



February 5, 2019

# Let's Be More Flexible: Rules and Tools for a Modern Power Grid

## RAP Roundtable Discussion

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David Farnsworth  
Senior Associate

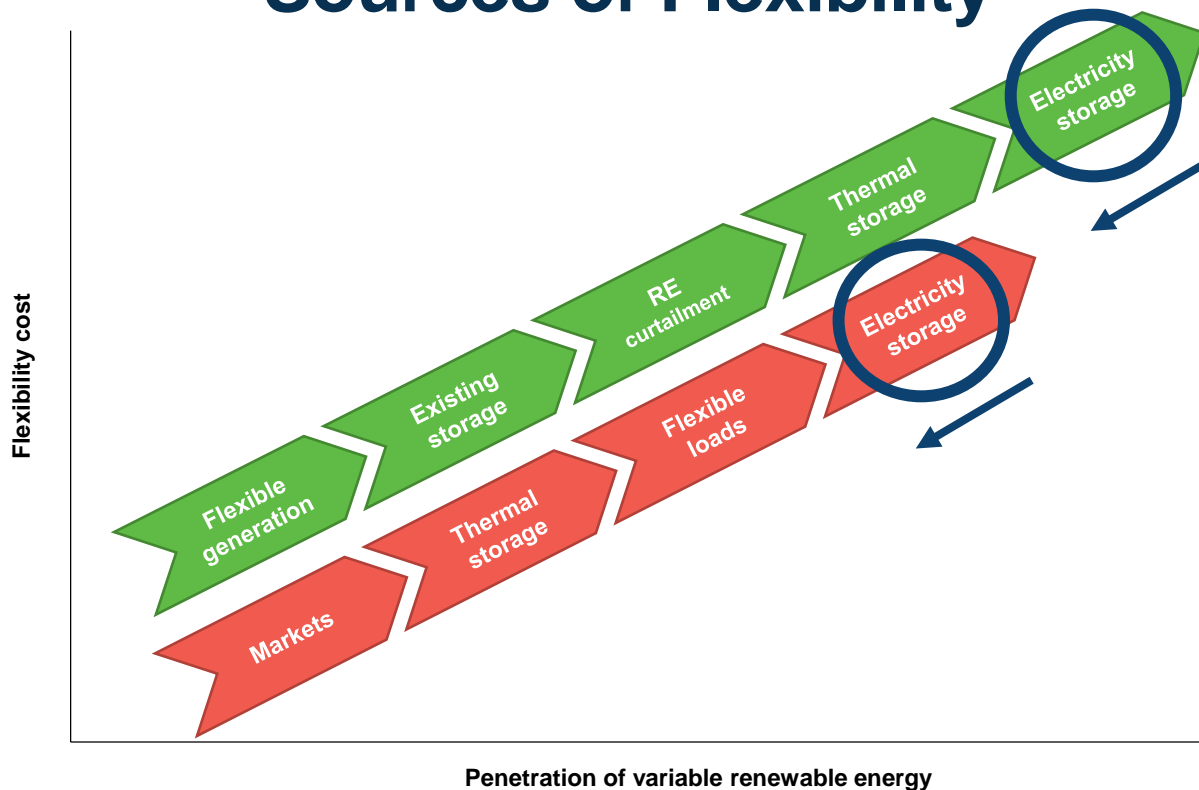
Jim Lazar  
Senior Advisor

David Littell  
Principal

Carl Linvill  
Principal

Jessica Shipley  
Associate

# Sources of Flexibility



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# Our Roundtable



**David Farnsworth**



**Jim Lazar**



**Carl Linvill**



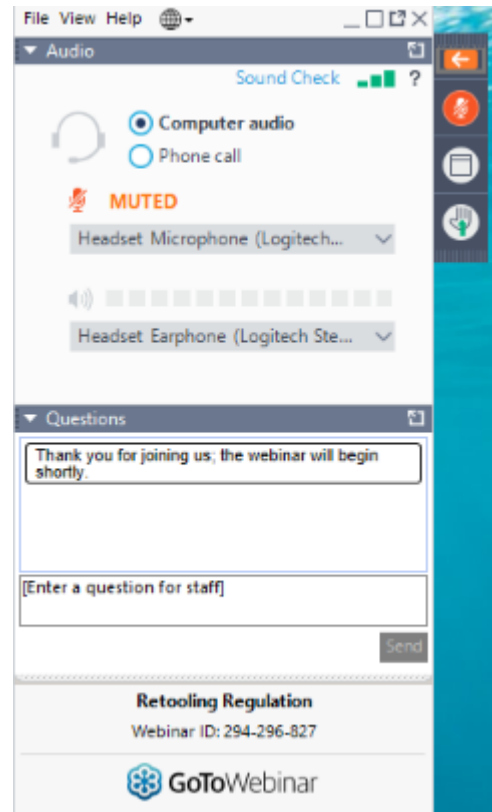
**David Littell**



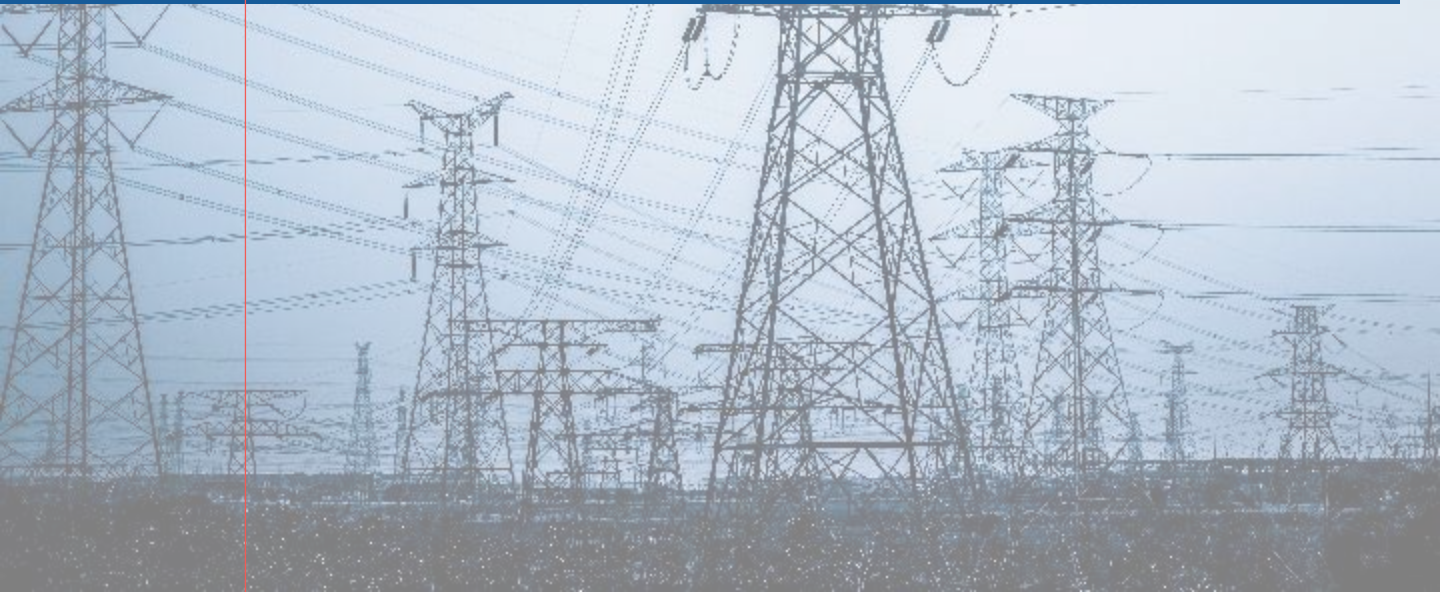
**Jessica Shipley**

# Questions?

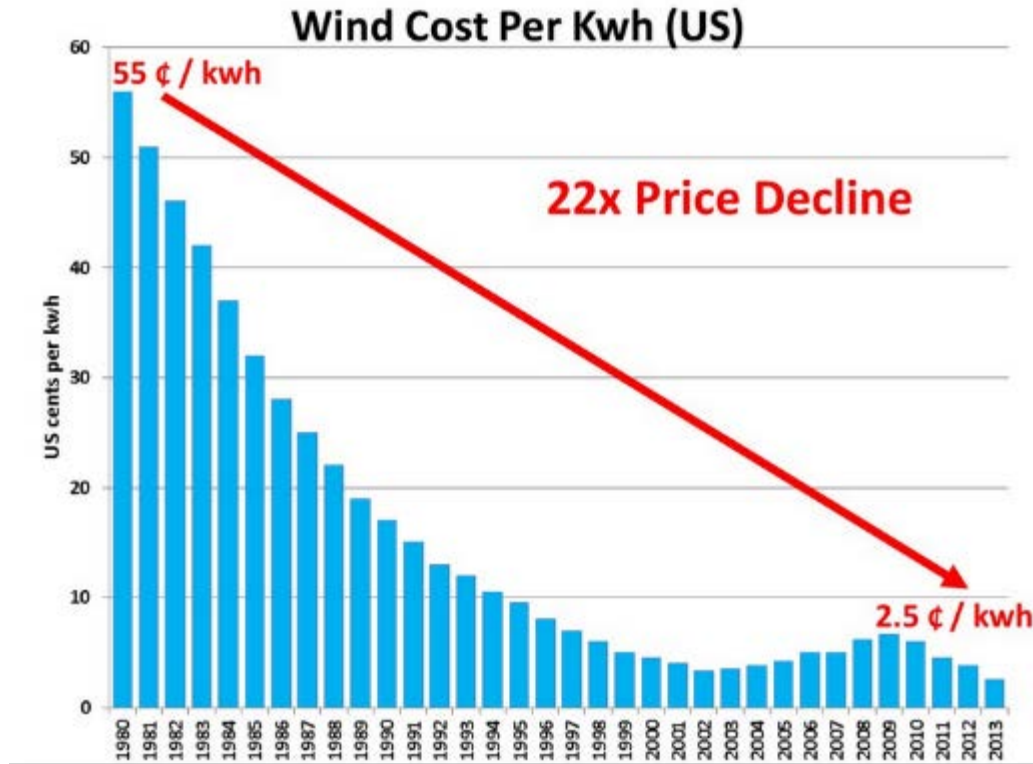
Please send questions  
through the Questions  
pane



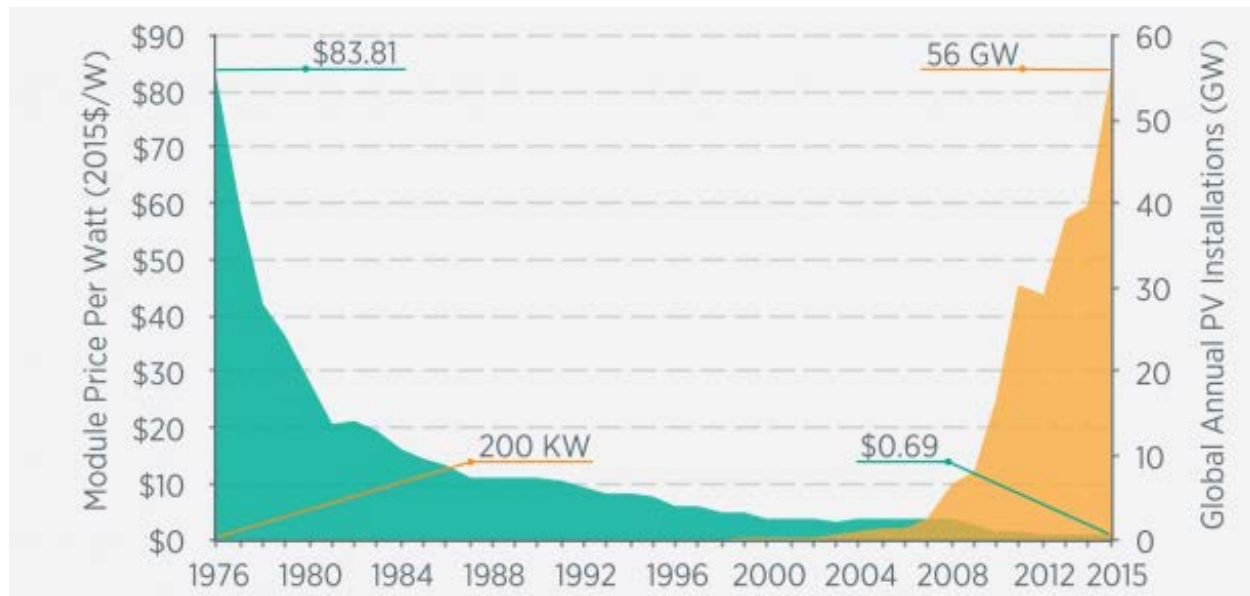
# 1 Lay of the Land



# Wind Costs Dropped a Decade Ago



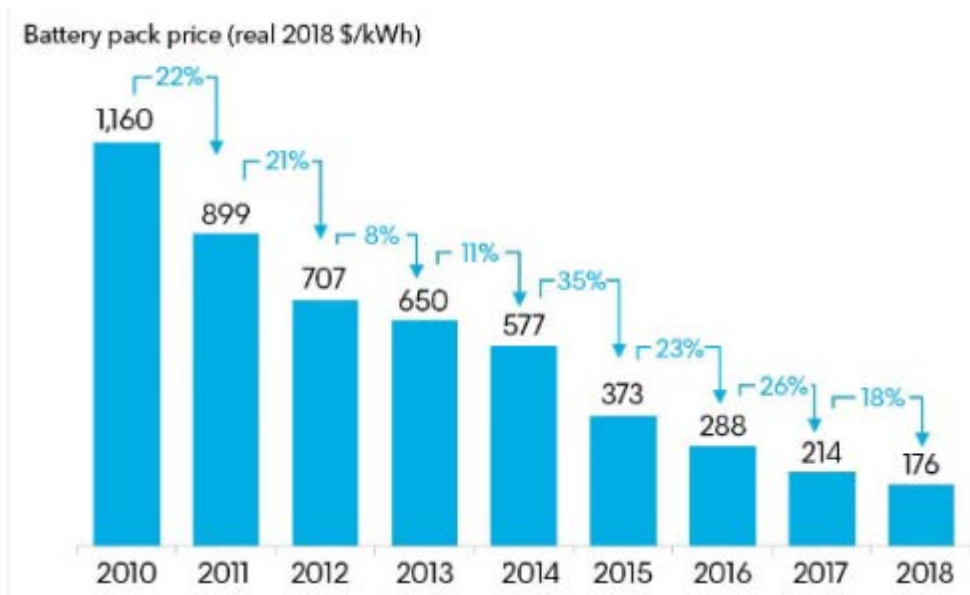
# Solar Is Following Close Behind



Source: SunShot, US  
Department of Energy



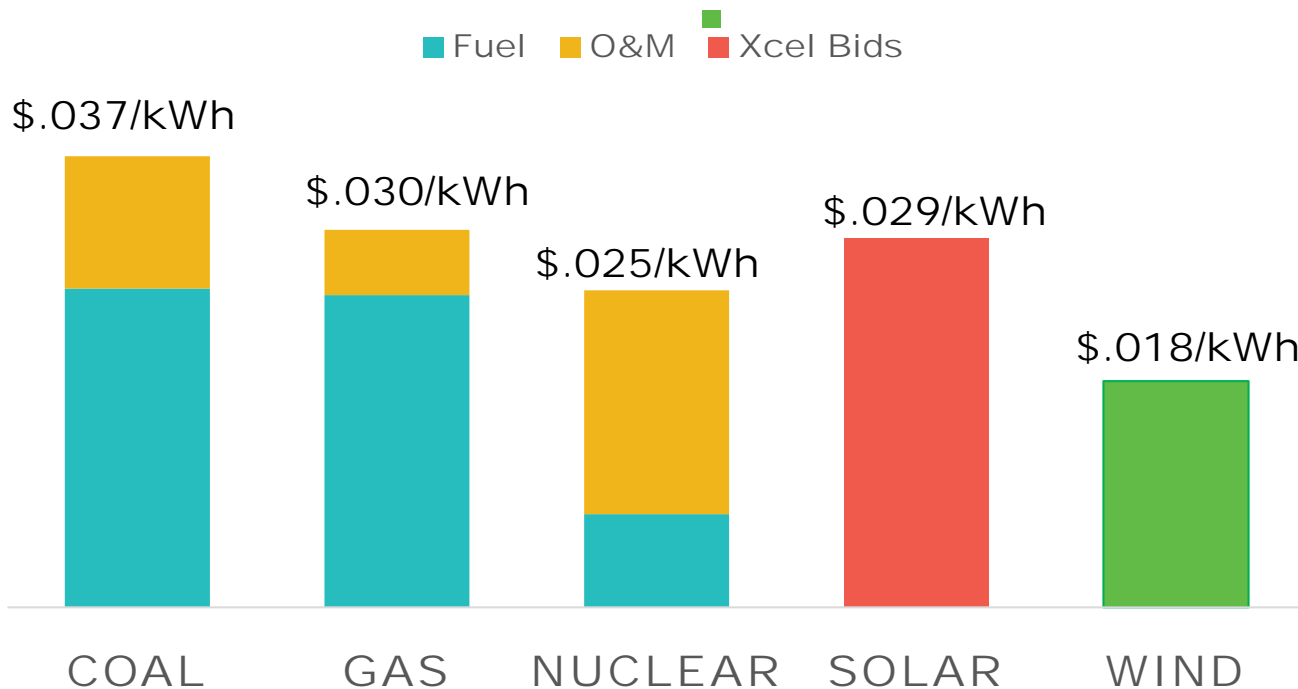
# This Year's News is the Battery Cost Slide



Source: BloombergNEF.  
Data adjusted to be in real  
2018 dollars.



# Existing Plants vs. Xcel Bids



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

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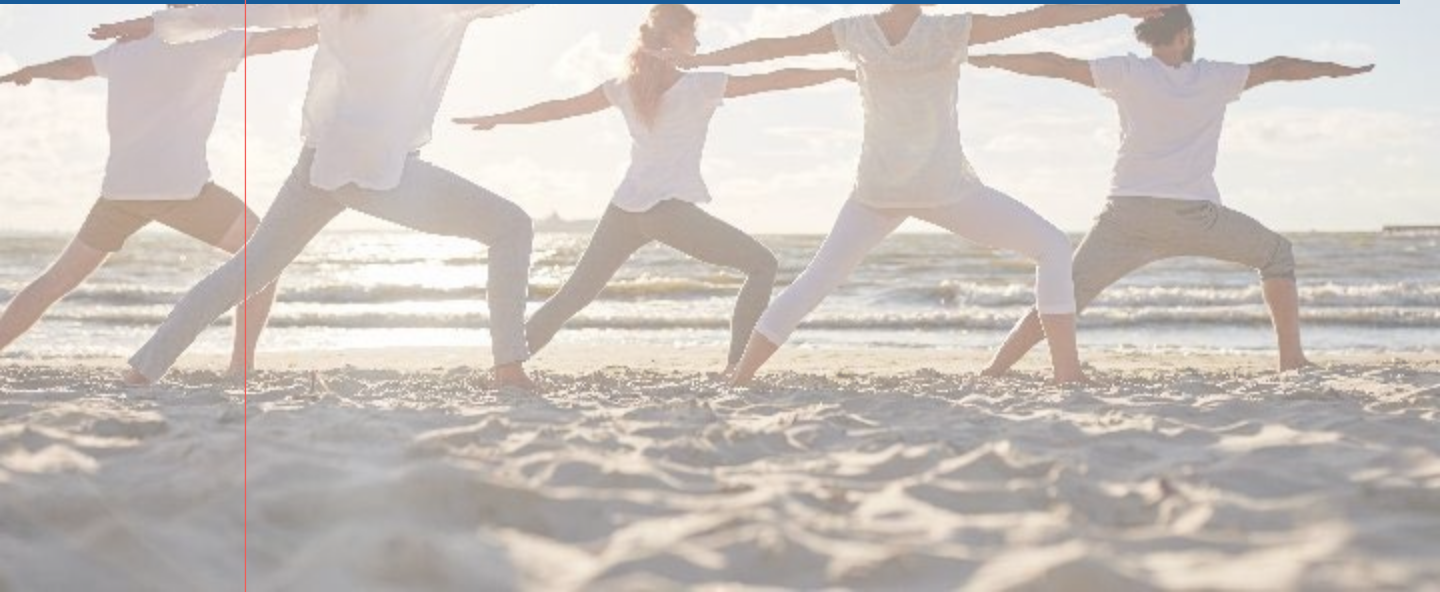
# Xcel Energy Plan

Wind: \$.011/kWh  
Solar: \$.023/kWh  
Solar plus storage:  
\$.030/kWh



Image credit: Jeffrey Beall, Wikimedia

## 2 Why is Flexibility Important? Examples from Around the Country

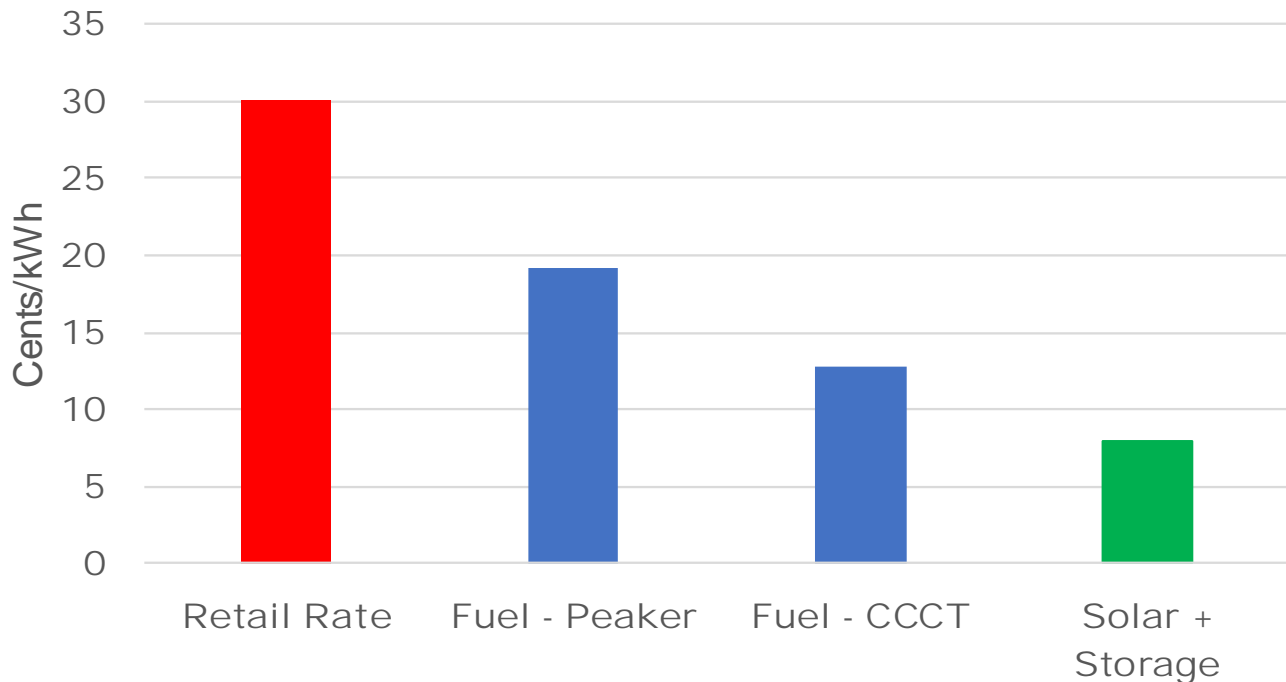


# Solar + Storage in Hawaii

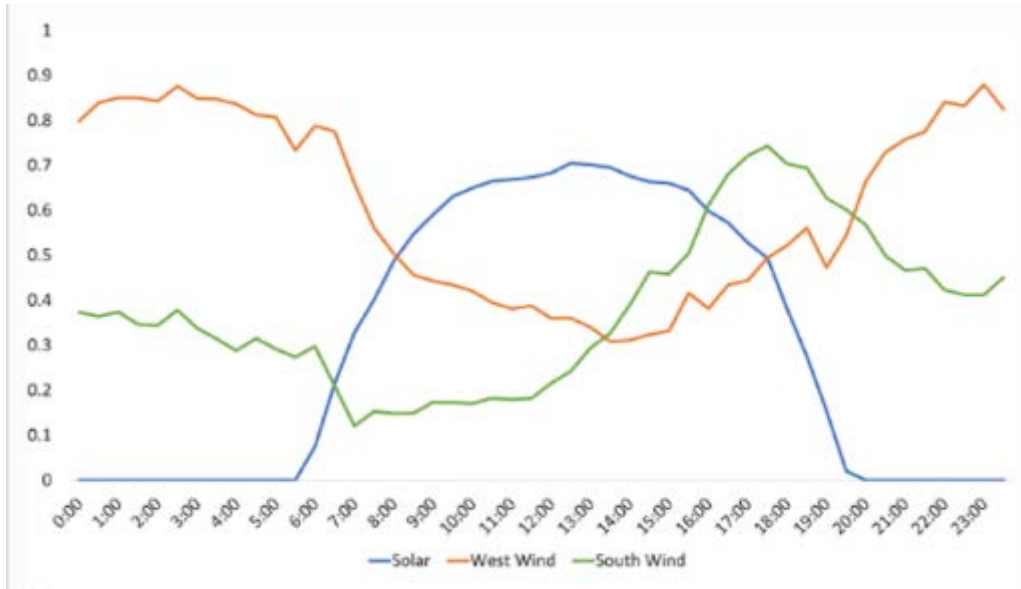
Project	Island	Developer	Size	Storage	Cost per kWh
Walkoloa Solar	Hawaii	AES	30 MW	120 MWh	\$0.08
Kuihelani Solar	Maui	AES	60 MW	240 MWh	\$0.08
Hale Kuawehi	Hawaii	Innergex	30 MW	120 MWh	\$0.09
Mililani I Solar	Oahu	Clearway	39 MW	156 MWh	\$0.09
Waiawa Solar	Oahu	Clearway	36 MW	144 MWh	\$0.10
Hoohana	Oahu	174 Power Global	52 MW	208 MWh	\$0.10
<del>Palahe Solar</del>	<del>Maui</del>	<del>Innergex</del>	<del>15 MW</del>	<del>60 MWh</del>	<del>\$0.12</del>

SOURCE: [Hawaiian Electric](#)

## Maui Electric Rates, Fuel, and New Supply

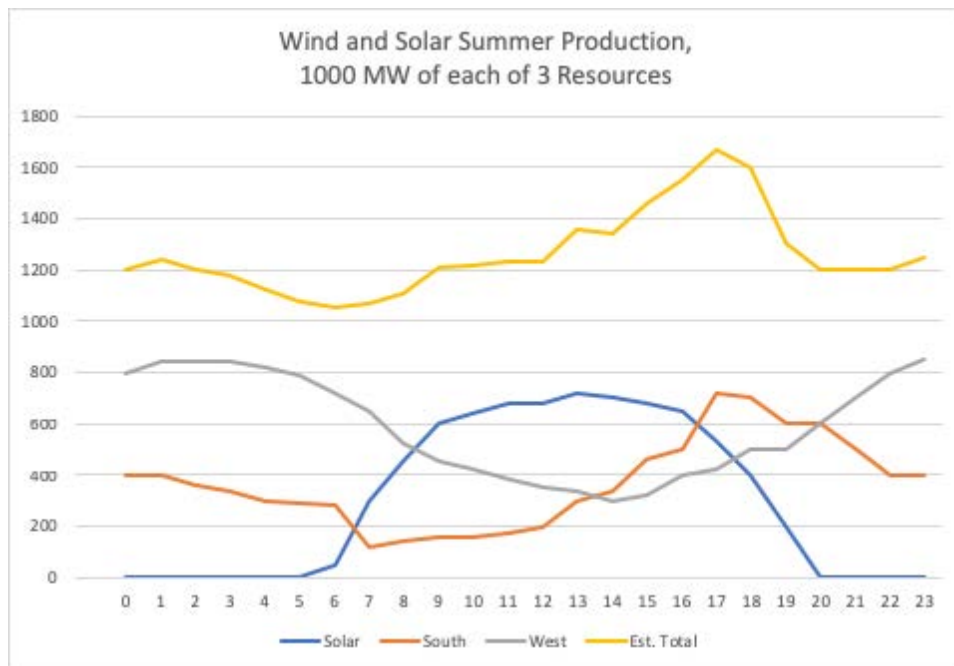


# Texas Wind Resources and Solar Resources have Complementary Load Capacity Profiles



Slusarewicz and Cohen, "Assessing Solar and Wind Complementarity in Texas,"  
*Renewables: Wind, Water and Solar*, 2018, Vol. 5, No. 7.

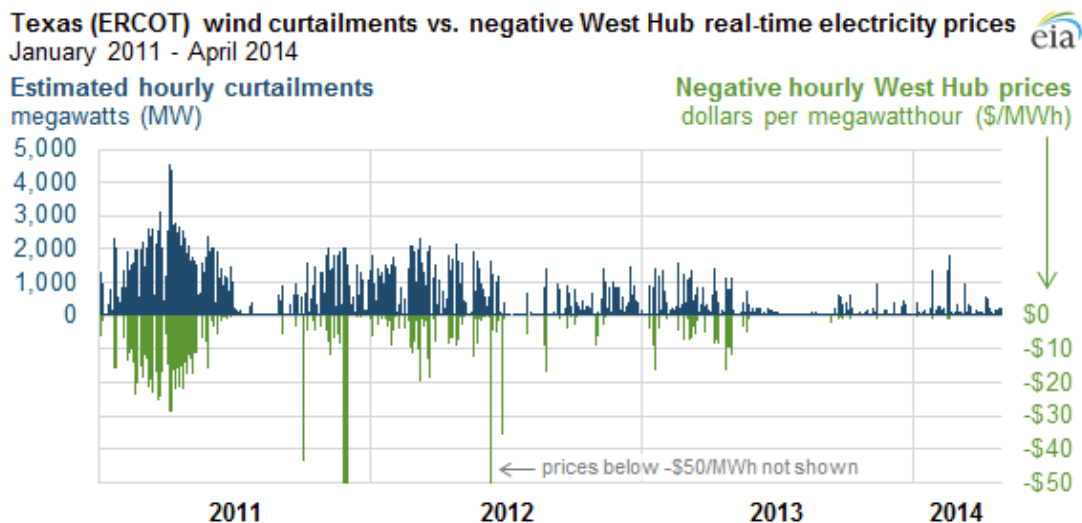
# Combined, They Produce a Smoother Profile that Approximates System Needs





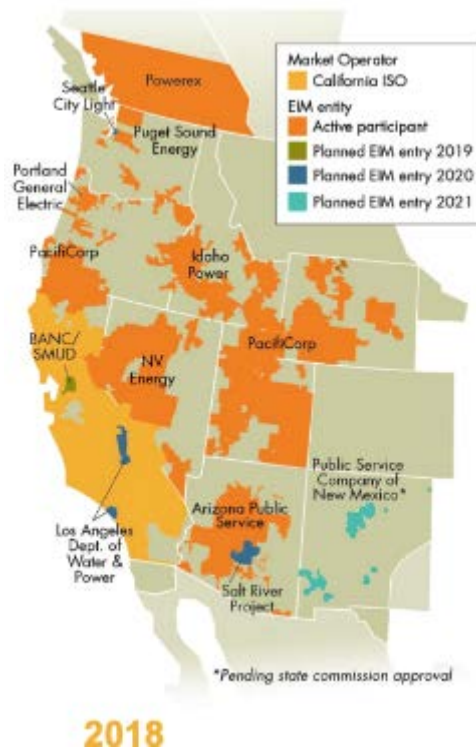
# Adding Transmission in Texas

Increasing Resource and Geographic Diversity Has Significantly Reduced Curtailments and Stabilized Prices

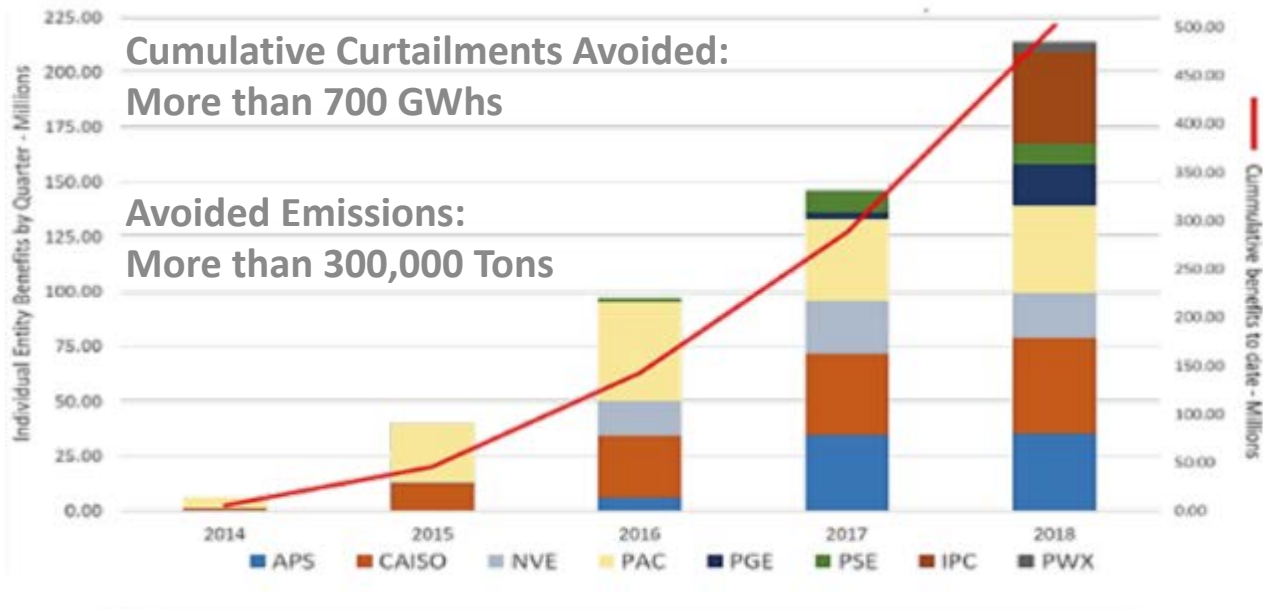


Source: U.S. Energy Information Administration, based on the [Electric Reliability Council of Texas](#) (ERCOT) for curtailments and [SNL Energy](#) for electricity prices

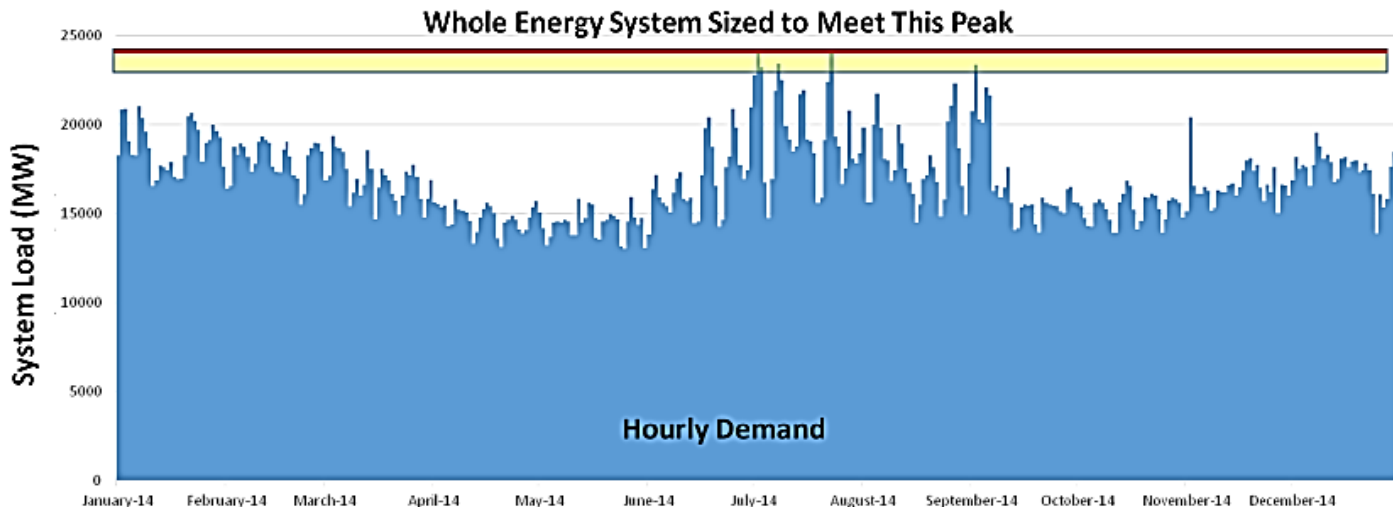
# The Western EIM Increases Diversity and Adds Flexibility



# Western EIM Economic Benefits Growing

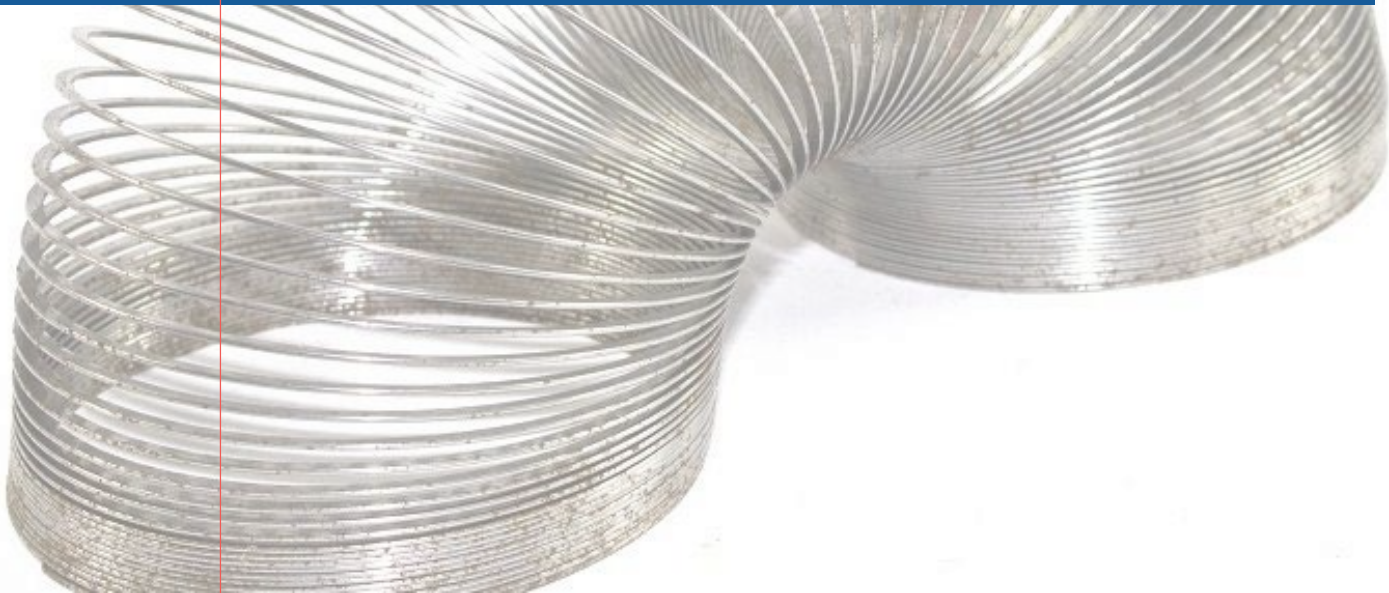


# New England: Expensive Peaks



Source: MA DOER, State of Charge report

# 3 What Flexible Capabilities do Advanced Technologies Provide?



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# Supply Side: Inverter-Based Technologies Provide Important System Benefits



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# Taking Notice at NARUC

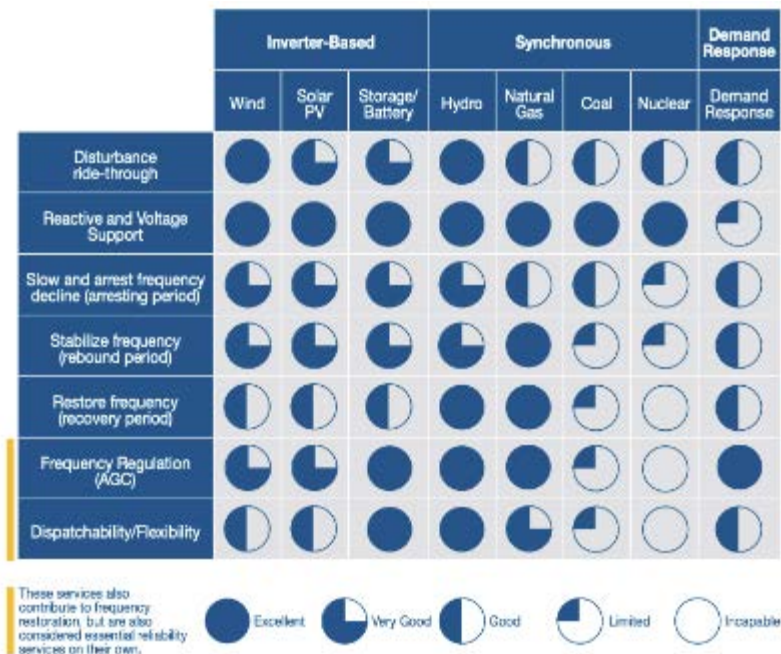
The Electricity Committee and Energy Resources and Environment Committee have acknowledged the importance of flexible resources.

(1) Utilities and utility commissions should be well educated about the different types of quantitative models that exist today ...

(2) Planning frameworks and modeling tools that are publicly and commercially available should model the full spectrum of services that energy storage and flexible resources are capable of providing ...

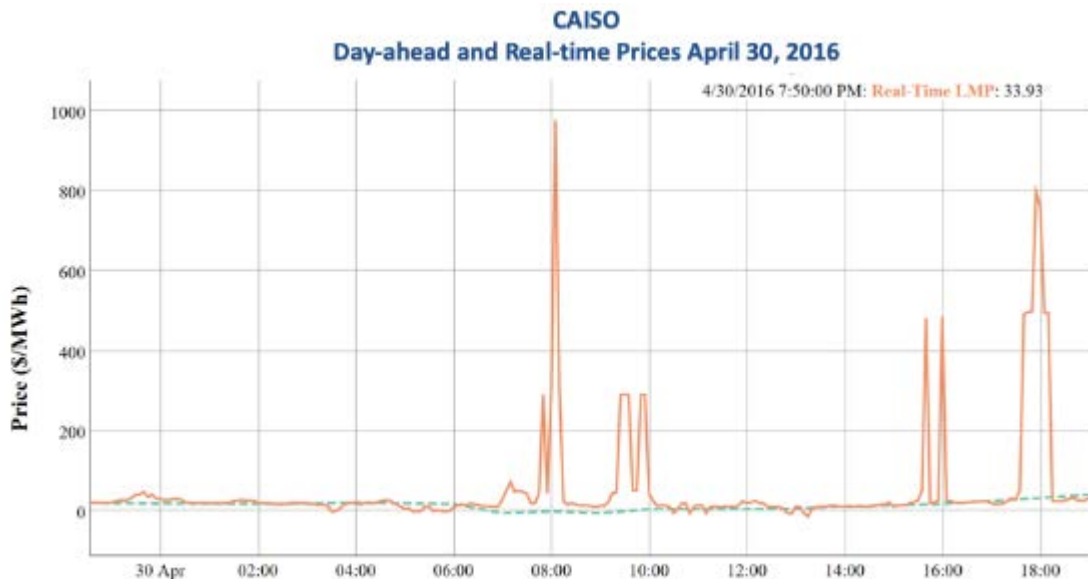


# Wind, Solar, and Batteries are Valuable in Real Time



Source: [www.milligangrid solutions.com](http://www.milligangrid solutions.com)

# You May Have Noticed that Inverter-Based Technologies Excel at being Fast

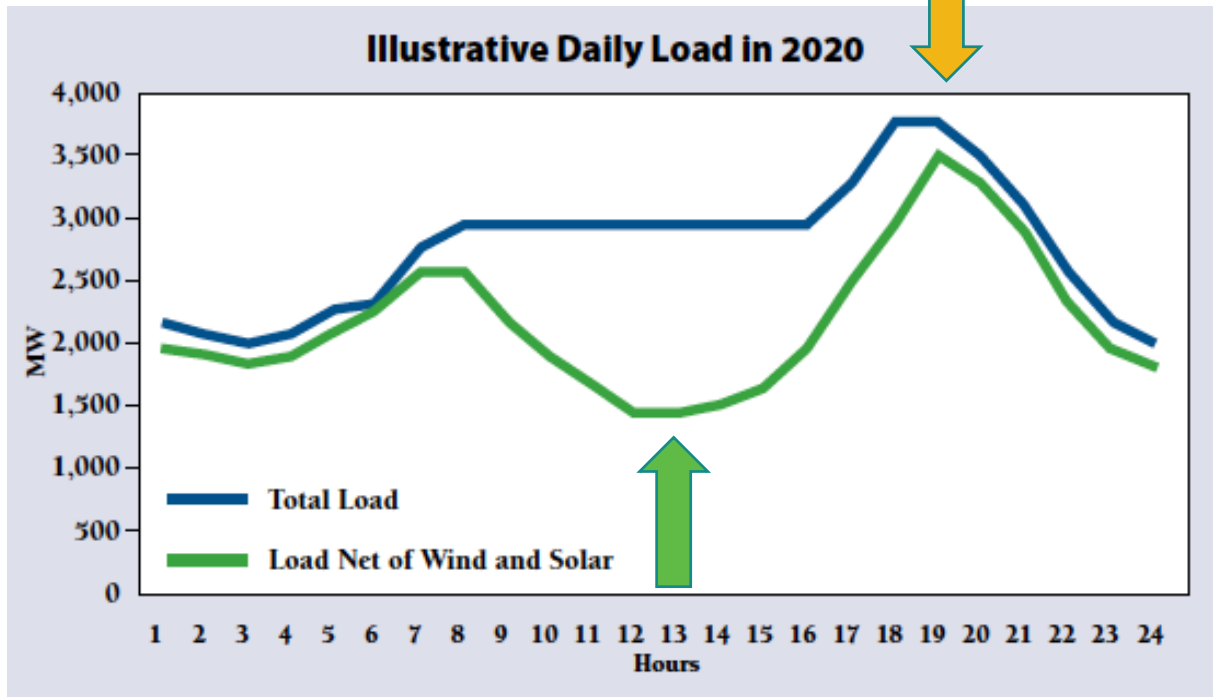


Source: [www.ascendanalytics.com](http://www.ascendanalytics.com)

# Demand Side: New Services Are Available

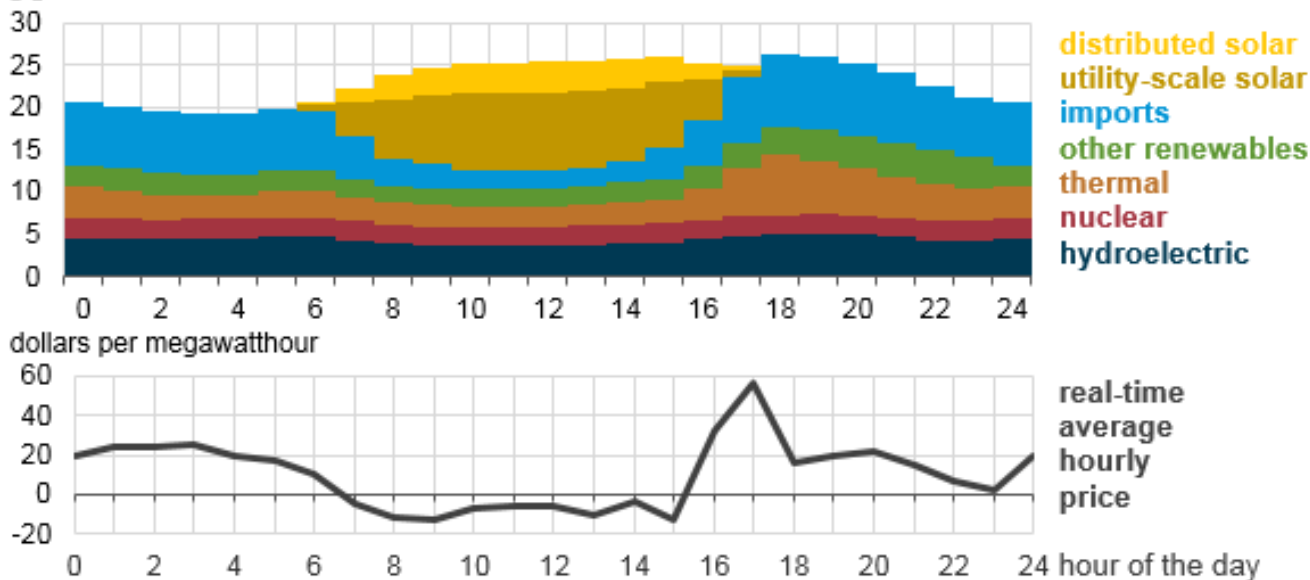


# Load-Side Resources to “Shape” the Demand Curve

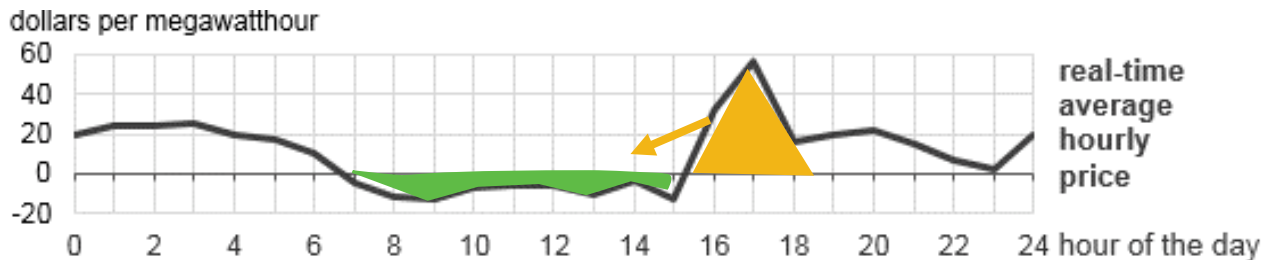


# Load-side Resources Can “Shift” Demand To Times When Surplus Power is Available

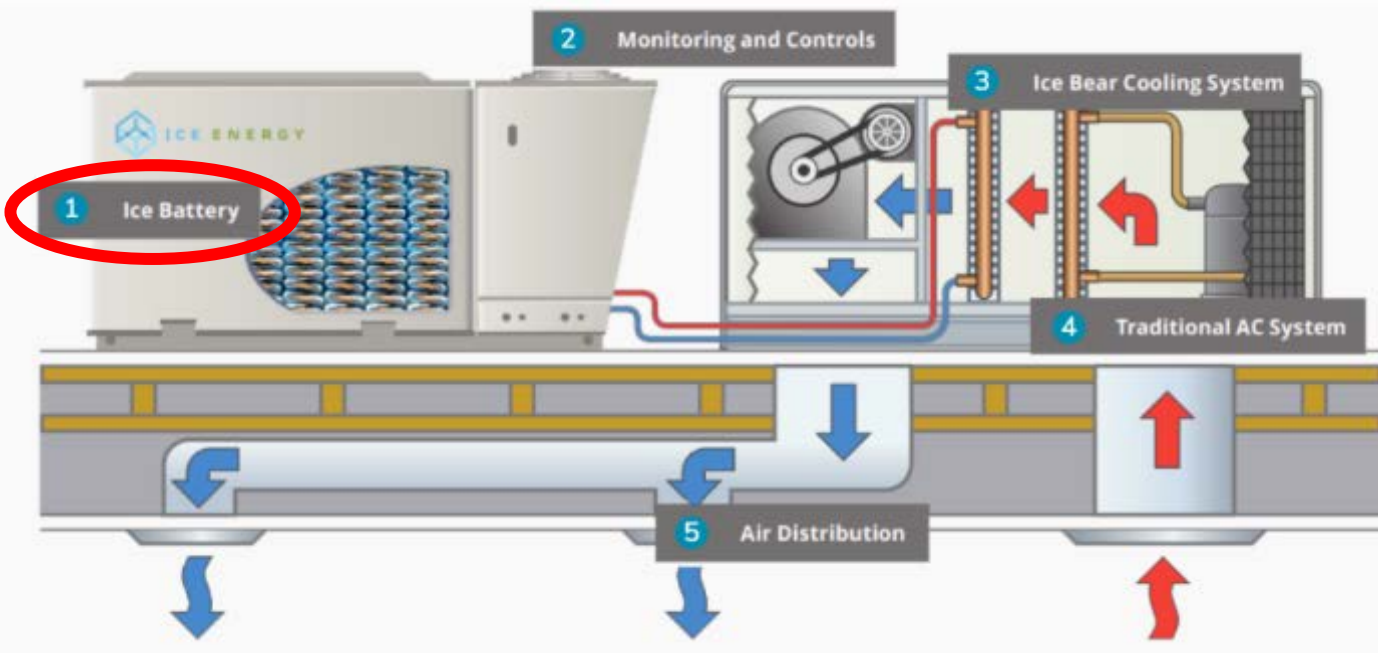
California Independent System Operator net generation, March 11, 2017  
gigawatthours



# Load-Side Resources Can “Shift” Demand

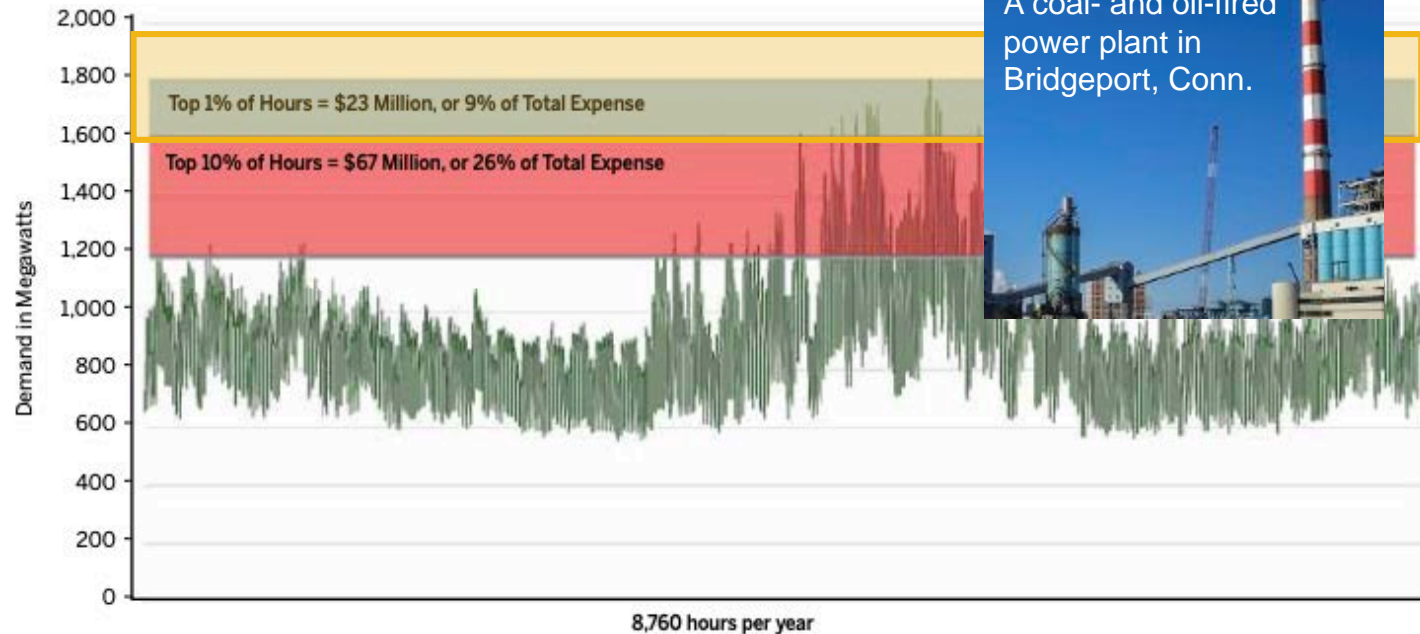


# Ice Storage Air Conditioning





# Limited Curtailment Can “Shed” During Critical Hours

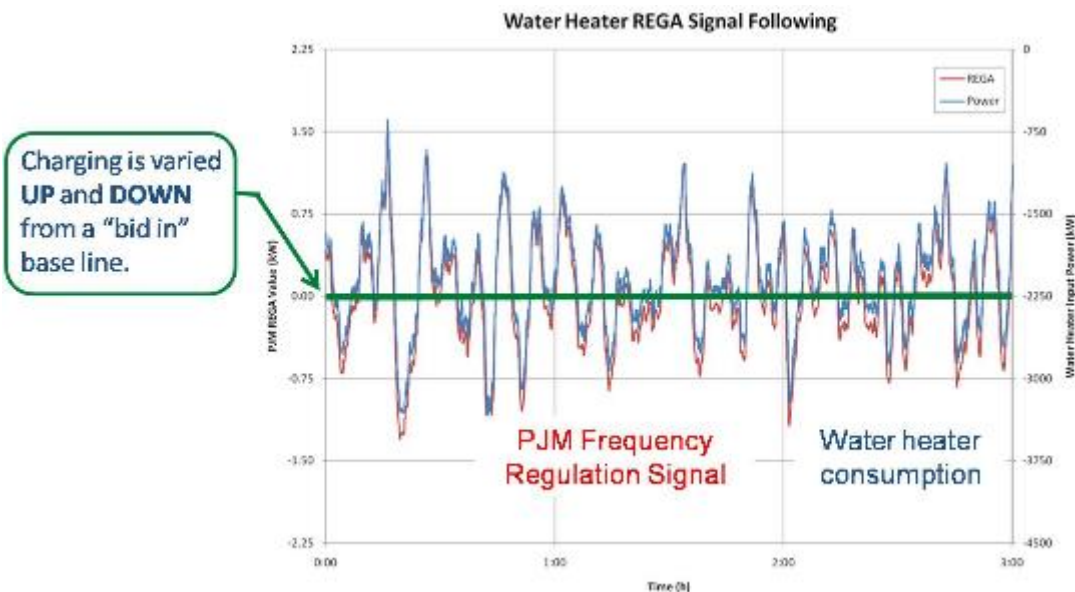


A coal- and oil-fired power plant in Bridgeport, Conn.



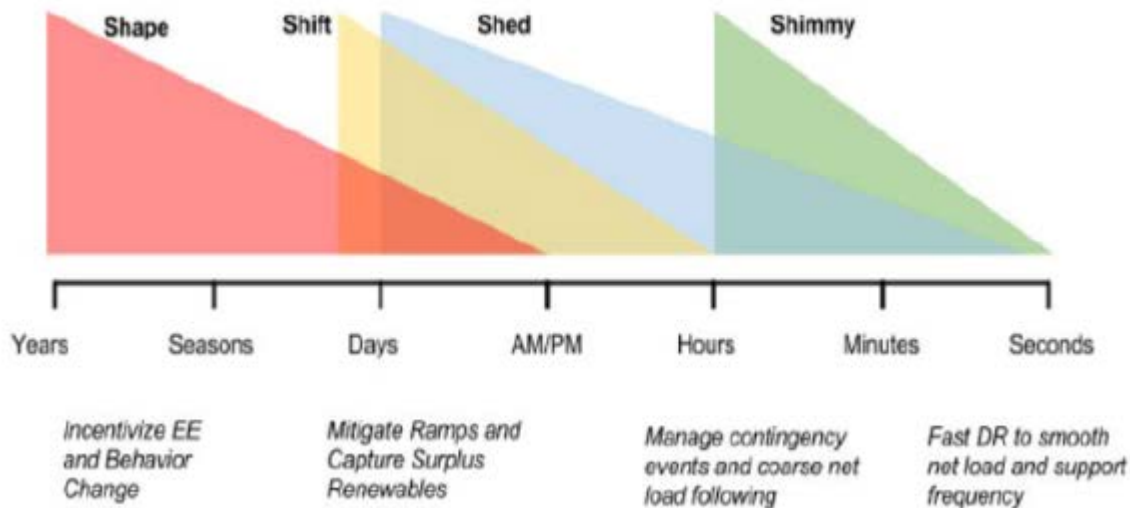
Source: Rhode Island Division of Public Utilities & Carriers, Office of Energy Resources, and Public Utilities Commission. (2017). Rhode Island Power Sector Transformation: Phase One Report to Governor Gina M. Raimondo. Image credit: Conservation Law Foundation

# Responsive Load Can “Shimmy” To Meet Short-Term Grid Needs



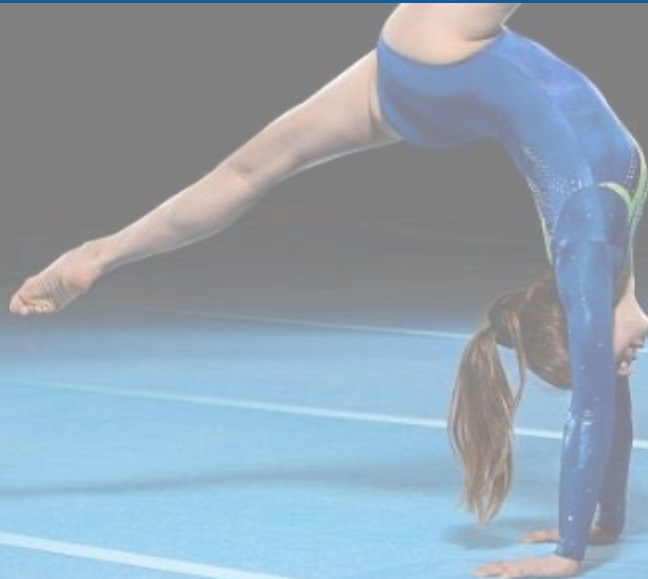
Source:  
PJM

# Flexibility Strategies for the Demand Side Now Span Many Timescales



Source: 2015 California Demand Response Potential Study, LBNL, November 2016

# 4 What Tools Do We Need to Optimize Flexibility?



# Retail Pricing and Price-Responsive Demand

Your electricity bill

Your service plan: Standard Rate

## Charges for electricity services

### Cost of electricity you used

Customer account charge

Delivery service charge

Environmental benefits surcharge

Federal environmental improvement surcharge

System benefits charge

Power supply adjustment\*

\$1.60

\$0.90

\$2.70

\$1.00

\$0.00

\$0.00

\$0.00

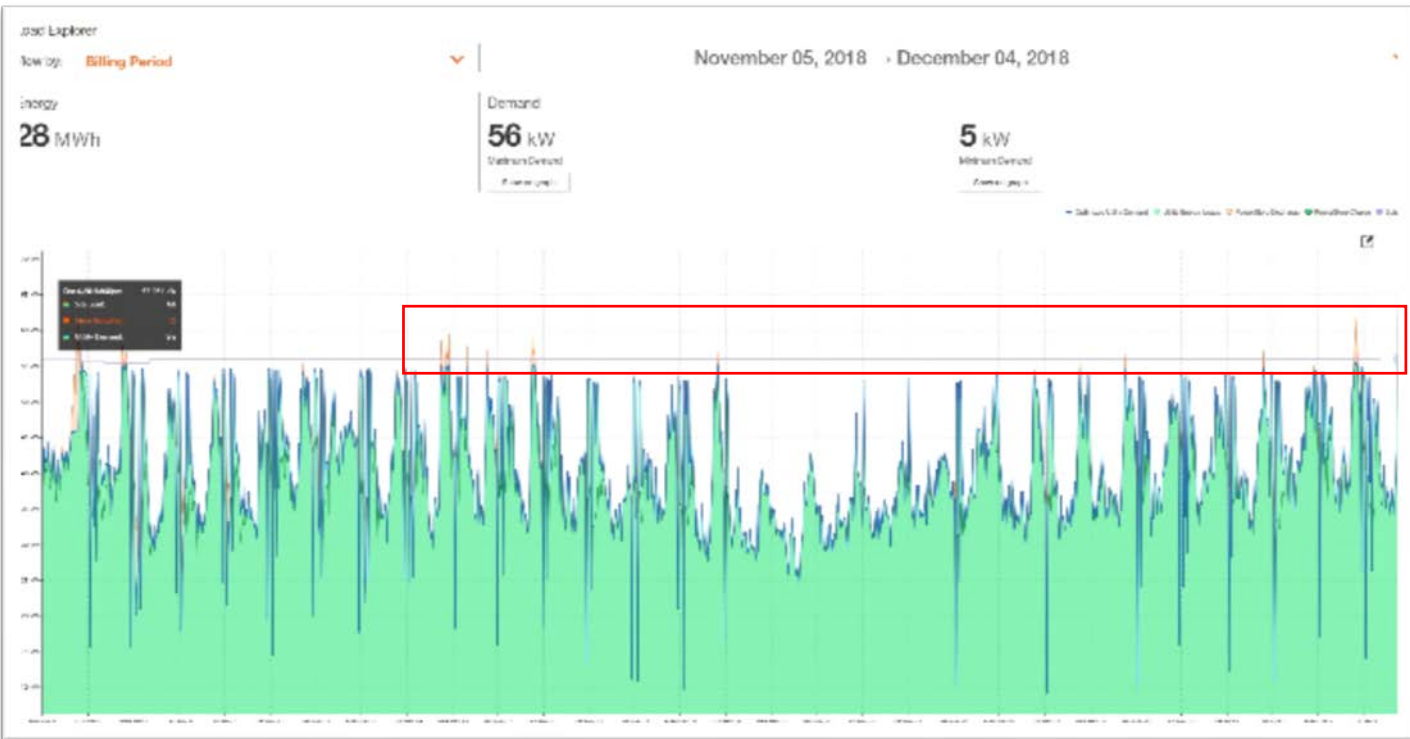


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# Getting Around Demand Charges



# STEM: 12 kW Savings Off 68 kW Peak



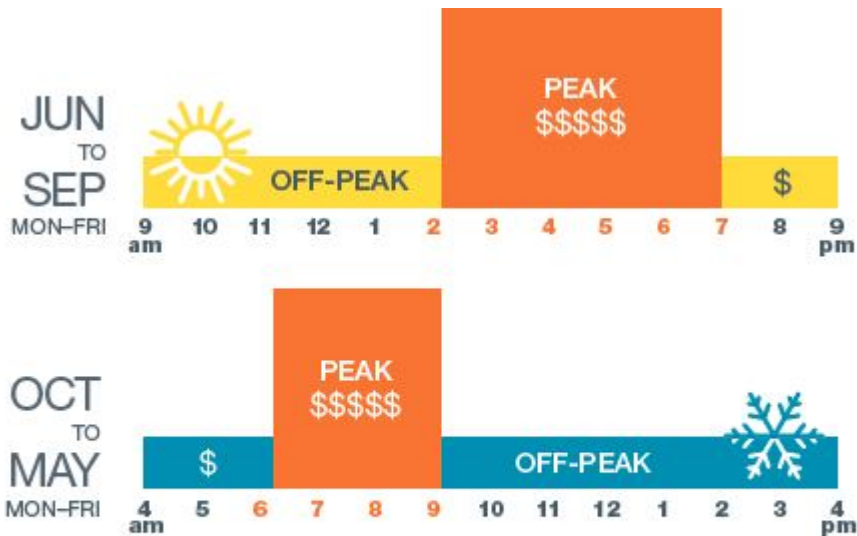
# Fort Collins: Smart Residential Rate

Customer Charge	\$ 6.78	
	Summer	Winter
Off-Peak	\$ 0.069	\$ 0.067
On-Peak	\$ 0.241	\$ 0.216
Tier Charge (Over 700 kWh)	+ \$.0194 / kWh	





# BG&E TOU Pilot



Excludes weekends and holidays, which are billed at off-peak rates. Holidays include New Year's Day, President's Day, Good Friday, Memorial Day, Independence Day, Thanksgiving, Christmas and the Monday following if any of these holidays fall on a Sunday.

# Controlled Loads

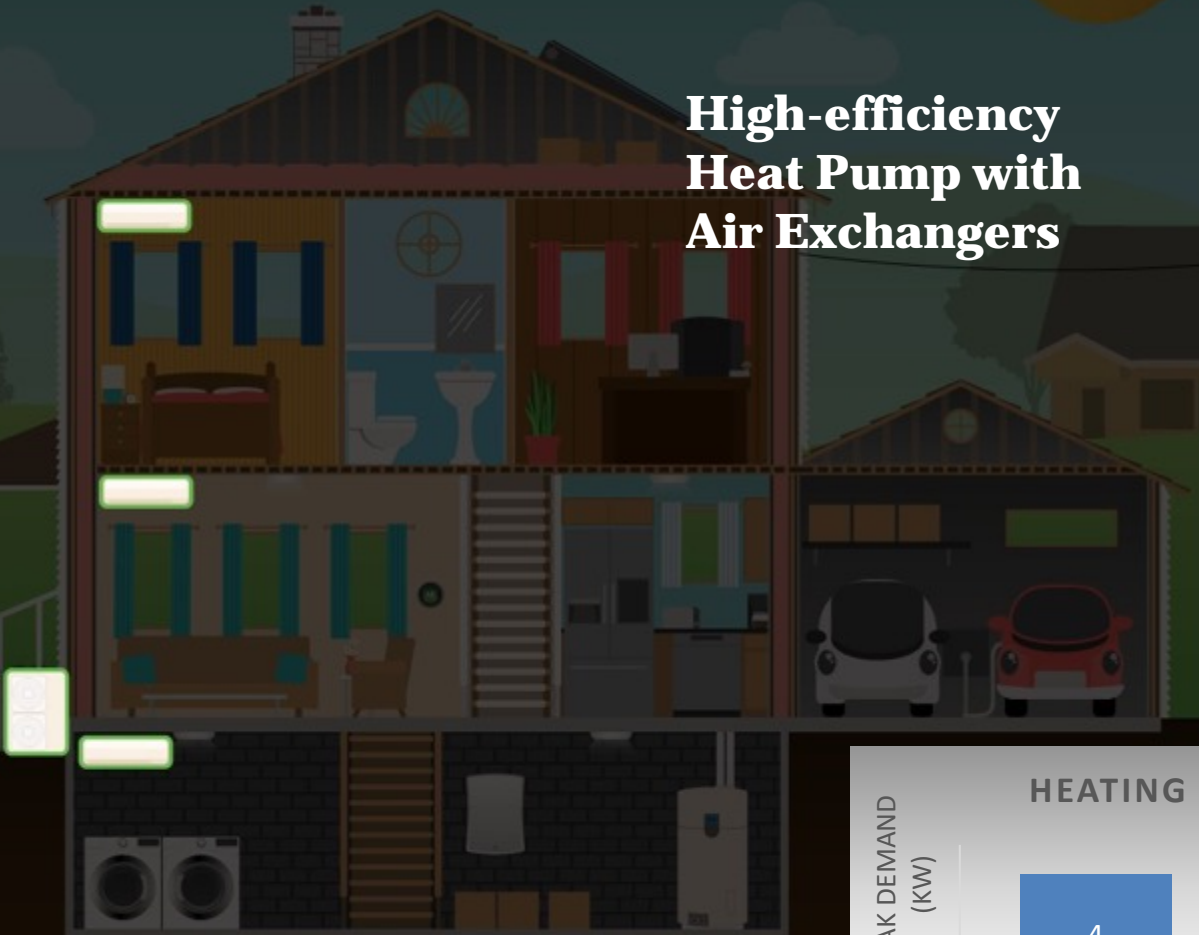




# Efficient Building Code



# High-efficiency Heat Pump with Air Exchangers



PEAK DEMAND  
(kW)

HEATING

4

# Ice Storage

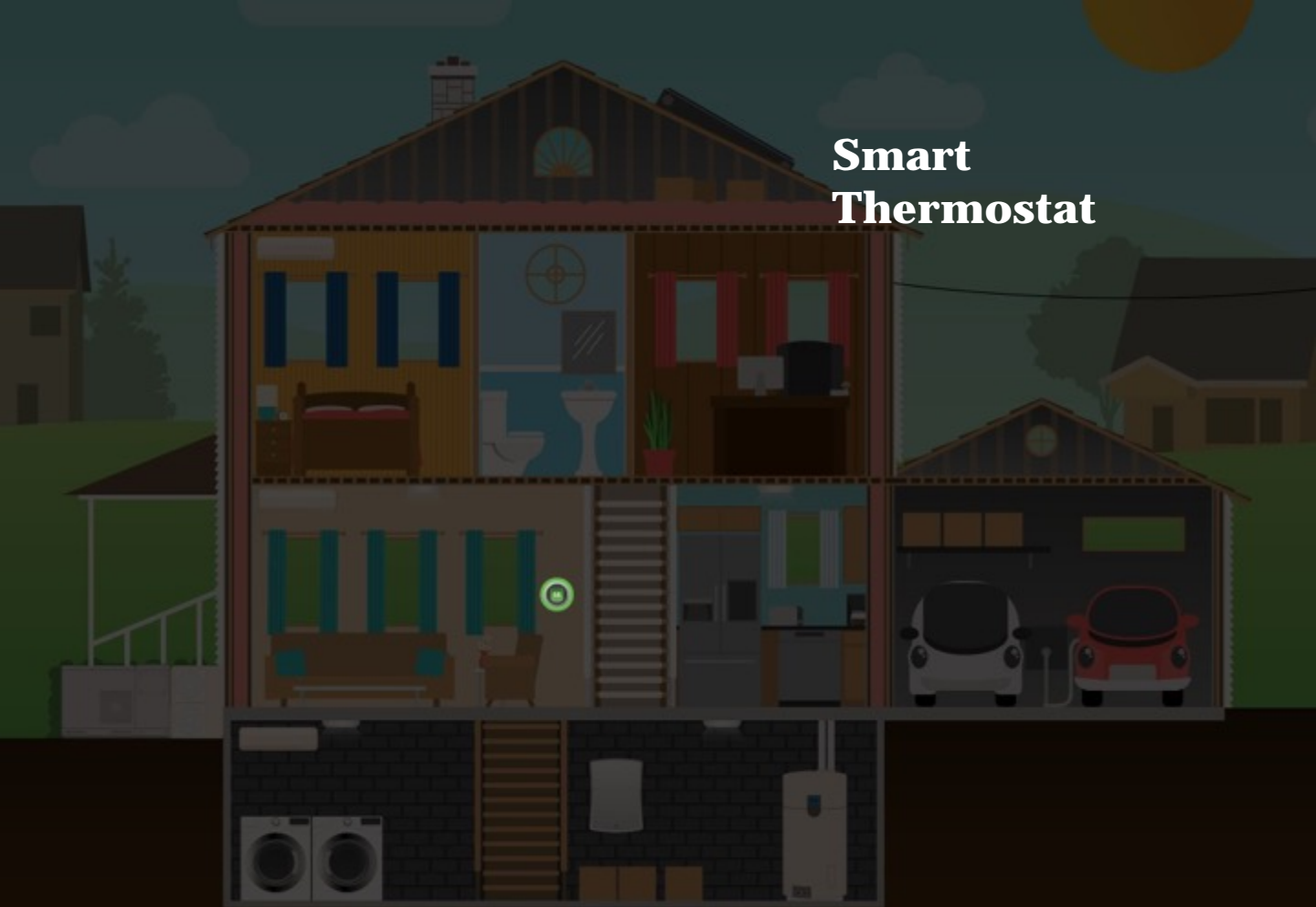


COOLING

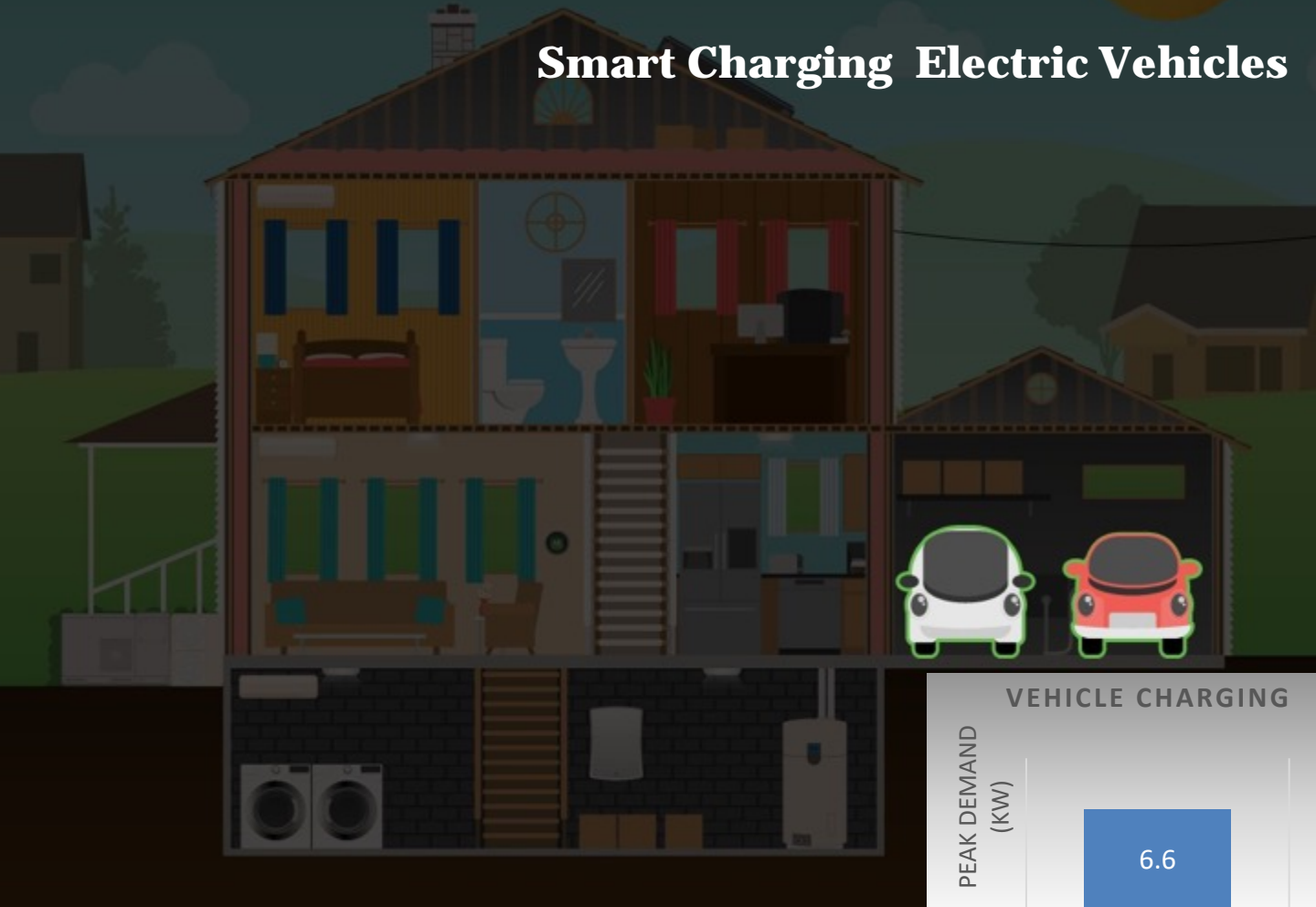
PEAK DEMAND  
(kW)

4

# Smart Thermostat



# Smart Charging Electric Vehicles





# Grid-Integrated Heat Pump Water Heater

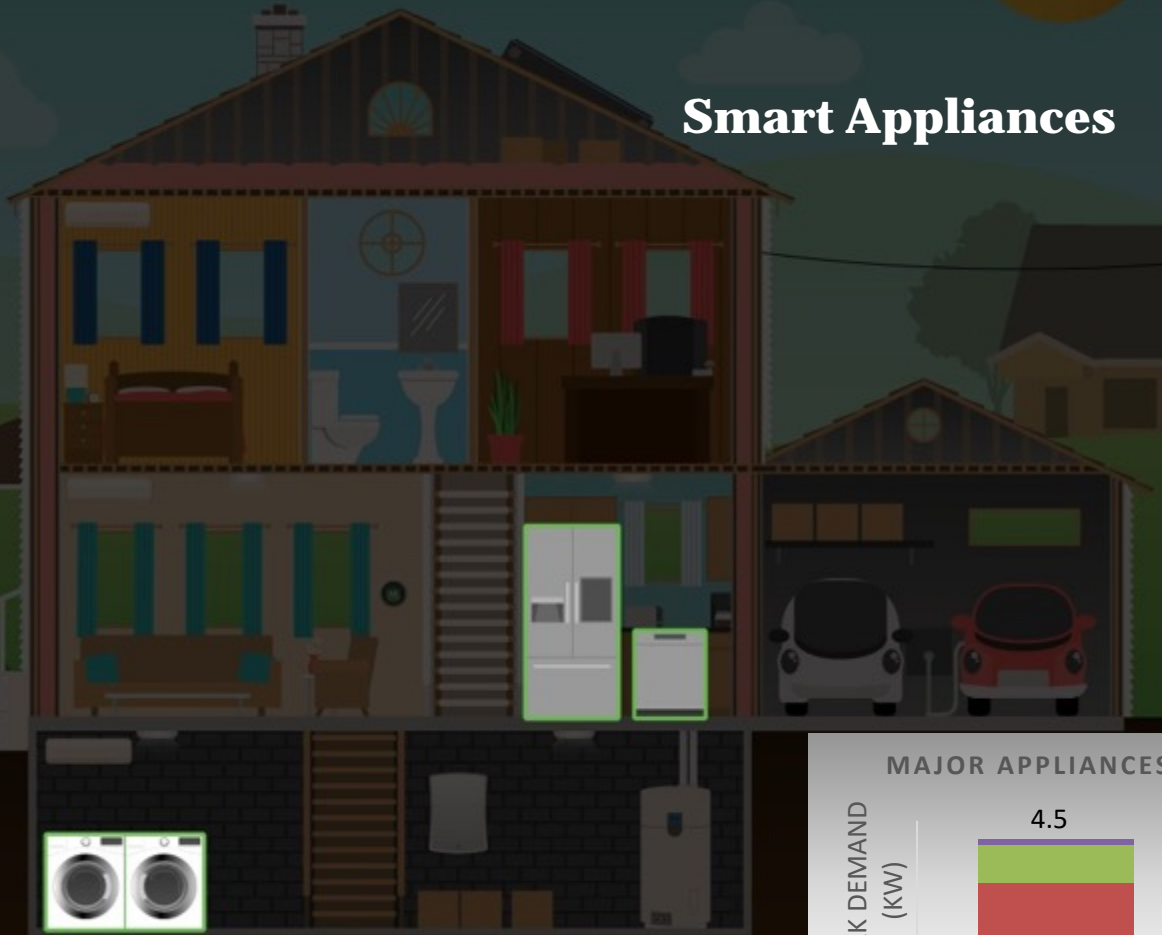


WATER HEAT

PEAK DEMAND  
(KW)

4.4

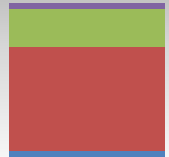
# Smart Appliances



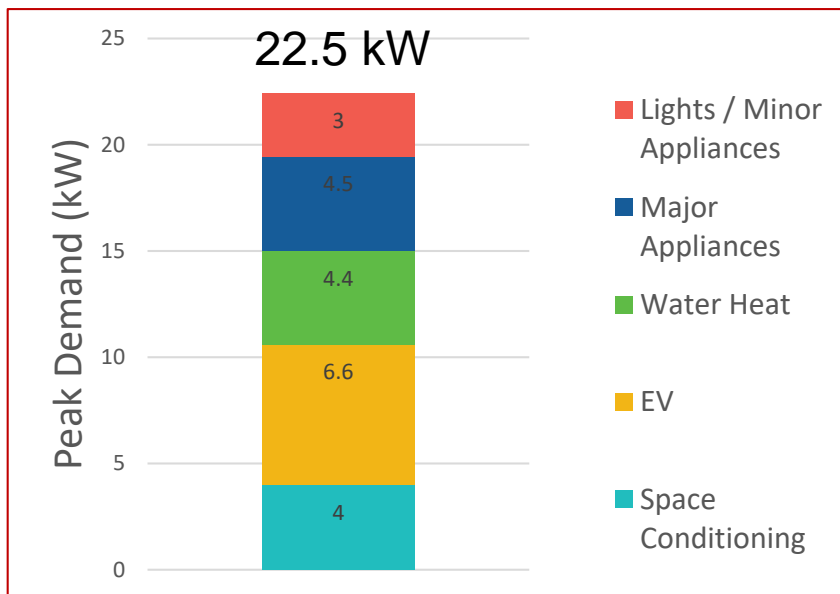
## MAJOR APPLIANCES

PEAK DEMAND  
(KW)

4.5



# Uncontrolled Household Loads Could Add Up To A Lot



# Flexibility Dramatically Cuts Peak Demand

Shift EV, Water Heat, Major Appliances, and Pre-Condition Spaces

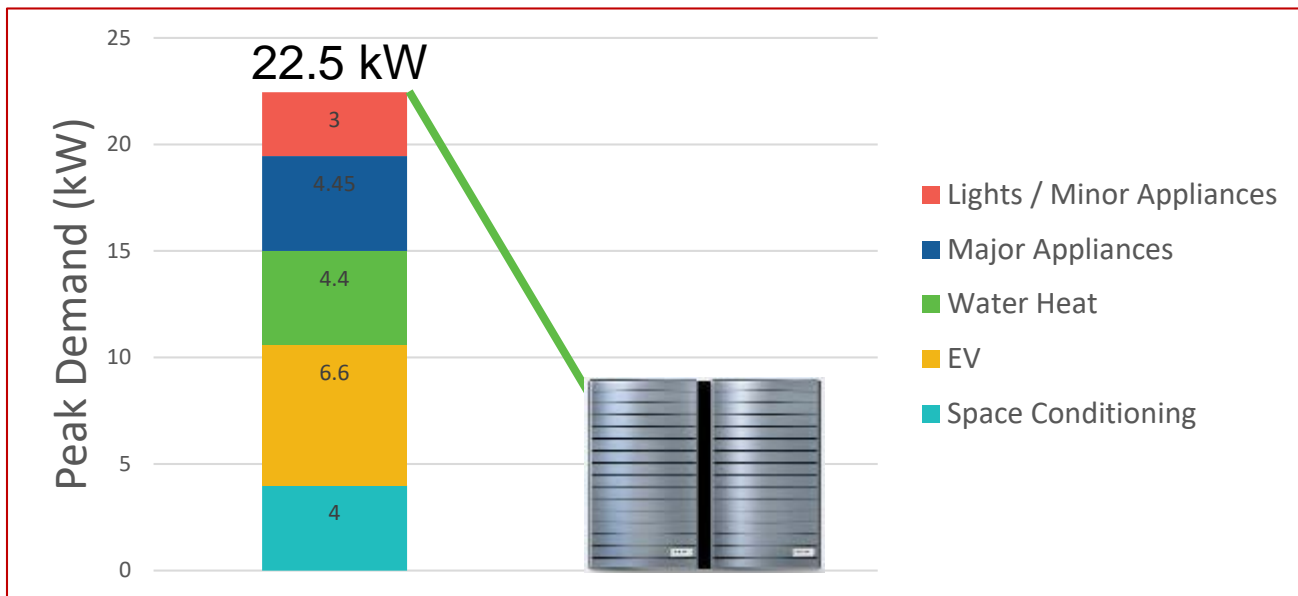


Image credit: <https://electricpower.com/powerpod/>



# Controlled Water Heaters

The CTA 2045 socket enables any control network to connect to any new water heater.



# Open Planning and Market Processes



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# Flexibility Needs Must be Modeled and Capabilities Compensated



Image credit: Getty Images

**... Make It So**



# Regulators Can Make a Difference:

## By Opening Procurement to Solar, Wind and Storage (Like Colorado)

RFP Responses by Technology

Generation Technology	# of		# of		Median Bid	
	Bids	Bid MW	Projects	Project MW	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		\$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	\$/kW-mo
Compressed Air Energy Storage	1	317	1	317		\$/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		\$/MWh
Waste Heat	2	21	1	11		\$/MWh
Biomass	1	9	1	9		\$/MWh
<b>Total</b>	<b>430</b>	<b>111,963</b>	<b>238</b>	<b>58,283</b>		

# By Soliciting Cost-Effective Solar and Storage Bids (like Nevada)



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# **By Opening up Wholesale Markets to Aggregated DERs and Storage (Like California)**

**The CAISO initiated the Electricity Storage and Distributed Energy Resources (ESDER) Initiative in 2014 to:**

**Enhance the ability of ISO connected and distribution-connected resources to participate in ISO markets**

**Phase 3 was completed in 2018 and market participation enhancements included providing a bidding mechanism that allows behind the meter resources to offer load using and load curtailing service**

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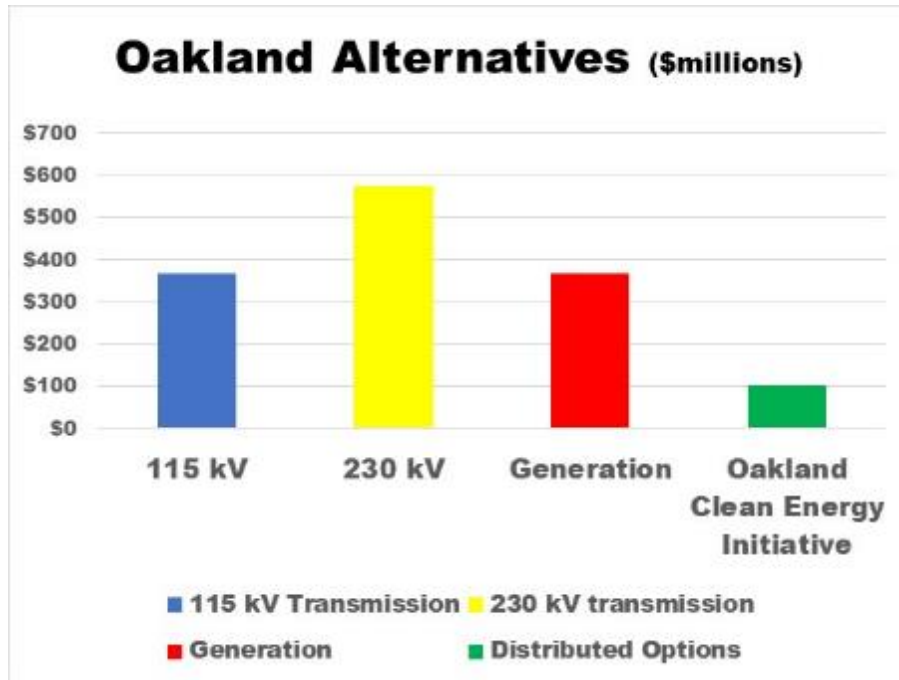
# And by Inviting Advanced Technology Alternatives when Fossil Retires ...

The PG&E and East Bay Clean Energy project, the Oakland Clean Energy Initiative (OCEI), replaces a retiring 165 MW Dynegy gas peaker, obviates need for 115 kV and 230 kV transmission.

The combination of resources includes:

- 25-40 MW combination of EE, DR, PVDG (minimum 19 MW of load reducing response)
- 10 MW/40 MWh storage
- Substation upgrades and line re-ratings

# ... Saving Ratepayers Money and Reducing Emissions



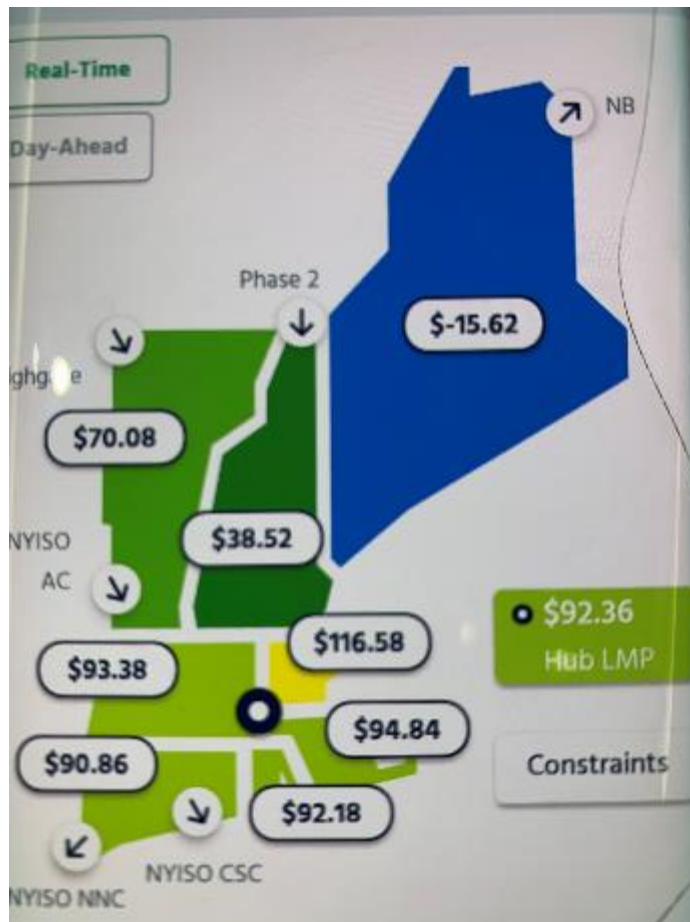
# By Using Demand Response to Manage Seasonal Loads



If there is a significant increase in energy prices or energy demand in the summer months, typically between June and September, your PeakRewards device may receive a signal to cycle your air conditioner up to your chosen cycling level (50%, 75% or 100%).

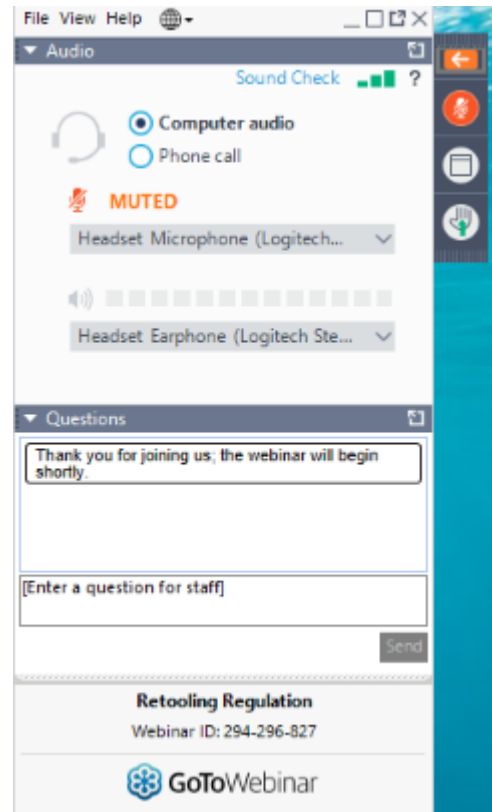
Source:  
Baltimore  
Gas &  
Electric

# By Designing Pricing to Reflect Grid Management Needs at the Regional, Utility, Zonal, Nodal, and Circuit Levels



# Questions?

Please send questions  
through the Questions  
pane





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# Summary

- Flexibility helps meet reliability needs at lower cost while adding significant amounts of renewables.
- Technology changes, new capabilities, and forms of grid interactivity are valuable opportunities for the electric sector.
- This is an opportunity for regulators to provide policy guidance to help realize the many benefits of a more flexible grid.

# 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](https://raponline.org)