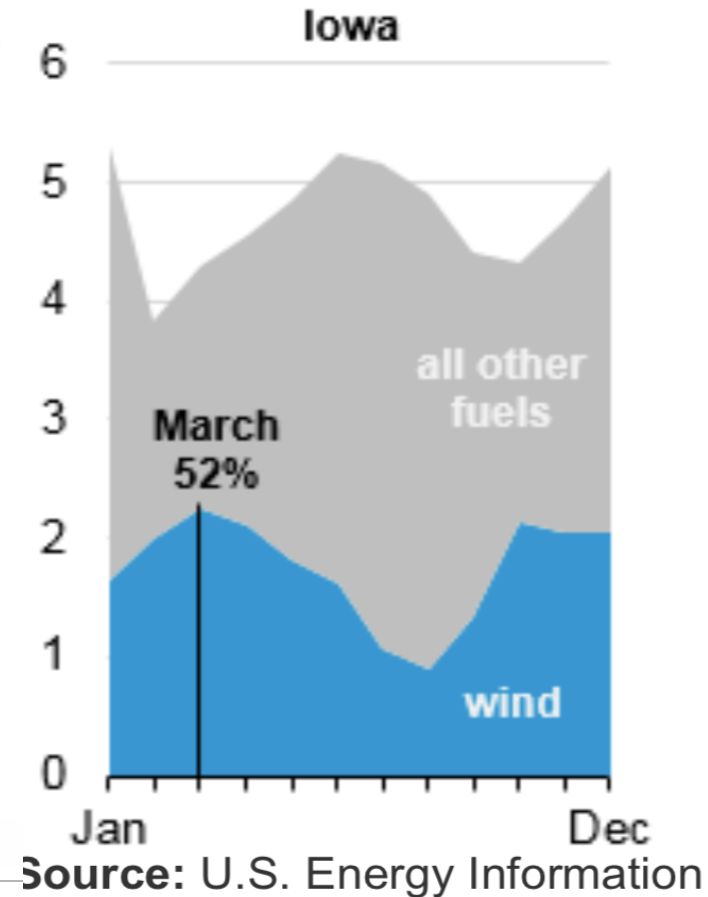
Source: U.S. Energy Information Administration, /

Midwest States Generating the Most % Electricity from Wind, But Texas Has the Most Wind Installed

Electricity generated from wind and solar in selected states (2017)



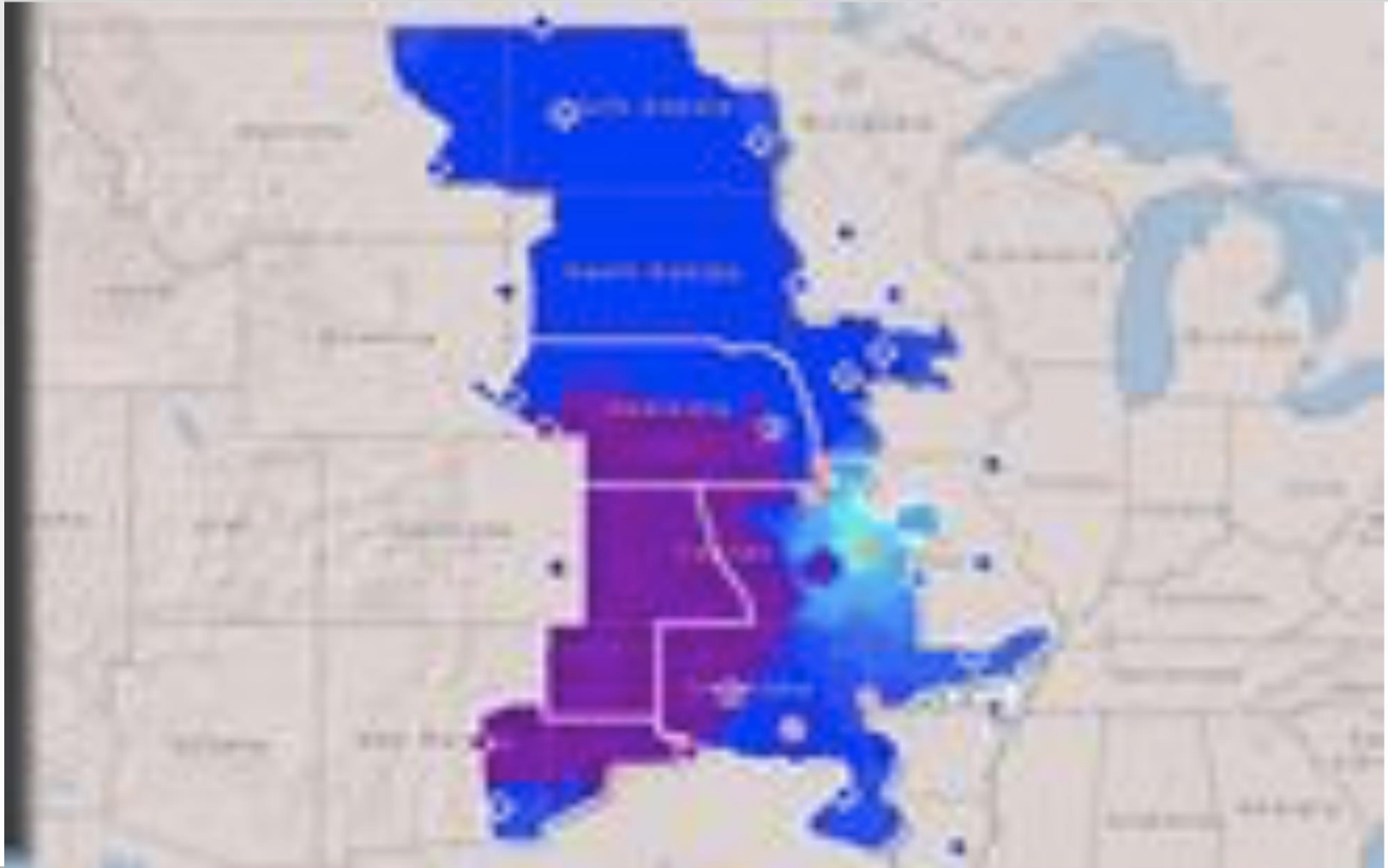
Source: U.S. Energy Information Administration, *Electric Power Monthly*



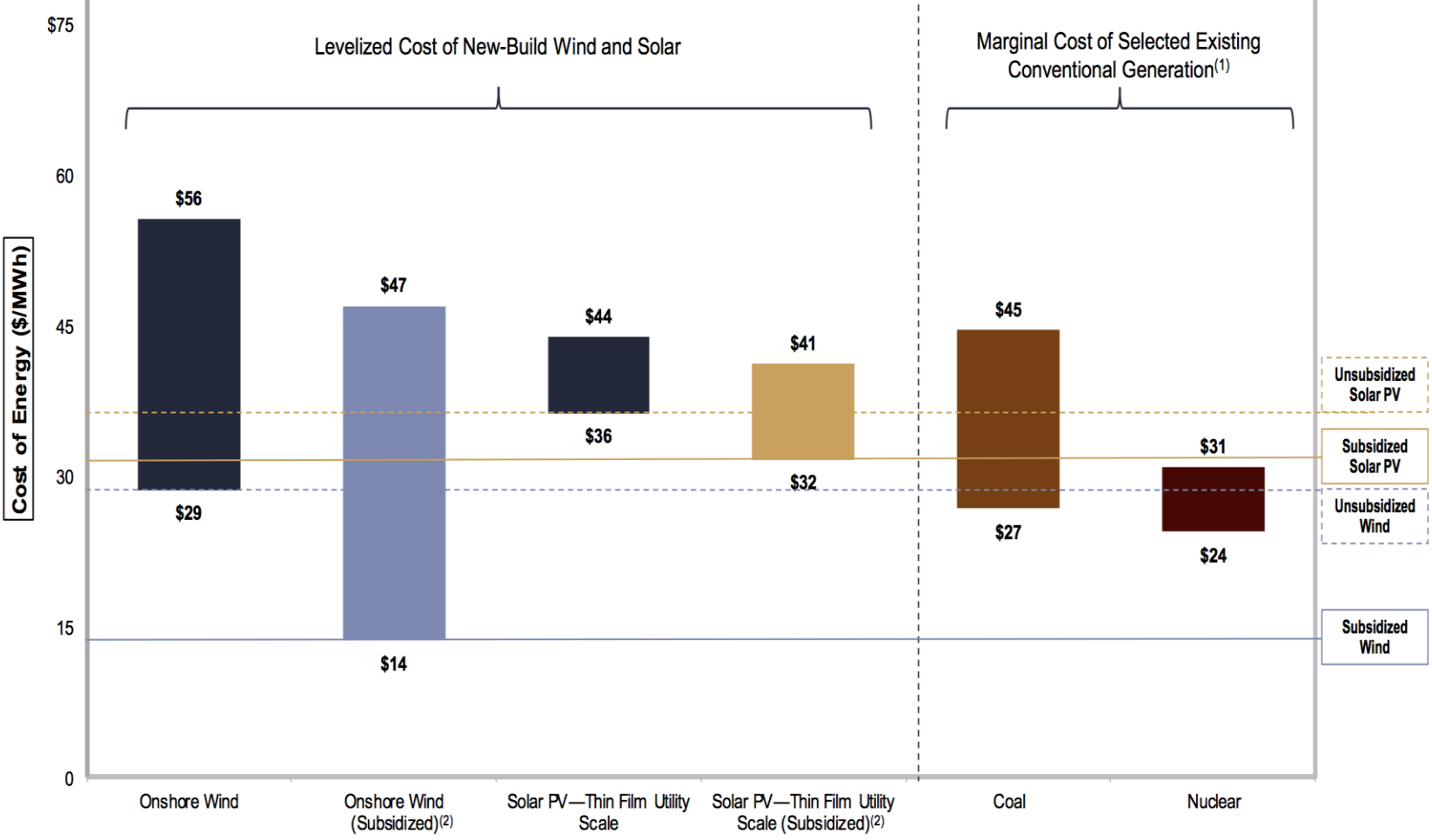
Source: U.S. Energy Information Administration



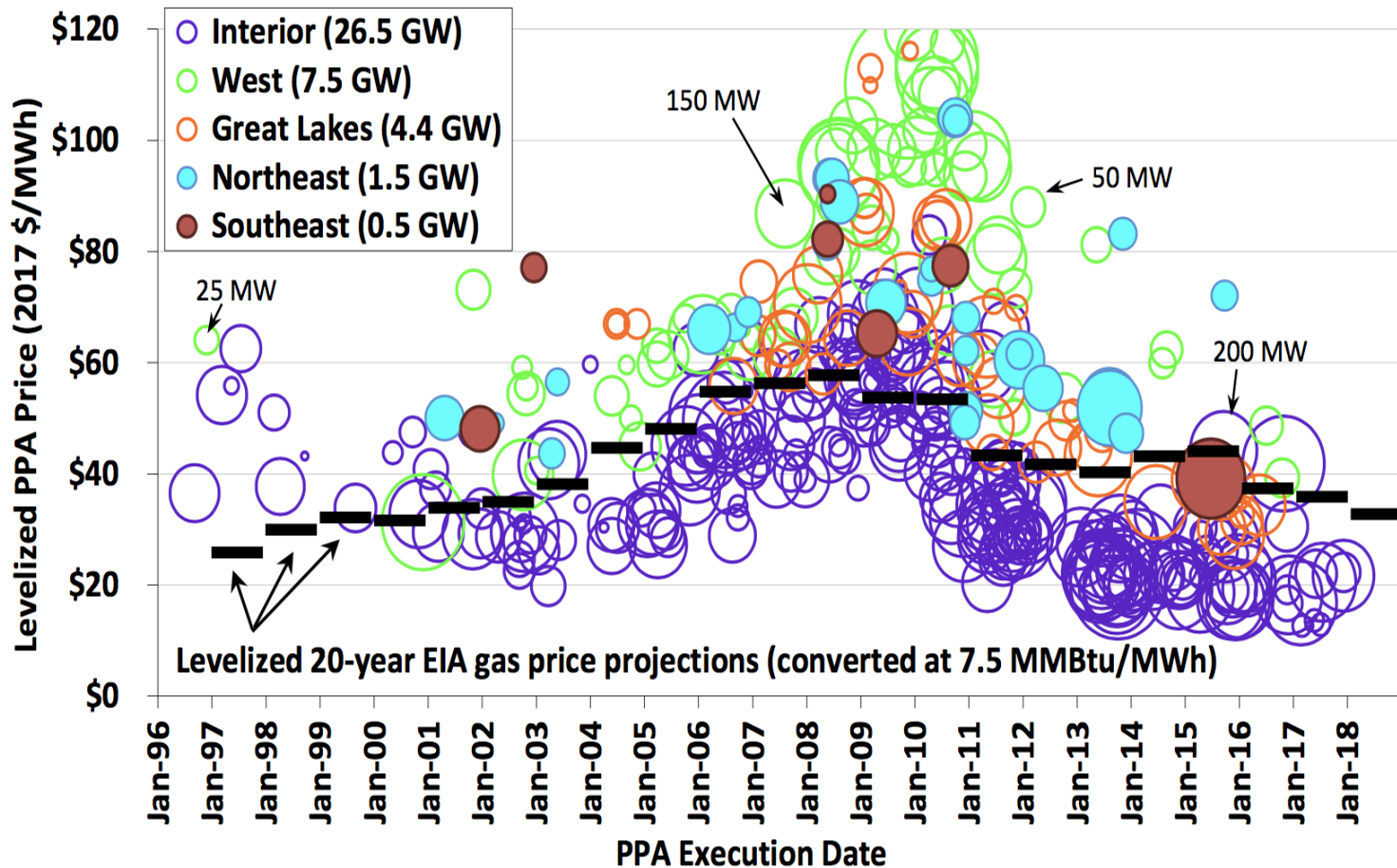
From Bloomberg Energy News on March 26th— Large Portions of US Selling Power at Negative Prices Due to Wind Availability and Warm Weather



Lazard: New-Build Renewables Competitive Existing Coal and Nuclear – Tax Credits for Wind End in 2020, for Solar in 2022

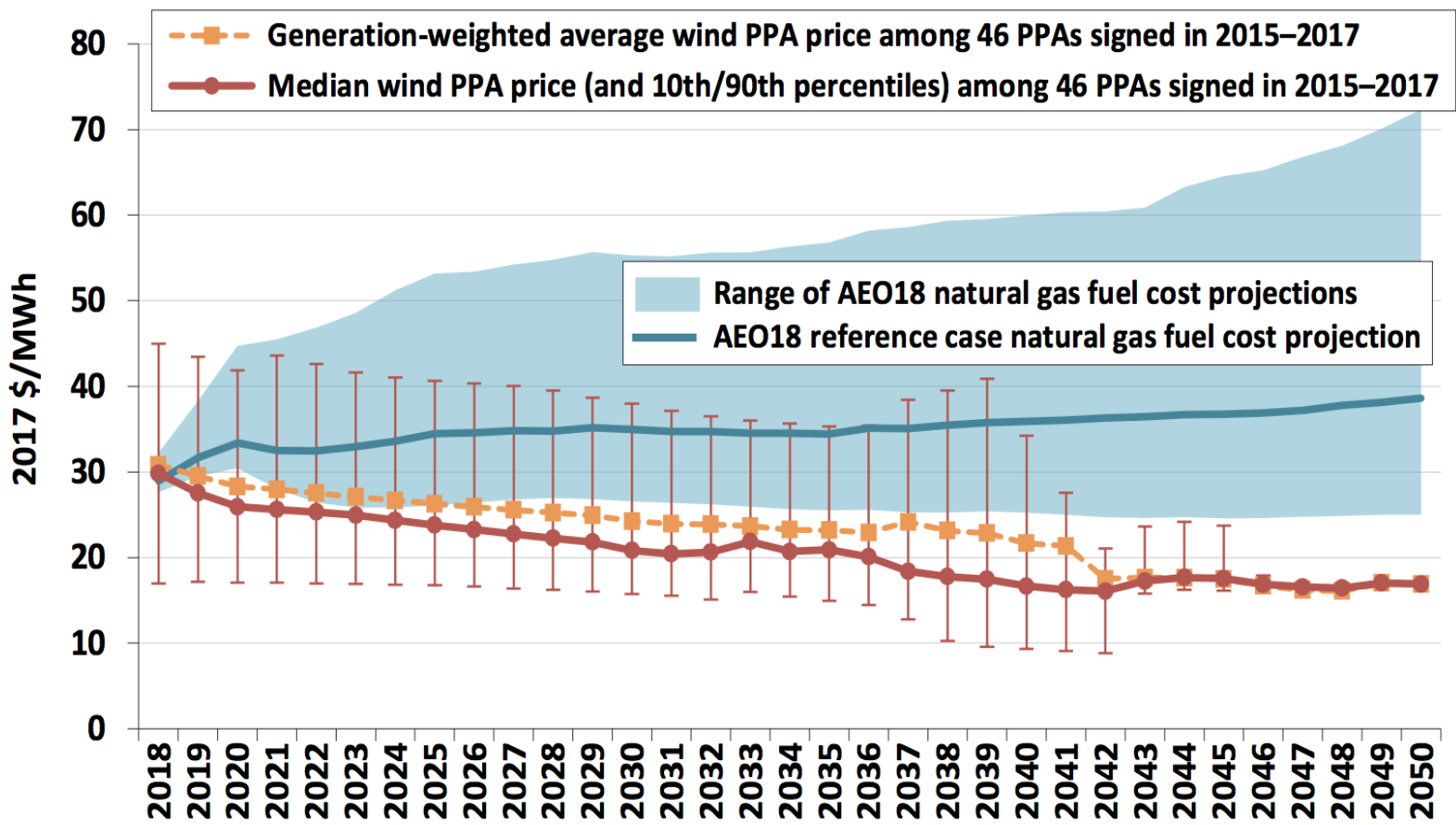


Power Purchase Agreement Prices for Wind Continue to Fall – note comparison to NGCC



Note: Area of "bubble" is proportional to contract nameplate capacity

Wind Generation Is Becoming Competitive with Natural Gas without Tax Incentives – Several preceding slides from Wiser. Bollinger, et al (LBNL)



Note: The 10th/90th percentile range narrows considerably in later years as the PPA sample dwindles

Sources: Berkeley Lab, Energy Information Administration's Annual Energy Outlook 2018 (AEO18)

Offshore Wind: Considerable Activity on US East Coast, Less on West Coast and Hawaii

Rhode Island's 30MW Deepwater Wind Project is the first offshore wind project completed in the US.

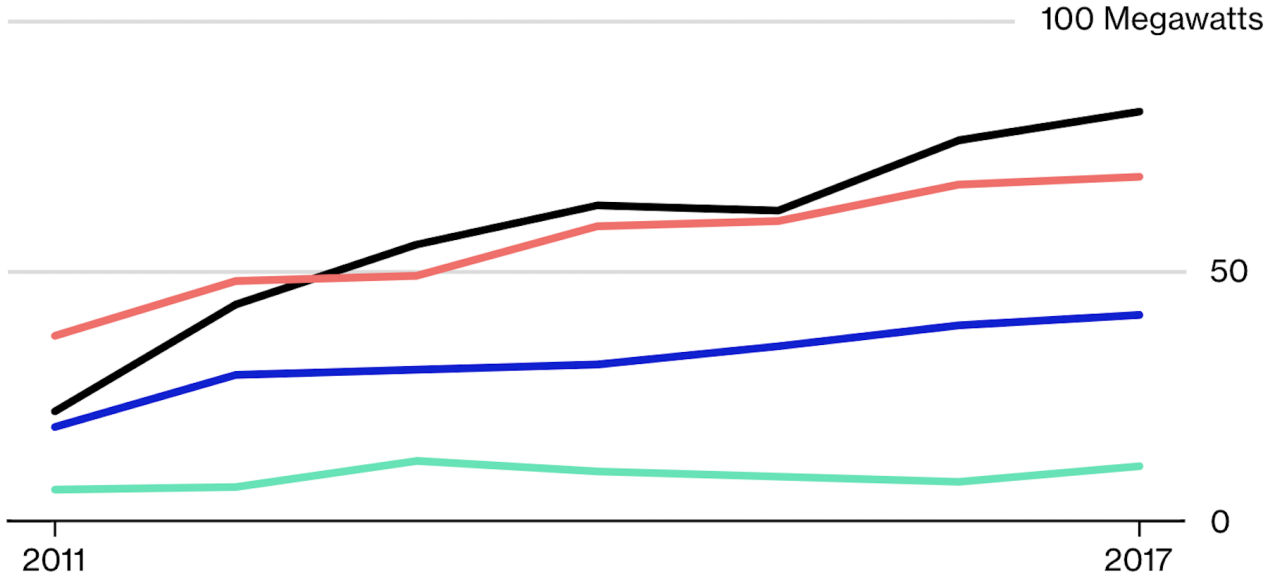


Small-Scale Wind Is a Growing Trend

The Northeast's Lead

Massachusetts and New York are among top states in net-metered wind capacity

Northeast Midwest West South



U.S. Energy Information Administration, Electric Power Annual

WHY GRID MODERNIZATION?

The existing U.S. power system has served us well...

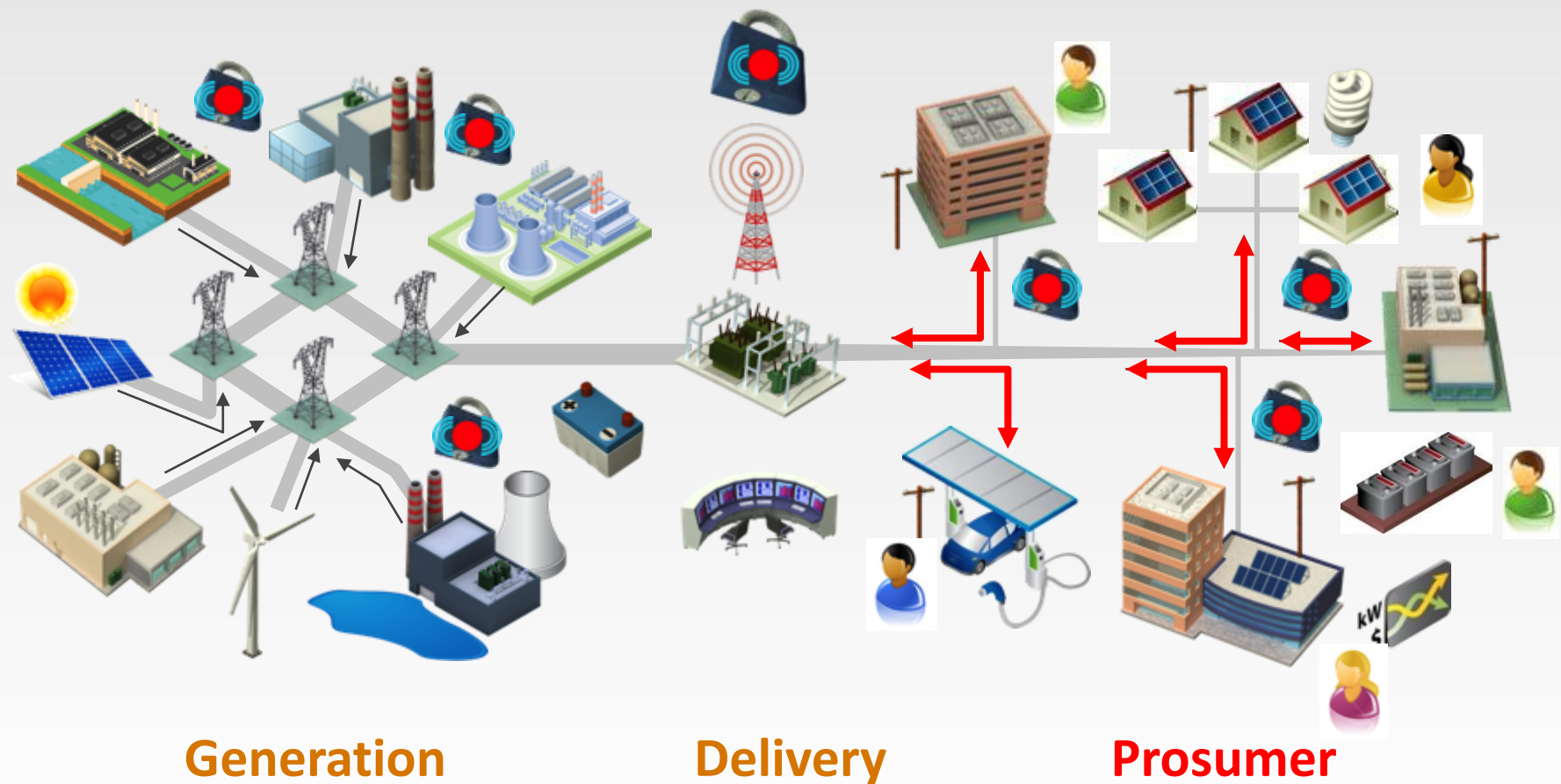
but a 21st Century economy needs a 21st Century grid.



Security Threats



Future Grid Will Require Better Telecommunication, Monitoring, Consumer Involvement, and Artificial Intelligence



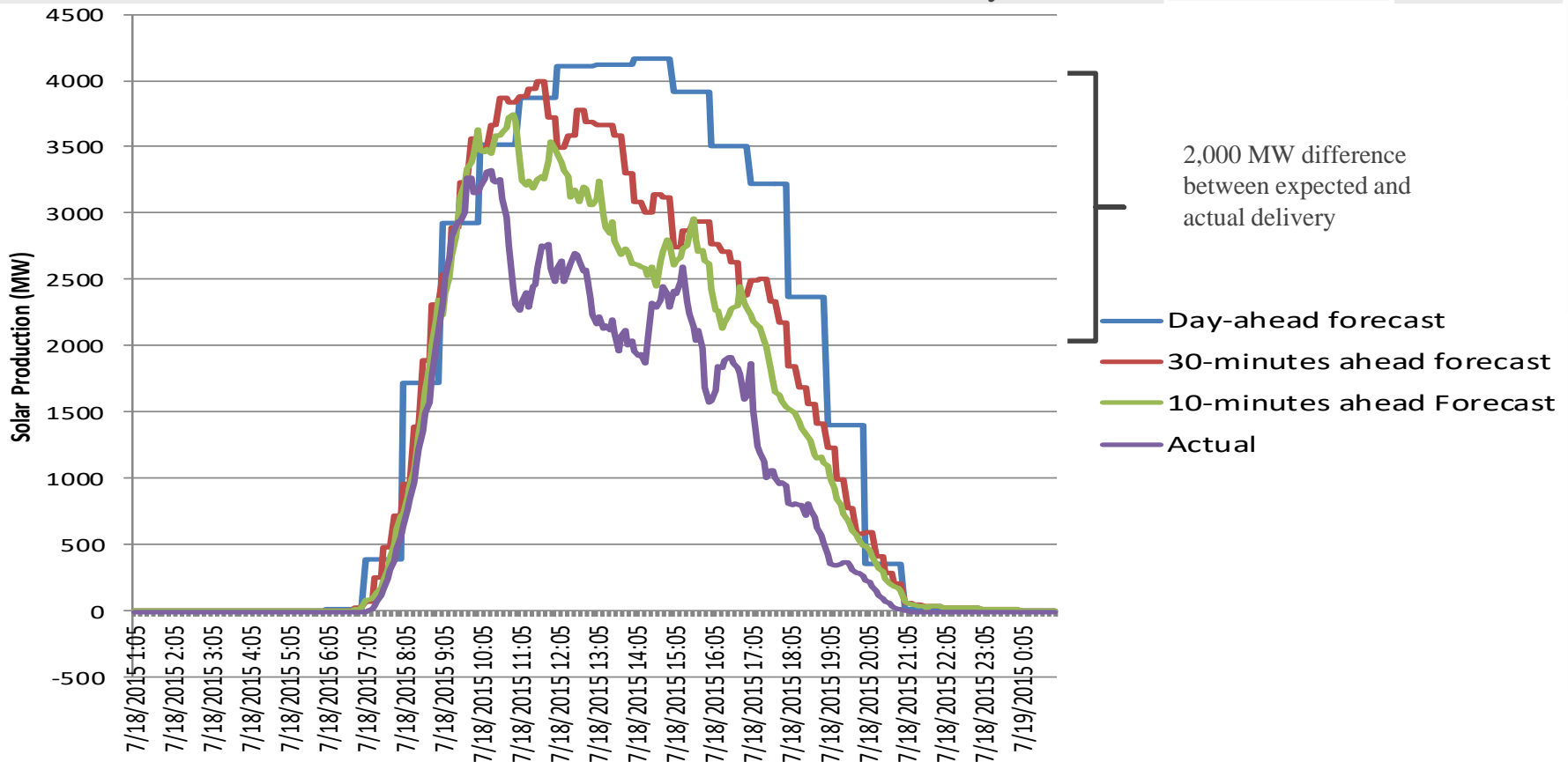
Solar Installations Have Increased – note significant percentage of BTM PV in Hawaii

State	PV generation as a % of in-state generation		PV generation as a % of in-state load	
	All PV	Utility-Scale PV Only	All PV	Utility-Scale PV Only
California	15.2%	10.1%	12.3%	8.1%
Hawaii	11.8%	2.0%	12.5%	2.1%
Vermont	11.5%	6.2%	4.4%	2.4%
Nevada	10.7%	9.7%	11.1%	10.0%
Massachusetts	8.1%	3.3%	4.3%	1.8%
Utah	6.2%	5.4%	7.5%	6.5%
Arizona	5.5%	3.8%	7.4%	5.2%
North Carolina	4.4%	4.3%	4.4%	4.3%
New Mexico	3.9%	3.3%	5.7%	4.8%
New Jersey	3.8%	1.6%	3.9%	1.6%
<i>Rest of U.S.</i>	<i>0.5%</i>	<i>0.3%</i>	<i>0.6%</i>	<i>0.3%</i>
TOTAL U.S.	1.8%	1.2%	2.0%	1.3%

Source: EIA's Electric Power Monthly (February 2018)

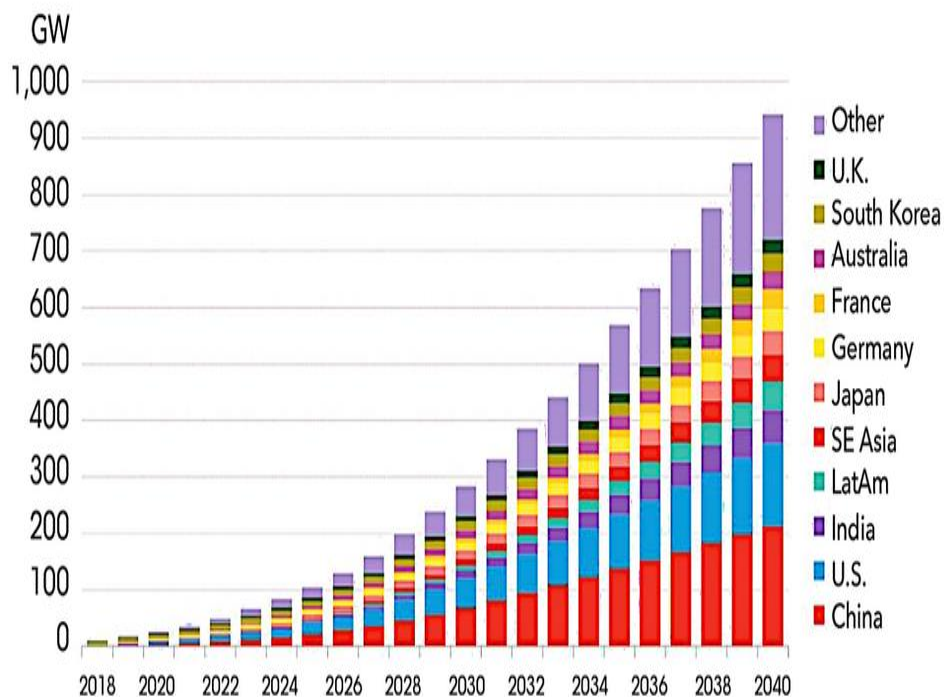
Need Further Improvements in Forecasting to Manage Supply Variability - ~50% Day-Ahead Error for Anticipated Solar

CAISO – Solar Forecast & Actual
July 18, 2015



As Lithium Ion Costs Continue to Fall, More Storage Is Being Deployed

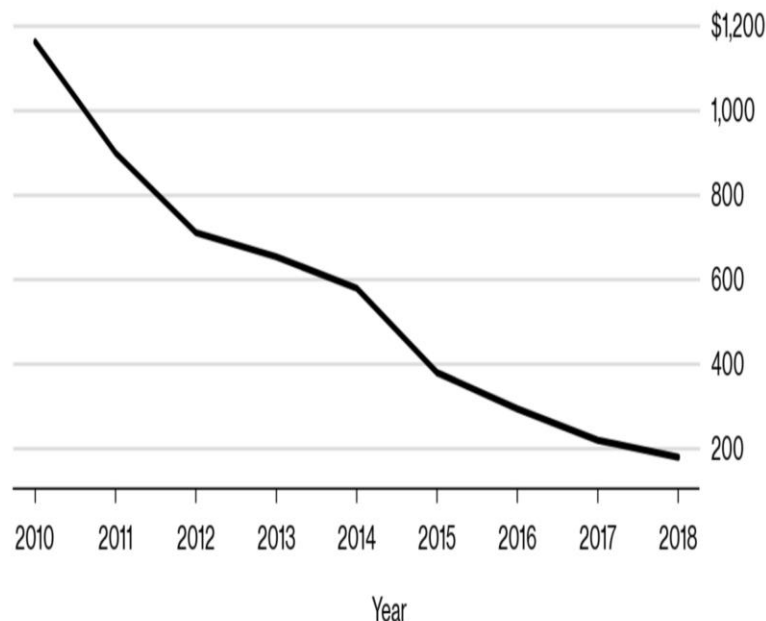
Global cumulative storage deployments



Source: BloombergNEF

Rising production of lithium-ion battery packs has slashed prices.

/ Price (\$/kWh)

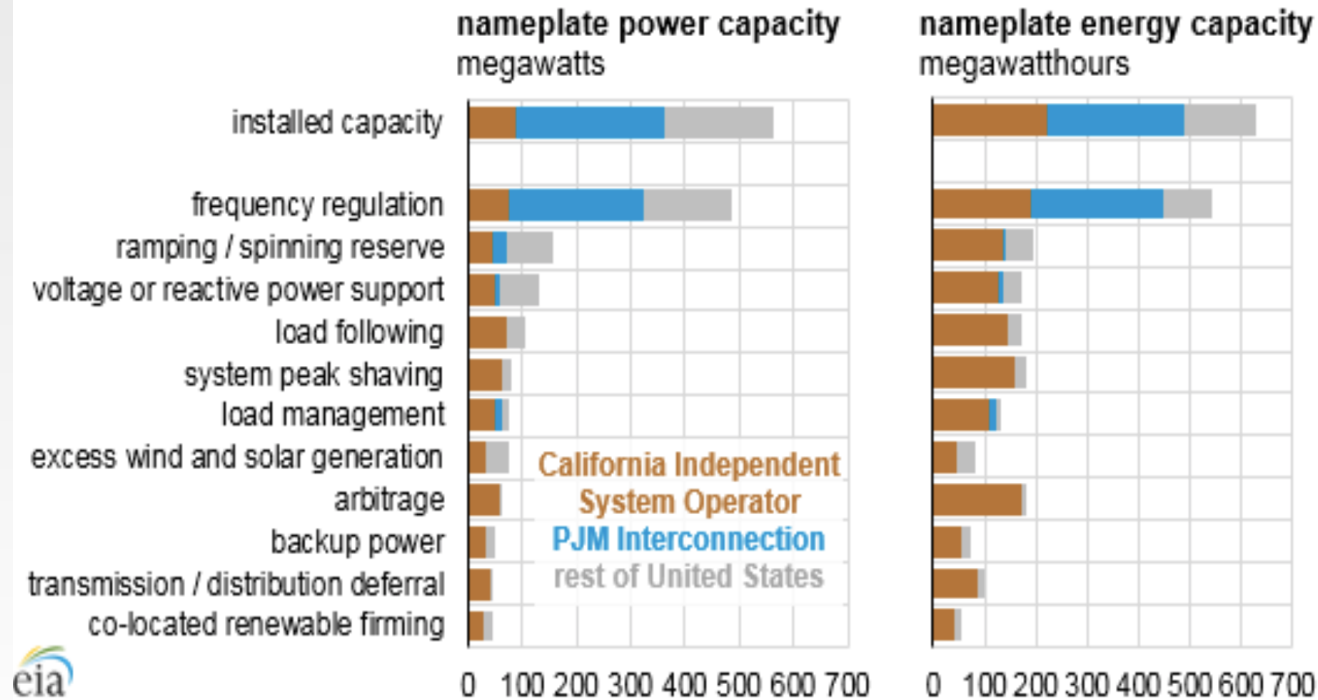


Source: BloombergNEF

Bloomberg

Currently, Main US Application Is Frequency Regulation, But “Duck’s Back” Will Lead to More Use for Ramping

Applications served by U.S. utility-scale battery storage installations (2016)

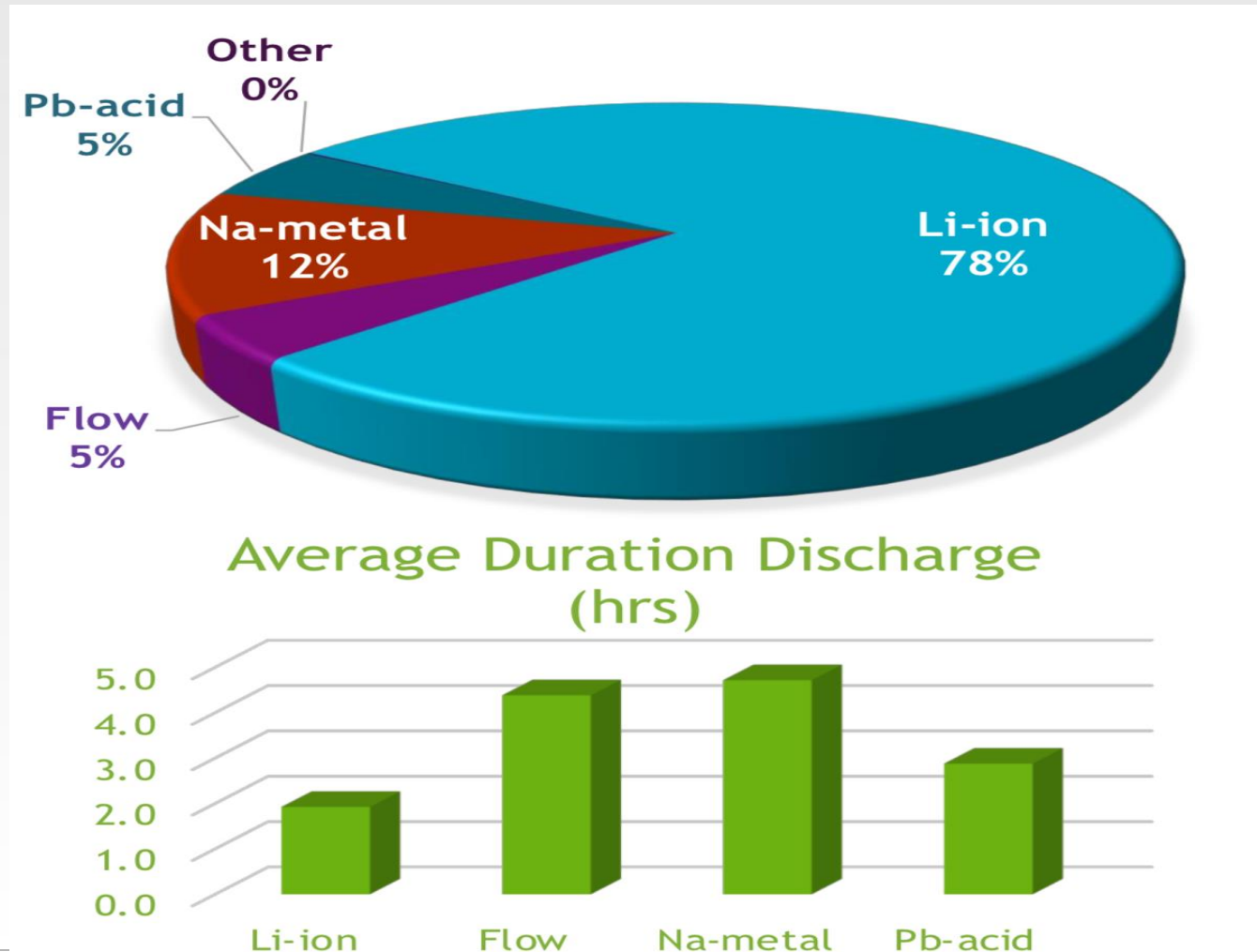


Source: U.S. Energy Information Administration, Form EIA-860, [Annual Electric Generator Report](#)

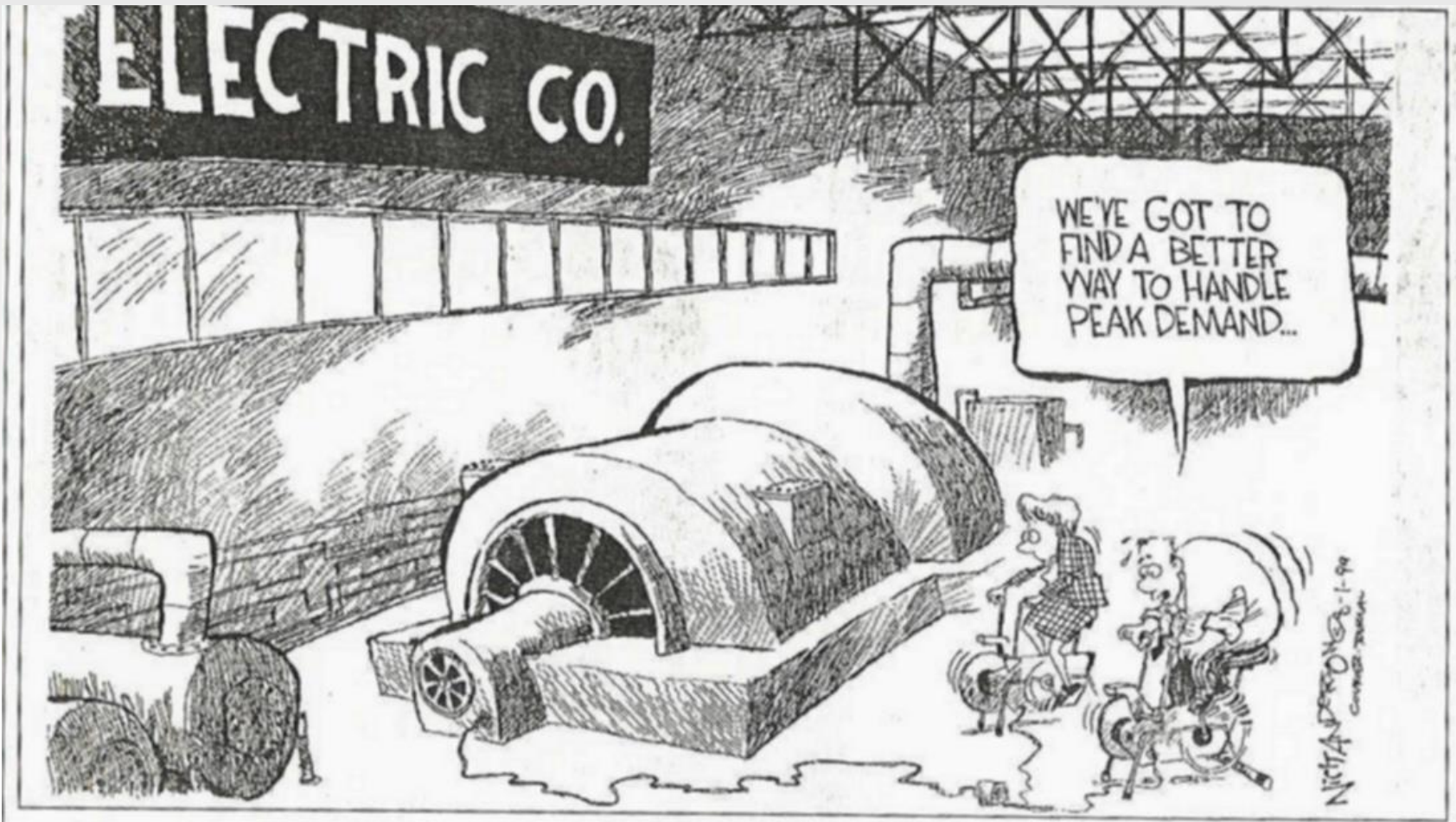
Note: Several battery systems provide more than one application.

Utility-scale battery storage capacity in other regions has not reached the levels observed in PJM and California, but acti

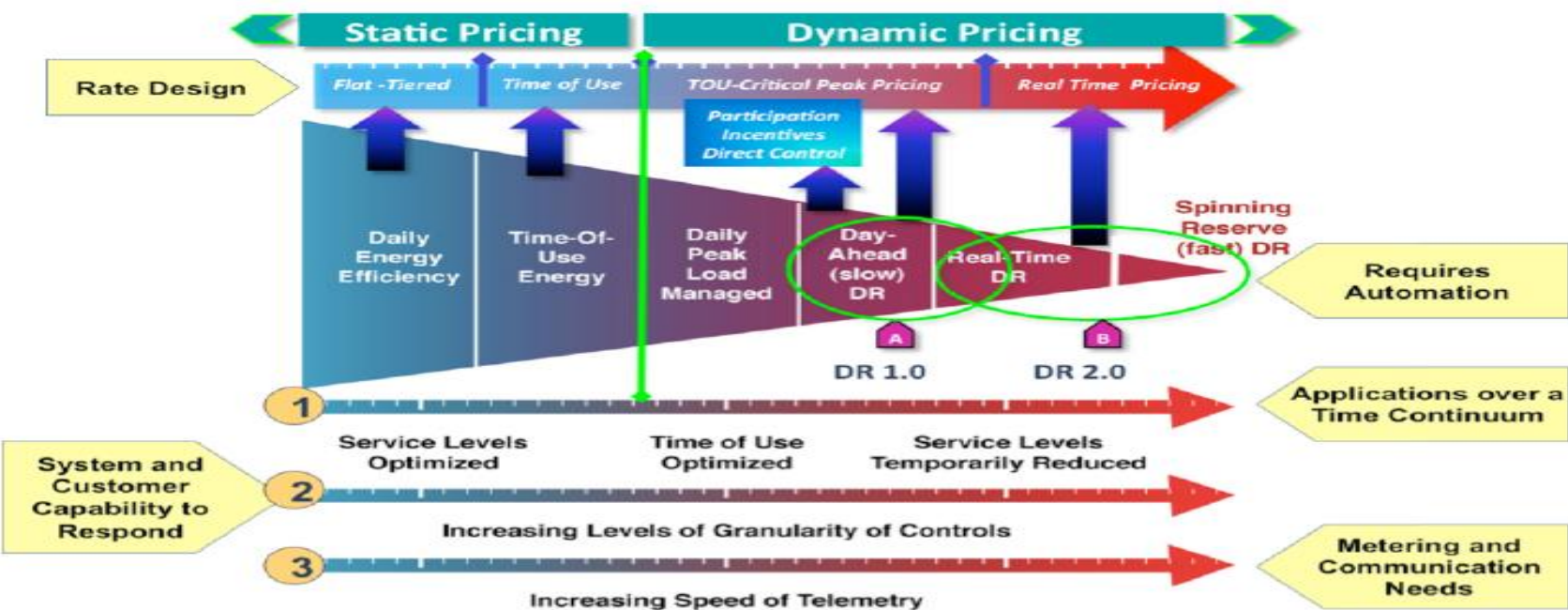
Li-Ion Now the Cheapest (~75% price drop), But Is It Best for Longer-Term Ramping?



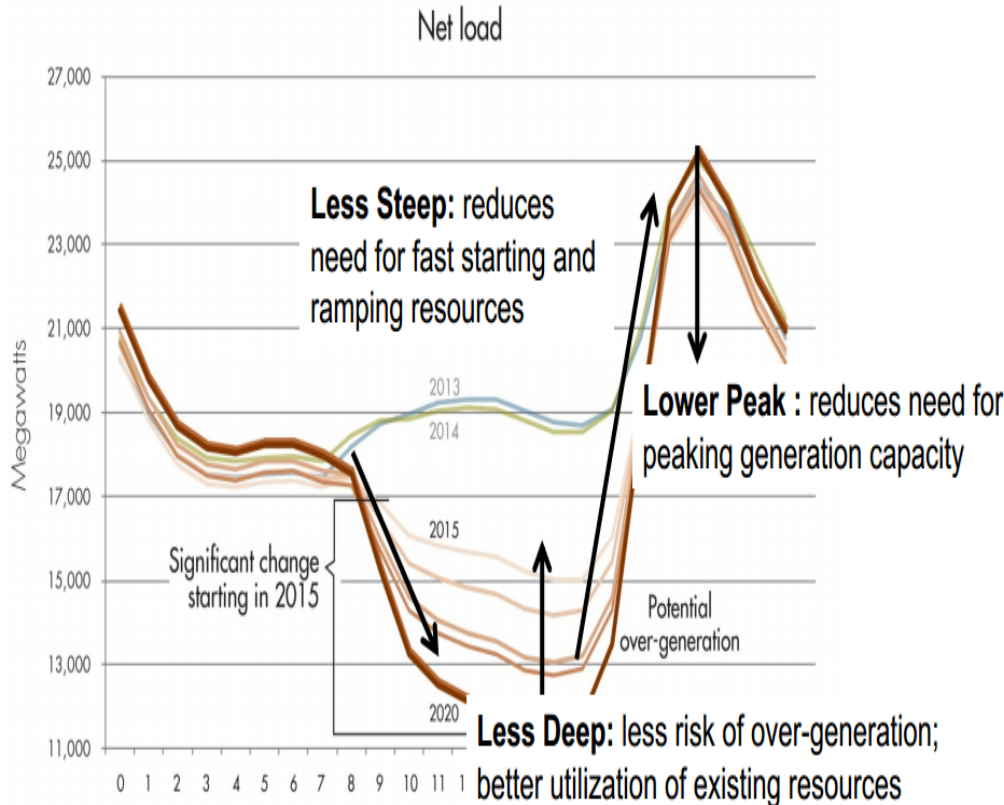
With Advent of New Technology, Automated Demand Response (ADR) Will Be a Tool for Managing the Grid



Demand Response Options should be designed using technology, incentives, and operating features that can adapt to address a continuum of control and system response objectives that provide capability to capture a variety of values for the customer.



Emerging IoT Systems Will Enable Improved Grid Management Using ADR That Addresses Both Generation and Peak Loads (Load Shifting), While Retiring Little-Used Peakers

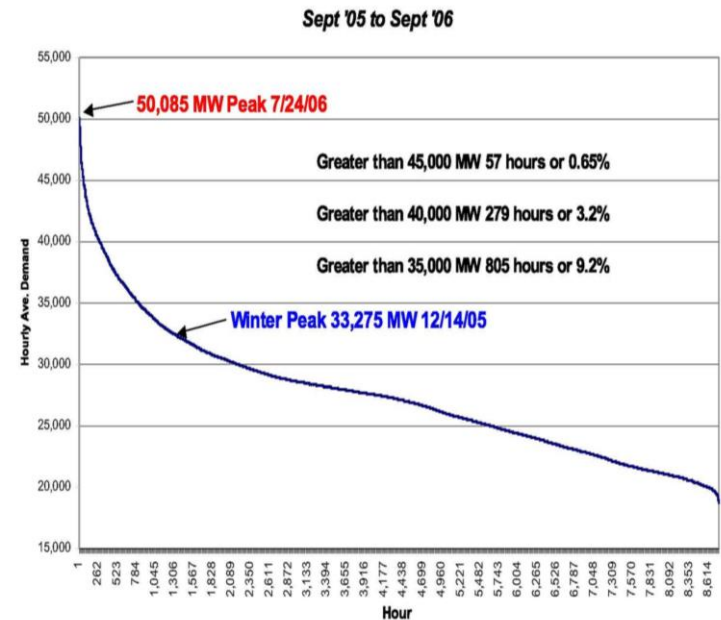


Note, this curve is being updated, it is used here to represent how we should look at what we are trying to accomplish



California Independent System Operator Corporation

CAISO Load Duration Curve

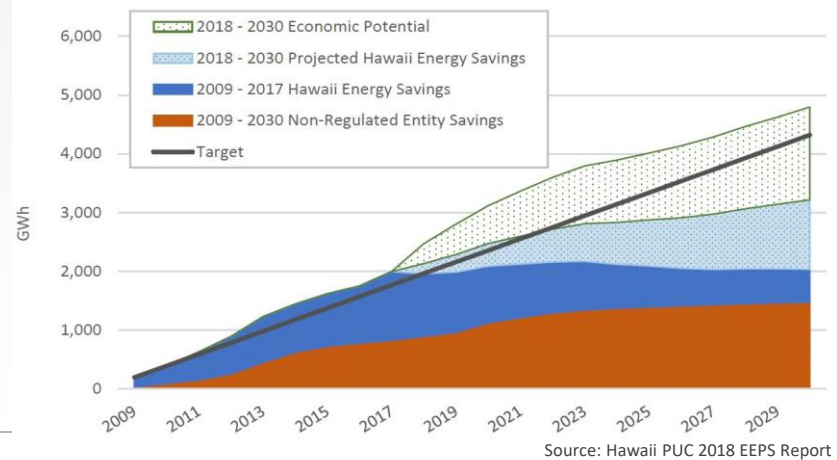
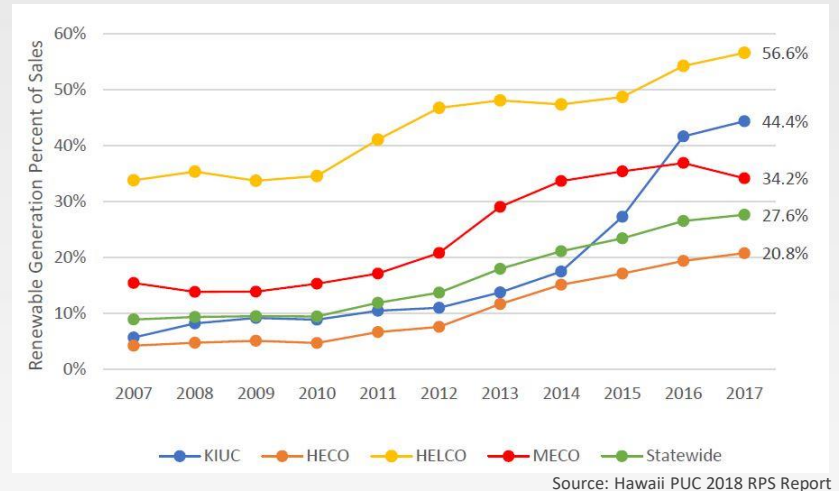


Latest from the Big Island - Lava Field During the Eruption – Geothermal Shut



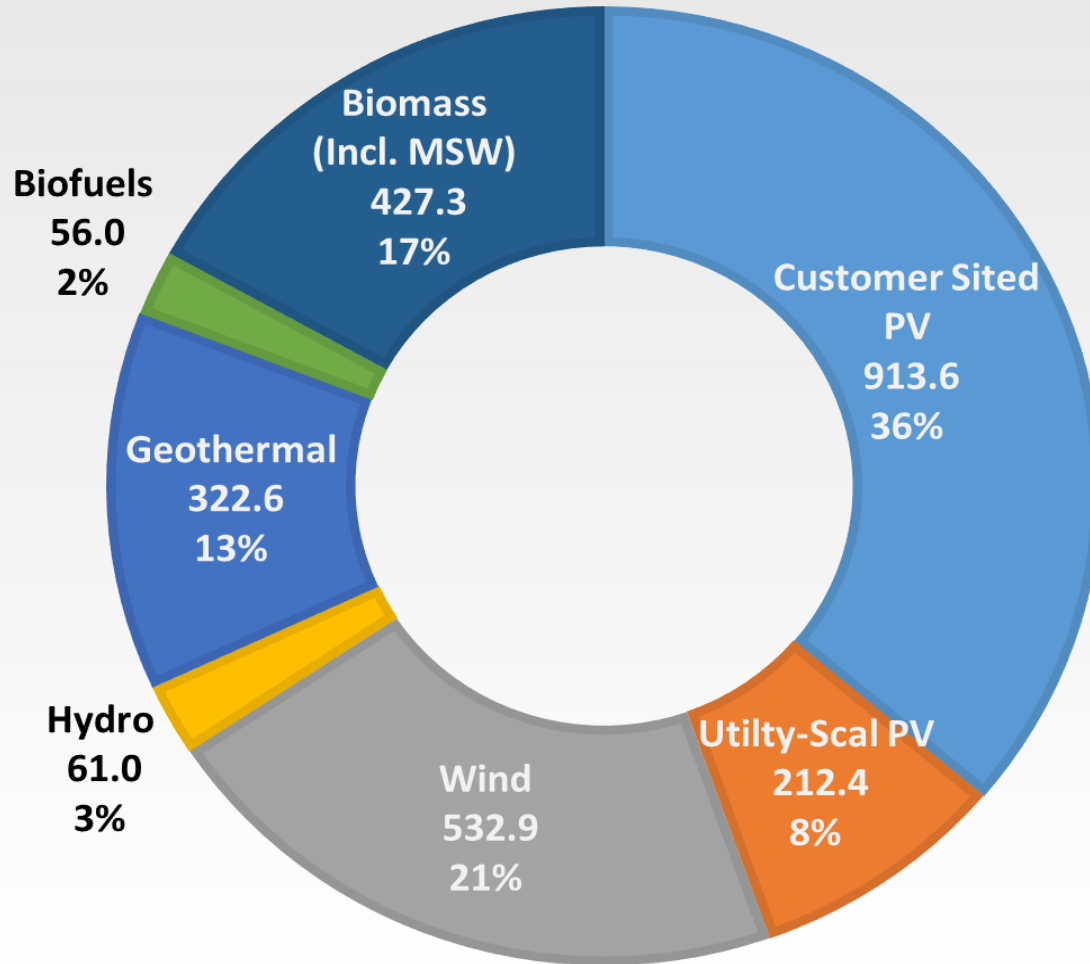
Hawaii's Clean Energy Policies and Growth: Accelerated by 30% FTC and 30% State Tax Credit

- Hawaii has some of the most aggressive clean energy policies in the country
 - 100% Renewable Portfolio Standard by 2045
 - 4,300 GWh Energy Efficiency Portfolio Standard by 2030
- Each of the islands is rapidly advancing towards these overarching policy objectives
- Success will represent a dramatic transformation of the electricity sector in Hawaii



Hawaii Renewable Energy by Technology: Problem for Utility, IPPs Are Only Bidding In Utility-Scale PV

2017 STATE RENEWABLE ENERGY GENERATION (GWHS)



Residential PV Plus Storage Permit on Oahu – To Reach 2030 Goals Could Require 4 kwh storage for each kw of PV

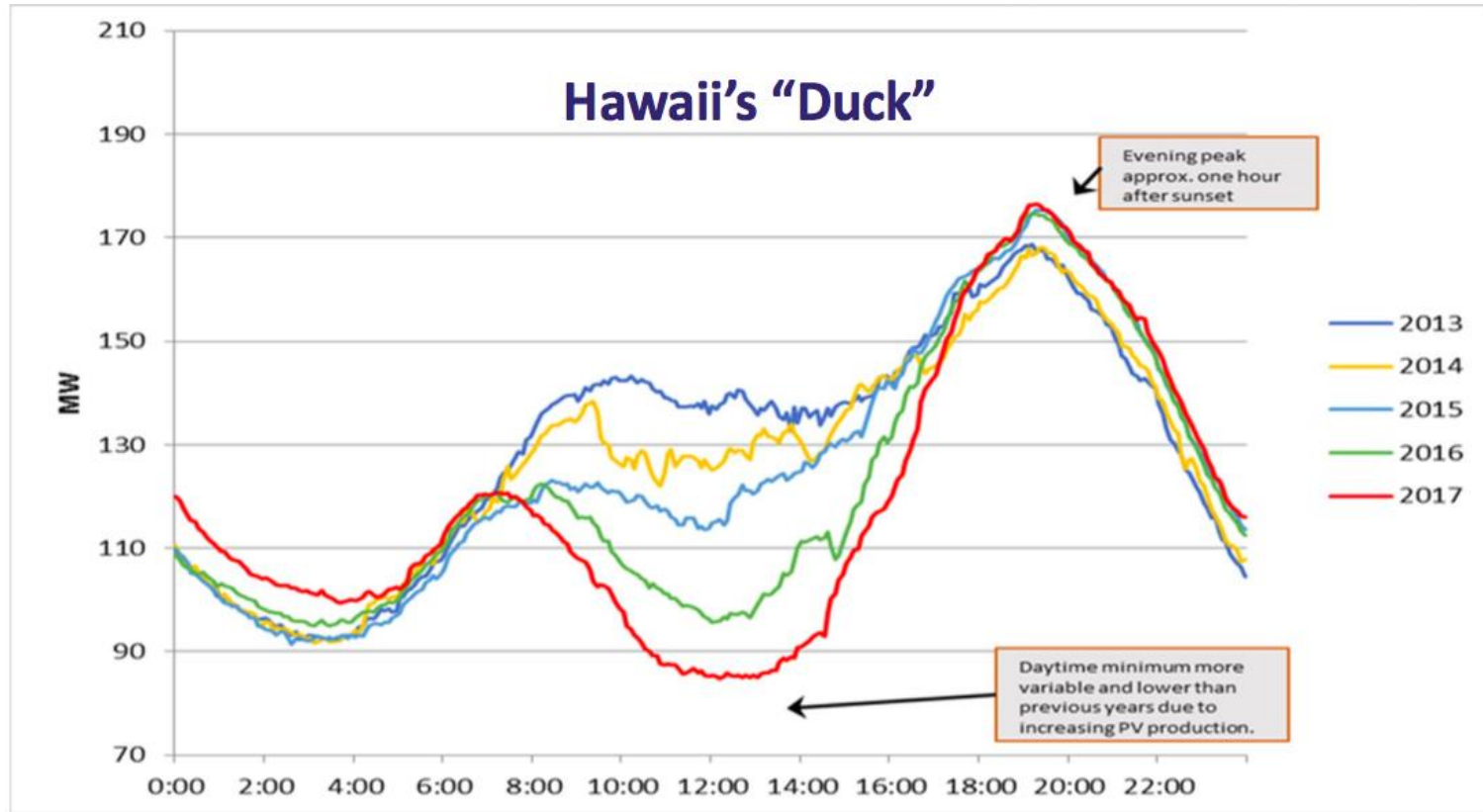


Source: Honolulu DPP, compiled by DBEDT Research

Growth of BTM Solar Allows RPS Goals to be Met, But Leads to Grid Problems: Almost 721 MW (June, 2018) - Some “negative peaks” on distribution lines are greater in magnitude than demand peaks, with a number of lines at 250% generation vs. MDL

	Number of PV Systems			PV Capacity, MW		
	Number	% Residential	% Commercial	Capacity	% Residential	% Commercial
Hawaiian Electric	51,828	96%	4%	519	54%	46%
Hawaii Electric Light	12,192	94%	6%	93	65%	35%
Maui Electric	12,265	92%	8%	110	60%	40%
TOTAL	78,285			721		

Additional Problem: There Can Now Be More Generation than Load: Thermal Generation Operates at Below “min power” – utility now pays IPPs for curtailed renewable power!!



HECO Wants to Get More Wind On-Line: Kaheawa and Auwaiha Wind Farms on Maui



Kaheawa Wind Power - Wikipedia



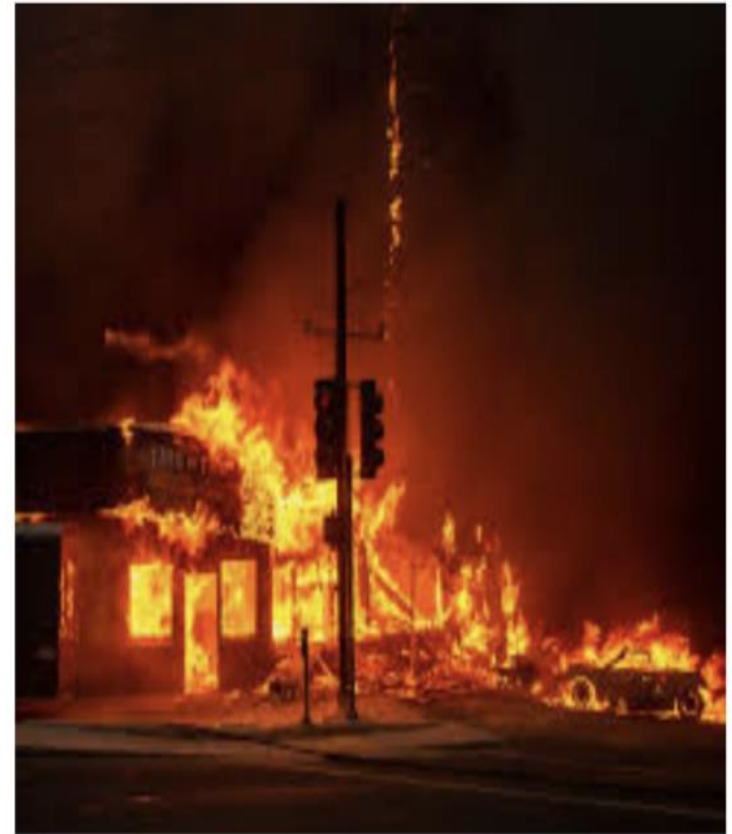
Additional Problem: Latest US Climate Report on Impacts of Climate Change on Energy – One Impact Is Flooding of Power Plants

Passive Flooding





Climate Change Comes to California – the 2017 and 2018 Fire Seasons – PG&E Has Filed for Bankruptcy



World's Second Largest Wind Project

Alta Wind Energy Center
1550 MW
Kern County, CA



The World's Largest Thin Film Solar PV Project



**Desert Sunlight Solar
Project
550 MW
Riverside County, CA**

The World's Largest Solar Thermal Power Plant (Tower)

Ivanpah Solar Thermal Project
393 MW
San Bernardino County, CA



The World's Largest Solar Thermal Power Plant (Trough)

Solar Energy Generating System (SEGS)

354 MW

San Bernardino County, CA



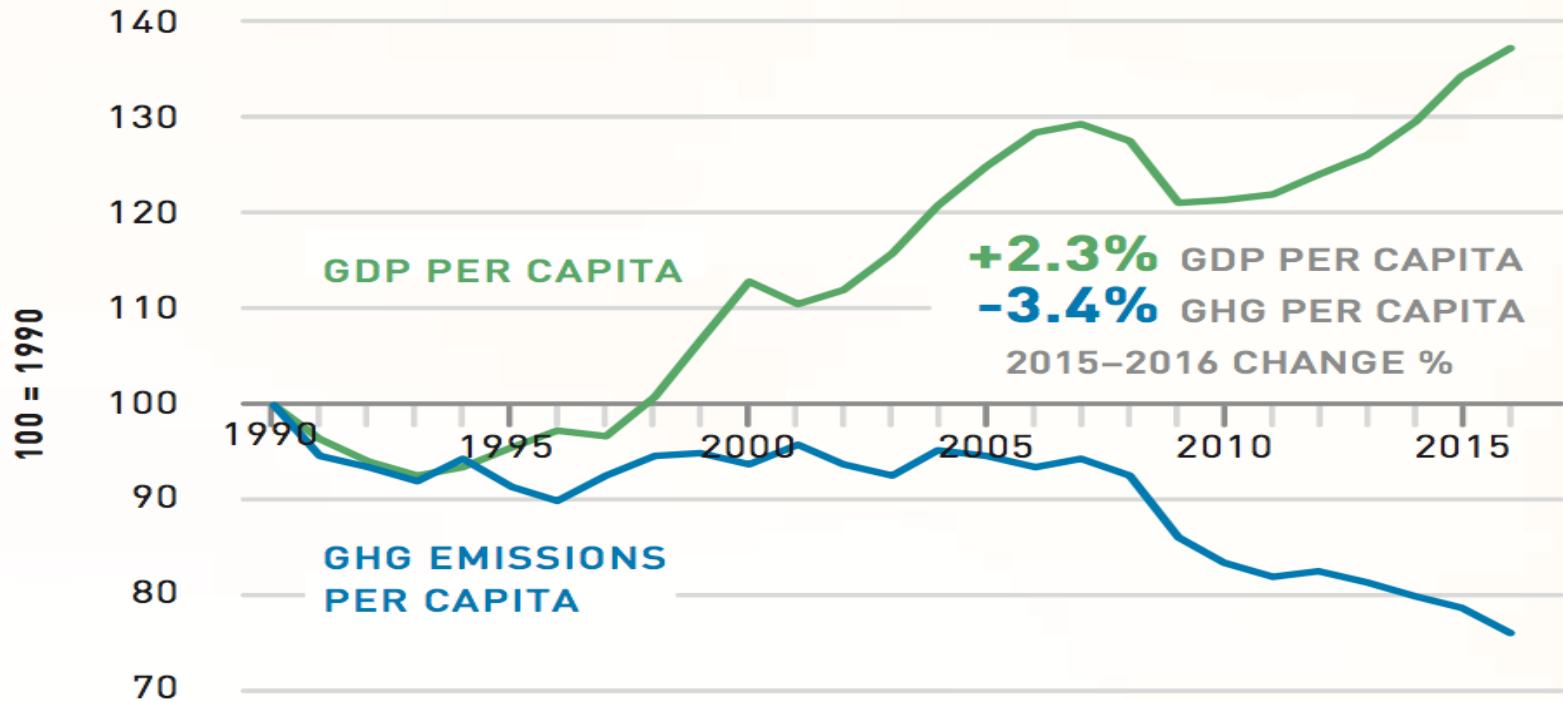
World's Largest Solar Rooftop

Apple HQ
Cupertino, CA
17MW



California's Success is Based on Aggressive Development of Codes, Standards, and Goals with Penalties

CALIFORNIA, IN 2016 \$

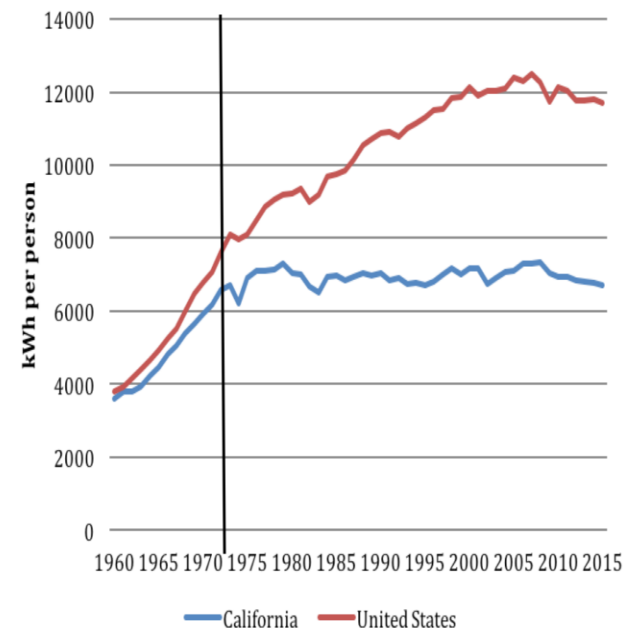


NEXT 10 CALIFORNIA GREEN INNOVATION INDEX. Data Source: California Air Resources Board, California Greenhouse Gas Inventory – by Sector and Activity; Bureau of Economic Analysis, U.S. Department of Commerce; U.S. Census Bureau. NEXT 10 / SF · CA · USA

CA Legislation and Regulation Has Impacted Electricity Use Since 1975

- CPUC Aggressive in developing new dockets:
- automated DR,
- carbon management
- Million solar roofs (sliding tax credit scale)
- CEC leads country in state-based RD&D
- US has adopted many CA appliance standards

Figure 3: The Rosenfeld Effect: California Energy Usage Per Capita vs. the Rest of the United States



Source: 2017 CEC Integrated Energy Policy Report

Industry transformation - March 4, 2018, at 12:58 PM, state's grid hit an all-time peak % of demand served by solar of 49.95%



Wind

- Unpredictable Output
- 4,773 MW Peak – April 24, 2016
- 6,087 MW Installed Capacity



Solar Thermal / Photo Voltaic

- Semi – Predictable Output
- 9,868 MW Peak – April 21, 2017
- ≈ 10,000 MW Installed Capacity

* Simultaneous wind and solar has exceeded 13,000MW on April 23, 2017



Roof Top Solar

- Semi – Predictable Output
- Behind the meter – Residential
- 5,000+ MW Estimated Capacity

Main Drivers:

- ✓ California RPS
- ✓ GHG reduction
- ✓ Once-through-Cooled plants retirement

Goals:

- ✓ Higher expectation of reliability
- ✓ Higher expectation of security
- ✓ Smart Grid
- ✓ Situational awareness through Visualization

With Substantial Increases in Renewables and Efficiency, Some Facilities Are No Longer Needed

Overview of CPUC Decisions Related to Stranded Assets

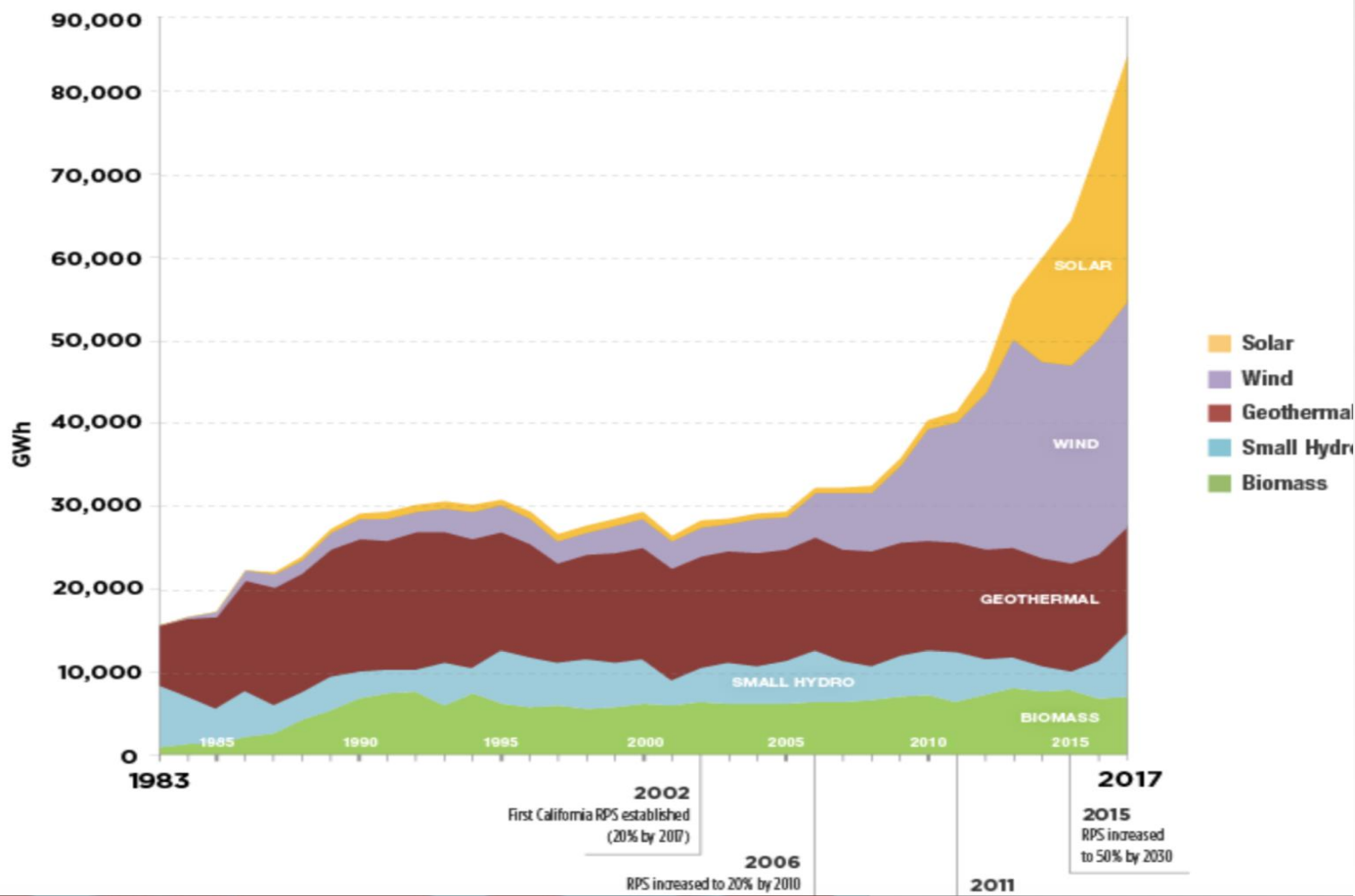
DECISION	UTILITY -- ASSET (S)	STRANDED VALUE
D.92497 (12/5/1980)	SCG - Coal Gasification Plant	\$9.7 million
D.83-08-031 (8/3/1983)	Pacific Telephone and Telegraph Company- Digital "Customer Premesis Equipment"	\$19-95.7 million (Estimated)
D.84-05-100 (5/16/1984)	PG&E - Various Plants	\$60.8 million (preconstruction costs)
D.84-09-089 (9/6/1984)	SCG & PG&E -Liquefied Natural Gas Project	\$133.7 million
D.85-08-046 (8/21/1985)	PG&E - Humboldt Bay power plant Unit 3	\$88 million
D.85-12-108 (12/20/1985)	SDG&E - Encina 1 and South Bay 3 power plants	--
D.89-12-057 (12/20/1989)	PG&E - Various	\$3.97 million
D.92-08-036 (8/11/1992) D.95-12-063 (1/10/1996)	SCE/SDG&E - San Onofre Nuclear Generating Station Unit 1	\$460 million
D.92-12-057 (12/16/1992)	PG&E - Geothermal Plant (Geyser 15) and Steam Payments	\$5.03 million and \$30.2 million
D.96-01-011 (1/10/1996)	SCE/SDG&E - San Onofre Nuclear Generating Station Units 2 & 3	\$3.461 billion
D.11-05-018 (5/5/2011)	PG&E - SmartMeters	\$341 million

Development More Practical When Close to Transmission Lines: Hatchet Ridge and BPA



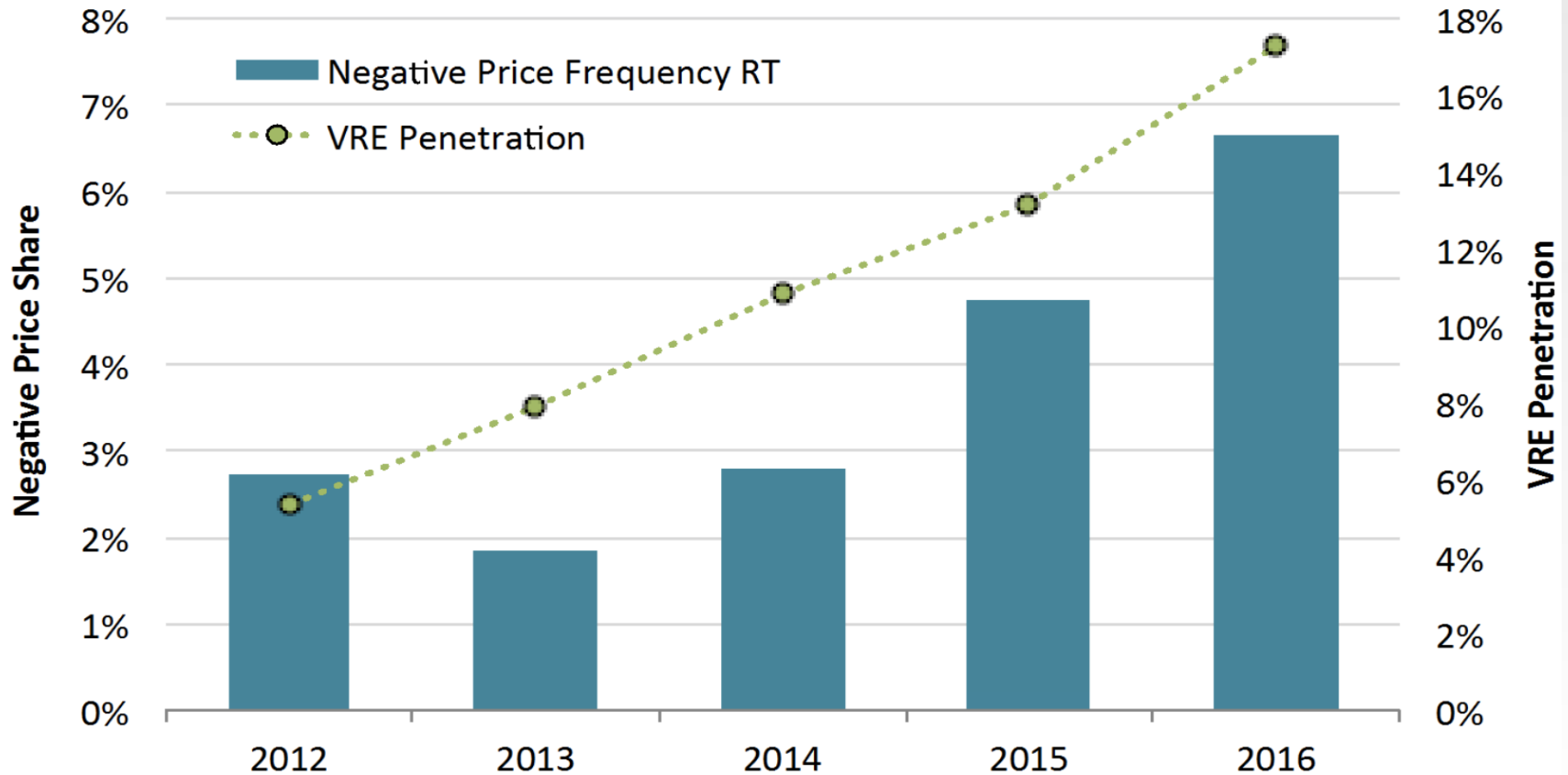
Aggregated Amount of Renewables in California – Does NOT Include Large-Head Hydro

Figure 6. Renewable Energy Generation 1983-2017 by Resource Type



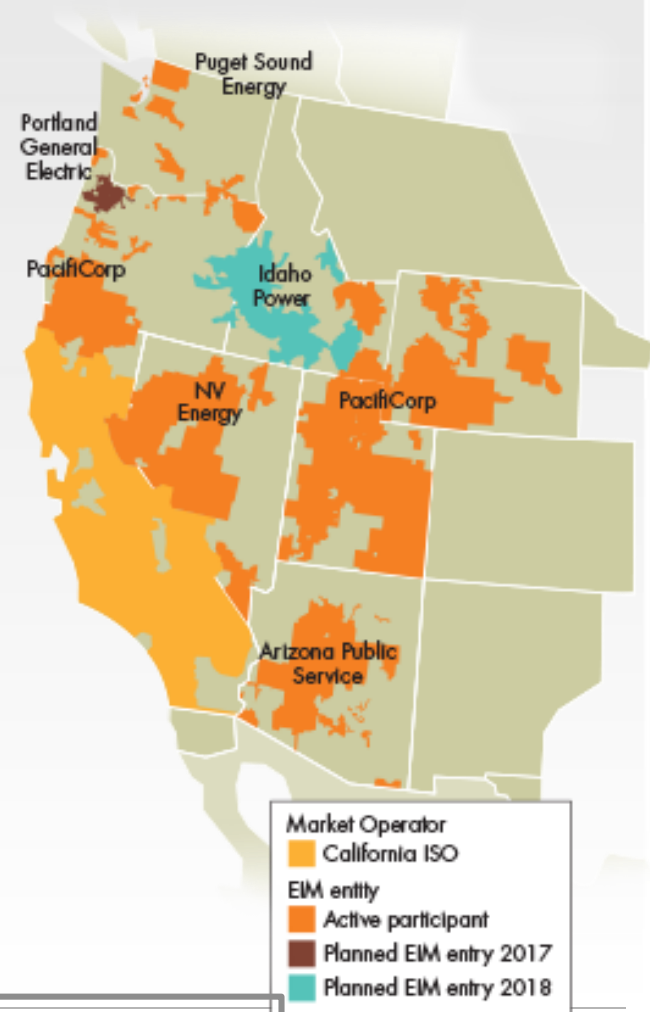
Variable Renewables Impact on Thermal Generation Causes Increased Amounts of Electricity to Be Sold at Negative Prices

Percentage of Annual Prices that are below \$0/MWh



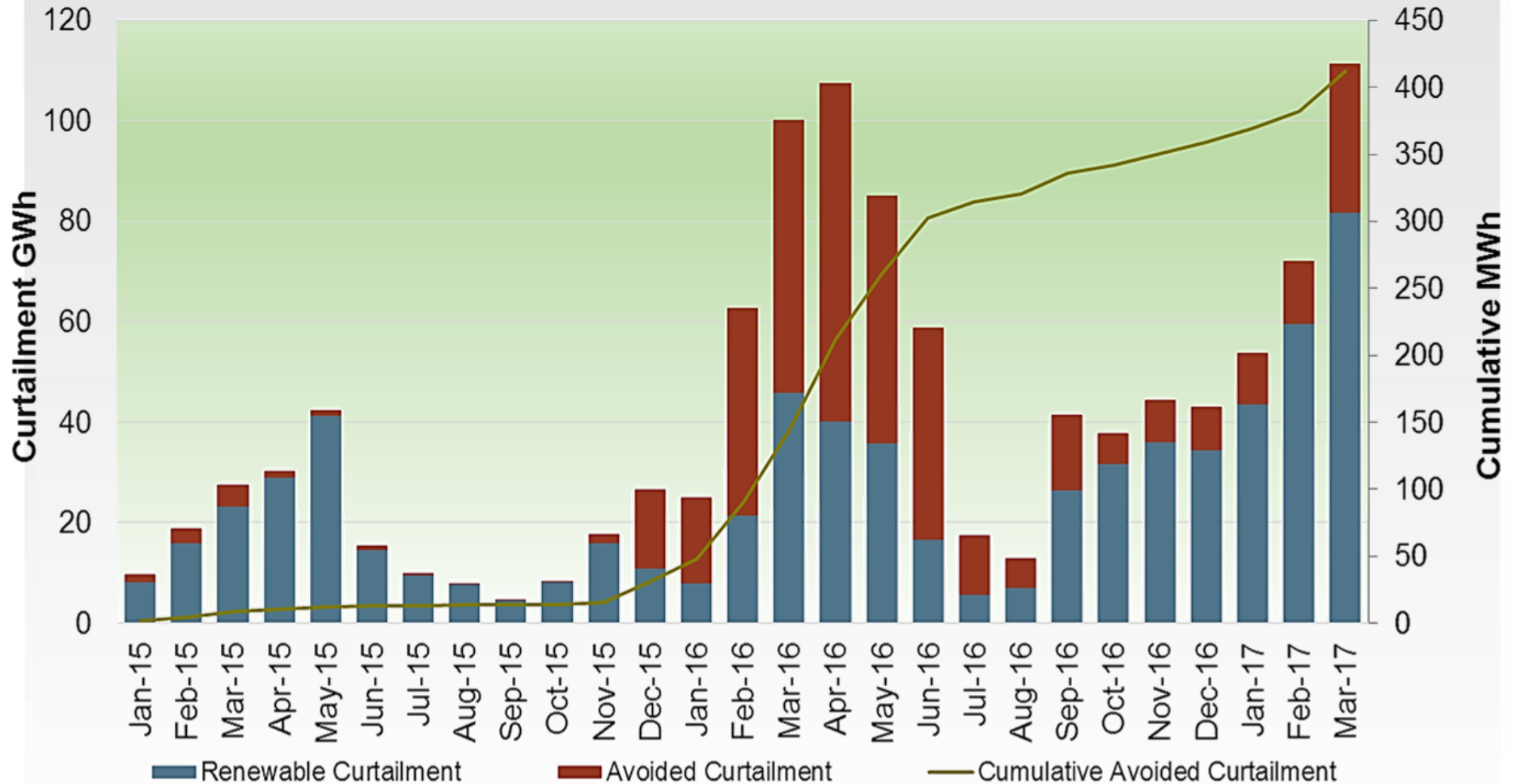
Energy Imbalance Market (EIM) Established to Address – in Part – Curtailment Issues

- In 2014, regional market system launched to increase coordination and interconnection between CAISO and other Western Basin orgs, in 2017, expansion to Southwest Power Pool
- Operated by CAISO, EIM enables real-time coordination (15- and 5-minute) and reserve sharing across a larger resource base
- Continued political problems in CA caused by Sierra Club, among others
- Demonstrated benefits during first two years include reductions of system costs, renewables curtailment, and GHG emissions



Gross Benefits (Million\$)	Curtailment Reductions (MWh)	GHG Emission Reductions (MMTon CO ₂ -e)
\$114.36	335,930	143,695

EIM Helps Avoid Renewable Curtailment



YTD estimated metric tons of CO2 displaced = 176,241, But Multi-state EIM has “Green” Critics

How Do You Optimize for the Future? Answer- It Ain't Easy

- RPS and EEPS goals
- Carbon reductions
- Other environmental impacts – fine particulates
- Land, water, and other resource use
- Price of electricity
- Equity – between richer and poorer households
- Grid resiliency and reliability
- Community values – non-quantifiable
- Cultural issues – non-quantifiable

Innovation Is Critical, But Be Flexible and Prepared for Unanticipated Consequences

