February 8, 2018

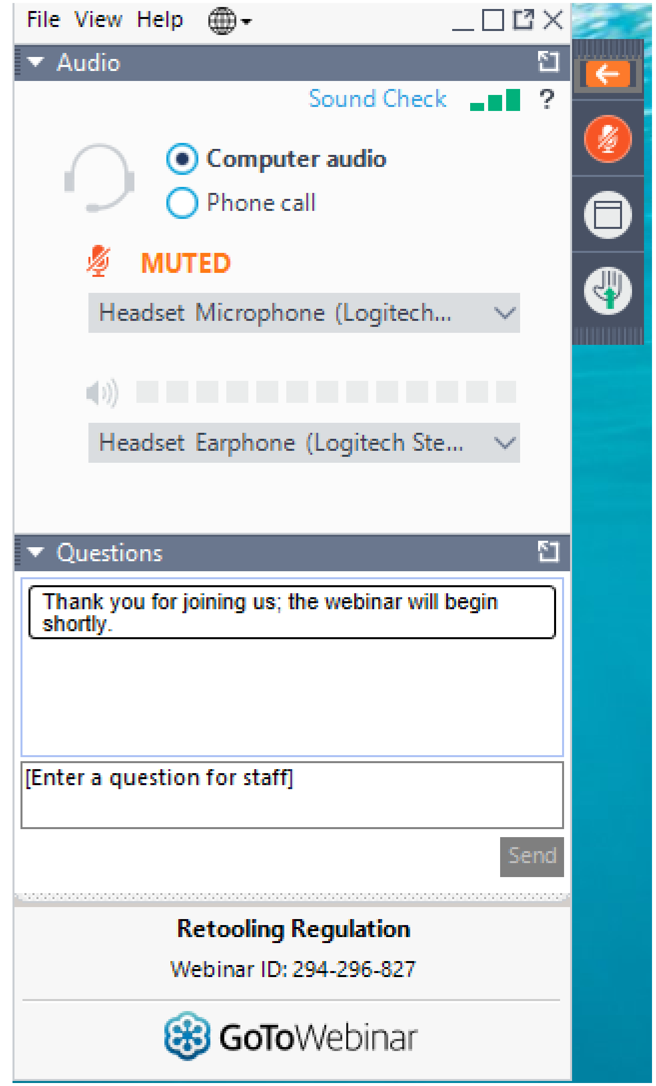
Getting Started: Rethinking Utility Regulation in an Era of Exponential Change

RAP Roundtable Webinar

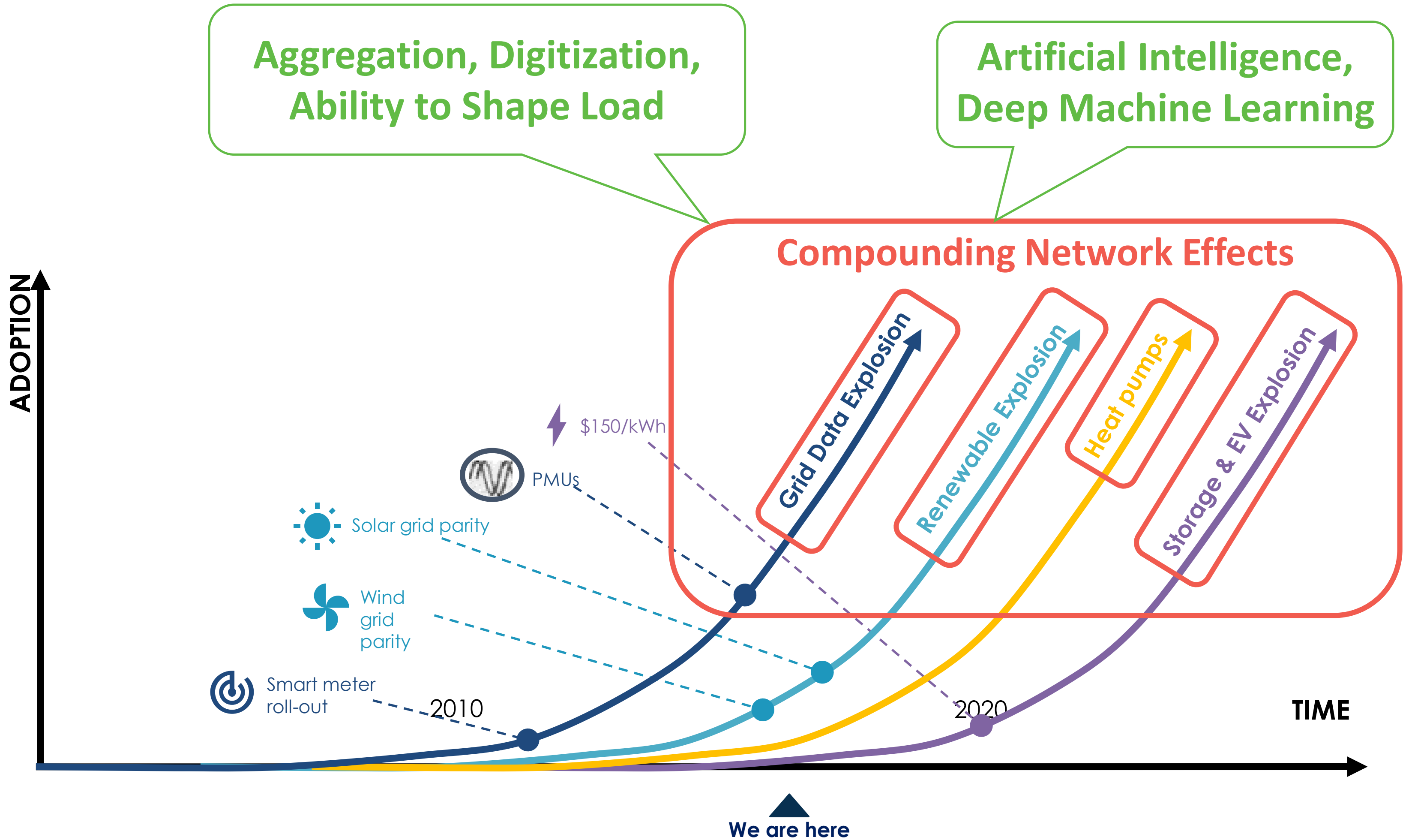
Regulatory Assistance Project
www.raponline.org

Questions?

Please send questions through the Questions pane



Disruptive Forces Transforming Electricity



Source: Chandu Visweswariah, Utopus Insights Inc.

Our experts

Ken Colburn

Richard Sedano

Jim Lazar

Michael Hogan

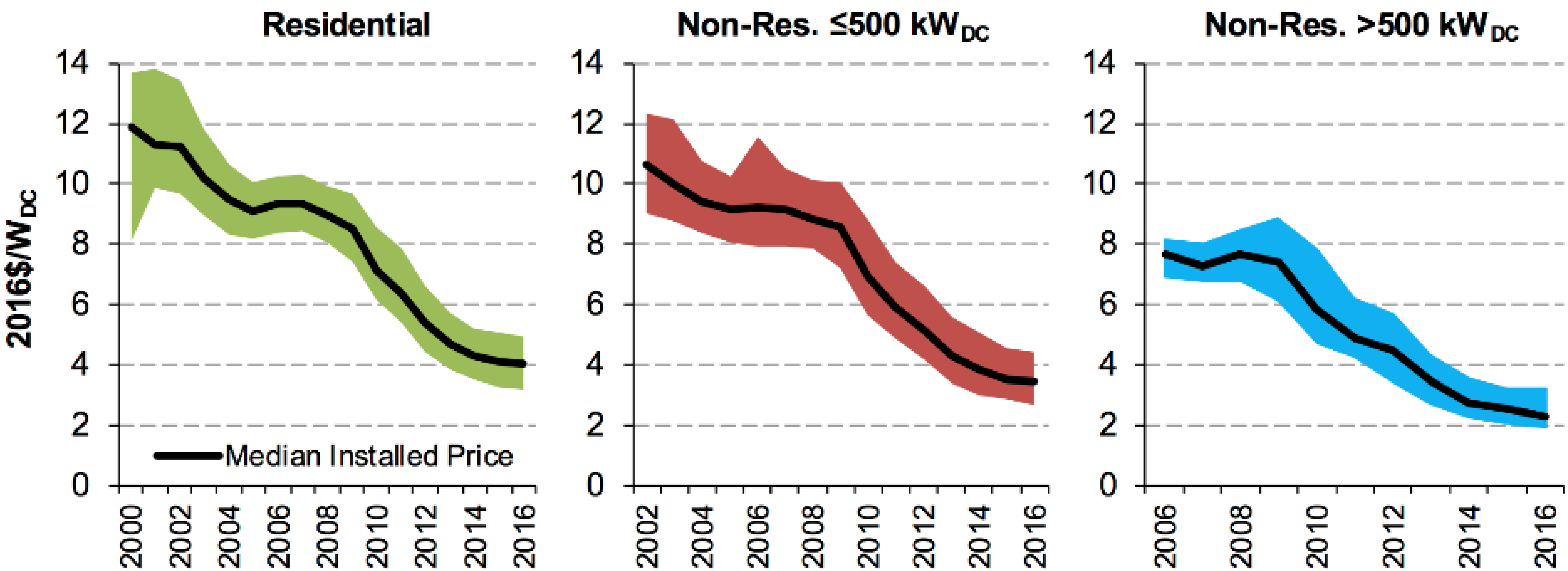
David Farnsworth

John Shenot

1 Falling Price of Renewables

What this means for costs and consumers

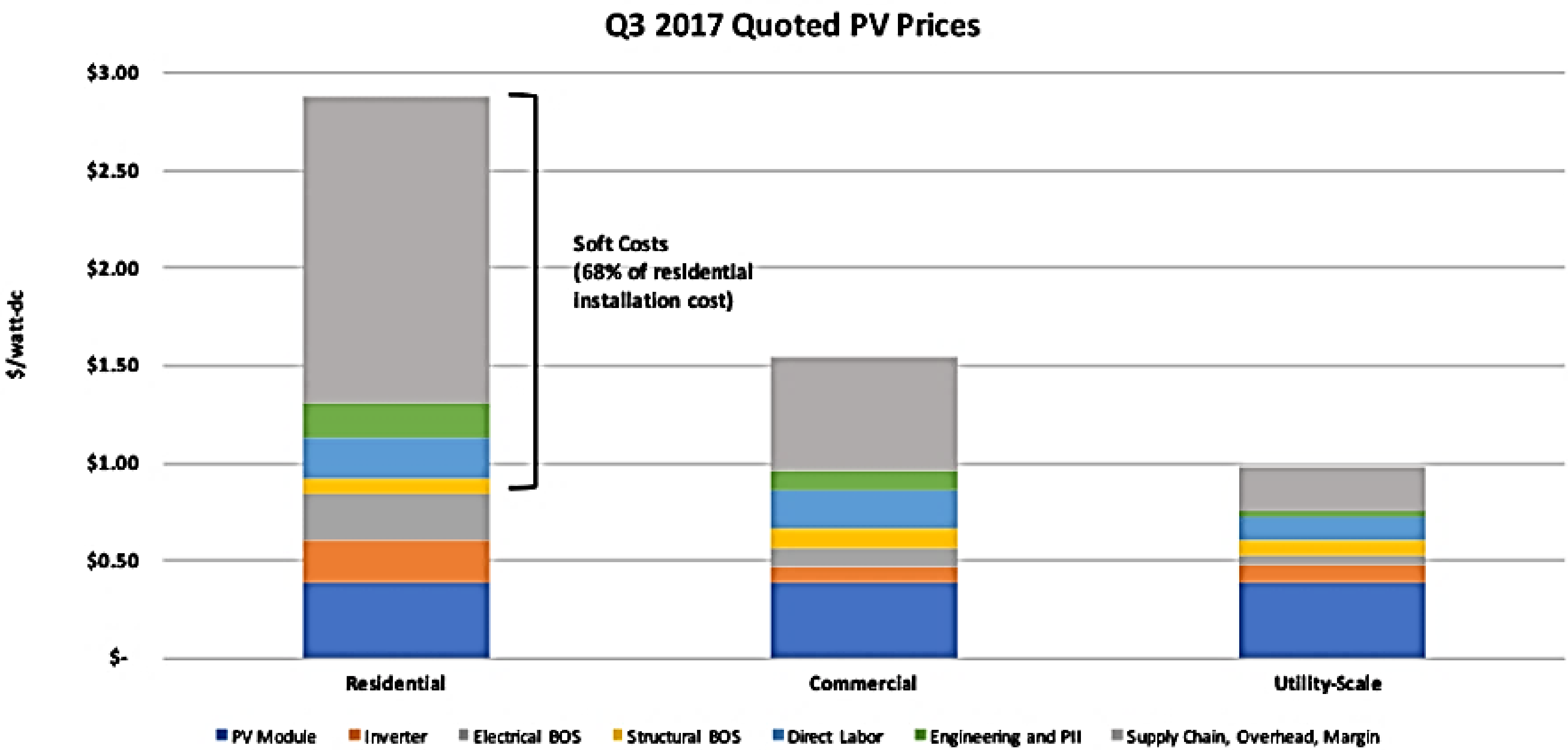
Solar Prices Have Declined



Notes: Solid lines represent median prices, while shaded areas show 20th-to-80th percentile range. Summary statistics shown only if at least 20 observations are available for a given year and customer segment.

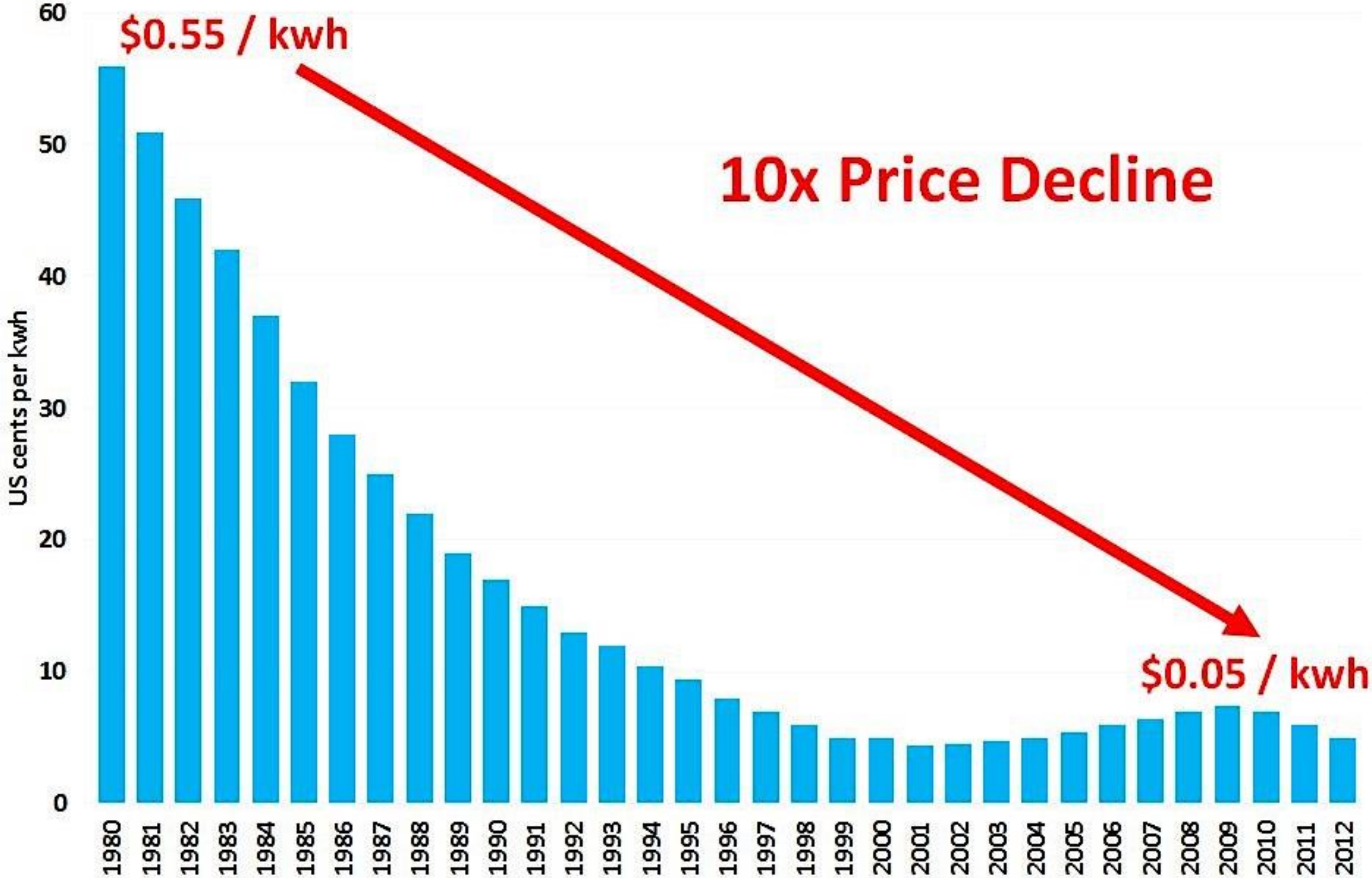
Sources: Tracking the Sun 10, Lawrence Berkeley National Laboratory and U.S. Department of Energy SunShot program

Declines Have Continued Into 2017



Sources: GTM Research and Solar Energy Industry Association

Wind Cost Per kWh (US)



Source: US Department of Energy data from http://www.ourworldofenergy.com

Global Best of Class: 2015

Solar PV

Country:	UAE
Bidder:	AQWA
Signed:	January 2015
Construction:	2017
Price:	**US$ 5.84 c/kWh**

Onshore wind

Country:	USA
Bidder:	Various
Signed:	2015
Construction:	2016
Price:	**US$ 4.5 c/kWh**

Source: Michael Liebreich, presentation to California ISO, October 18, 2017. Data from Bloomberg New Energy Finance; images from Siemens, Wikimedia Commons, and Electrek

Global Best of Class: 2016

Solar PV		Onshore wind	
			
Country:	Mexico	Country:	Morocco
Bidder:	FRV	Bidder:	Enel Green Power
Signed:	2016	Signed:	2016
Construction:	2019	Construction:	2018
Price:	**US$ 2.69 c/kWh**	**Price:**	**US$ 3.0 c/kWh**

Source: Michael Liebreich, presentation to California ISO, October 18, 2017. Data from Bloomberg New Energy Finance; images from Siemens, Wikimedia Commons, and Electrek

Global Best of Class: 2017

Solar PV

Country:	Saudi Arabia
Bidder:	Masdar
Signed:	2017
Construction:	2019
Price:	**US$ 1.79 c/kWh***

Onshore wind

Country:	India
Bidder:	ReNew Power
Signed:	2017
Construction:	2019
Price:	**US$ 2.0 c/kWh**

** Headline figure only - may include elements of subsidy, price support or price escalation; not final*

Source: Michael Liebreich, presentation to California ISO, October 18, 2017. Data from Bloomberg New Energy Finance; images from Siemens, Wikimedia Commons, and Electrek

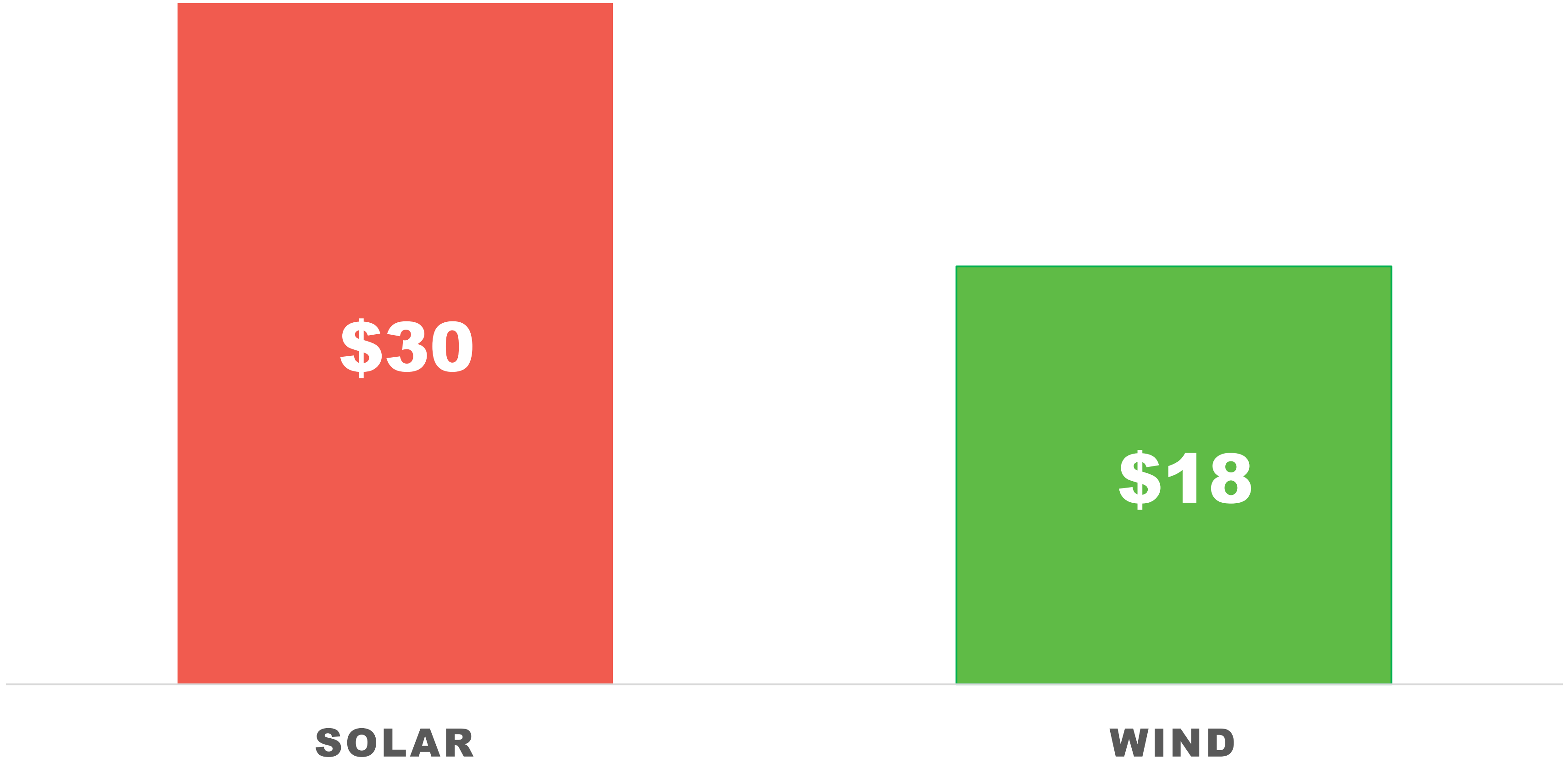
Xcel Energy All-Source Bids, December 2017

RFP Responses by Technology

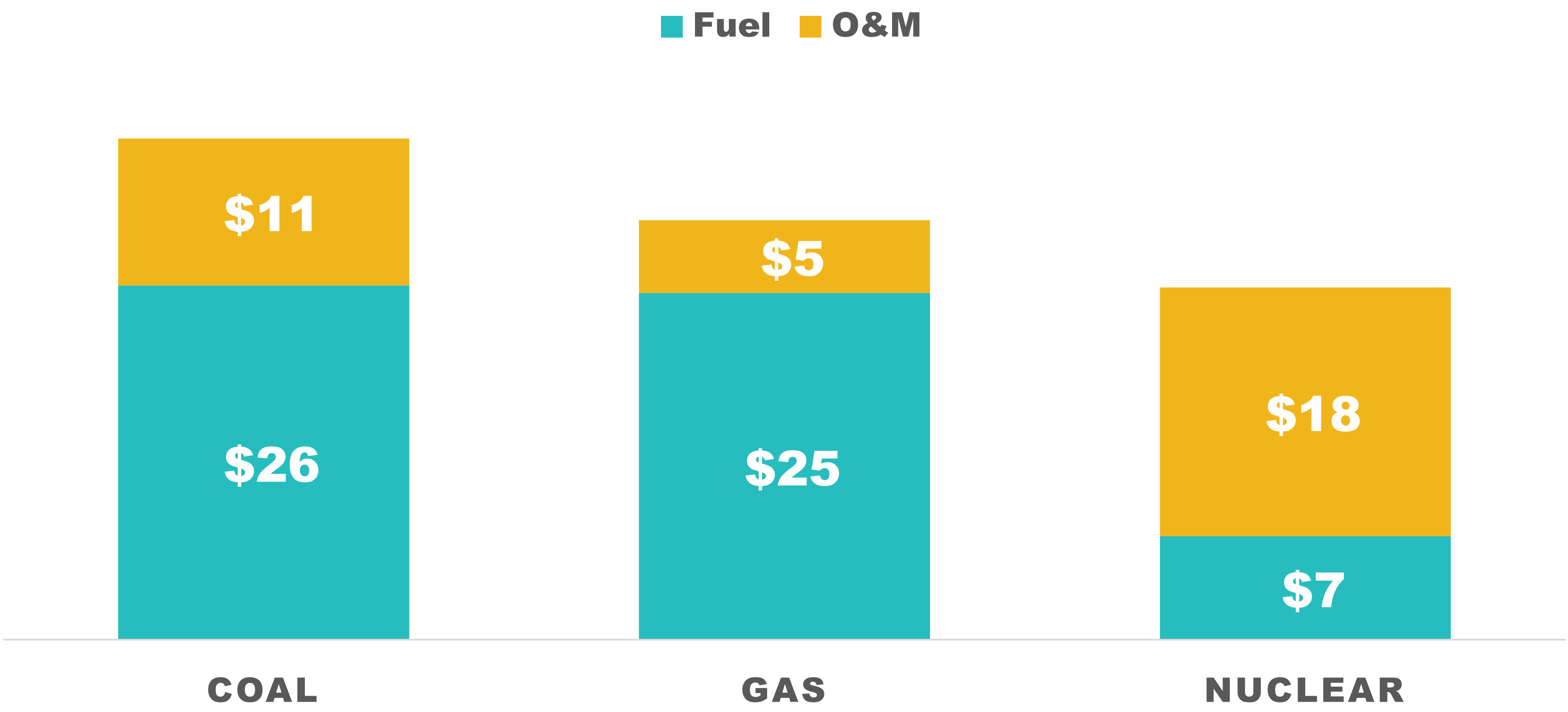
Generation Technology	# of Bids	Bid MW	# of Projects	Project MW	Median Bid Price or Equivalent	Pricing Units
Combustion Turbine/IC Engines	30	7,141	13	2,466	$ 4.80	$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.20	$/kW-mo
Gas-Fired Combined Cycles	2	451	2	451	[redacted]	$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	$/kW-mo
Compressed Air Energy Storage	1	317	1	317	[redacted]	$/kW-mo
Wind	96	42,278	42	17,380	$ 18.10	$/MWh
Wind and Solar	5	2,612	4	2,162	19.90	$/MWh
Wind with Battery Storage	11	5,700	8	5,097	21.00	$/MWh
Solar (PV)	152	29,710	75	13,435	29.50	$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.60	$/MWh
Solar (PV) with Battery Storage	87	16,725	59	10,813	36.00	$/MWh
IC Engine with Solar	1	5	1	5	[redacted]	$/MWh
Waste Heat	2	21	1	11	[redacted]	$/MWh
Biomass	1	9	1	9	[redacted]	$/MWh
Total	430	111,963	238	58,283		

Source: Xcel Energy, 2018

Xcel bid median prices $/MWh

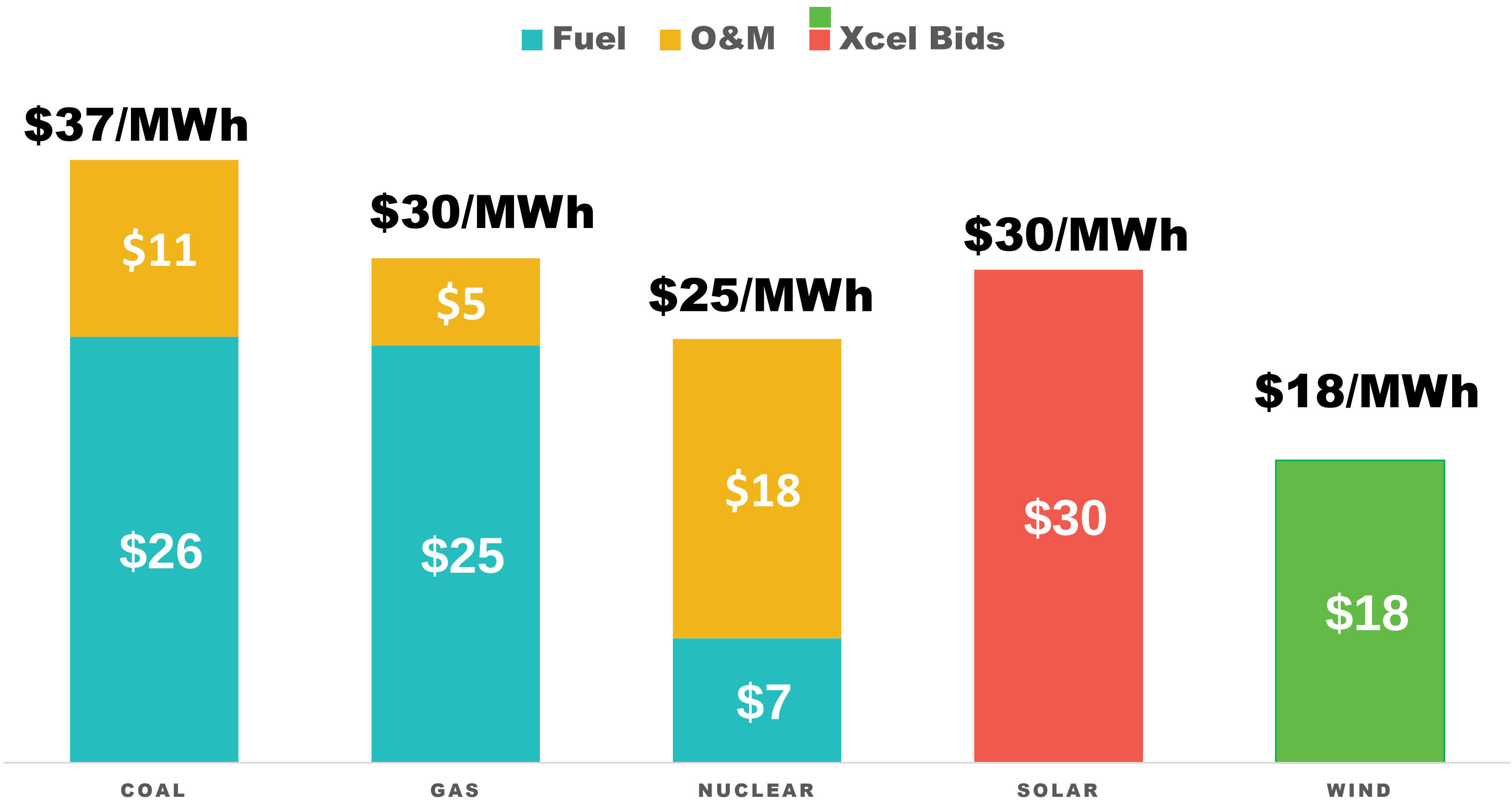


Existing power plant operating costs per USEIA



Existing Plant Average Fuel and O&M from USEIA Table 8.4 Electric Power Annual 2016

Existing plants vs. Excel bids



Existing Plant Average Fuel and O&M from USEIA Table 8.4 Electric Power Annual 2016

Xcel Was Not Alone

Oklahoma, 2017
Wind Catcher
2,100 MW
$7 billion in savings

Mexico, 2017
Solar: $17.70/MWh
Wind: $22/MWh

CFE
Comisión Federal de Electricidad

Photo: GE Renewable Energy

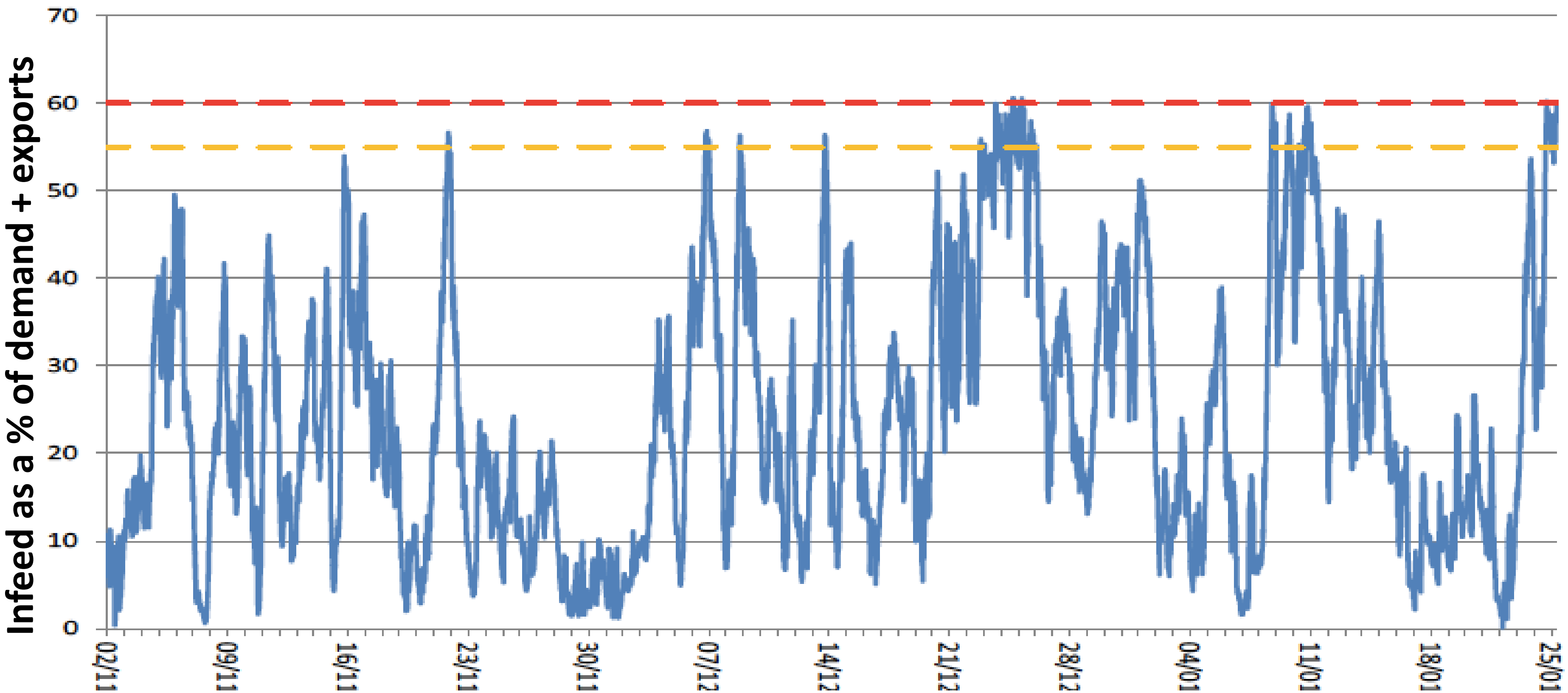
2 Flexibility and Pricing

The evolving value of investment

Key Points

- Flexible services moving to center stage
- Greater range of services required
- Shifting money from capacity remuneration to remuneration for energy and services…
- …amplifying real-time prices to better capture the value of flexible resources - supply & demand side
- C&I customers and retail aggregators should see more opportunity to reshape the demand curve

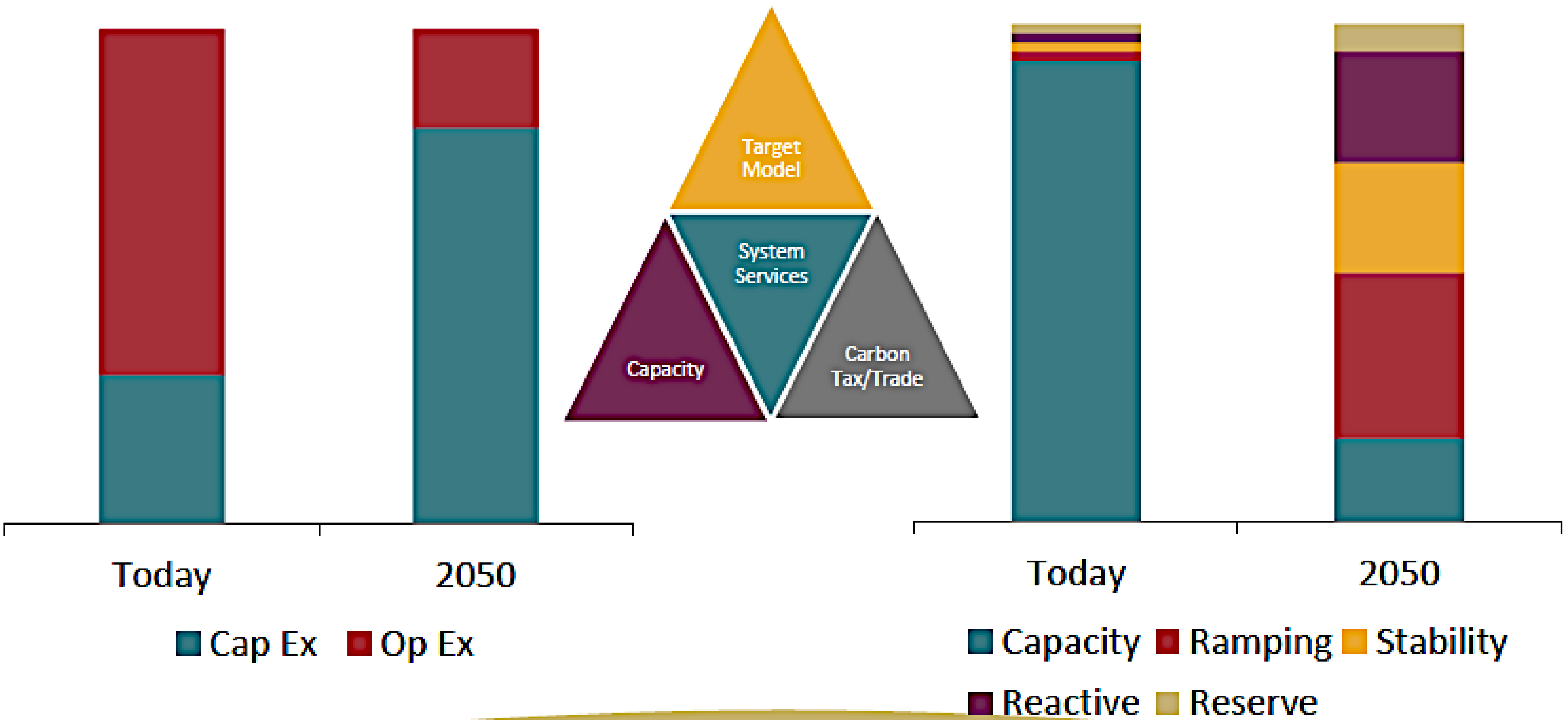
Wind Production in Ireland



Nov-Dec 2016 non-synchronous infeed to All-Ireland Grid

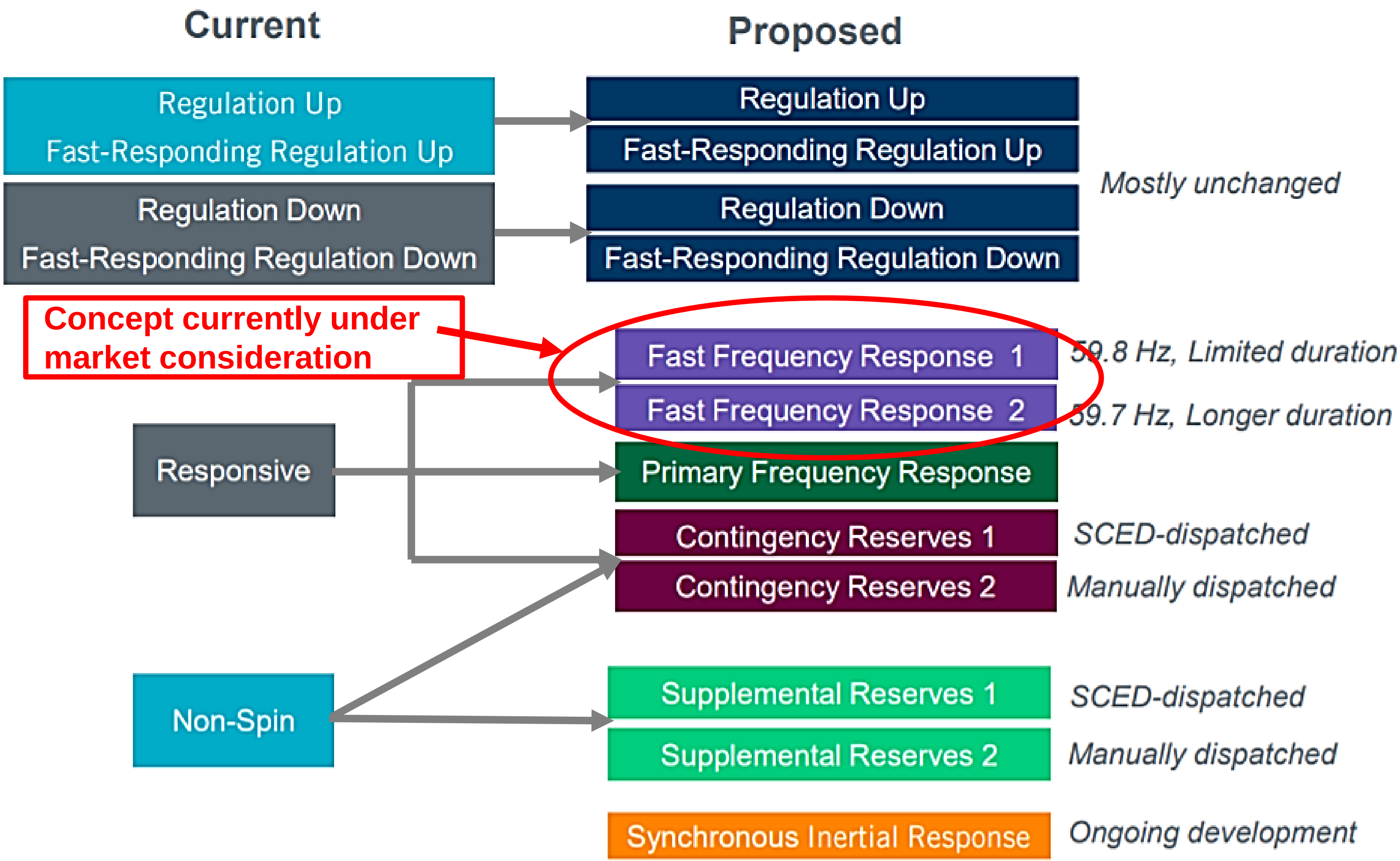
Source: EirGrid

More Capital-Intensive…in *Energy Services*



EIRGRID

Demand for Wider Range of Energy Services



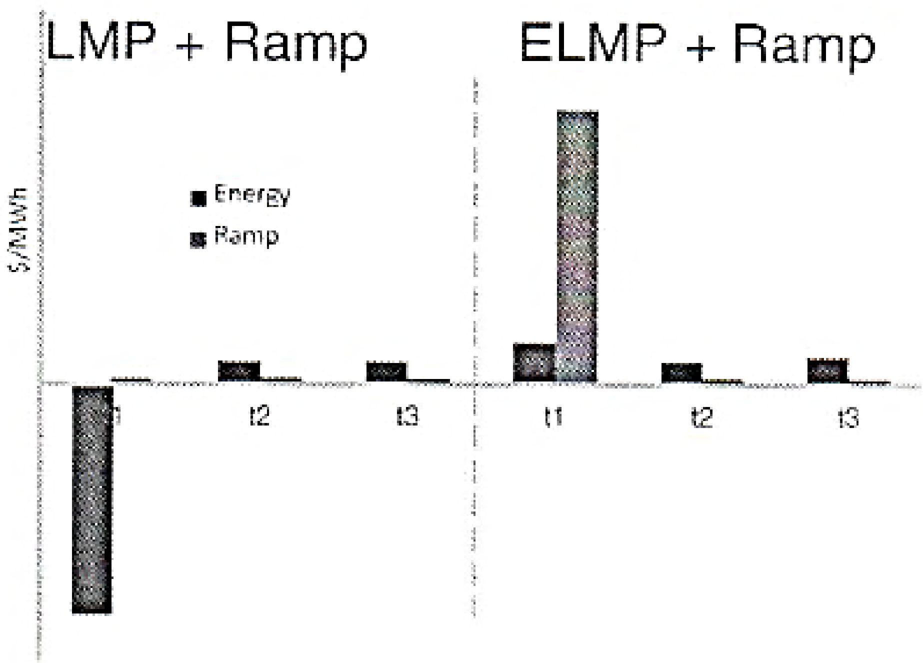
Source: ERCOT Future Ancillary Services

“New resource mix will change both the need for [ancillary services] and the capabilities of resources providing [ancillary services].”

ERCOT Presentation
September 2017

Improving Price Formation

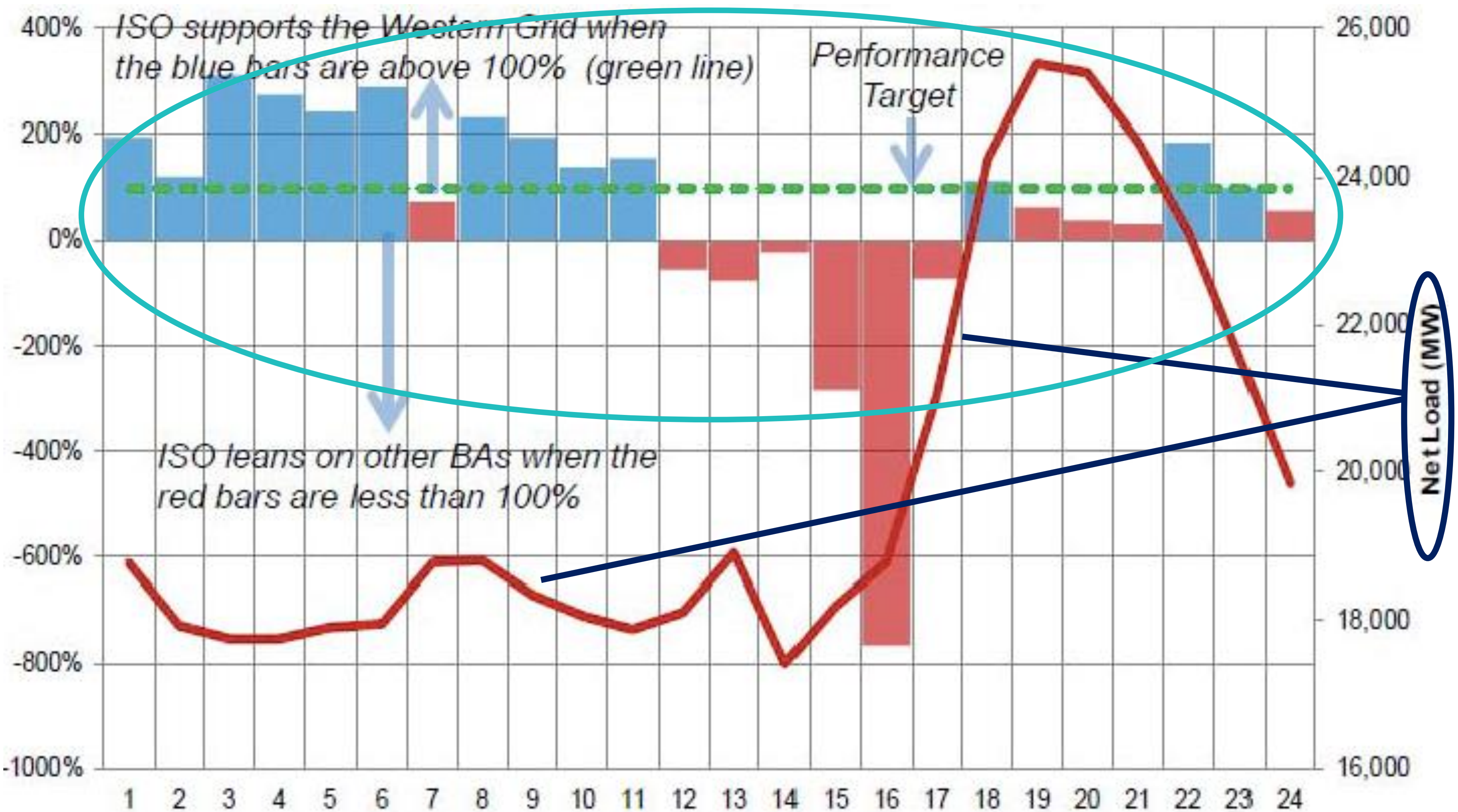
ELMP complements products like ramp by better pricing the total production costs to meet an operating need indicated by a product



- Without ELMP, Ramp reflects only marginal cost
- Without Ramp, ELMP reflects only energy needs

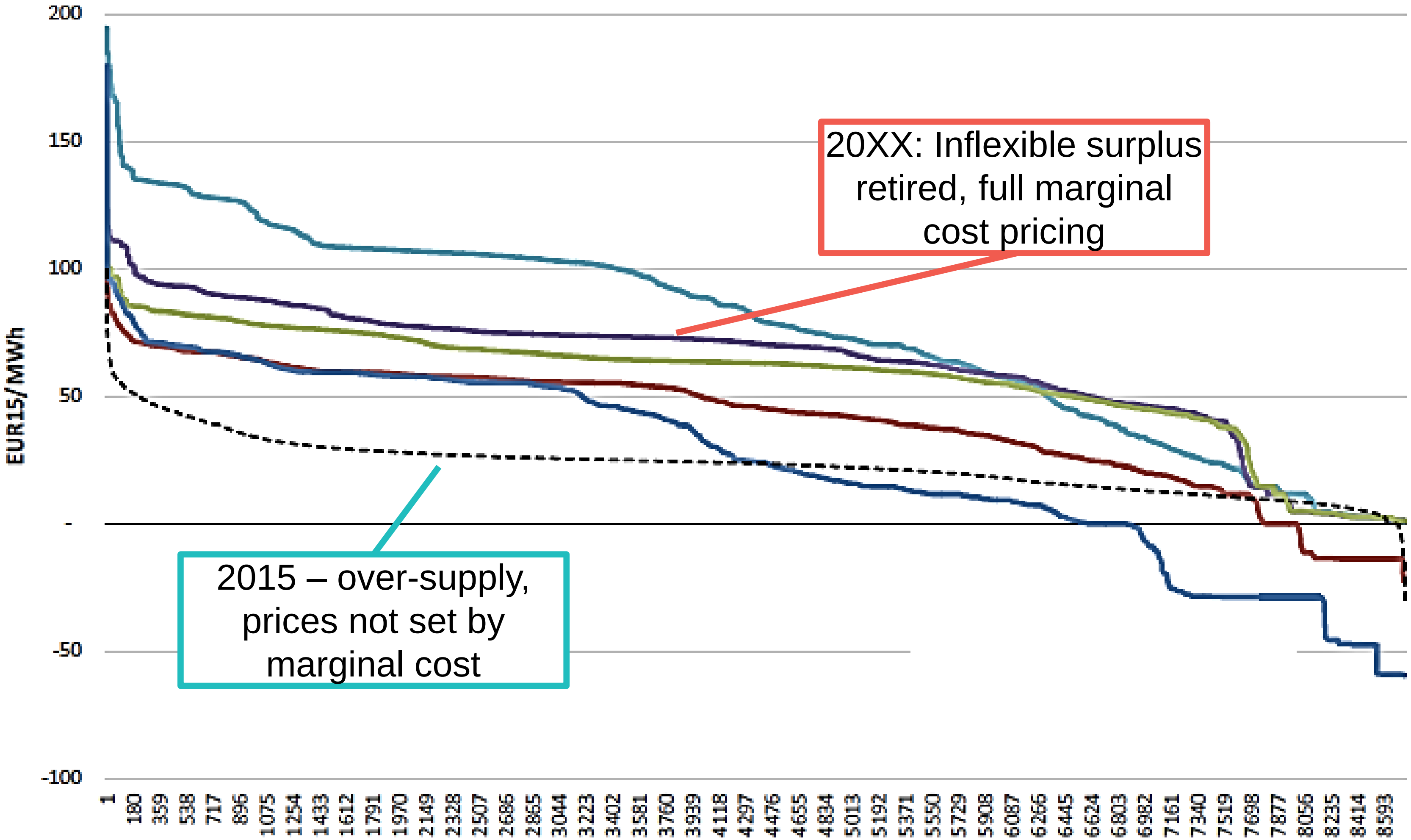
MISO

Hourly Balancing Reserves Requirement



Source: California Independent System Operator via Calpine

Price Duration in a 70% RES Grid



Source: Ea Energy Analyses for Denmark's Orsted power utility

3 Managing Load

Flexibility Changes Everything

Changes in the Electric Industry

- New technologies
  - EVs, heat pumps, and HP water heaters
- New interactive choices for utility customers to consume and produce

Beneficial Electrification Defined

- Electrification is beneficial if it meets one or more of three conditions, without adversely affecting the other two:
- Saves consumers money over the long run;
- Reduces environmental impacts; and
- Enables better grid management.

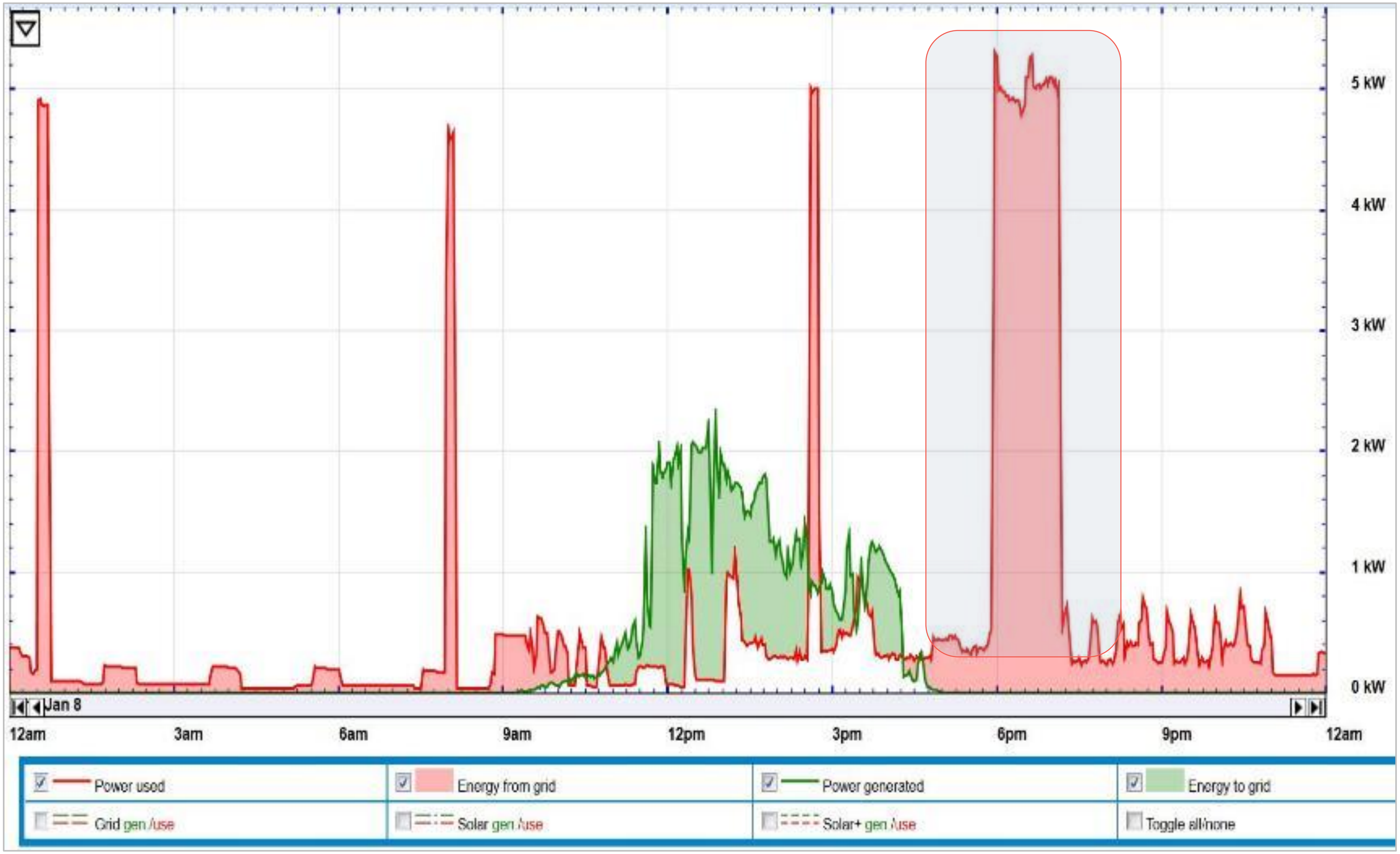
What Sort of Load are we Talking About?

- Relative Efficiency of Electrification Load
  - Heat pump water heaters move heat instead of generating it – 1.5 - 3X more efficient
  - EVs vs. gasoline passenger cars (60% vs. 20%)

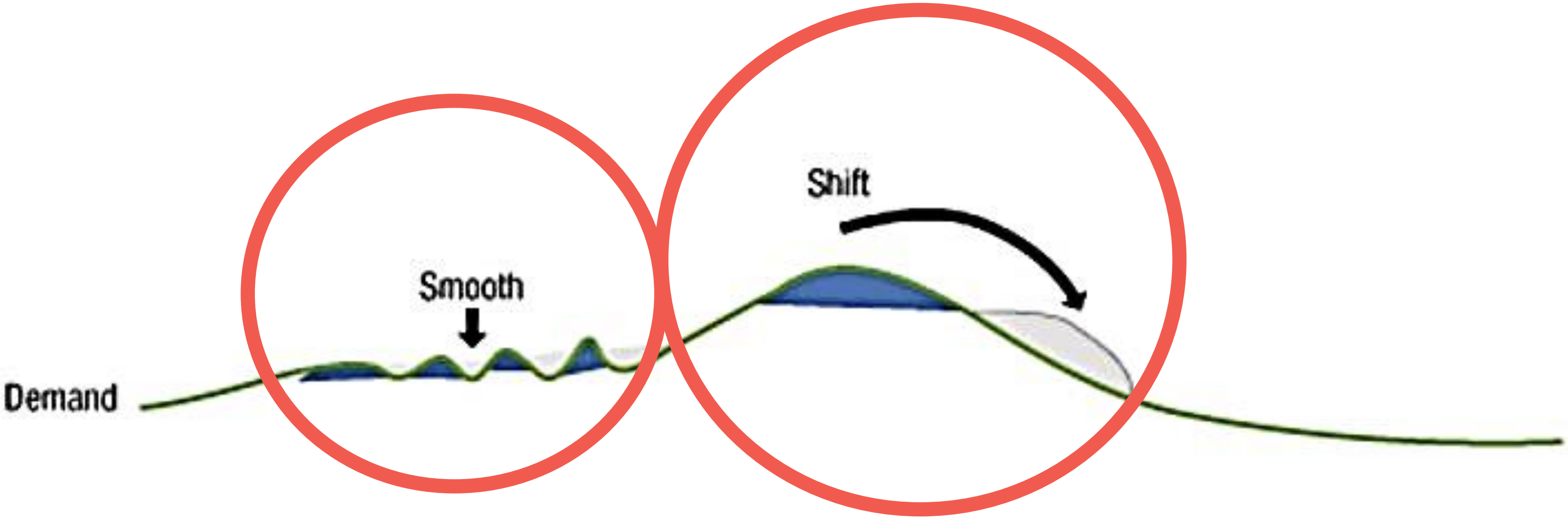
What Sort of Load are we Talking About?

- More Flexible Load:
  - Traditionally, generation followed load for virtually immediate consumption
  - Today, because it can be stored (thermally or electrically) some load can follow generation
  - Flexible load is valuable

Unlike this Inflexible Load …

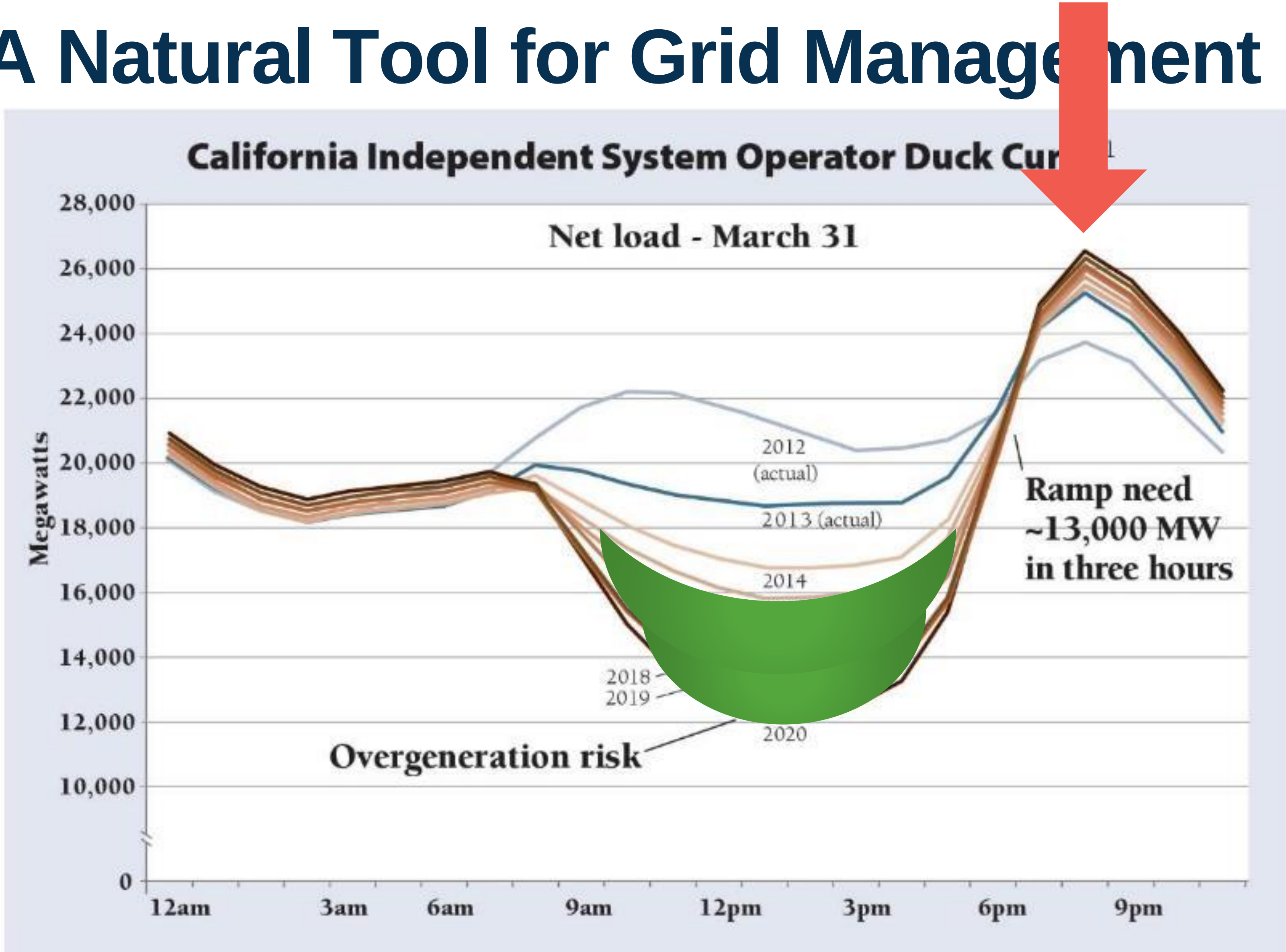


… BE Load Can Fill Valleys and Shave Peaks

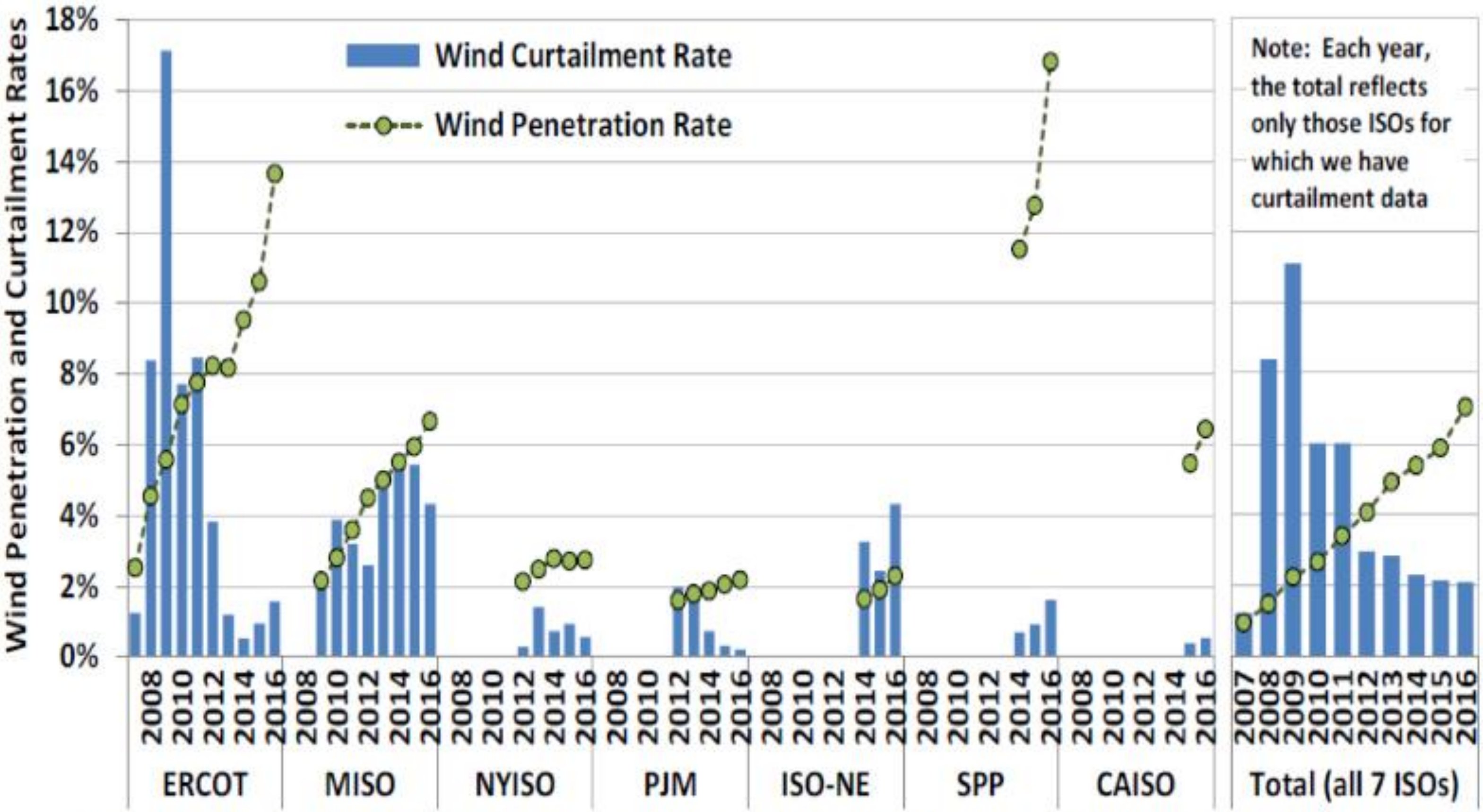


Source: E Source, adapted from Integral Analytics Inc.

A Natural Tool for Grid Management



Valuable for Reducing Curtailments



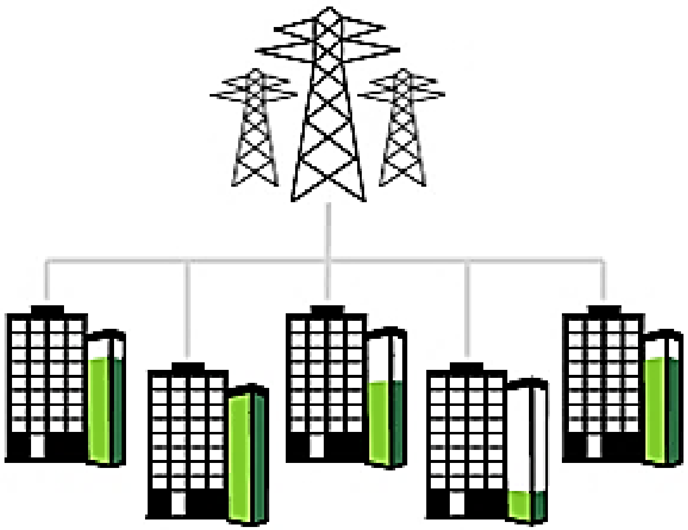
Note: All curtailment percentages shown in the figure represent both forced and economic curtailment. PJM's 2012 curtailment estimate is for June through December only.

“2016 Wind Technologies Market Report,” Ryan Wiser and Mark Bolinger, Lawrence Berkeley National Laboratory

Virtual Power Plants: The Business of Aggregating Buildings with Batteries

Capabilities

August 28, 2017 Stem dispatches 14 *Virtual Power Plants* (VPPs) to support the grid during a heatwave.



Source: Stem

SmartCharge New York

Source: https://www.fleetcarma.com/smartchargenewyork/

SmartCharge New York

Source: https://www.fleetcarma.com/smartchargenewyork/

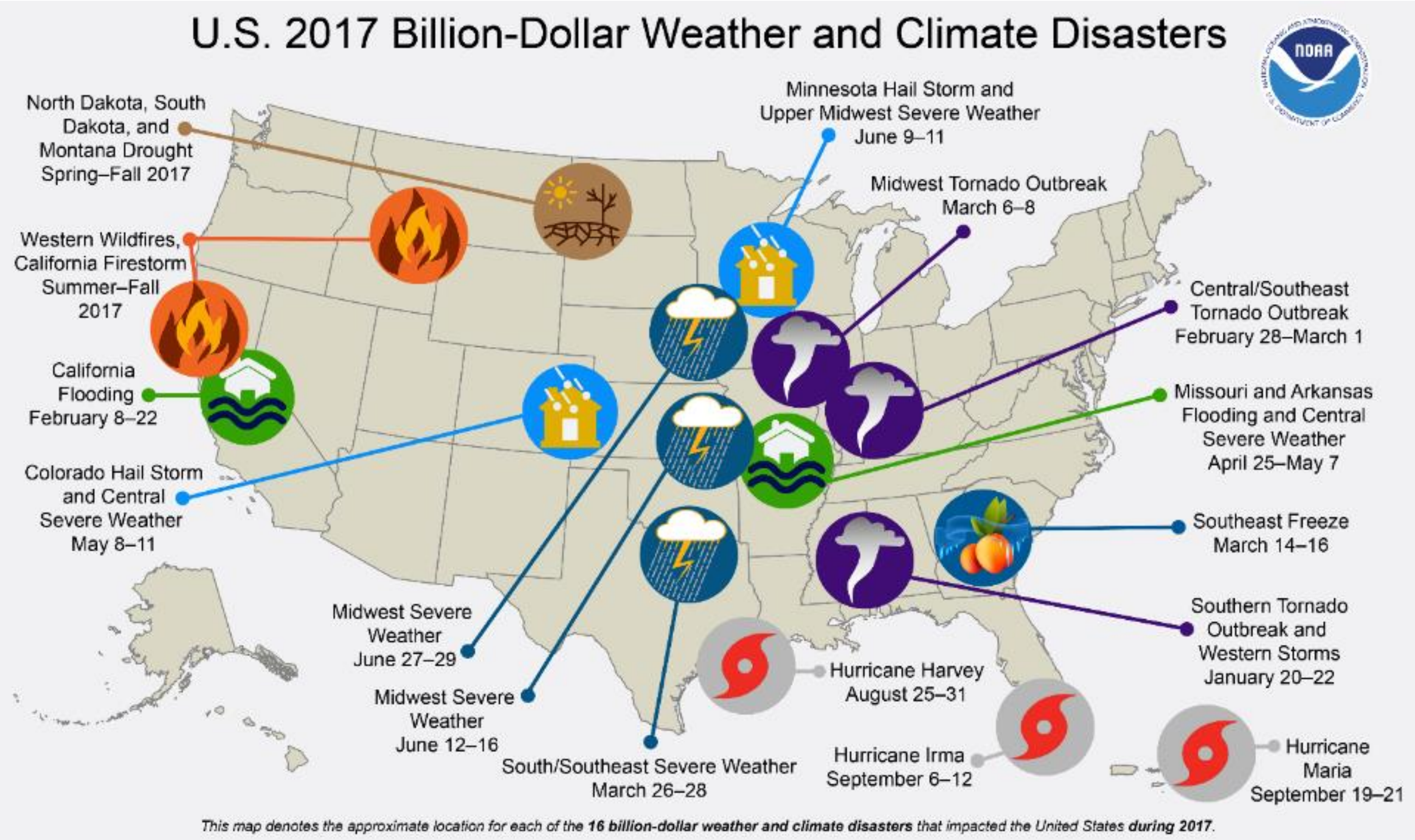
4 Resilience

What goes down, must come up

What is Resilience?

- **The ability to withstand and reduce the magnitude or duration of disruptive events**
- **Anticipate, adapt, and rapidly recover**

Source: National Infrastructure Advisory Council (2009), *Critical Infrastructure Resilience Final Report and Recommendations*.

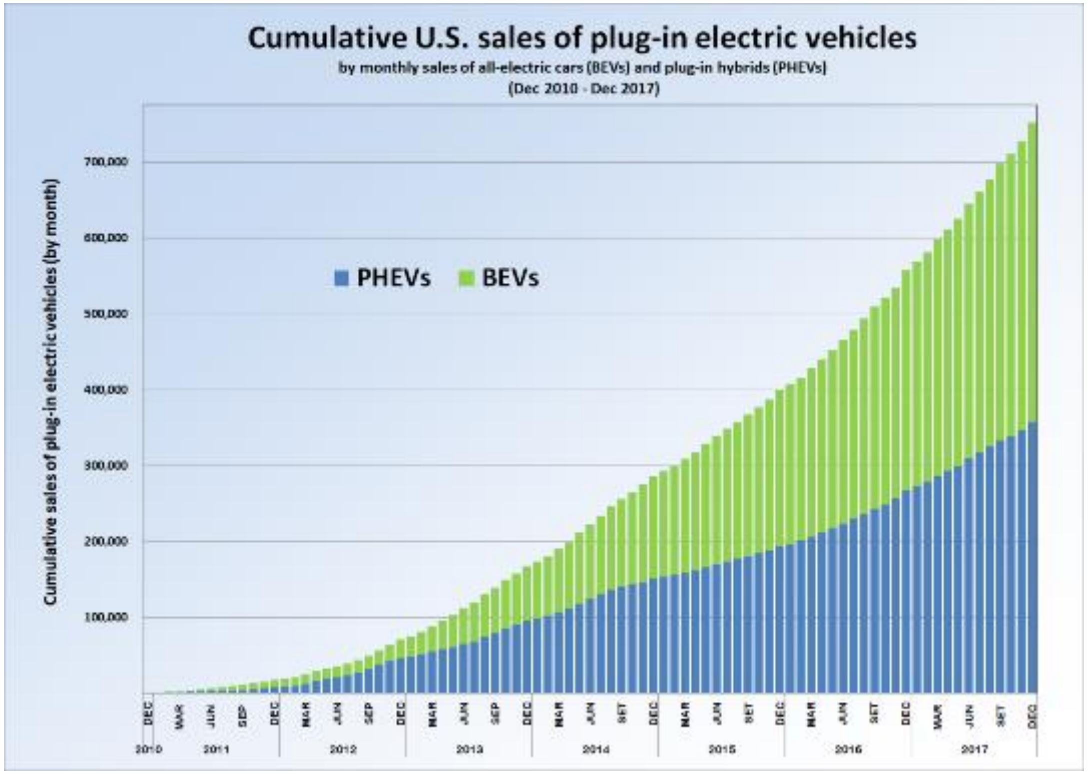

U.S. 2017 Billion-Dollar Weather and Climate Disasters
NOAA
North Dakota, South Dakota, and Montana Drought Spring–Fall 2017
Minnesota Hail Storm and Upper Midwest Severe Weather June 9–11
Midwest Tornado Outbreak March 6–8
Western Wildfires, California Firestorm Summer–Fall 2017
Central/Southeast Tornado Outbreak February 28–March 1
California Flooding February 8–22
Missouri and Arkansas Flooding and Central Severe Weather April 25–May 7
Colorado Hail Storm and Central Severe Weather May 8–11
Southeast Freeze March 14–16
Southern Tornado Outbreak and Western Storms January 20–22
Midwest Severe Weather June 27–29
Hurricane Harvey August 25–31
Midwest Severe Weather June 12–16
Hurricane Irma September 6–12
Hurricane Maria September 19–21
South/Southeast Severe Weather March 26–28
This map denotes the approximate location for each of the 16 billion-dollar weather and climate disasters that impacted the United States during 2017.

The Grid Resiliency Pricing Rule

24% of North American utility executives believe there is a "significant likelihood" (>20%) of a cyber attack interrupting electricity supply in the next 5 years

Source: Accenture Consulting (2017), Outsmarting Grid Security Threats

Beneficial Electrification Makes Us *Even More D*ependent on the Grid



Army Office of Energy Initiatives (OEI)
Renewable and Alternative Energy Resilience Projects

U.S. ARMY

Resilience Stats

- 100% with Onsite Generation
- 42% with Onsite Storage or Supply
- 42% with Onsite Controls
- 42% Islandable *

* *An islandable project is defined as a project able to maintain operations when the electric grid goes down.*
% = Percentages of Project Portfolio

ROCK ISLAND ARSENAL, IL Microgrid
8.5 MW Contingency Microgrid
8.5 MW Hydro Power
14 Day Minimum Capability

FT. DRUM, NY • Microgrid, PPA
28 MW Contingency Microgrid
60 MW Biomass
32 Day Minimum Capability

FT. DETRICK, MD Generation, PPA
15 MW Solar
Access to onsite non-contingency generation

ANNISTON ARMY DEPOT, AL Generation
...r
...eady onsite generation,
...ternal grid

CAMP ROBERTS, CA • Generati...
1.5 MW Solar
Microgrid-ready onsite generation, feeds the external grid

JFTB LOS ALAMITOS, CA • Microgrid
2.1 MW Contingency Microgrid
4 MW Combust. Gen./16 MW Solar
14 Day Minimum Capability

...ON ARMY DEPOT, AL ...icrogrid, ERCIP
...ntingency Microgrid
...tural Gas
...nimum Capability

FT. JACKSON, SC • Generation, Infrastructure
23 MW Solar
Onsite generation, infrastructure improvements, feeds the external grid

...non-contingency generation

FT. GORDON, GA • Generation
30 MW Solar
Microgrid-ready onsite generation, feeds the external grid

FT. HUACHUCA, AZ • Generation
18 MW Solar
Microgrid-ready onsite generation, feeds the external grid

FT. HOOD, TX • Generation, PPA
50 MW Wind/15 MW Solar
Access to onsite non-contingency generation

FT. GORDON, GA • Microgrid
9 MW Contingency Microgrid
6 MW Diesel Gen. / 10 MW Solar
14 Day Minimum Capability

FT. BENNING, GA • Microgrid
1.5 MW Contingency Microgrid
2 MW Diesel / 10 MW Solar
14 Day Minimum Capability

SCHOFIELD BARRACKS, HI • Microgrid
50 MW Contingency Microgrid
50 MW Biofuel
30 Day Minimum Capability

FT. RUCKER, AL • Generation
10 MW Solar
Microgrid-ready onsite generation, feeds the external grid

FT. BENNING, GA • Generation
30 MW Solar
Microgrid-ready onsite generation, feeds the external grid

FT. STEWART, GA • Generation
30 MW Solar
Microgrid-ready onsite generation, feeds the external grid

As of January 16, 2018

Project Status

- ***Phase 1:*** Assessment
- ***Phase 2:*** Validation
- ***Phase 3:*** Contracts & Agreements
- ***Phase 4:*** Construction
- ***Phase 5:*** Operational

Renewable & Alternative Energy Key

Biomass	Diesel	Natural Gas	Battery Storage	"Islandable"
Biofuel	Generation	Solar	Storage / Supply	No Storage
CHP	Hydro	Wind	Controls	No Controls

INCREASING **ENERGY SECURITY** AND **RESILIENCE** ACROSS ARMY INSTALLATIONS

Example: Salt Lake City

- First “net zero energy” public safety building in US (pictured)
- 30% of panels wired to provide electricity to the building during grid outages

Example: Duluth

- Hartley Nature Center (city-owned facility) retrofitted with solar+storage
- Serves as Emergency Base of Operations for the city

DOE Toolkit: Building Resilience with Solar+Storage

Compendium of resources and case studies at:

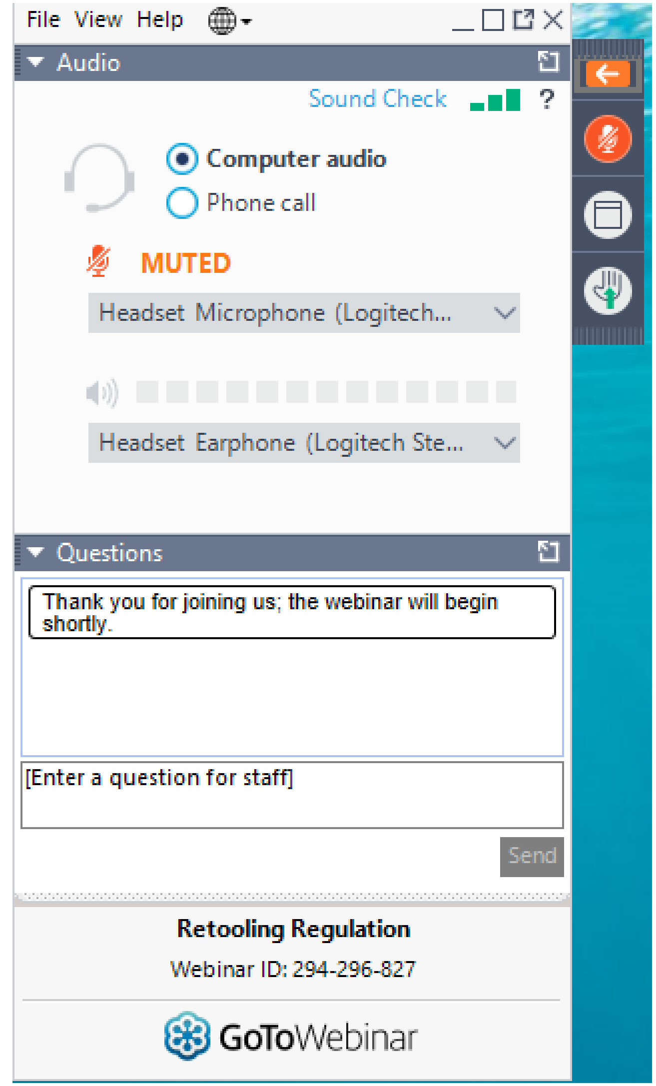
http://solarmarketpathways.org/innovation/resilience/

Examples of Resilience Issues for State Utility Regulators

- Prudence of grid-hardening investments
- Distribution system planning/grid modernization
- Utility vs. third-party ownership of distributed generation, storage, and microgrids
- Tariff design for microgrids
- Interconnection standards and processes

Questions?

Please send questions through the Questions pane



Conclusions

Where regulators can align power sector transformation with the public interest:

- In structuring and operation of more open, transactive electricity markets;
- In new approaches to rate design and transparent price formation; and
- In business models used to provide clean, affordable, and resilient energy services to consumers.

About RAP

The Regulatory Assistance Project (RAP)® is an independent, non-partisan, non-governmental organization dedicated to accelerating the transition to a clean, reliable, and efficient energy future.

Learn more about our work at raponline.org

Contact us at info@raponline.org