

# Staff Subcommittees on Energy Resources & the Environment, Electricity and Electric Reliability



# Behind-the-Meter Energy Storage

## Next Level DR for Individual Customers and Virtual Power Plants

Ted Ko  
Director of Policy  
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**stem**

# Stem Overview



Year Founded:	2009
Headquarters:	Millbrae, CA
Operations:	CA, HI, NY, TX
Employees:	140+
Installed:	~300+ sites, 3.5 M RTH
Pipeline & Installed:	700+ sites, 130+ MWh
Project Finance Capacity:	\$500 MM

## High Caliber Global Investors



## Distinguished Honors & Awards

**SEPA Power Player 2017: Innovative Partner of the Year**



# Solution Components



## Athena™ Artificial Intelligence

Automatically controls when energy storage charges and discharges to optimize timing, maximize savings, and create virtual power plants.

## Energy Storage Systems

Modular options for all facility sizes and locations. Batteries from leading global manufacturers.

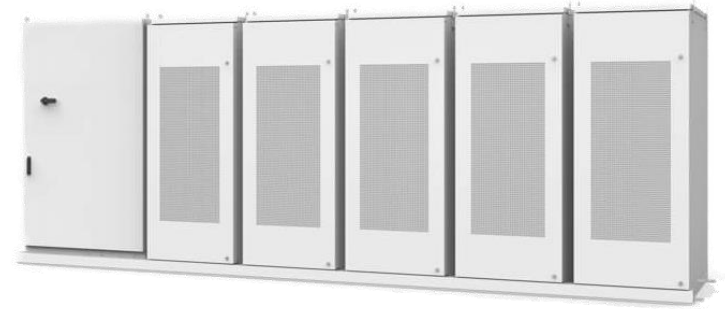
Small indoor  
18 kW modules  
(gym locker size)



Medium indoor  
132 kW modules  
(server rack size)



Large outdoor  
Scalable from 100 kW to 5+ MW



# Storage extends DR to more customers

*“Fixed behind the meter battery storage is in a sense “perfect” DR technology. When combined with a battery, any load can provide flexible services”*

*“Residential and Commercial batteries have potential to provide significant services to the distribution and transmission grid along with highly-valued site-level reliability and bill savings benefits”*

*- Lawrence Berkeley National Laboratory*

## FORTUNE 500 COMPANIES USE STEM'S SOLUTIONS

Select Enterprise Customers



KAISER PERMANENTE®



RR DONNELLEY

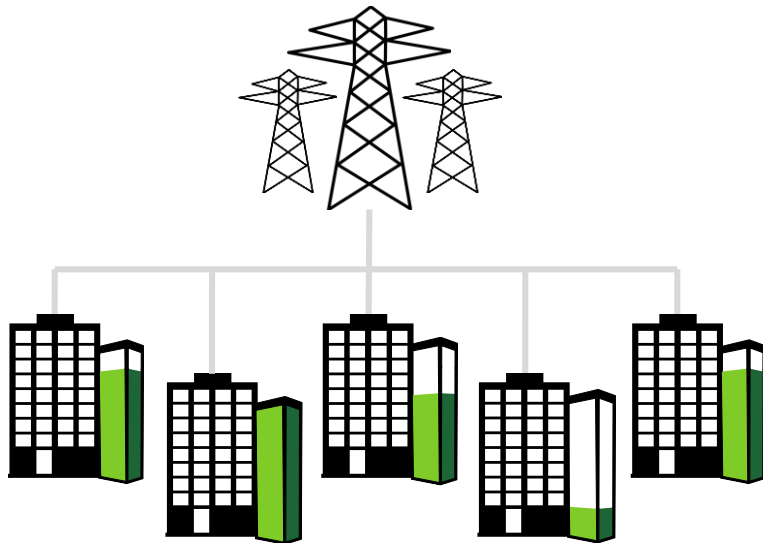




# Networks of Storage

Coordinated groups of installations act as “Virtual Power Plants”

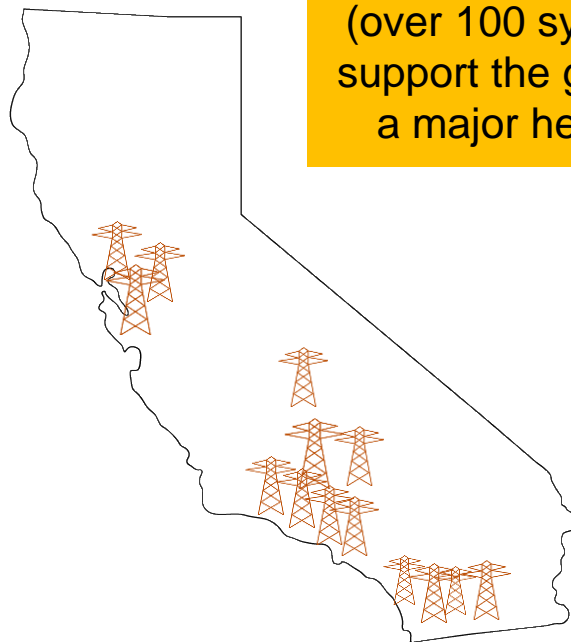
*“Controllable DR resources, including behind the meter battery storage, can provide flexible services to existing wholesale markets...support the integration of renewable energy sources, and support policy targets for renewable standards and a low carbon future”*



- Artificial Intelligence software selects storage systems with spare energy
- Networked group provides energy and services to utilities and grid operators
- VPPs unlock new value streams for customers

# VPPs Support The Grid Today

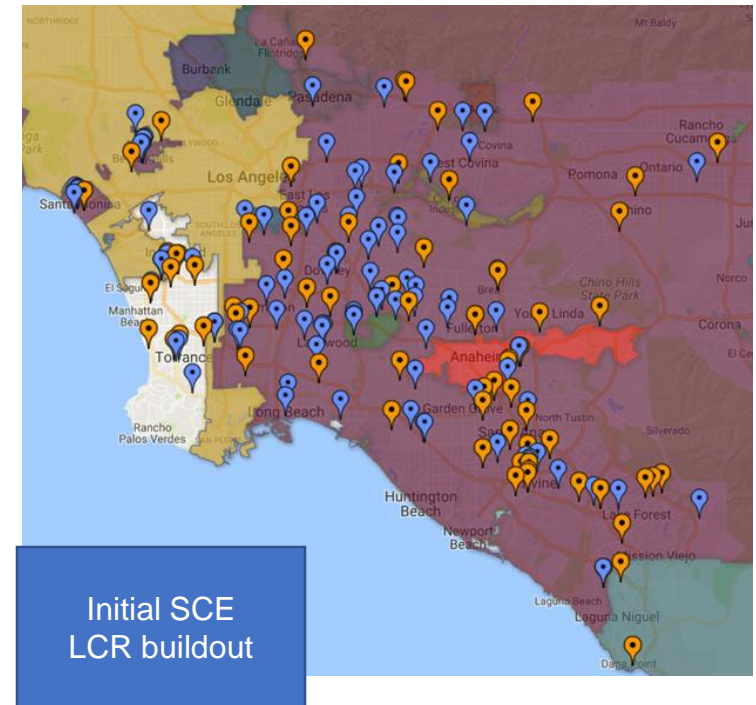
- Stem's network has responded to over 500 grid dispatch requests since 2015
- Bidding Day-Ahead in SCE, PG&E regions in 2017
- 150 “real-time” (5-min) calls in SDG&E region from Jan – May 2017 alone
- Support for the grid during unprecedented heatwaves on June 20 and August 28
- Customers enjoyed knowing they helped California avoid blackouts
- No manual intervention
- Delivered on-time and more than promised



On August 28, 2017  
Stem simultaneously  
dispatched 14 VPPs  
(over 100 systems) to  
support the grid during  
a major heatwave.

# Utility Contracts Demonstrate New DR Variations

- SCE: 85 MW, 4 HR peak capacity resource
  - Year-round availability (10 am to 9 pm)
  - Day ahead and 20-minute RT dispatch
- DRAM: Contracts with IOUs for Resource Adequacy (RA), must offer in ISO
- ConEd: BQDM distribution deferral
- HECO: 1 MW, 3-year pilot to respond to high penetrations of PV
- Austin Energy: SHINES grant to increase grid performance and reliability and enable high PV





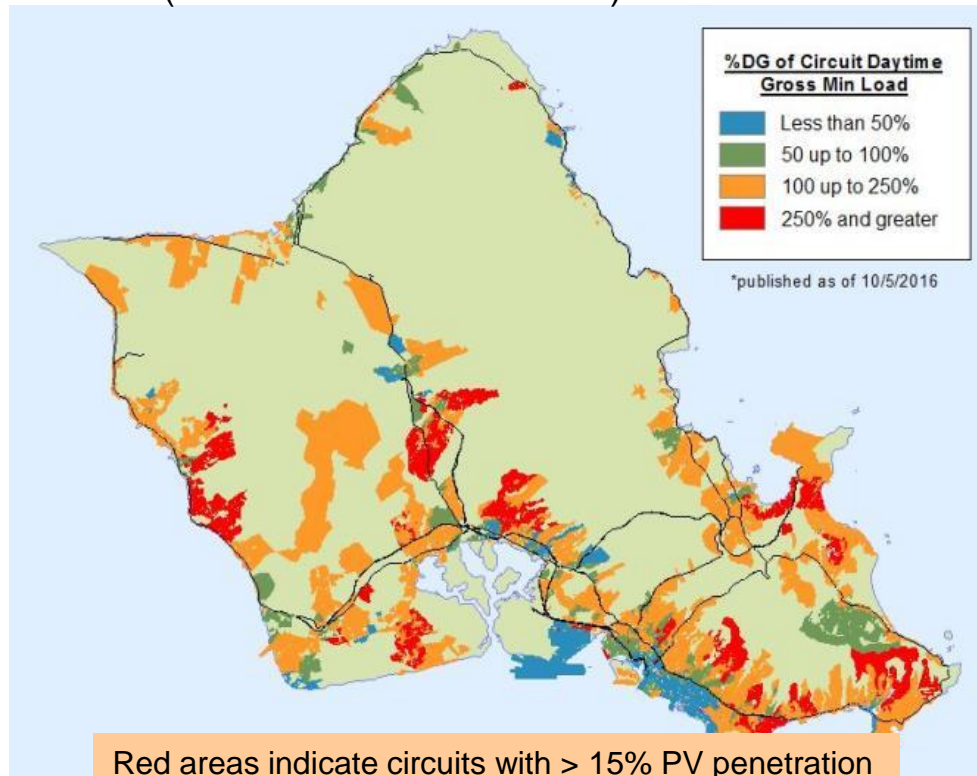
# Hawaii's Challenge: PV Congestion

## 3 Drivers:

- High PV DG
- Goal of 100% Renewables by 2045
- Engaging Customers in the Solutions

### Locational Value Maps Trending Penetration Levels

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



# Aggregator Interface & Real-time Dispatch Testing



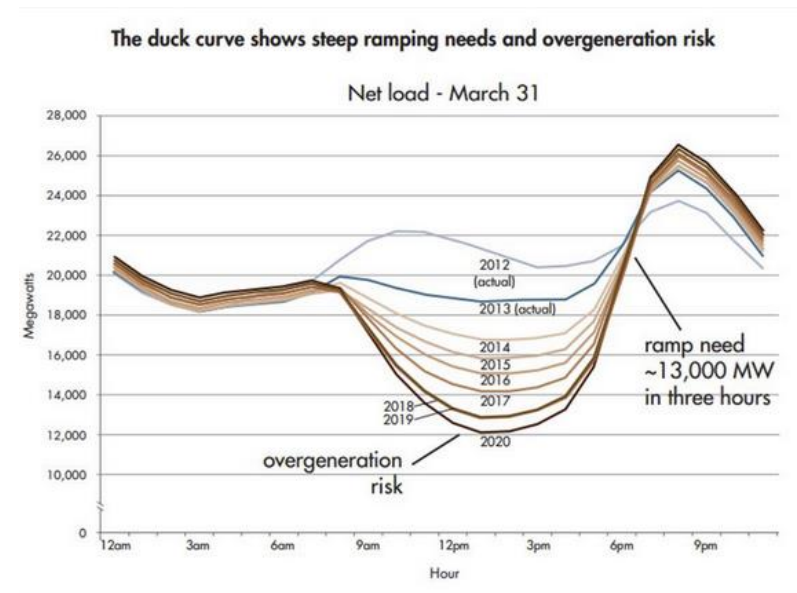
# DR for renewables integration

Electricity grids with very large amounts of solar and wind power experience several new balancing problems

This chart shows the electricity demand on the California grid with large amounts of solar:

- Fast energy “ramps”
- Too much solar = “over generation”
- Quick up & down = “intermittency”

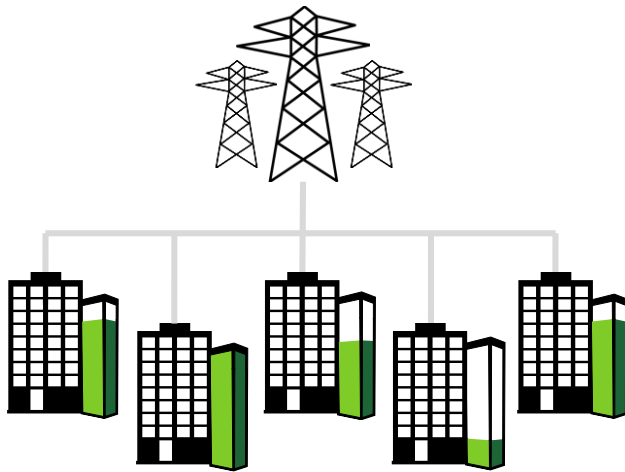
**Storage-based DR can address all three issues**



# CAISO: Proxy Shift Resource (PSR) Concept

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Related to “Reverse-DR” but key differences



## **Sub-Type of Proxy Demand Resource (PDR)**

- Must qualify as a shift resource
- Min size is 100 KW

## **Bidding:** As PDR today

- Positive bid for discharge
- Negative bid for charge
- No must-offer obligations for negative bids (not capacity)

## **Metered Generator Output (MGO)**

**Net Benefits Test:** Does not apply to charging direction

# Next Level Demand Response

Any technology that performs like storage can provide next level benefits



## Empower Energy Consumers

Activate energy consumers and engage them in solving distribution-level challenges.



## Increase Grid Efficiency

Relieve the strain on the grid to reduce the need for “peaker” plants and increase utilization rates.



## Enable Renewable Energy

Stabilize the grid at high penetration levels of wind and solar

# Staff Subcommittees on Energy Resources & the Environment, Electricity and Electric Reliability

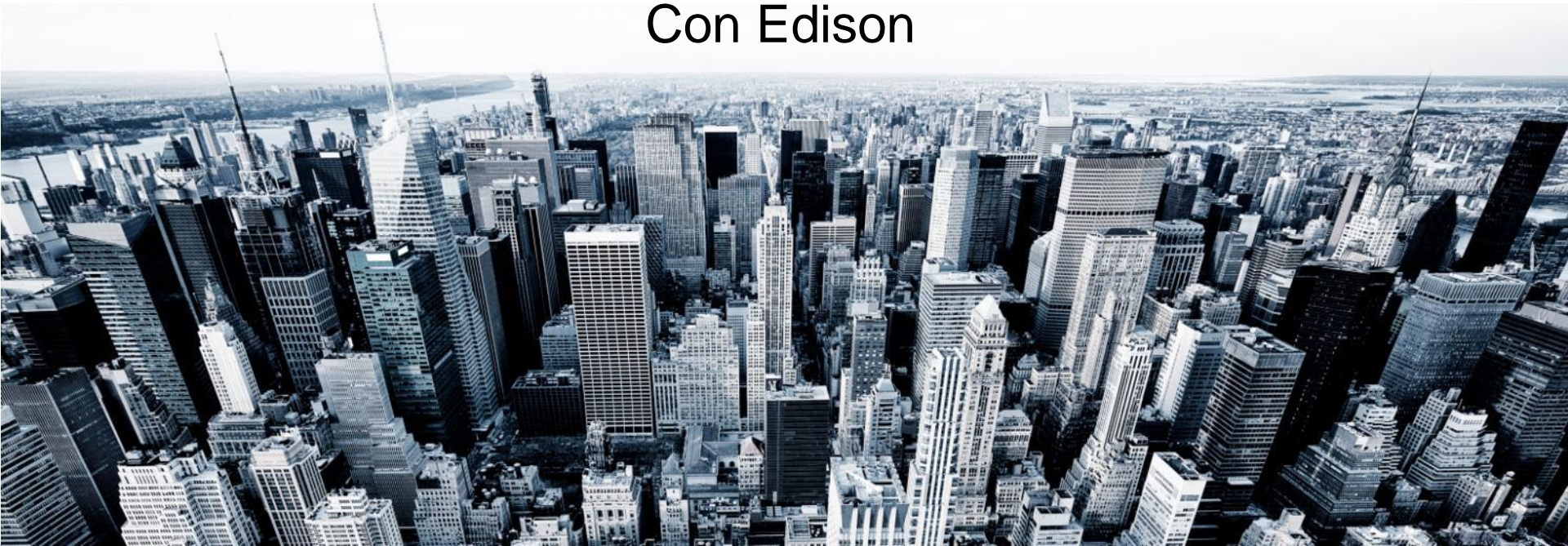




EVERYTHING MATTERS

# Non-Wires Solution Programs

Damei Jack  
Con Edison



# Agenda

- About Con Edison
- Non-Wires Solutions
- Brooklyn Queens Demand Management Program (BQDM)
- New Opportunities
- Q&A

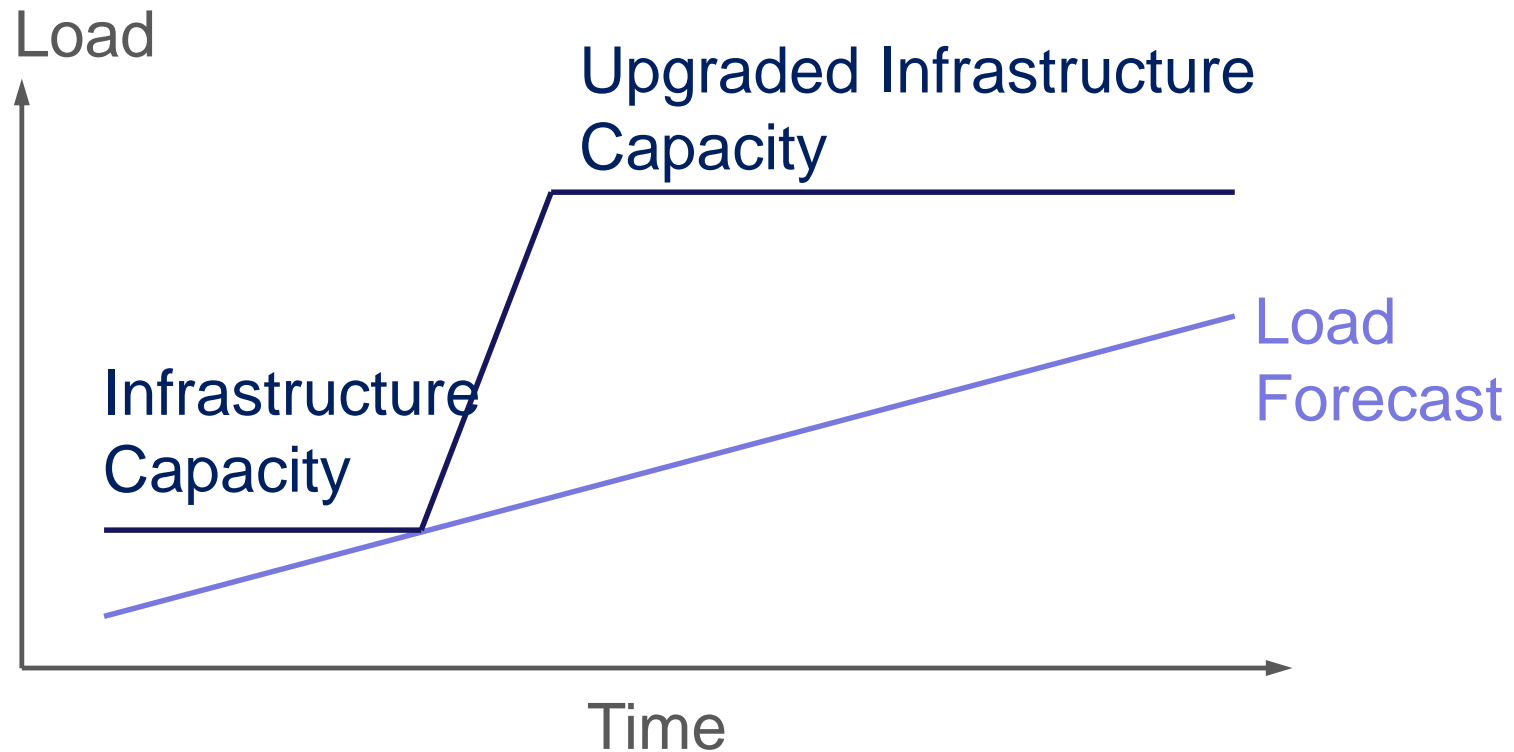
# About Consolidated Edison

	Customers	Infrastructure	Service Territory
Electric	3.3 million	One of the largest underground systems in the world	All 5 boroughs and Westchester County
Gas	1.1 million	4,333 miles of gas mains and services	3 out of the 5 boroughs and Westchester County
Steam	1,760	Largest district steam system in the world	Manhattan below 96 <sup>th</sup> Street



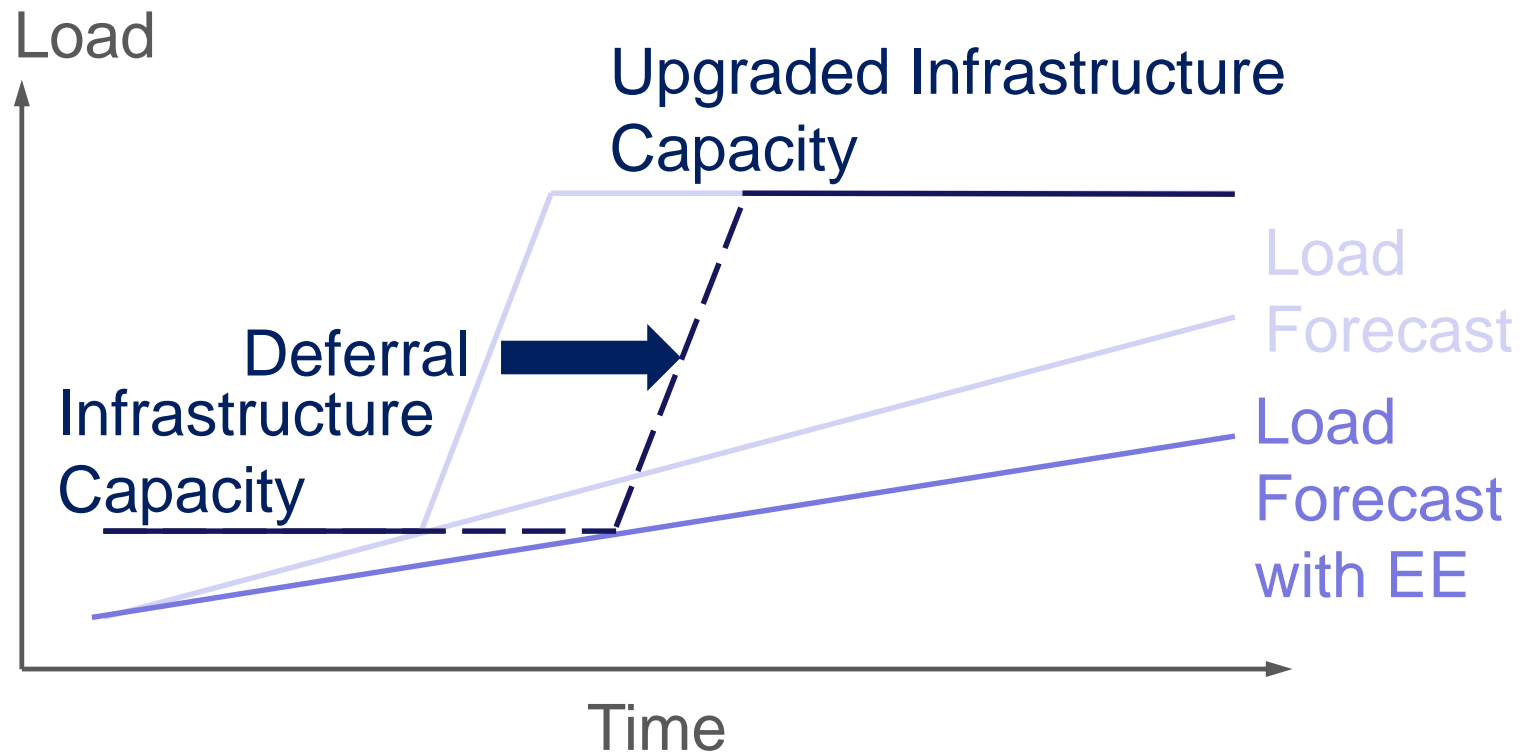
# Non-Wires Solutions

- Traditional approach: build capacity based on forecast



# Non-Wires Solutions

- Non-wires solution approach: lower forecast through EE/DM to defer upgrade



# Non-Wires Solutions Brooklyn-Queens Demand Management Program (BQDM)

## BQDM Program

- Strong peak growth in three networks in Brooklyn-Queens
- \$200 million budget
- Defer infrastructure upgrade through non-wires solutions

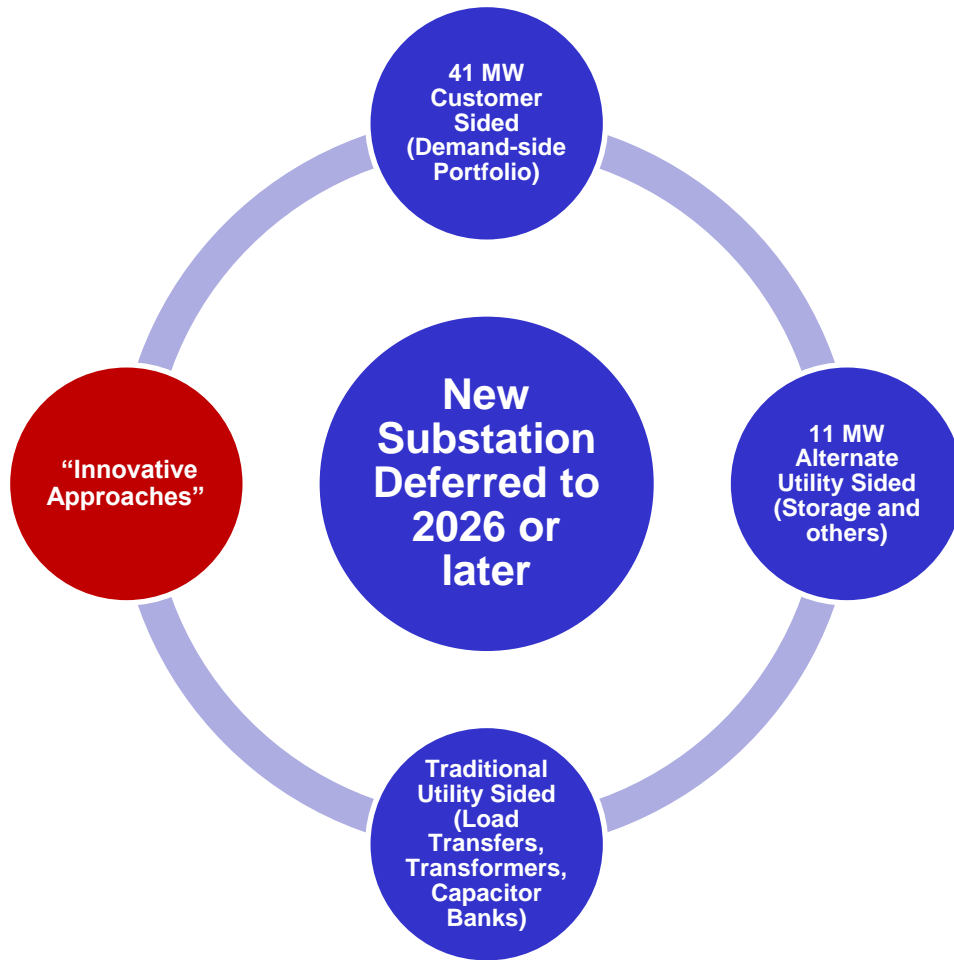
## BQDM Geography





# Addressing the BQDM Overload

## Portfolio Approach

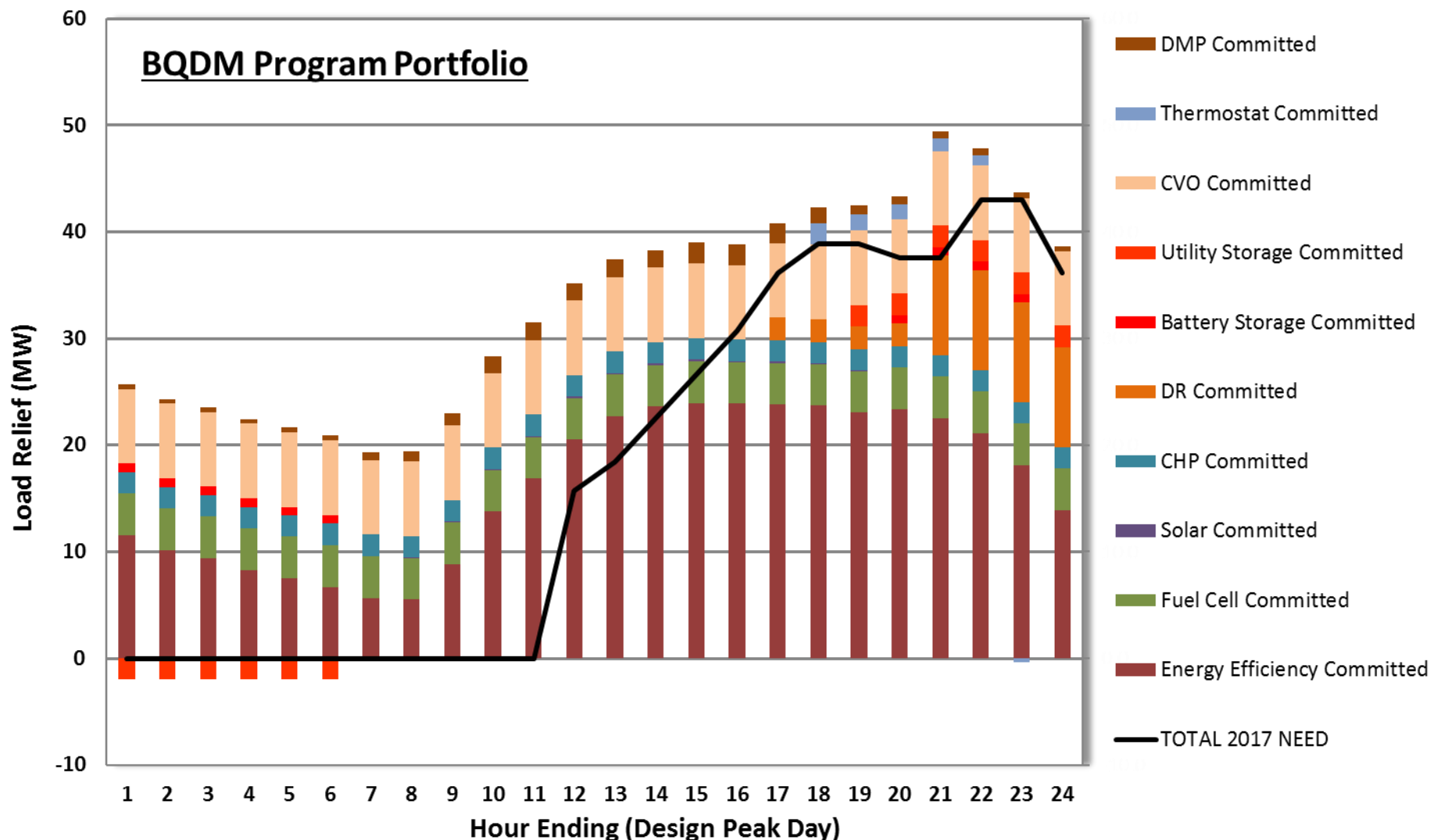


- Demand-side Resources
  - Portfolio of solutions
  - Reliable and Innovative
  - Addressing the system need
  - Learning along the way
- Storage plays a role in implementation

# BQDM CSS AND USS SOLUTIONS PORTFOLIO

## Summer 2018 Outlook

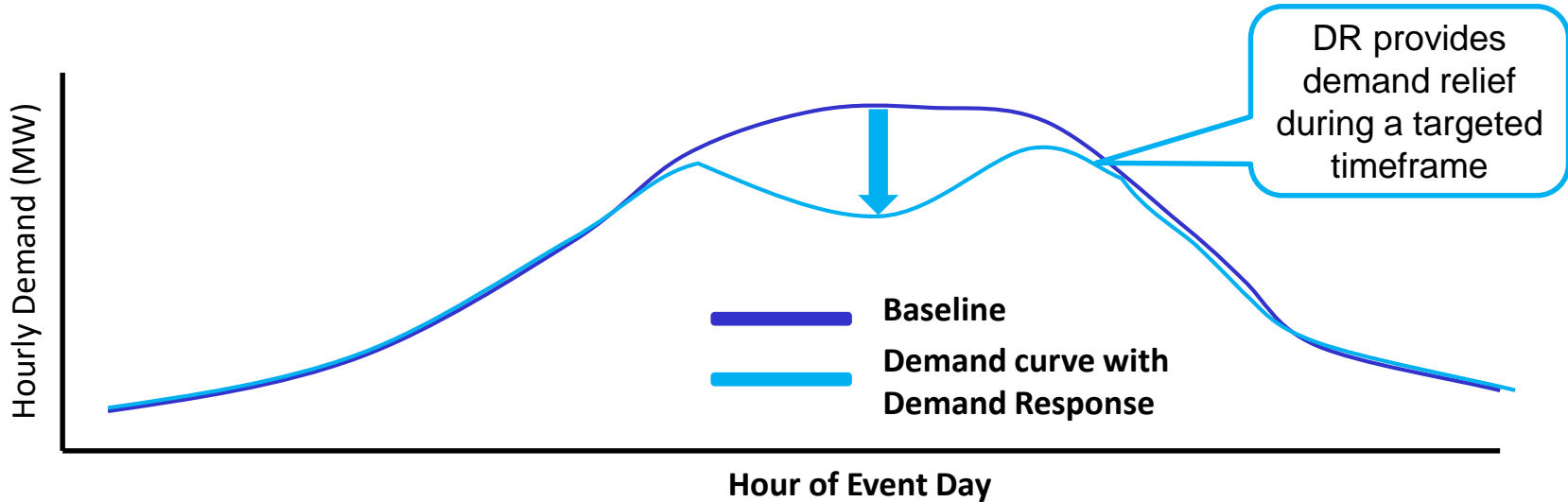
**ACRONYMS**  
 DR – Demand Response  
 CHP – Combined Heat and Power  
 DMP – Demand Management Program  
 CVO – Conservation Voltage Optimization  
 C&I – Commercial and Industrial  
 CSS- Customer-Side Solutions  
 USS-Utility-Sited Solutions



# Demand Response in BQDM

## Demand Response Example

Hour of Event Day



- Incentives paid based on reduction during targeted timeframe

# BQDM Customer-Sided Multi-Technology Project

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DER technologies installed at an affordable housing facility include:

- 300kW/1200kWh Li-ion Battery
- 400 kW Fuel Cell
- 390 kW Solar



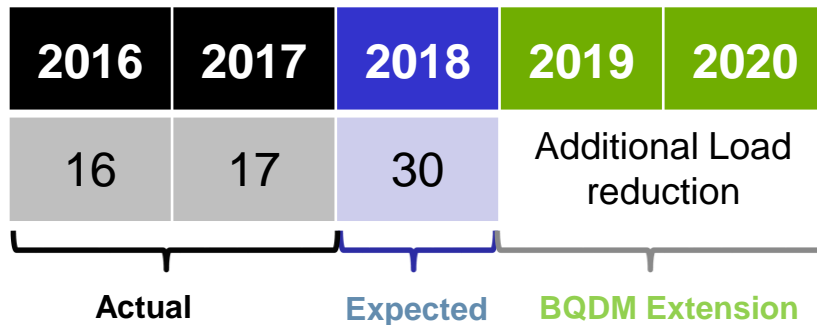
**The Project is completed and operational**

## BQDM PROGRAM

# Achievements and Future Options

### BQDM Program

- BQDM Program Achievements (Peak MWs)

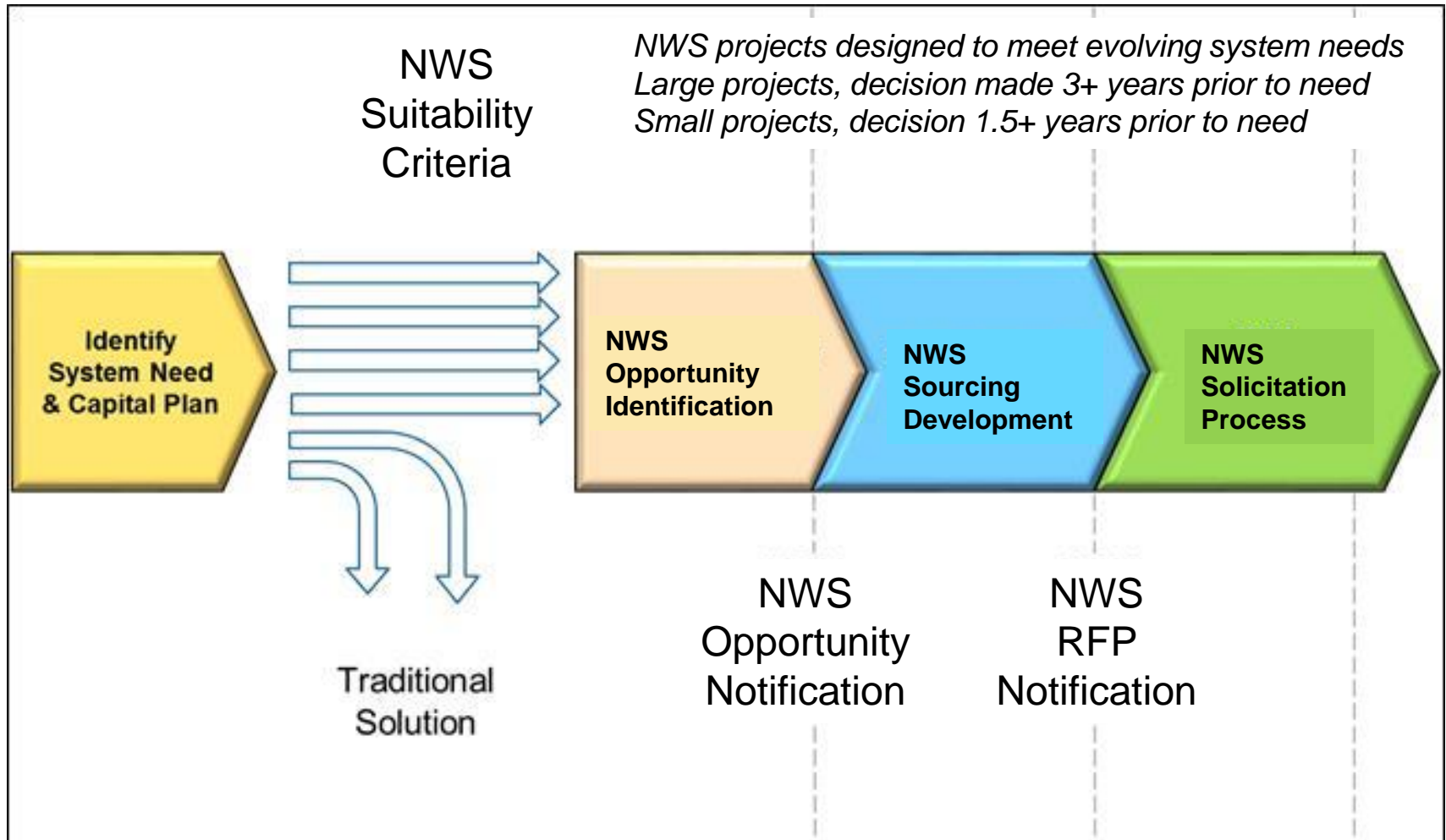


### Future Plan

- BQDM Extension Approved
  - Allows for additional non-traditional solutions
  - Expansion on program portfolio
  - Market solicitation for innovative solutions
  - Known area and demographic
- Benefits can include:
  - Deferred or Avoided T&D
  - Environmental (E.g. Carbon)
  - Increased Resiliency

## NON WIRES SOLUTIONS

# Streamlined process to identify the candidates





# UPCOMING NON WIRES SOLUTIONS

## Seven Opportunities Identified

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### Current Status

- 7 Non-wires solutions identified
- 2 RFPs under review
- 3 RFPs in the market place
  - ` posted
  - Market engagement webinar – November 14
  - [www.coned.com/nonwires](http://www.coned.com/nonwires)
- Upcoming 2017 solicitations
  - 2 RFPs planned for December

### NWSs in the Marketplace

- Water Street, Williamsburg, Plymouth Street
  - Technology agnostic
  - RFPs released October 31
  - Market engagement webinar – November 14
  - Responses Due January 2018



EVERYTHING MATTERS

**Thank You**



# Staff Subcommittees on Energy Resources & the Environment, Electricity and Electric Reliability

# Next Level Demand Response

Kent Walter

Manager, Customer Technology Product Development

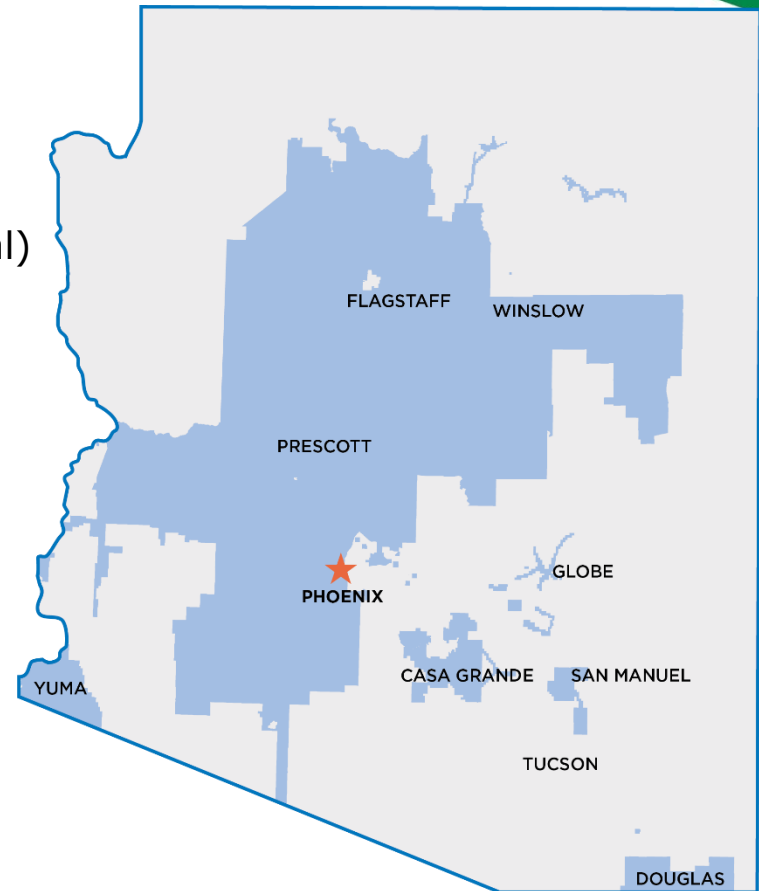
November 12, 2017



# APS Service Territory

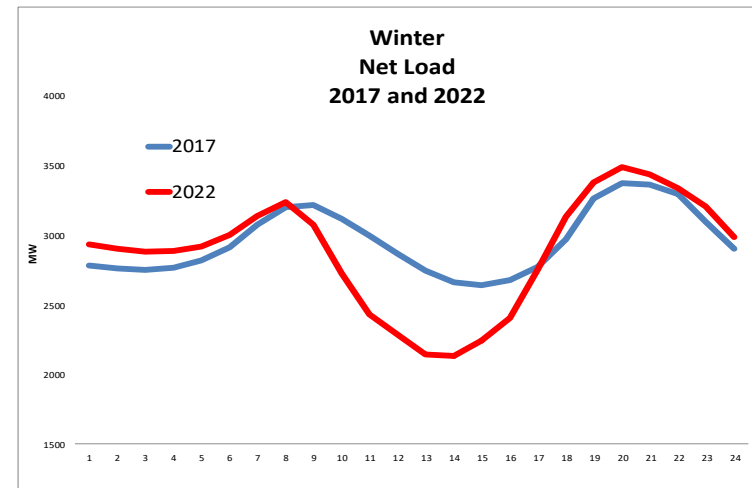
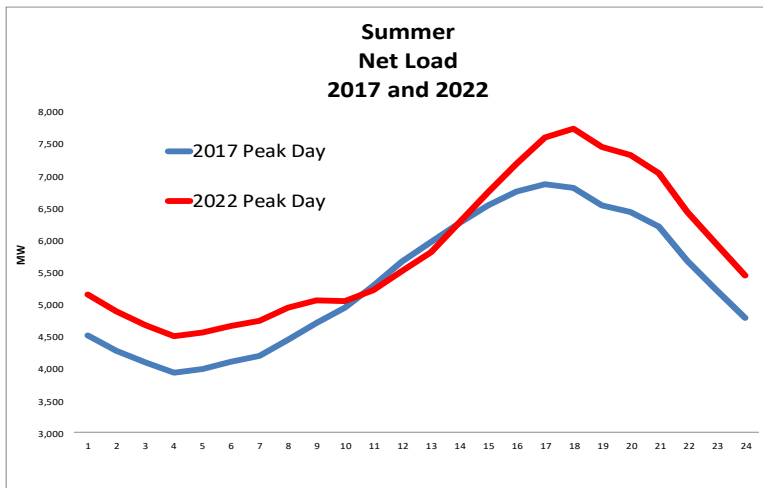
**Arizona's largest and longest-serving utility  
– since 1886**

- **Service Territory**
  - 11 of 15 counties
  - 1.2 million customer accounts (89% residential)
  - 34,646 square miles
- **Arizona's largest taxpayer**
  - \$3.4 billion annual economic impact to AZ
  - \$1 billion spent annually with AZ businesses
  - \$400 million with minority and women-owned businesses
- **Investor-owned utility—subject to forms of public control and regulation**
- **~6,300 employees**
- **Peak load ~7,400 MW in 2017**



# Arizona Resource Needs are Changing

Value of energy saved not the same for all hours of the year



- Continued resource needs for summer peaking period
- Needs for greater mid-day load in non-summer periods
  - Steep ramp
  - Trending below generation minimums
- Proposed moving from compliance-based energy efficiency to high value-based Demand Side Management



# Why Advanced Rates Matter

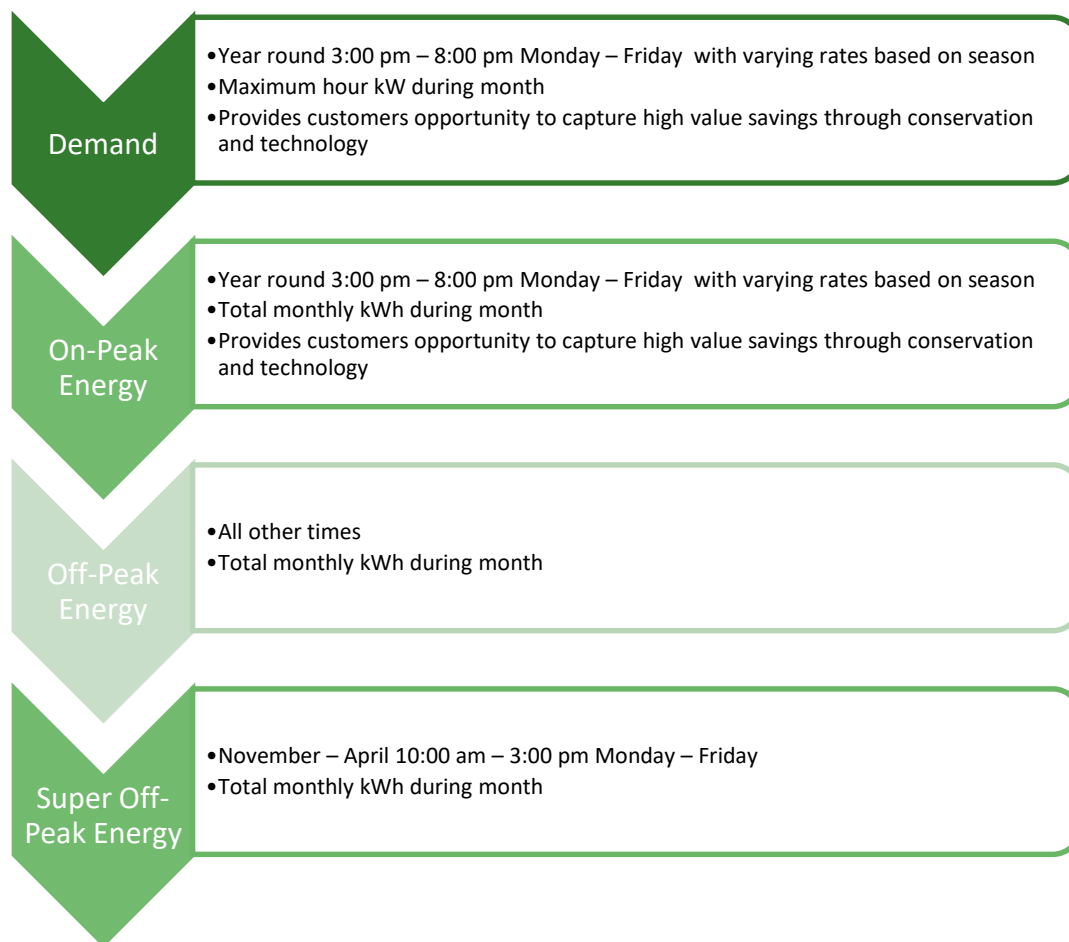
- Value of energy varies greatly throughout the day, throughout the year – market prices since joining the Energy Imbalance Market in October 2016
- Advanced rates align customers to value and foster an environment for innovation to develop
  - Large residential battery announcements in APS service territory
  - Evolving customer offerings

Percent of Negatively Priced Hours for ELAP\_AZPS

Year	Month	Hour																							
		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
		12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
2016	Oct				3%	3%				3%	13%	16%	19%	13%	10%	10%	6%								
	Nov			3%			3%	3%	7%	13%	20%	20%	20%	33%	20%	10%	3%								3%
	Dec					6%	6%				3%	10%	29%	26%	26%	10%	3%								
2017	Jan	3%	6%	6%	10%	10%	10%			6%	19%	13%	16%	26%	23%	13%	13%	6%							
	Feb		7%	7%	18%	25%	11%	4%		18%	39%	36%	43%	29%	29%	29%	29%	25%							4%
	Mar		3%	6%	13%	39%	13%	3%	10%	23%	45%	52%	55%	52%	65%	42%	48%	32%	10%				3%		6%
	Apr	7%		10%	10%	17%	13%	7%	13%	30%	23%	30%	50%	37%	33%	37%	33%	27%	13%	3%		3%			3%
	May	3%	3%	3%	3%			6%	23%	26%	16%	19%	16%	19%	19%	19%	10%								
	June				7%			17%	23%	30%	27%	17%	13%	13%	10%	10%	7%								3%
	July	3%	3%	3%			3%	3%	3%	6%	3%														

# What are Advanced Rates

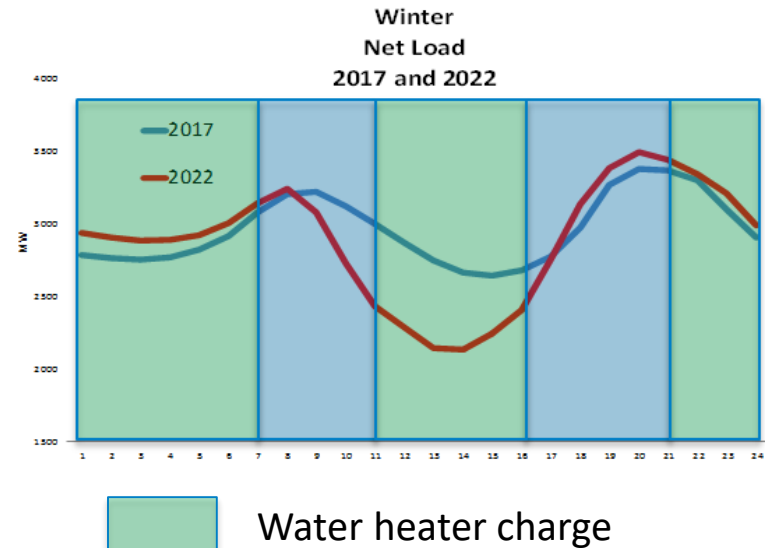
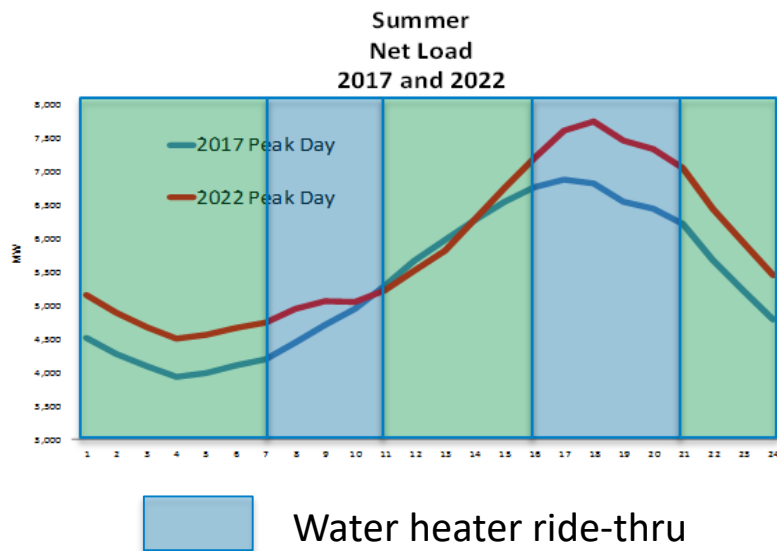
- Advanced rates include combinations of billing components such as Demand, On-Peak Energy, Off-Peak Energy, and Super Off-Peak Energy
- Advanced rates create shared opportunities with customers in line with value to non-participating customers
- More than 50% of APS residential customers on advanced rates



## **Advanced Rates Create Next Level Customer Engagement**

- Advanced rates creates an opportunity for performance based value through bill savings
- Advanced rates encourage customers to manage demand daily instead of waiting until called

# Advancements in Demand Response



- *Water heating is approximately 17% of an Arizona home's usage with electric water heating*
- *Alignment to resource value*
  - *Demand reductions during summer peaking period*
  - *Shifts morning water heater demand to mid-day load in non-summer periods and reduces ramp needs*
- *Alignment to customer value*
  - *Bill savings through demand management and shifting to super off-peak charging in advanced rates*
- *Daily actions are more valuable than callable resources*

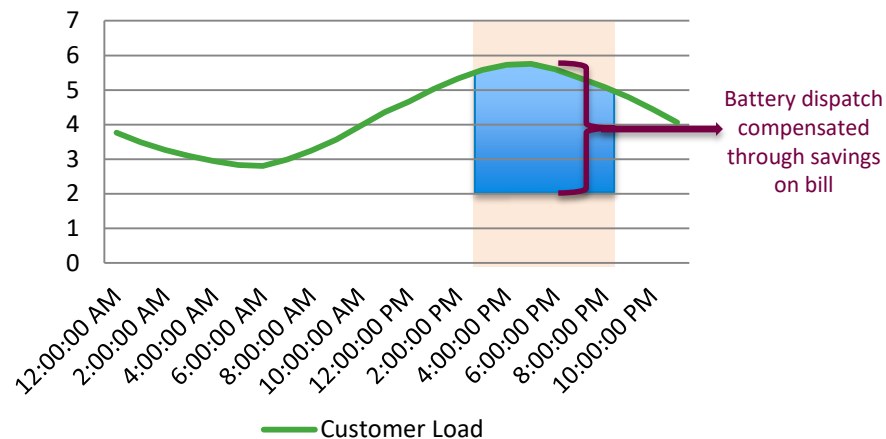
# Advancements in Demand Response

- Technologies targeting savings have a tool through rates to receive value
- Incremental value may exist when asking customers to modify comfort



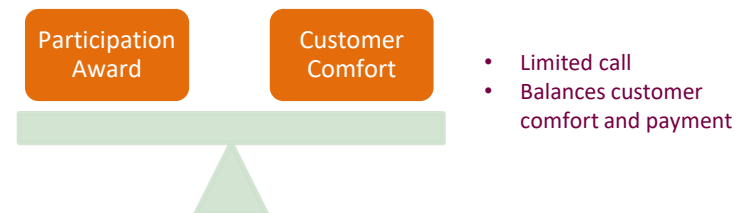
## Battery Optimization

\*May be local needs that could create environment for joint use outside that value captured through advanced rates



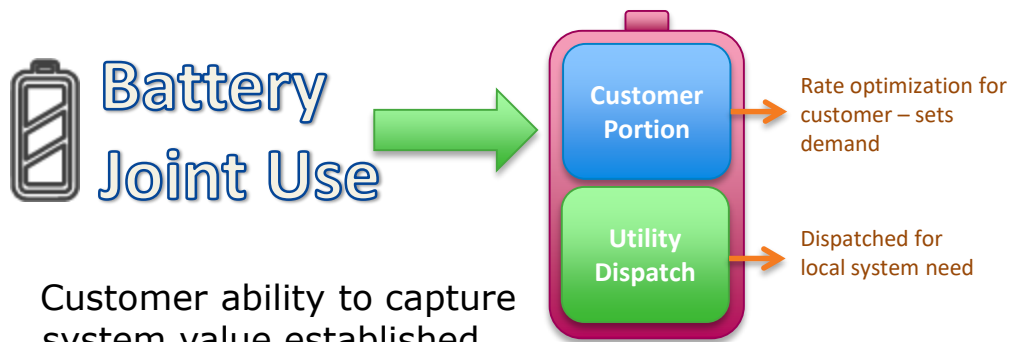
## Thermostat Adjustments

Customer asked to endure a few hours of higher indoor temperature and incremental compensation may be needed

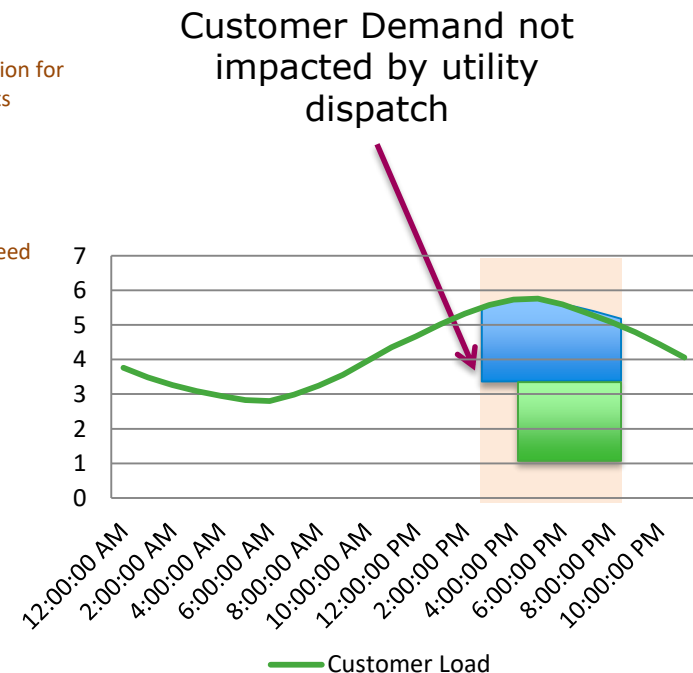


# Advanced Rates and Joint Use

- Direct engagement and utility operation may be warranted to manage local need
- APS Storage Rewards Program



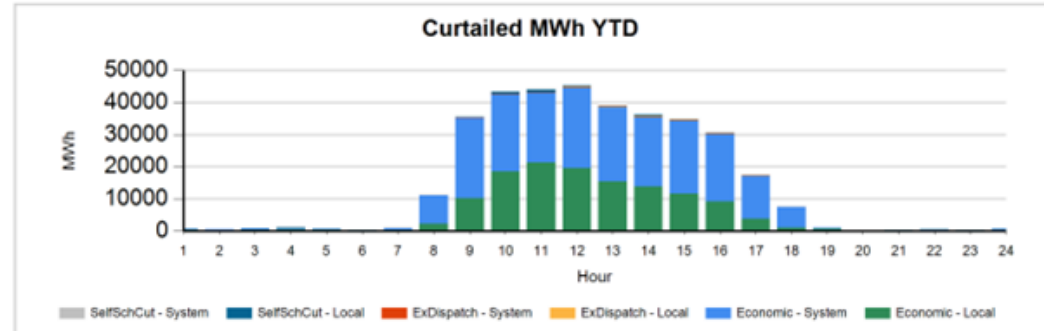
- Customer ability to capture system value established through management of demand
- Virtual partitions (defined kWh) can alleviate somewhat unclear DR value proposition and measurement
- Direct utility engagement where local reliability needs drive co-investment opportunity
- Unused utility portion of battery can serve customers as back-up power when available



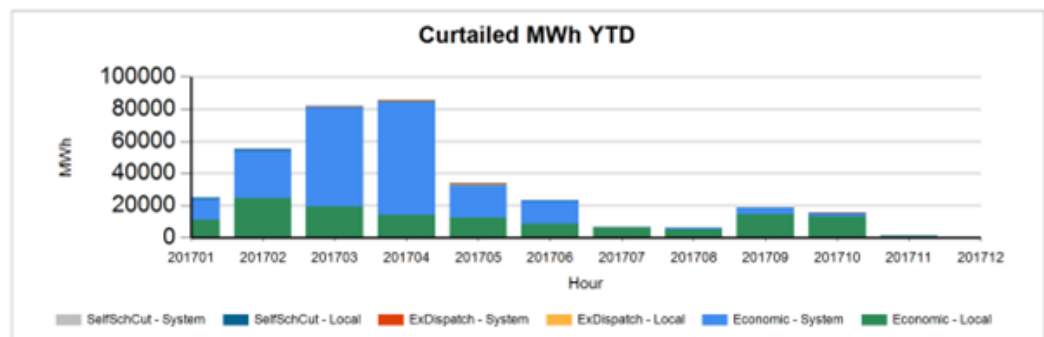
# Opportunity for Reverse Demand Response

- Targeting community benefiting technologies that are not essential – not load shifting
- 353,754,000 kWh curtailed in CAISO YTD 11/5/2017
- APS participates in CAISO Energy Imbalance Market

The following charts show hourly year to date wind and solar curtailment by category, if any.



The following charts show monthly year to date wind and solar curtailment by category, if any.





# Reverse Demand Response

## What is Reverse Demand Response?

- IS: Dispatch-able load resource for negative market prices
- IS Not: Load shifting

## Why isn't it load shifting?

- Advanced rates capture load shifting through time differentiated rates
- Market prices have not converged

## Customer Value

- Participating customer receives free energy for a benefiting technology
- Market activity benefits go to customers through adjustor mechanism

# APS Demand Response Activity

- Traditional DR: short period callable resources
  - 25 MW of C&I
  - residential smart thermostat
- Next level DR: daily demand management
  - Electric Vehicles
  - Electric Buses
  - Water heaters
  - Smart thermostat pre-cooling
  - Reverse demand response
  - Energy storage deployment

# Staff Subcommittees on Energy Resources & the Environment, Electricity and Electric Reliability

# Next Level Demand Response

National Association of Regulatory Utility Commissioners

November 12, 2017

Virginia Lacy, Principal





# About Rocky Mountain Institute (RMI)



- Founded by Amory Lovins 35 years ago, we are 501(c)3 non-profit of about ~150 employees in the US and China.
- Our mission is to drive the transformation of the U.S. and global energy system to a clean, prosperous and secure future.
- We are a “think and do” tank that convenes and collaborates with diverse partners—business, government, academic, nonprofit, philanthropic, and military—to accelerate and scale solutions.



**RMI transforms global energy use to create a clean, prosperous, and secure future.**

# RMI's work in electricity

## Research and analysis



## Utility partnerships and engagement



## Industry network collaboration



## Utility commission support



RMI transforms global energy use to create a clean, prosperous, and secure future.

# Recent trends have been challenging many “truths” of our historic electric system

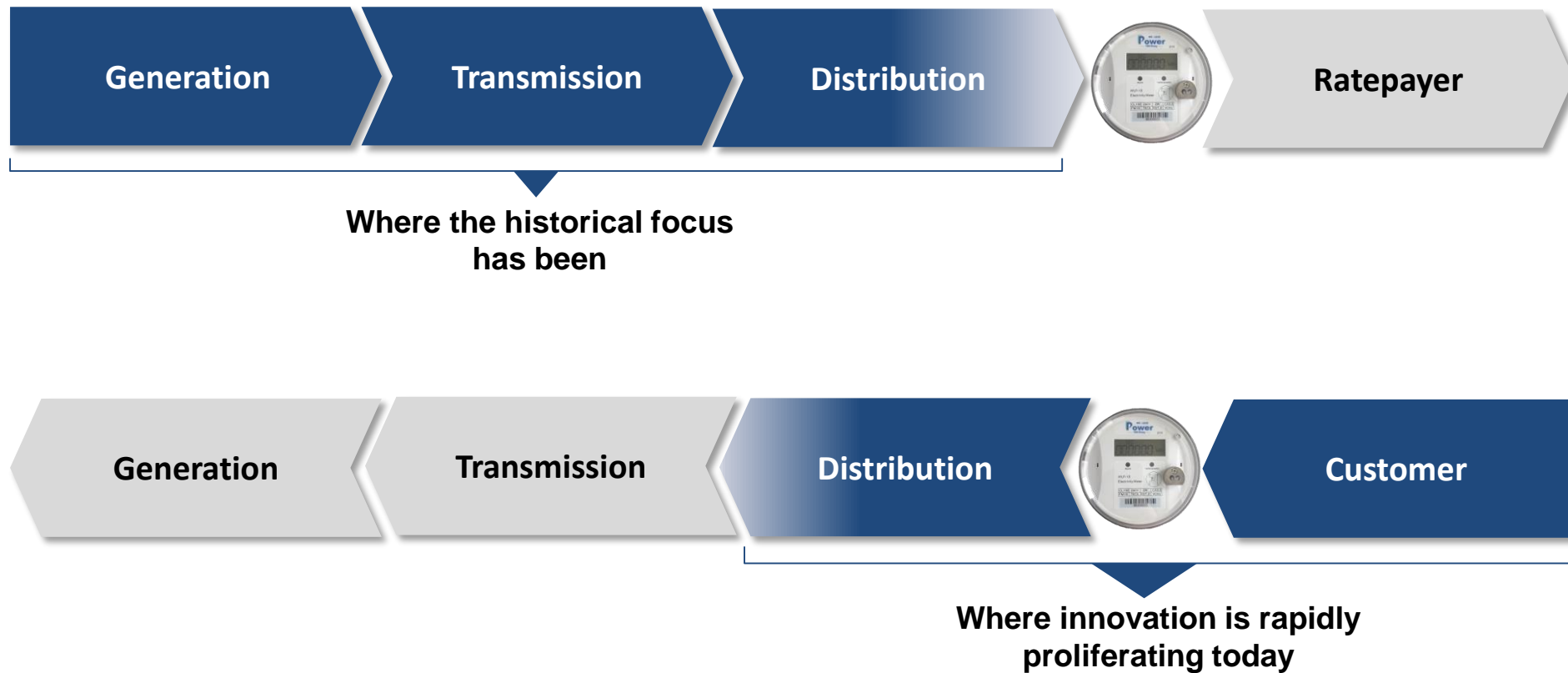
- ✓ BIGGER IS ALWAYS BETTER: ECONOMIES OF SCALE
- ✓ POWER & INFORMATION FLOW ONE WAY
- ✓ NATURAL MONOPOLY ACROSS VALUE CHAIN
- ✓ PASSIVE, HOMOGENEOUS CUSTOMERS



**RMI transforms global energy use to create a clean, prosperous, and secure future.**



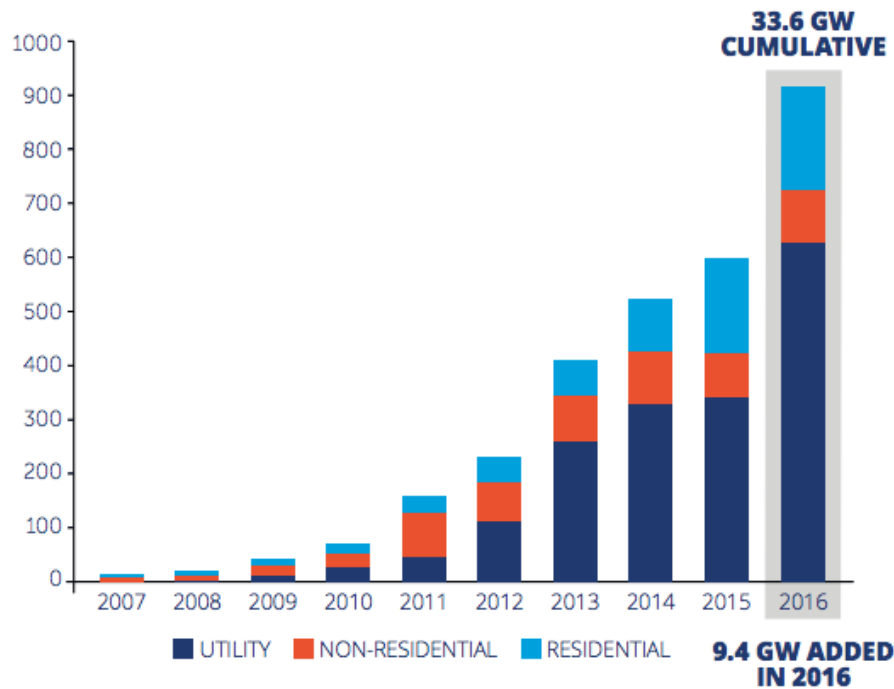
One of the most significant shifts: the role of customers and the distribution system—beyond the substation *and* behind the meter



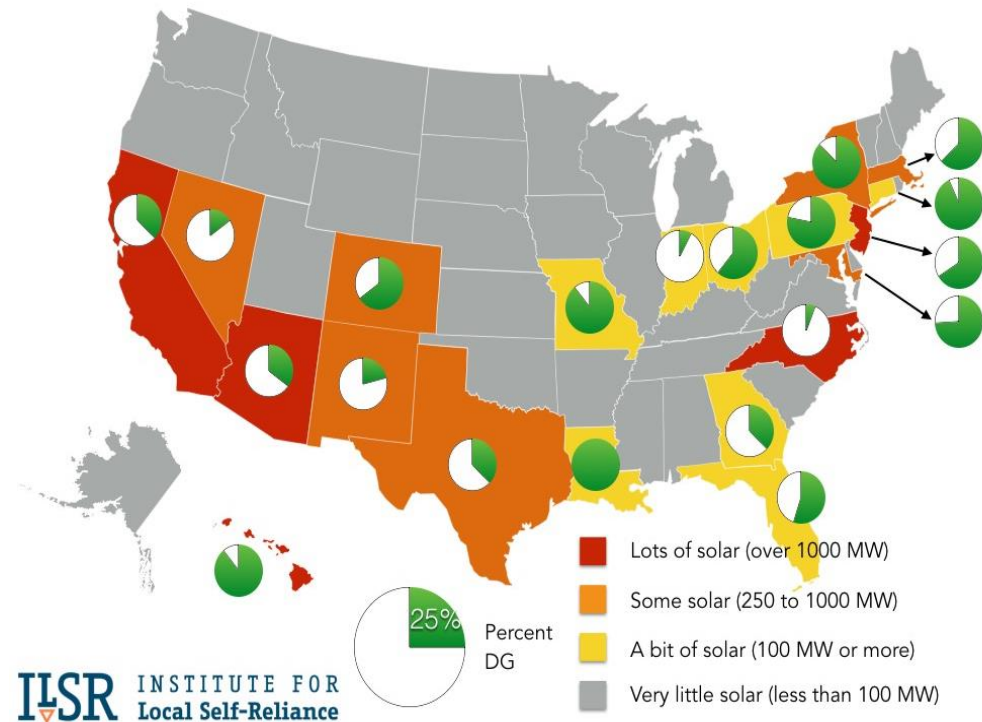
RMI transforms global energy use to create a clean, prosperous, and secure future.

# One-third of today's installed solar PV is on the customer's side of the meter or associated with customer accounts

48



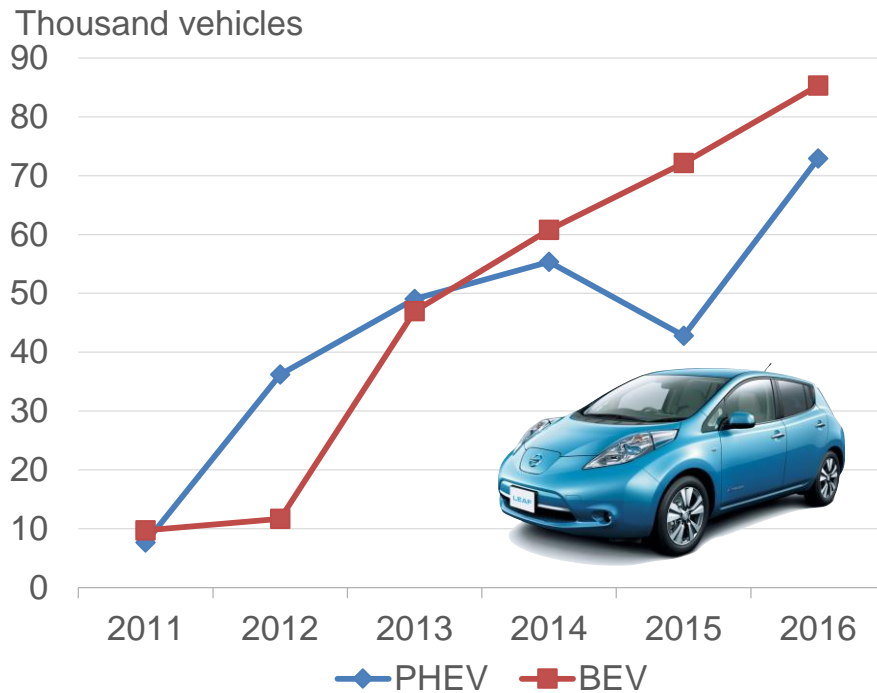
Source: Smart Electric Power Alliance, 2007-2017.



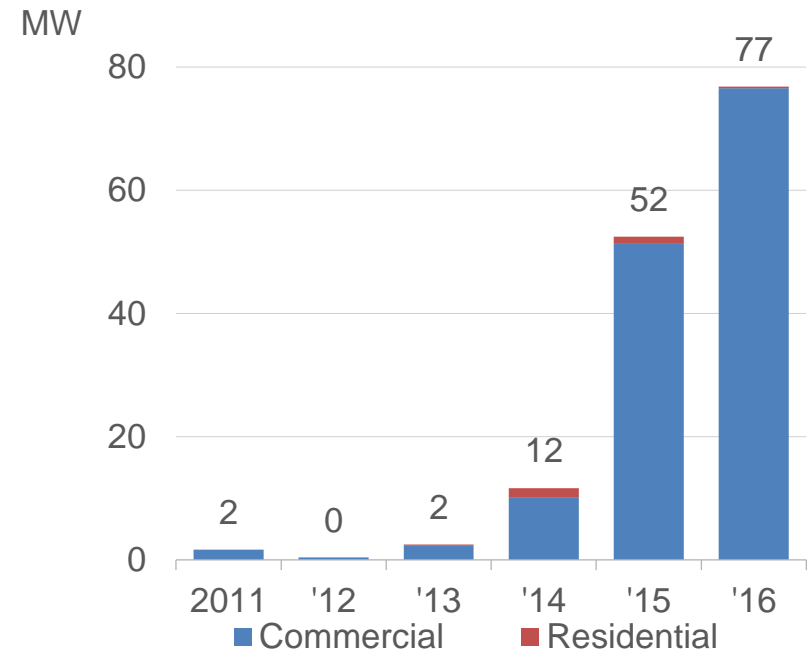
RMI transforms global energy use to create a clean, prosperous, and secure future.

# With customer sited storage, we are in emerging stages of growth...

Annual battery electric and plug-in hybrid vehicle sales in the U.S.



U.S. behind-the-meter energy storage deployments



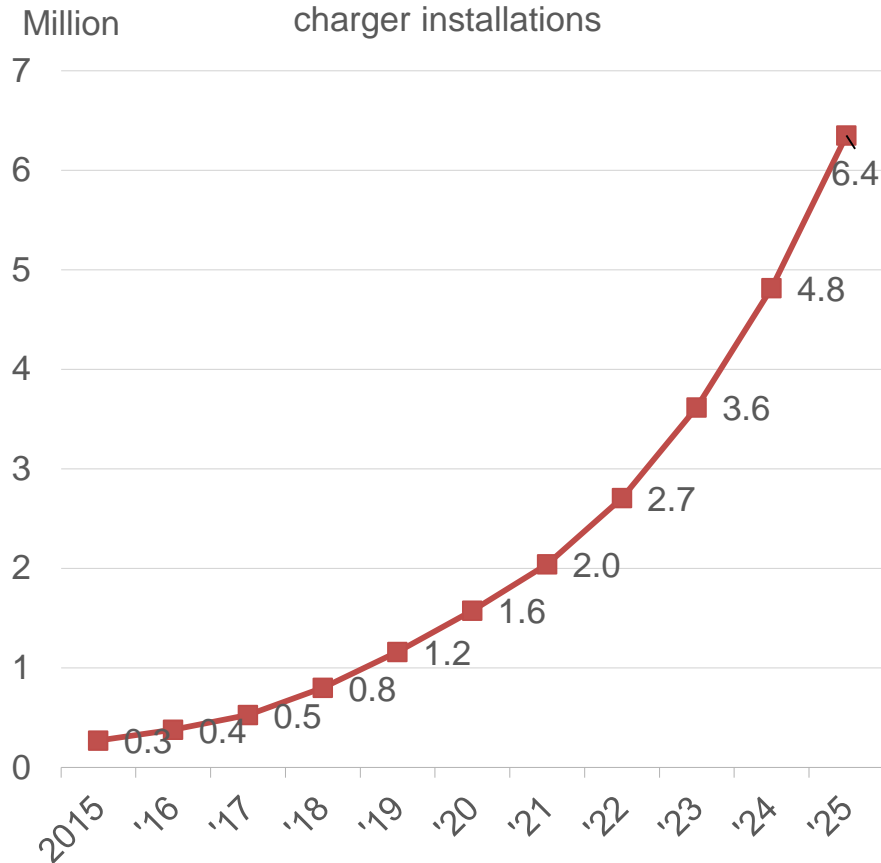
Source: Bloomberg New Energy Finance



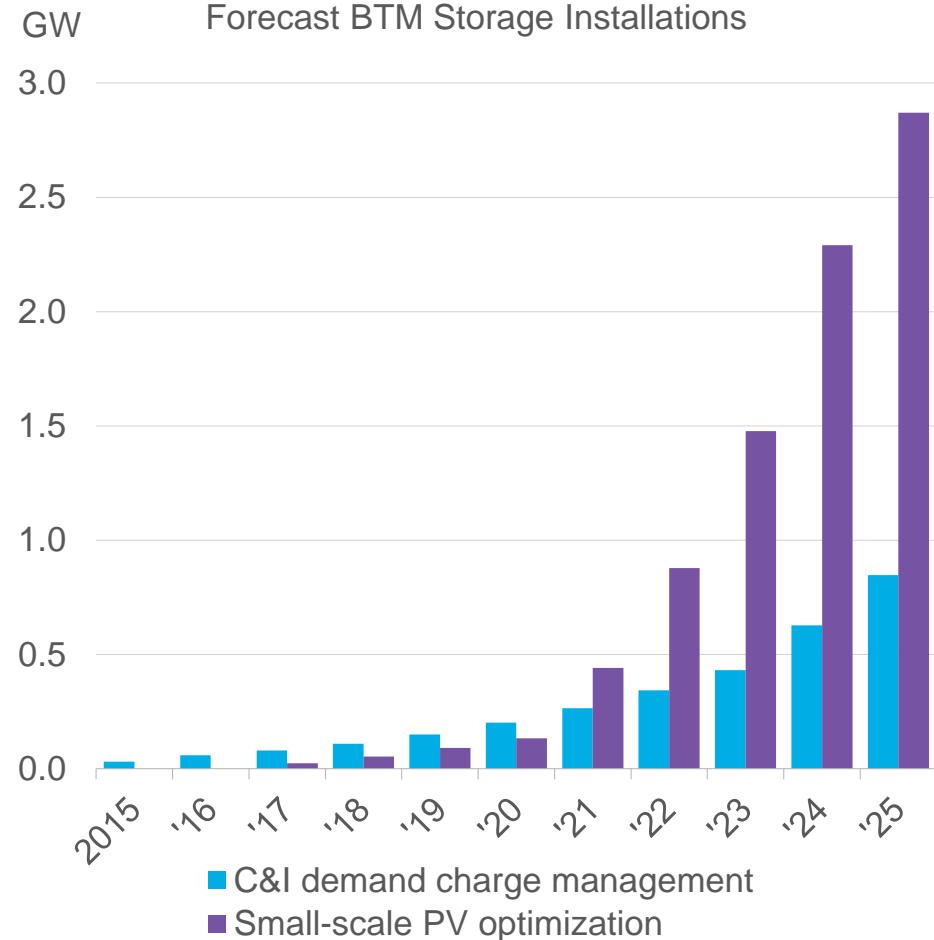
**RMI transforms global energy use to create a clean, prosperous, and secure future.**

# ...with forecasts similar to the growth of solar PV

Forecast U.S. cumulative home EV  
charger installations



GW Forecast BTM Storage Installations



Source: Bloomberg New Energy Finance



**RMI transforms global energy use to create a clean, prosperous, and secure future.**

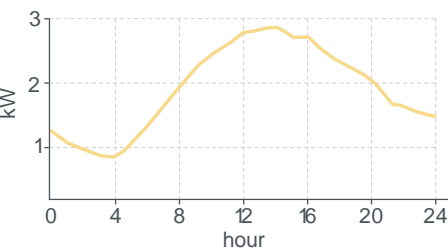
# Customers will continue to have more options in how they meet their own electricity needs and in how they can respond to grid needs



## “Buy it”

### Grid Purchases

Buy kWh from the grid as and when needed.

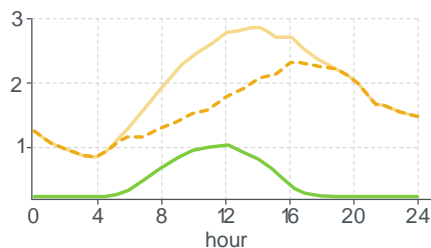


Normal Load

## “Make it”

### Distributed Generation

Generate electricity, changing the profile of net grid demand while reducing total grid demand.

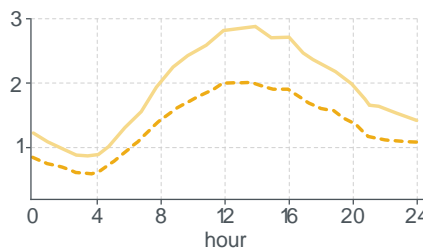


Normal Load PV Net Load

## “Avoid it”

### Energy Efficiency

Reduce demand whenever load is operated, thus lowering the daily load curve.

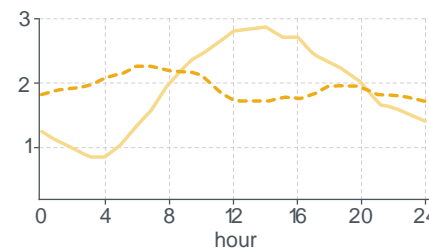


Normal Load Efficient Load

## “Shift it”

### Demand Flexibility

Shift eligible loads across the hours of a day to lower-cost times, reshaping the daily load curve.



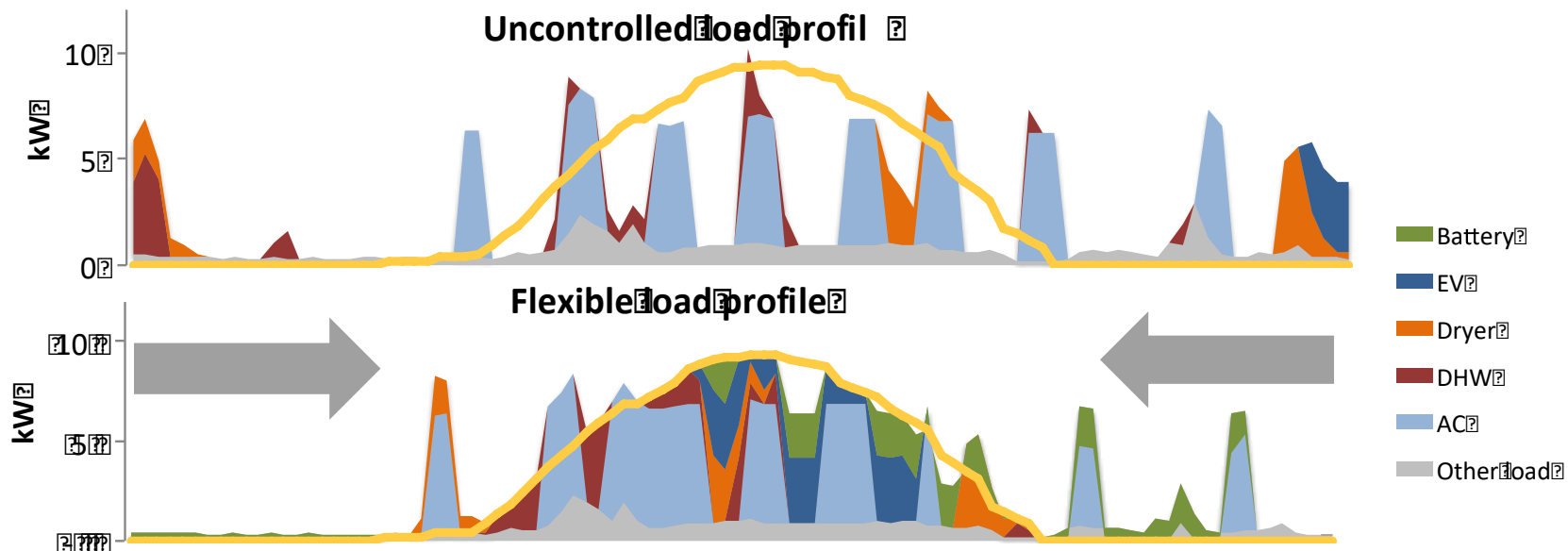
Normal Load Flexible Load



**RMI transforms global energy use to create a clean, prosperous, and secure future.**

# Trends in rate design will continue to increase value of demand flexibility

Rate	Overview	Examples
Time-varying energy pricing	Prices for energy change, as often as hourly, depending on time of day.	ComEd, Ameren (IL), California, Massachusetts, >600 others
Demand charges	Customers pay a fee corresponding to maximum demand during a given period (e.g. monthly)	Salt River Project, Arizona Public Service, Westar Energy
Reduced export compensation for PV	Exported PV is compensated at less than the retail rate	HECO, Alabama Power



**RMI transforms global energy use to create a clean, prosperous, and secure future.**

Source: RMI The Economics of Demand Flexibility

# Advanced demand response offerings are expanding the traditional DR market, technology portfolio, and potential services and value streams



Traditionally, industrial and large commercial customers have comprised the majority of demand response, which can modulate processes (manufacturing equipment, pumps, motors, etc.) and other large demands for compensation.



## Shed load

Reduce energy use during times of peak demand or high cost

## Shift load

Move consumption from high cost or grid stress times to low cost times

## Provide bulk power or distribution grid services

Dynamically raise or lower demand to manage frequency, or respond to contingency events

Manage voltage, increase circuit hosting capacity, or relieve grid stress at local level

Market not limited to EVs or battery storage. Existing:

- 53M electric water heaters
- 77M households with central AC
- 12M electric heat pumps
- 30 M electric resistance heating

- **Especially when combined, these options have significant potential to optimize customer loads while supporting the grid**
- **Programs or offerings that combine multiple services will generate multiple value streams (“value stacking”)**



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# Example load shifting programs or offerings

**Applicable technologies:** Water heating, some pre-heat/cool for space heating with smart thermostats; battery storage

## How it works

- Customer device optimizes for TOU rates by pre-heating or pre-cooling during low-price periods and minimizing load during high price periods
- 
- Utility-managed program shifts loads on a daily basis

## Examples

- Nest Time of Savings



- Aquanta TOU scheduler (resistance water heaters)



- Green Mountain Power eWater



- Green Mountain Power Powerwall



# Example grid support service programs or offerings

**Applicable technologies:** Water heating, especially resistance water heaters; aggregated air conditioning or heat pumps with smart controls; battery storage

## How it works

- Aggregated resources bid into ISO market
- 
- Utility-run DER management platform with customer devices enrolled directly or through aggregators

## Examples

- Mosaic Power water heater participation in PJM regulation market



- Hawaiian Electric proposed DR portfolio



**Example services:** fast frequency response, frequency regulation, contingency reserves (often called synchronous, non-synchronous, spinning, or non-spinning)



# The greatest value will come from approaches that combine services from the same devices, i.e. “value stacking,” such as GMP’s Tesla Powerwall offering

## Program overview



- Green Mountain Power partnered with Tesla to offer home battery storage while reducing peak demand
- Customers can lease a Tesla Powerwall 2 battery for \$15/month for 10 years, or buy for \$1500
- GMP is targeting 2,000 customers, which could provide 10 MW peak reduction
- Customers gain backup power in the event of grid outage

## GMP dispatches the batteries for multiple value streams, including peak reduction



**Annual peak reduction:** GMP reduces demand during the ISO NE system-wide peak, reducing its needs in the capacity market

**Local transmission peak reduction:** GMP manages monthly peaks to reduce transmission expenses



**Energy arbitrage:** GMP charges and discharges to capture value from the spread in locational marginal pricing

**Ancillary services:** In the future, these batteries may provide additional value through services like frequency regulation or operating reserves



# GMP's eWater provides a similar approach using customer's existing thermal storage— no battery storage needed!

Green Mountain Power's eWater program, like its Powerwall storage offering, combines several values from both water heater and thermostat control



Smart products to save you money and increase comfort.



## Typical optimization merit order

1

Curtail load during ISO New England annual peak events (generation capacity)

2

Curtail load during GMP-specific monthly peaks (transmission capacity)

3

Shift load to low cost periods based on daily ISO market prices

4

Potential to bid resources into ISO markets for operating reserves or regulation



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# Thank you

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# Staff Subcommittees on Energy Resources & the Environment, Electricity and Electric Reliability