TRANE

Trane Engineers Newsletter Live

Demand Response in Commercial Buildings

Presenters: Matt Bye, Susanna Hanson, Trevor Joelson and Chuck Lanager with Jeanne Harshaw (host)

AIA CONTINUING EDUCATION GBCI CMP

Ingersoll Rand

Trane program number: APP-CMC064-EN

Agenda

Trane *Engineers Newsletter Live* Series

Demand Response in Commercial Buildings

Abstract

Advanced building designs and component technology continue to reduce loads and embrace features such as thermal mass to shift cooling and heating loads to more advantageous times of day. At the same time, utilities and campuses are increasing efforts to include renewable energy that require more advanced energy storage and demand response strategies to balance generation and consumption. Stretch codes and labelling programs have begun to specifically recognize building designs and operations that incorporate these features. For example, version 4 of the U.S. Green Building Council's LEED® rating program includes up to two credits for building designs that include demand response.

This program discusses the relevant improvements that load shifting and demand response can provide, with examples of the types of utility and funding programs that are available.

Presenters: Trane engineers Matt Bye, Trevor Joelson, Susanna Hanson and Chuck Lanager

After viewing attendees will be able to:

1. Identify types of programs/capabilities that would be considered demand response
2. Summarize where these programs are most likely available today and where new opportunities are forming
3. Compare various financial vehicles that are available for demand response
4. Summarize different strategies that can generate revenue and/or save energy cost

Agenda

- Definition of Demand Response
- Evolution of Markets
- Evolution of Products
- Current Opportunities
- Future Opportunities

Presenter biographies

Demand Response in Commercial Buildings

Chuck Lanager | Director of Energy Operations | Trane Energy Supply Services (ESS)
Chuck is the Director of Energy Operations for Trane's Energy Supply Services (ESS) business. Chuck joined ESS in 2010 and leads the ESS business' procurement and 24/7 power control center (PCC) teams. Chuck has over 30 years of energy supply services experience through his work with regulated utilities and non-regulated businesses nationally including co-founding his own electricity trading and consulting business in 2007. His areas of expertise include retail electricity supply and rates, wholesale electricity markets and generation, state and federal energy regulations, and renewable energy contracting. Chuck holds a degree in electrical engineering from the Pennsylvania State University..

Susanna Hanson | systems engineer | Trane
Susanna is an applications engineer at Trane with over 15 years of experience with chilled-water systems and HVAC building load and energy analysis. Her primary responsibility is to aid system design engineers and Trane personnel in the proper design and application of HVAC systems. Her main areas of expertise include chilled-water systems and ASHRAE Standard 90.1. She is also a Certified Energy Manager.

Susanna has authored several articles, manuals and system catalogs on chilled-water plant design, and is a member of ASHRAE SSPC 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings. Susanna earned a bachelor's degree in industrial and systems engineering from the University of Florida, where she focused on building energy management and simulation.

Trevor Joelson | energy services business development | Trane
Trevor joined Trane Energy Supply Services in August of 2011. In his role as Account Manager, Trevor partners with Trane offices and customers to ensure they achieve low cost electricity and natural gas supply in coordination with their high-performing buildings. Trane customers obtain particular benefit from Trevor's thought leadership in deregulated energy markets. Trevor received his Bachelor of Arts degree in Sport Administration with minors in Marketing and Political Science from the University of Louisville in Louisville, Kentucky.

Matt Bye | portfolio manager, utility and grid solutions | Trane Energy Services
Matt joined Trane in 2005 and has served multiple product management and strategy roles. Before Ingersoll Rand, Bye was product manager for utility solutions at Honeywell. Bye has also held a number of other positions including energy manager for the City of Minneapolis, product engineer on a number of EPRI products, and started his career as a utility demand side management project manager. He has led energy management product management for solutions ranging from real time pricing control to distributed generation.

Matt assumed his current role in 2016. In this role he works to manage and develop products, solutions and technology that complement Trane's utility and grid business strategies. This includes efforts to develop cloud based software, controls and automation technology, as well as behind the meter energy solutions. He earned his Bachelor of Science degree in Energy Management at Minnesota State University.

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Credit for viewing today's program can be applied toward LEED credential maintenance requirements .

www.USGBC.org

Visit the Registered Continuing Education Programs (RCEP) Website for individual state continuing education requirements for Professional Engineers.

www.RCEP.net

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Learning objectives

- Define what is meant by a Demand Response program
- Summarize the current Demand Response opportunities available to commercial and industrial building owners
- Identify the types of demand Response products available today
- Summarize the steps to follow to determine whether your building can participate in Demand Response programs

AGENDA

- What is demand response
- Why we need demand response
- Evolution of Markets
- Evolution of Products
- Current Opportunities
- Future Opportunity

Today's Presenters

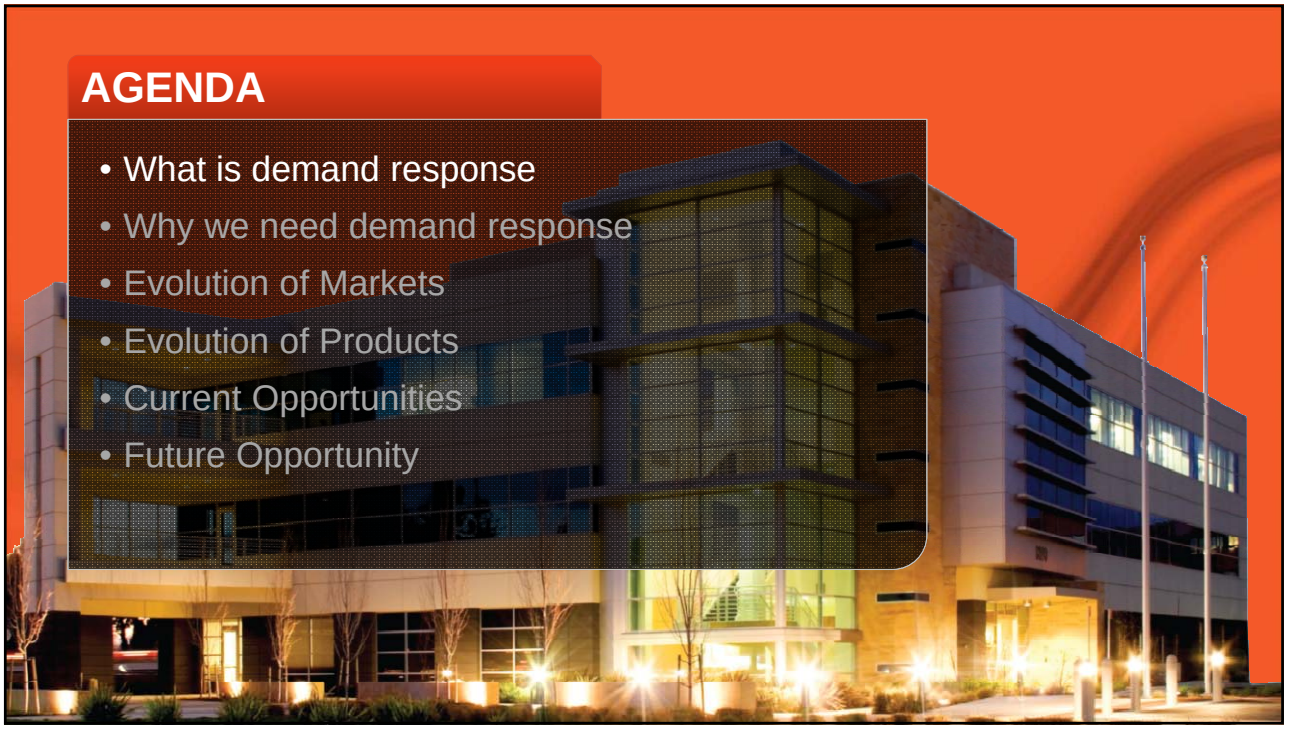
Matt Bye
Product Manager

Chuck Lanager
Energy Operations Director

Trevor Joelson
Business Development

Susanna Hanson
Applications Engineer

AGENDA



- What is demand response
- Why we need demand response
- Evolution of Markets
- Evolution of Products
- Current Opportunities
- Future Opportunity

Power:

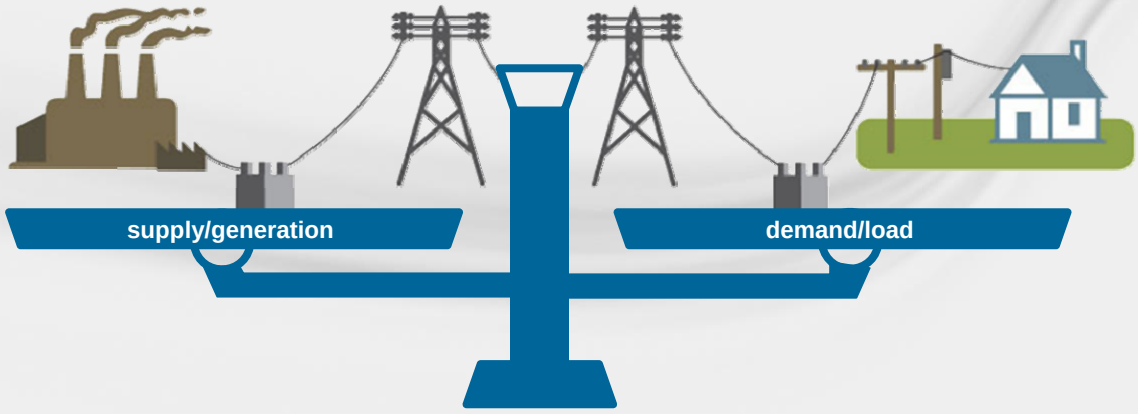
Generated, Transmitted, Distributed

supply/generation

demand/load

n)

Power:
Generated, Transmitted, Distributed



Source: Adapted from National Energy Education Development Project (public domain)

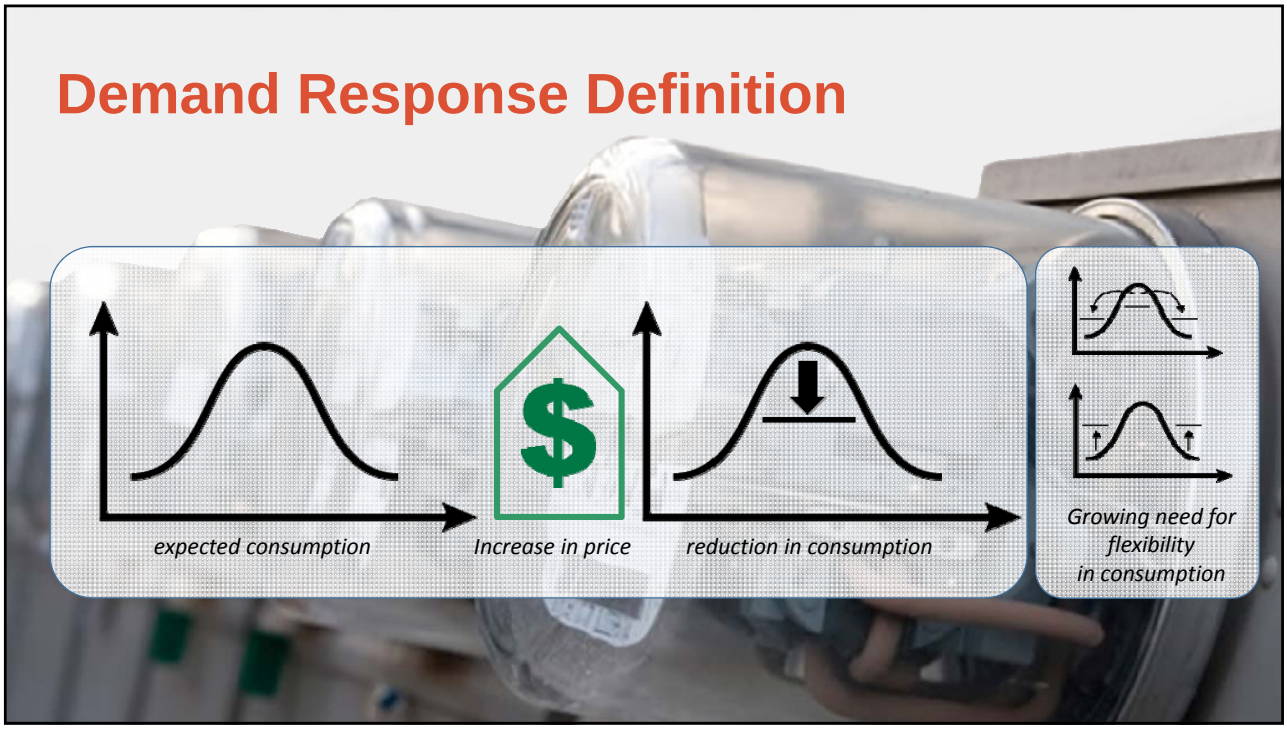
Demand Response Definition

"a reduction in the consumption of electric energy by customers from their expected consumption in response to an increase in the price of electric energy or to incentive payments designed to induce lower consumption of electric energy."

Source:

FERC Federal Energy Regulatory Commission

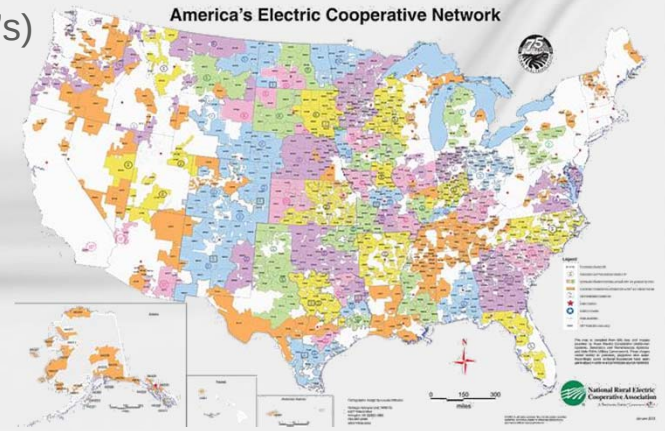
Demand Response Definition



Utilities, RTOs and Markets

Over 3,200 Utilities in United States

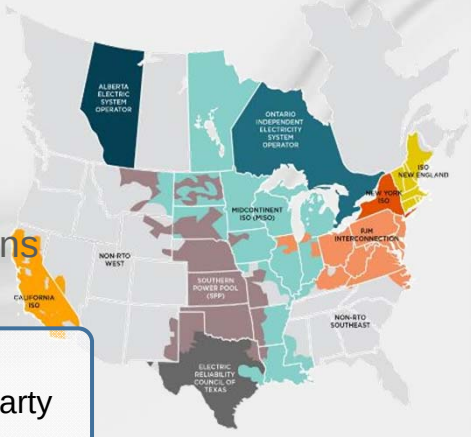
- Investor owned utilities (IOU's)
- Municipals (Muni's)
- Cooperatives (Coop's)



Utilities, RTOs and Markets

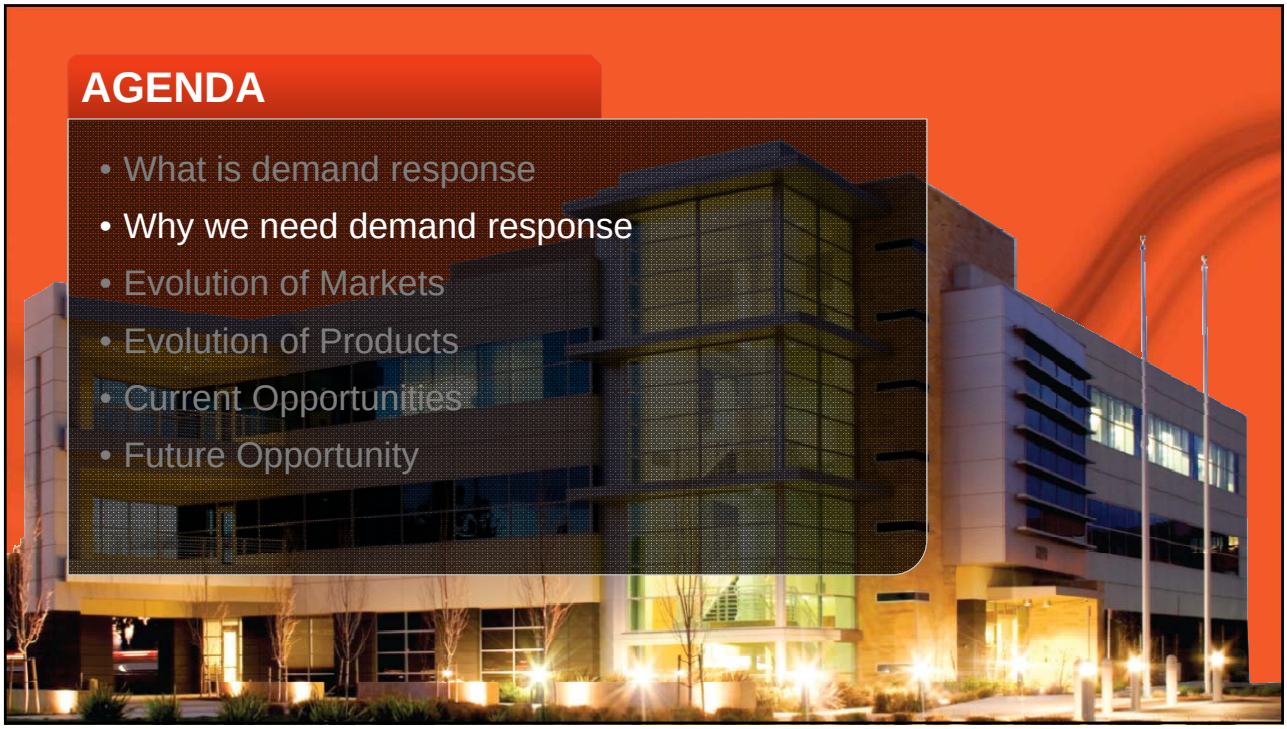
Organized Markets: ISO's and RTO's

- Seven Independent System Operators (ISO's)
- Typically confined to a single state
- Four Regional Transmission Organizations (RTO's)



- Reliable electric system
- Independent & neutral party
- Organized

AGENDA



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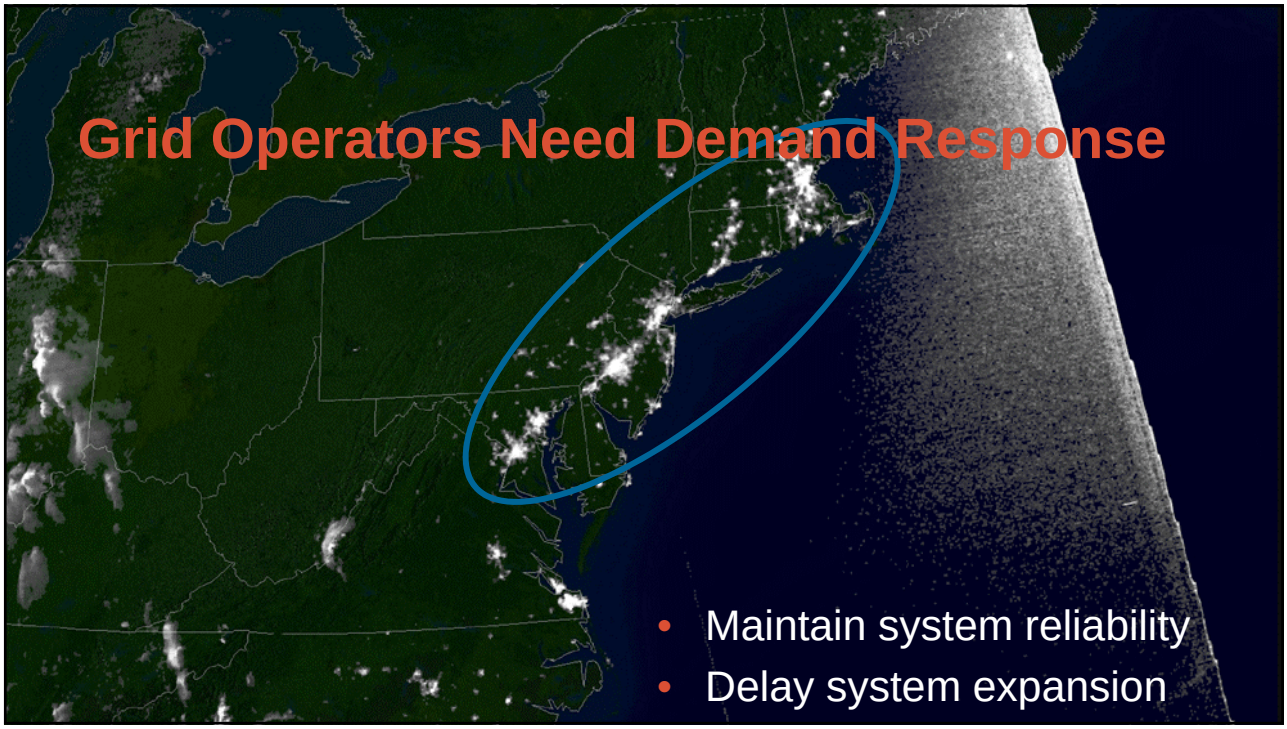
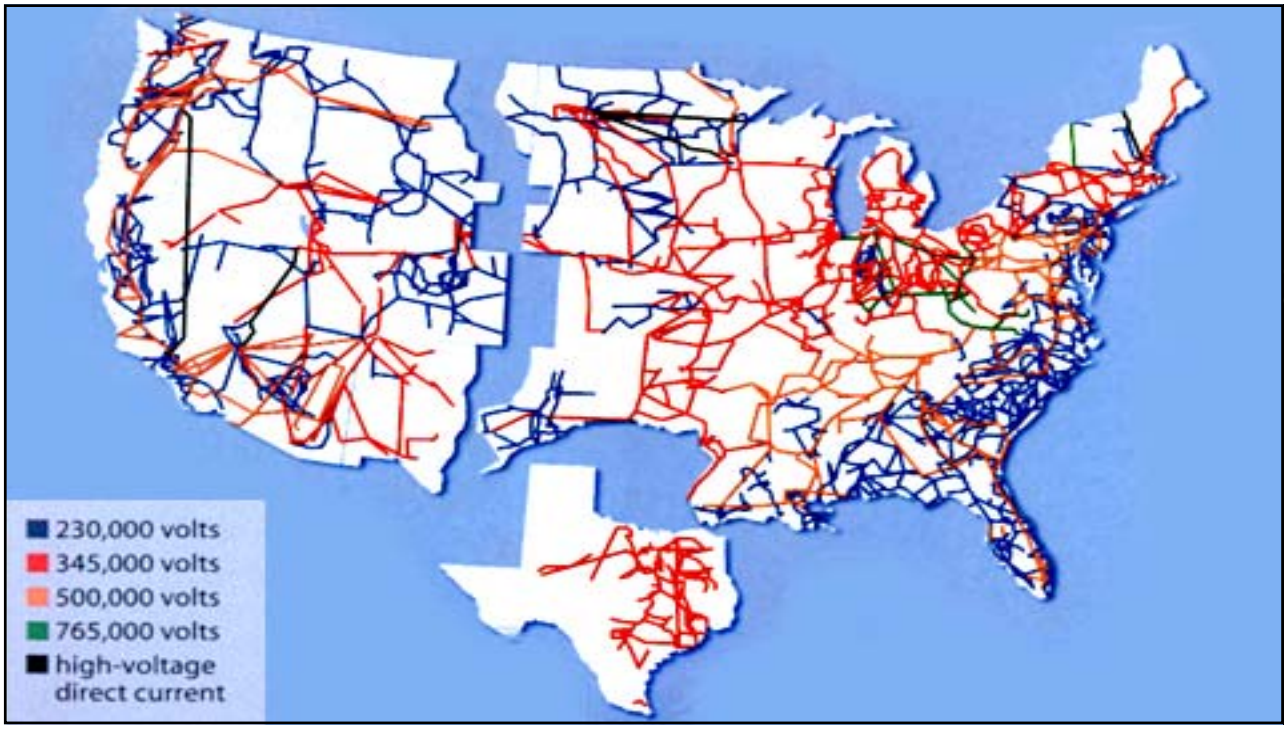

Grid Operators Need Demand Response
Maintain system reliability
Delay system expansion


230,000 volts
345,000 volts
500,000 volts
765,000 volts
high-voltage direct current

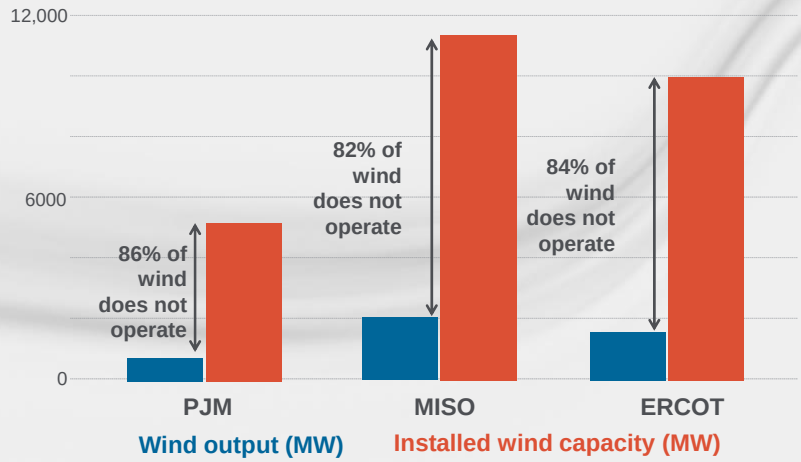
Utilities Need Demand Response Too

- Localized outages or overloading
- Cost of purchased power
- Capacity to meet currency and future customer loads

Renewables Need Demand Response

Wind output during highest top 10 Demand Response days

- Less than 20% of installed wind capacity available at peak
- Greater than 90% of traditional power capacity available at peak



Renewables and Grid Reliability

- "Duck Curve"
- Oversupply followed by undersupply
- Intermittent solar and wind energy with traditional generation

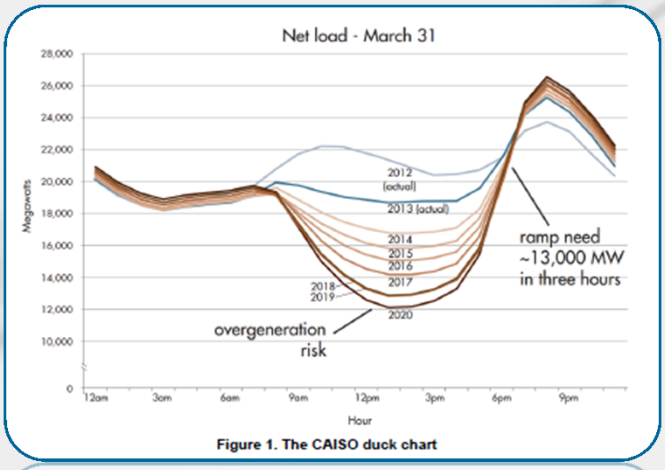
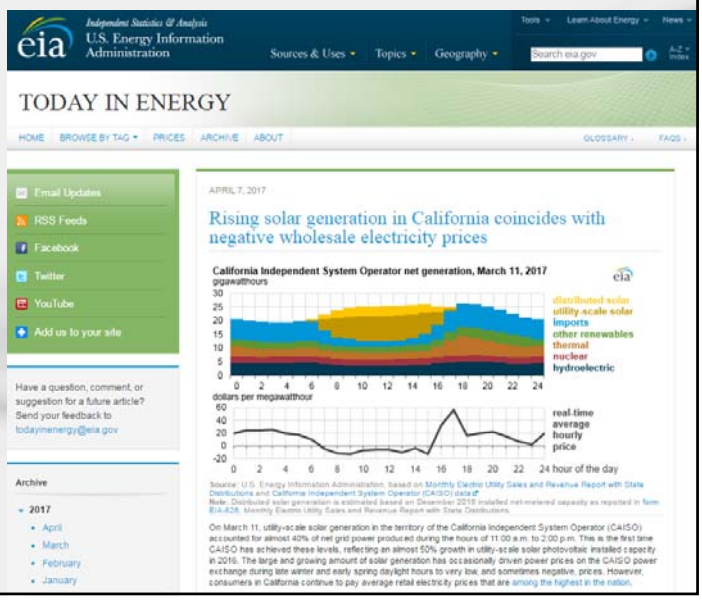


Figure 1. The CAISO duck chart

Renewables and Grid Financials

Solar over-generation on cool sunny days. Utilities have to pay to dump it

- **Good news**
  if you can use it
  and you know about it
- **Bad news**
  peak rates go up to compensate



Renewables' Impact on the Grid

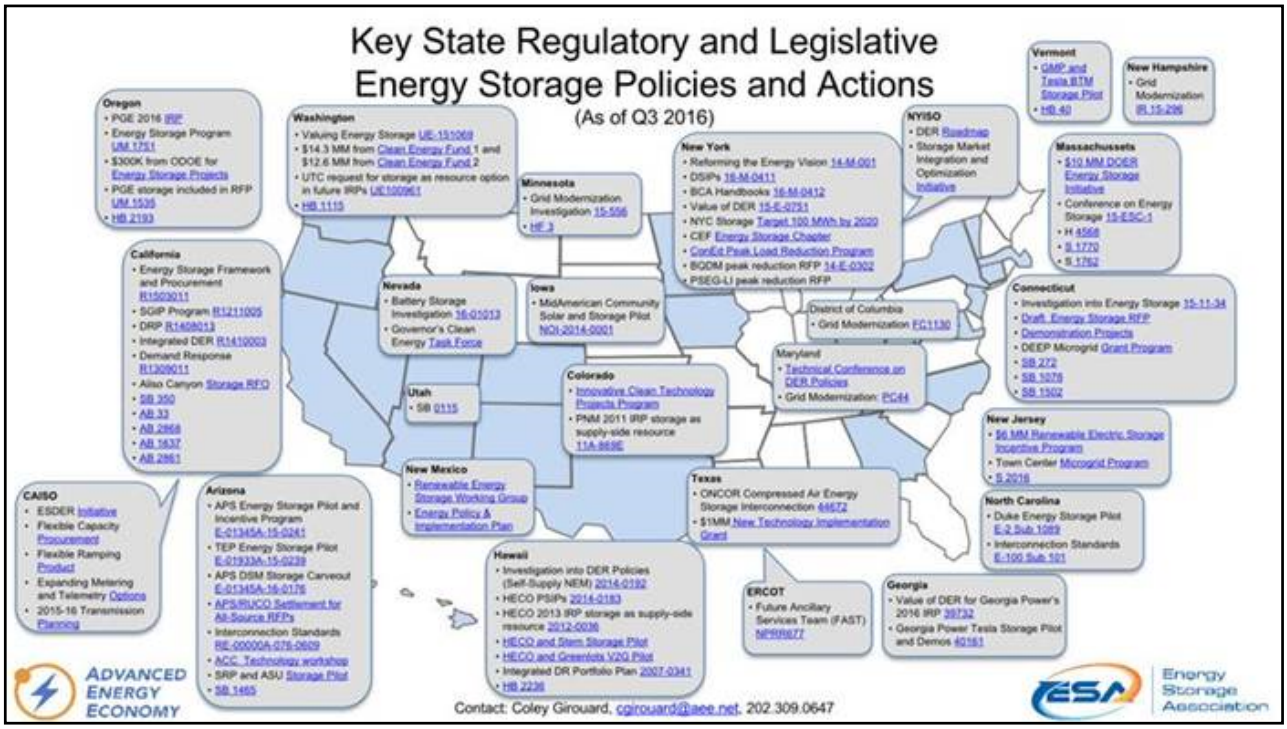
Thermal energy storage

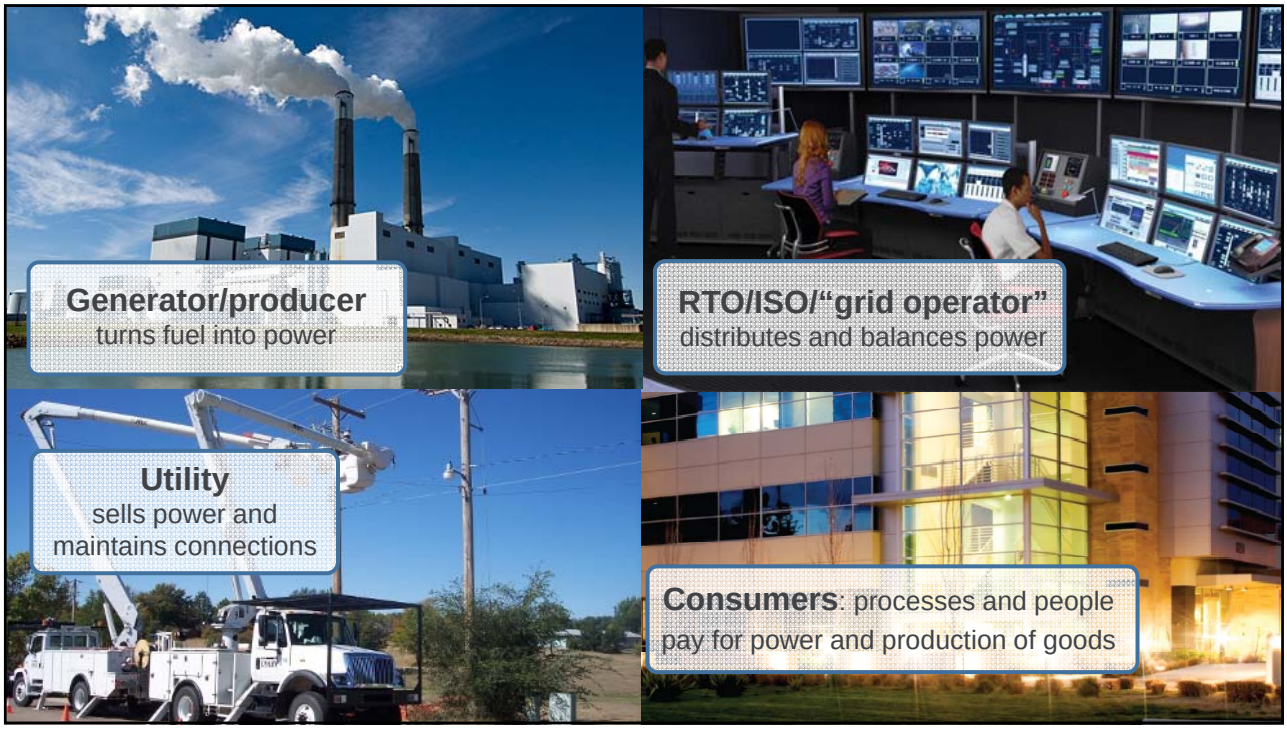
- Charges when other electric loads are low
- When the wind is blowing
- When the sun is shining

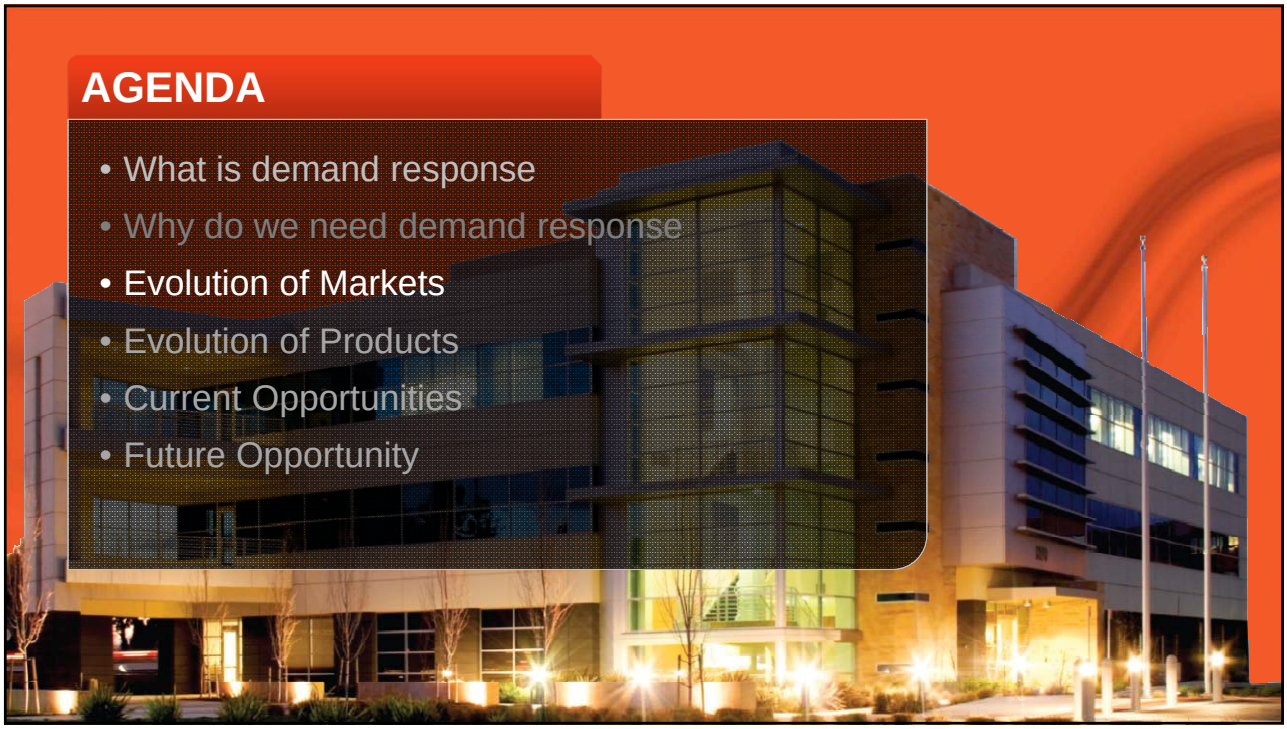
Why do we need Demand Response?

Energy stored for cooling

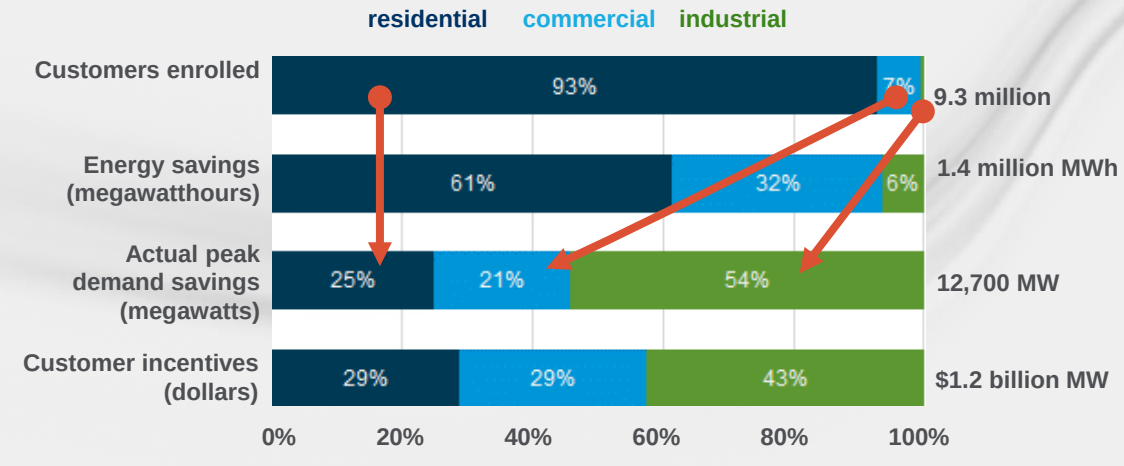
- Doesn't contribute to the problem
- Provides opportunities to correct for it
- Offloads solar when over-generation is least likely
- Reduces dirtiest peak power
- More likely to be used because it is doesn't affect customer


Key State Regulatory and Legislative Energy Storage Policies and Actions
(As of Q3 2016)
Oregon
• PGE 2016 IRP
• Energy Storage Program UM 1751
• $300K from ODOE for Energy Storage Projects
• PGE storage included in RFP UM 1535
• HB 2193
Washington
• Valuing Energy Storage UE-151069
• $14.3 MM from Clean Energy Fund 1 and $12.6 MM from Clean Energy Fund 2
• UTC request for storage as resource option in future IRPs UE100961
• HB 1115
California
• Energy Storage Framework and Procurement R1503011
• SGIP Program R1211005
• DRP R1408013
• Integrated DER R1410003
• Demand Response R1309011
• Aliso Canyon Storage RFO
• SB 350
• AB 33
• AB 2868
• AB 1637
• AB 2861
Nevada
• Battery Storage Investigation 16-01013
• Governor's Clean Energy Task Force
Minnesota
• Grid Modernization Investigation 15-556
• HF 3
Iowa
• MidAmerican Community Solar and Storage Pilot NOI-2014-0001
Utah
• SB 0115
Colorado
• Innovative Clean Technology Projects Program
• PNM 2011 IRP storage as supply-side resource 11A-869E
New Mexico
• Renewable Energy Storage Working Group
• Energy Policy & Implementation Plan
CAISO
• ESDER Initiative
• Flexible Capacity Procurement
• Flexible Ramping Product
• Expanding Metering and Telemetry Options
• 2015-16 Transmission Planning
Arizona
• APS Energy Storage Pilot and Incentive Program E-01345A-15-0241
• TEP Energy Storage Pilot E-01933A-15-0239
• APS DSM Storage Carveout E-01345A-16-0176
• APS/RUCO Settlement for All-Source RFPs
• Interconnection Standards RE-00000A-076-0609
• ACC Technology workshop
• SRP and ASU Storage Pilot
• SB 1465
Hawaii
• Investigation into DER Policies (Self-Supply NEM) 2014-0192
• HECO PSIPs 2014-0183
• HECO 2013 IRP storage as supply-side resource 2012-0036
• HECO and Stem Storage Pilot
• HECO and Greenlots V2G Pilot
• Integrated DR Portfolio Plan 2007-0341
• HB 2236
New York
• Reforming the Energy Vision 14-M-001
• DSIPs 16-M-0411
• BCA Handbooks 16-M-0412
• Value of DER 15-E-0751
• NYC Storage Target 100 MWh by 2020
• CEF Energy Storage Chapter
• ConEd Peak Load Reduction Program
• BQDM peak reduction RFP 14-E-0302
• PSEG-LI peak reduction RFP
NYISO
• DER Roadmap
• Storage Market Integration and Optimization Initiative
District of Columbia
• Grid Modernization FC1130
Maryland
• Technical Conference on DER Policies
• Grid Modernization: PC44
Texas
• ONCOR Compressed Air Energy Storage Interconnection 44672
• $1MM New Technology Implementation Grant
ERCOT
• Future Ancillary Services Team (FAST) NPRR677
Georgia
• Value of DER for Georgia Power's 2016 IRP 39732
• Georgia Power Tesla Storage Pilot and Demos 40161
Vermont
• GMP and Tesla BTM Storage Pilot
• HB 40
New Hampshire
• Grid Modernization IR 15-296
Massachussets
• $10 MM DOER Energy Storage Initiative
• Conference on Energy Storage 15-ESC-1
• H 4568
• S 1770
• S 1762
Connecticut
• Investigation into Energy Storage 15-11-34
• Draft Energy Storage RFP
• Demonstration Projects
• DEEP Microgrid Grant Program
• SB 272
• SB 1078
• SB 1502
New Jersey
• $6 MM Renewable Electric Storage Incentive Program
• Town Center Microgrid Program
• S 2016
North Carolina
• Duke Energy Storage Pilot E-2 Sub 1089
• Interconnection Standards E-100 Sub 101
ADVANCED ENERGY ECONOMY
Contact: Coley Girouard, cgirouard@aee.net, 202.309.0647
ESA Energy Storage Association


Generator/producer
turns fuel into power
RTO/ISO/"grid operator"
distributes and balances power
Utility
sells power and maintains connections
Consumers: processes and people pay for power and production of goods



Market Segment Characteristics



demand response
Residential Programs

- Water heater
- HVAC
- Passive
- Utility driven

demand response
Industrial Programs

- Industrial
  - Abrupt force – rock crusher
  - Consistent force – pump
  - Thermal – smelter
- Utility Driven
  - Telephone, e-mail, pager
- Newer Opportunity
  - Bid into day ahead market

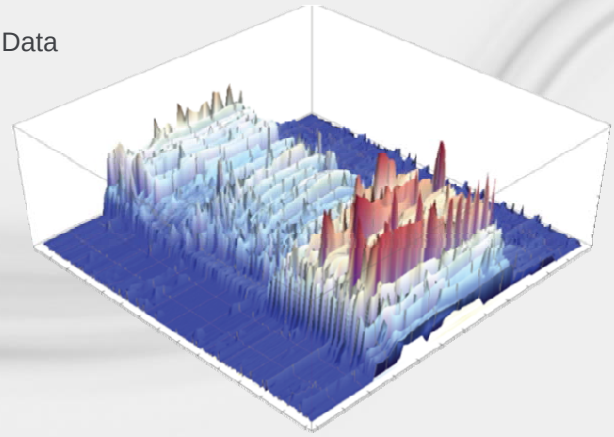
How can buildings help?

Over 5 million buildings across the United States

Lodging	Healthcare	Office Space	Warehouse	Education	Other
158,000	157,000	1,012,000	796,000	389,000	*3 Million+*

Finding the Load and Connecting to Utility

Step 1: Collect and Analyze Building's Energy Data



Finding the Load and Connecting to Utility

Step 1: Collect and Analyze Building's Energy Data

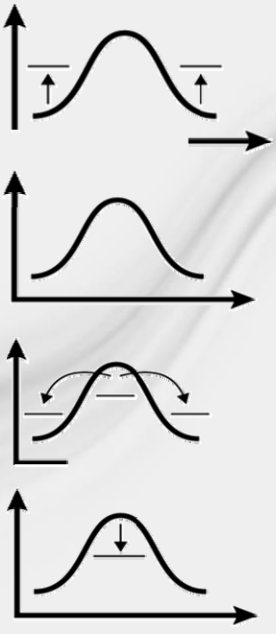
Step 2: Understand Business Profile

Finding the Load and Connecting to Utility

Step 1: Collect and Analyze Building's Energy Data

Step 2: Understand Business Profile

Step 3: Model the potential solutions



Finding the Load and Connecting to Utility

Step 1: Collect and Analyze Building's Energy Data

Step 2: Understand Business Profile

Step 3: Model the potential solutions

Step 4: Implement control changes

Step 5: Connect to Market or Utility

Finding the Load and Connecting to Utility

Step 1: Collect and Analyze Building's Energy Data

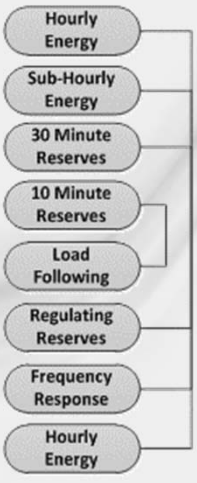
Step 2: Understand Business Profile

Step 3: Model the potential solutions

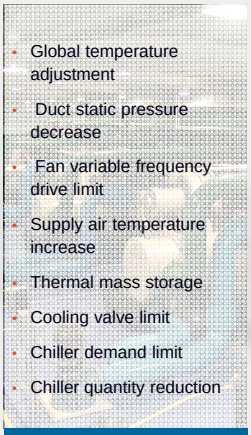
Step 4: Implement control changes

Step 5: Connect to Market or Utility

Step 6: Respond to test and actual events

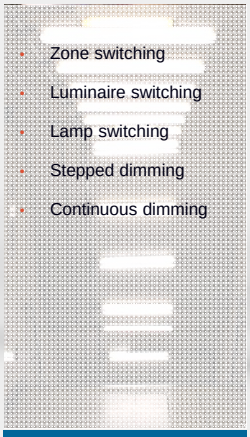


Strategies to Participate



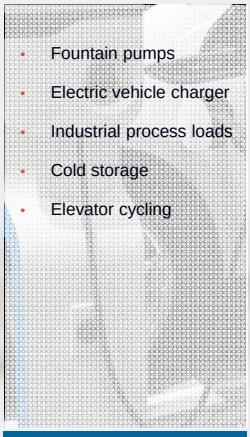
- Global temperature adjustment
- Duct static pressure decrease
- Fan variable frequency drive limit
- Supply air temperature increase
- Thermal mass storage
- Cooling valve limit
- Chiller demand limit
- Chiller quantity reduction

HVAC



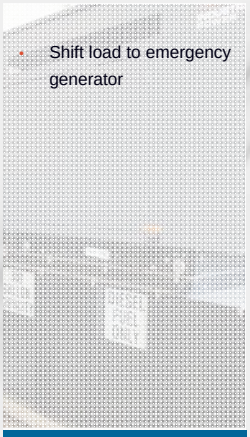
- Zone switching
- Luminaire switching
- Lamp switching
- Stepped dimming
- Continuous dimming

LIGHTING



- Fountain pumps
- Electric vehicle charger
- Industrial process loads
- Cold storage
- Elevator cycling

MISCELLANEOUS EQUIPMENT



- Shift load to emergency generator

GENERATION

Each building is unique…

300 kW

Lodging

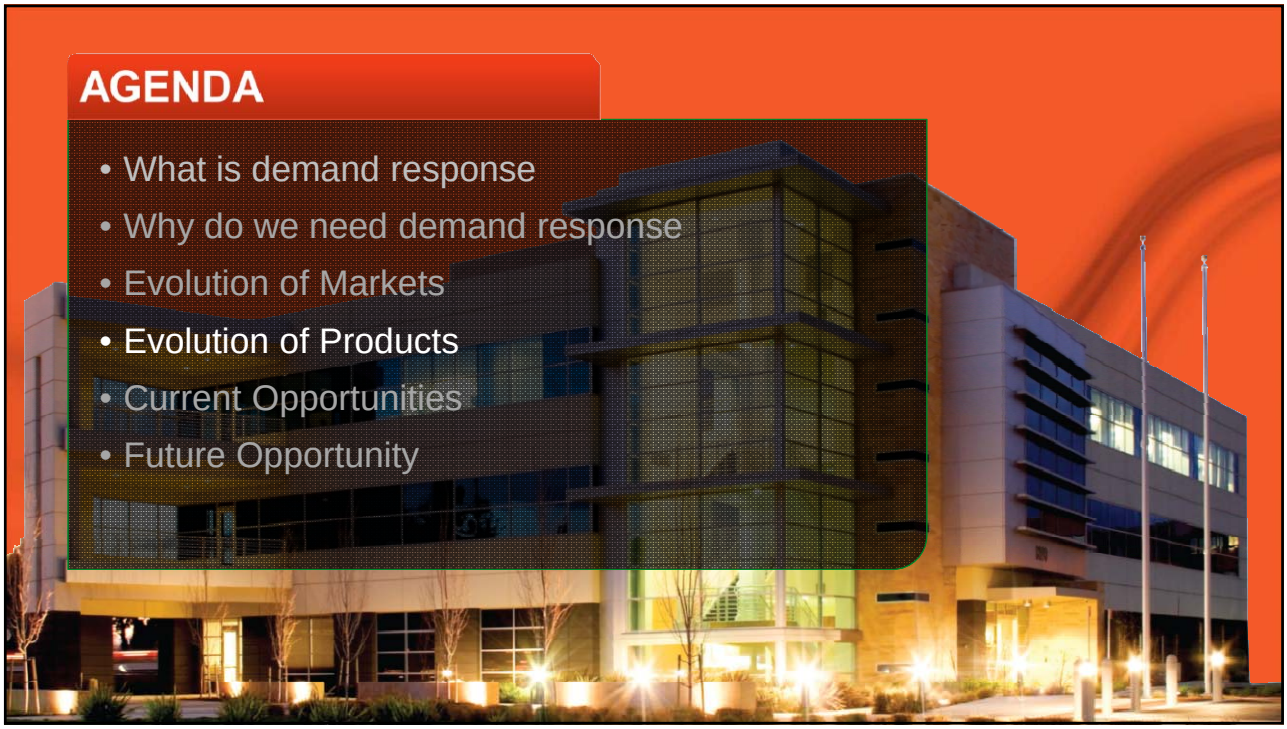
500 kW

Hospital

100 kW

Office Space

- Each building represents a unique **grid services** opportunity
- Most have potential to provide a variety of **grid services**
- Thousands of possibilities



Grid Products

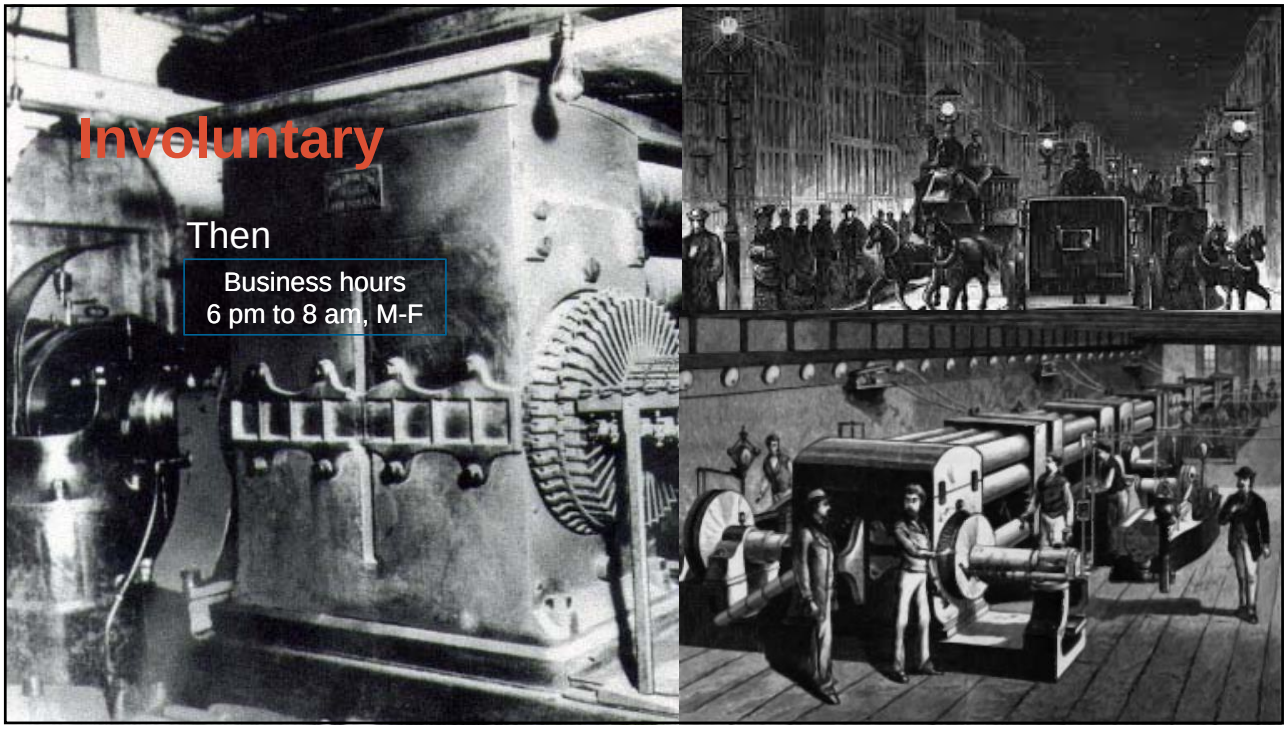
traditional demand response

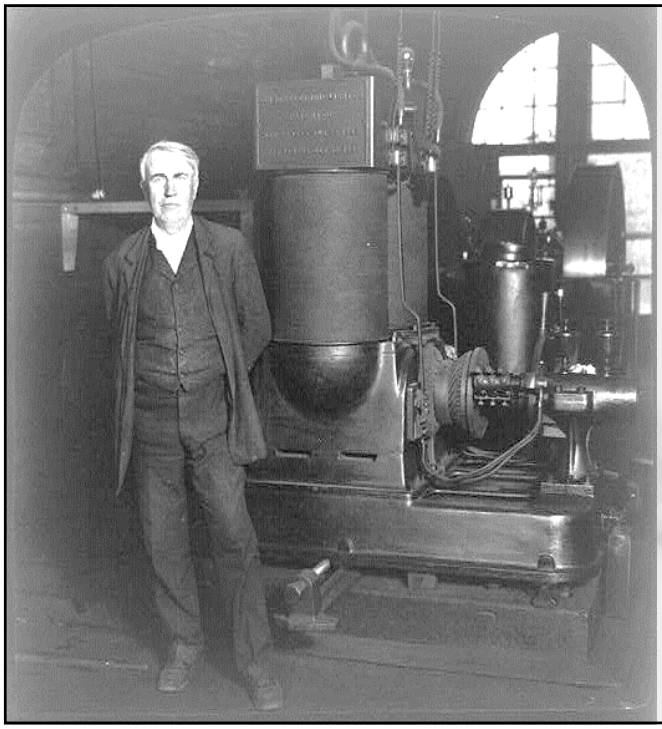
Grid Products	Response Time	Traditional Solutions	Alternative Solutions
Capacity	Hourly Schedule	• Nuclear • Coal • Hydro • Combined Cycle • Gas Peaker	• Controllable building loads • Batteries • Thermal storage • Compressed Air • Pumped storage • Flywheels
Energy	Hourly Schedule		
Ancillary Services			
30 Minute Reserves	30 Minutes		
10 Minute Reserves	10 Minutes		
Load Following	5 Minutes		
Regulating Reserves	2-4 Seconds		
Frequency Response	0.2-0.5 Seconds		

Behind the meter solutions

Evolution of Demand Response Products

- Involuntary – brown out/black out
- Voluntary for emergency
- Utility rates – demand charges, curtailable, interruptible, on/off peak
- Grid operator capacity charges
- Pay for performance
  - Emergency standby
  - Economic curtailment
- Load acting as a resource



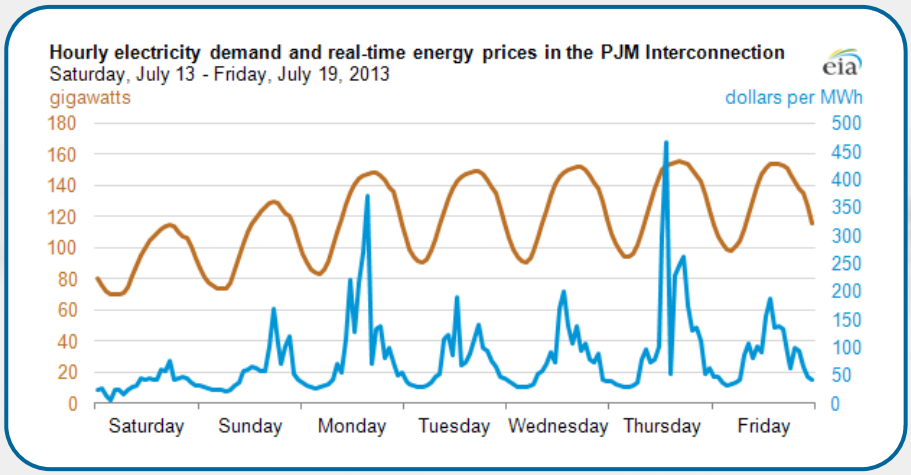


Voluntary for Emergency

Excuse me, sir,
but would you mind very much
shutting down your
business so that my
lines don't burn down?

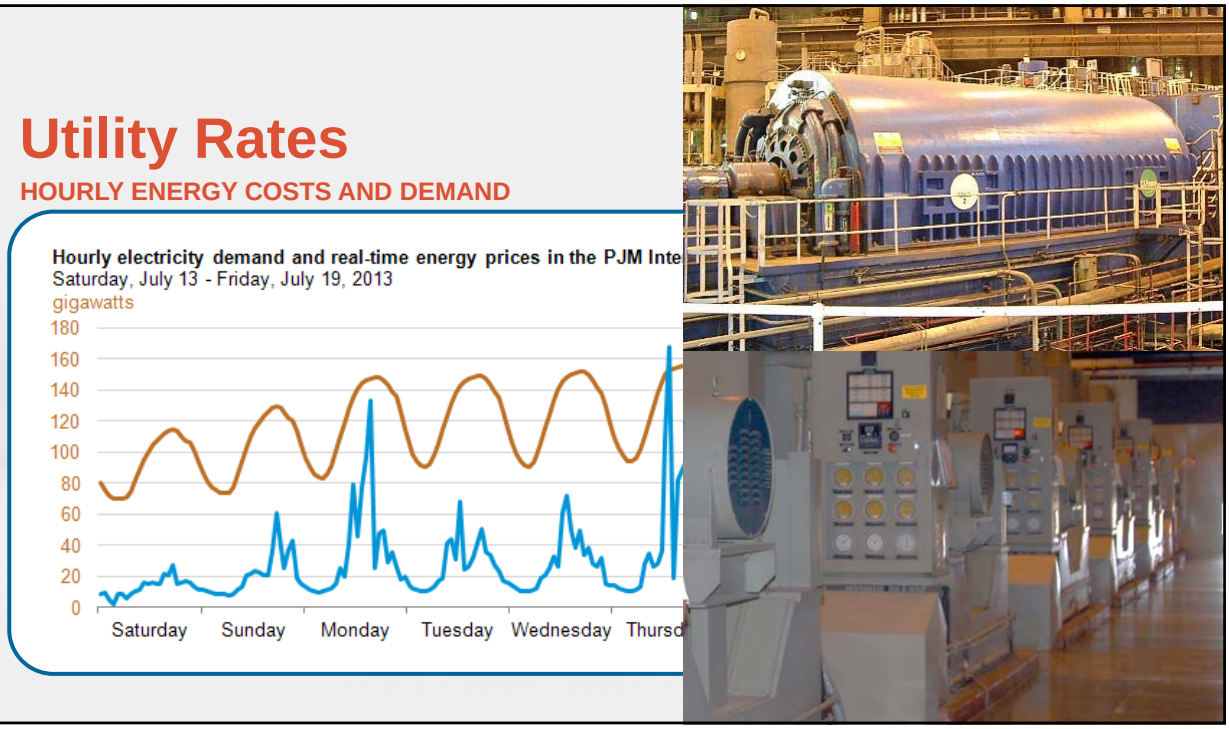
Utility Rates

HOURLY ENERGY COSTS AND DEMAND



Utility Rates

HOURLY ENERGY COSTS AND DEMAND



Utility Rates

- Demand charges
- On/off peak pricing
- Curtailable/interruptible rates

Grid Operator Capacity Charges

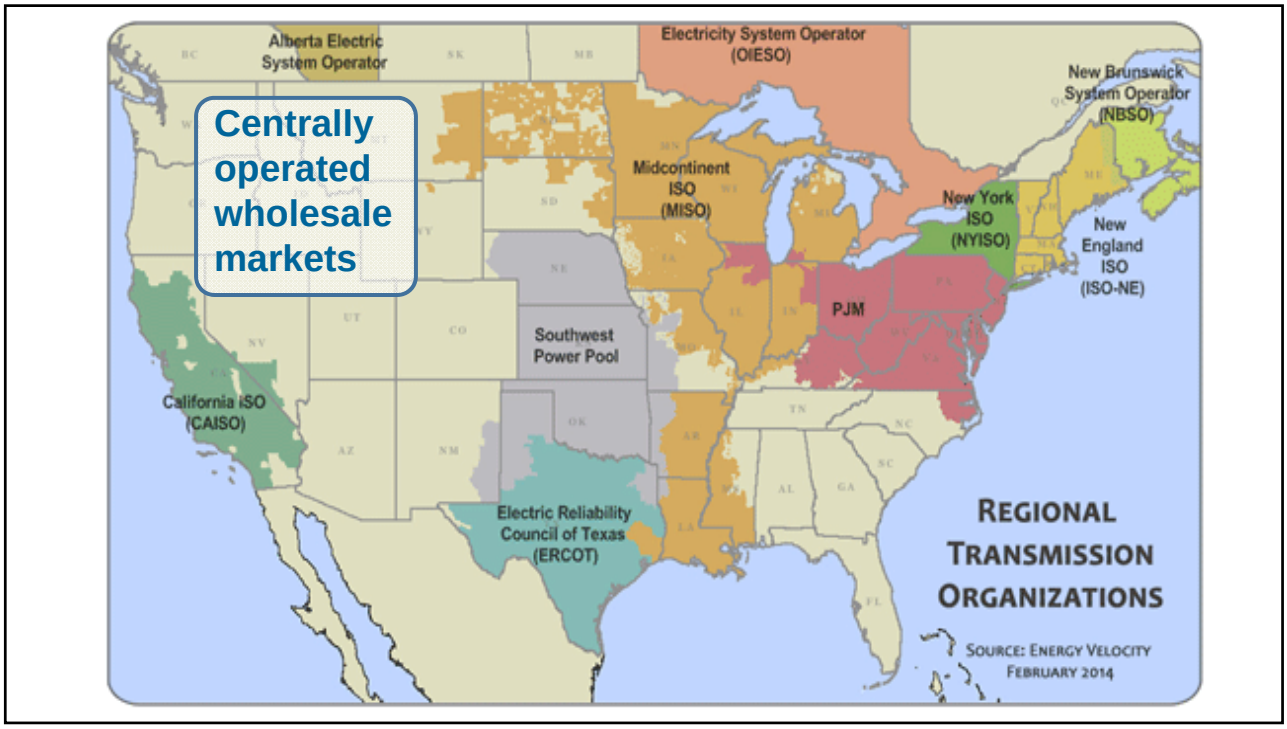
- Market value of each kW of capacity
- Amount of required capacity

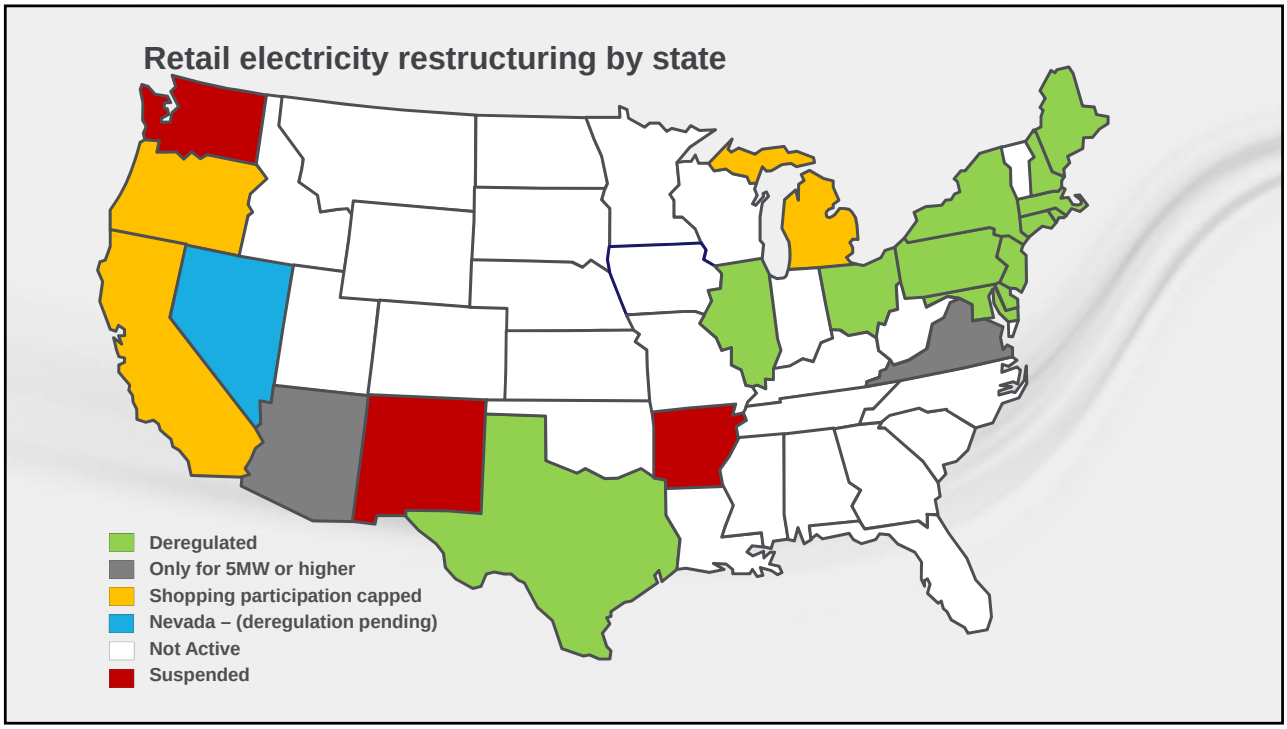
Revenue Opportunities: Aggregator

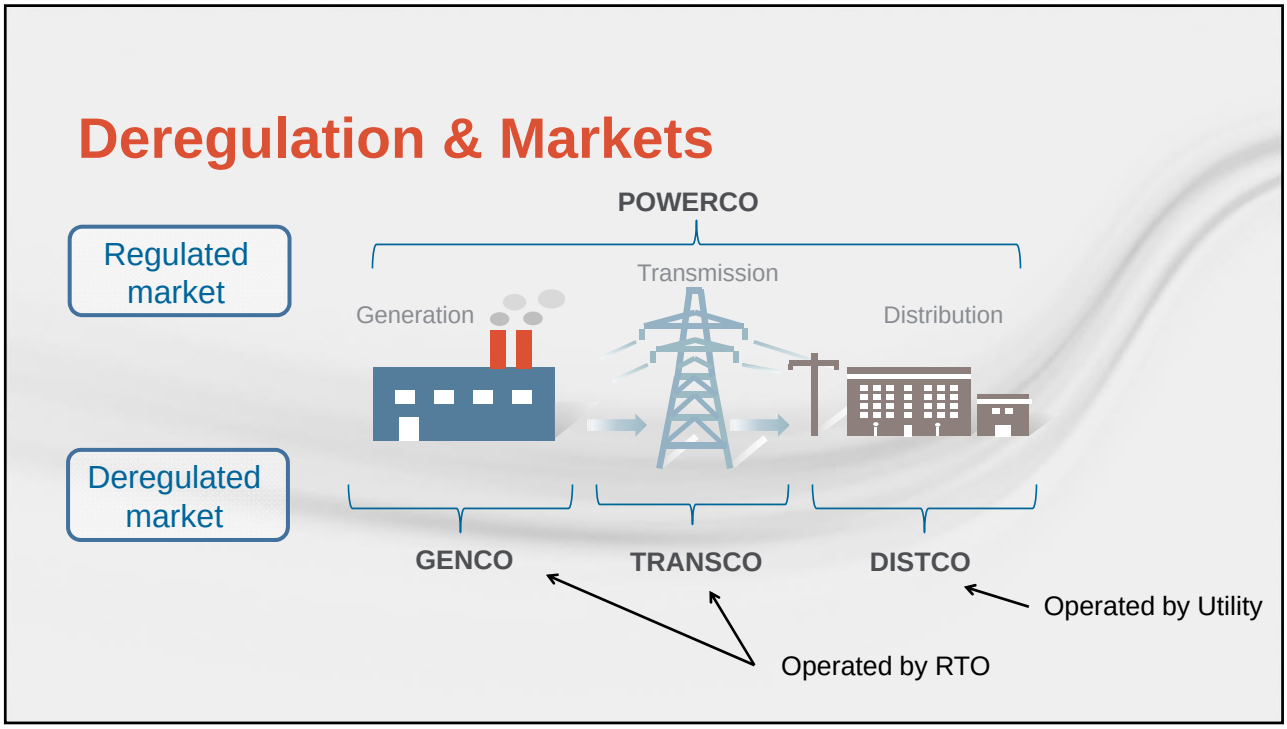
Revenue Opportunities

- Emergency standby
- Economic curtailment


AGENDA
• What is demand response
• Why do we need demand response
• Evolution of Markets
• Evolution of Products
• Current Opportunities: Regulated vs. Deregulated
• Future Opportunity


Centrally operated wholesale markets
Alberta Electric System Operator
Electricity System Operator (OIESO)
New Brunswick System Operator (NBSO)
Midcontinent ISO (MISO)
New York ISO (NYISO)
New England ISO (ISO-NE)
PJM
Southwest Power Pool
California ISO (CAISO)
Electric Reliability Council of Texas (ERCOT)
REGIONAL TRANSMISSION ORGANIZATIONS
SOURCE: ENERGY VELOCITY FEBRUARY 2014


Retail electricity restructuring by state
Deregulated
Only for 5MW or higher
Shopping participation capped
Nevada – (deregulation pending)
Not Active
Suspended

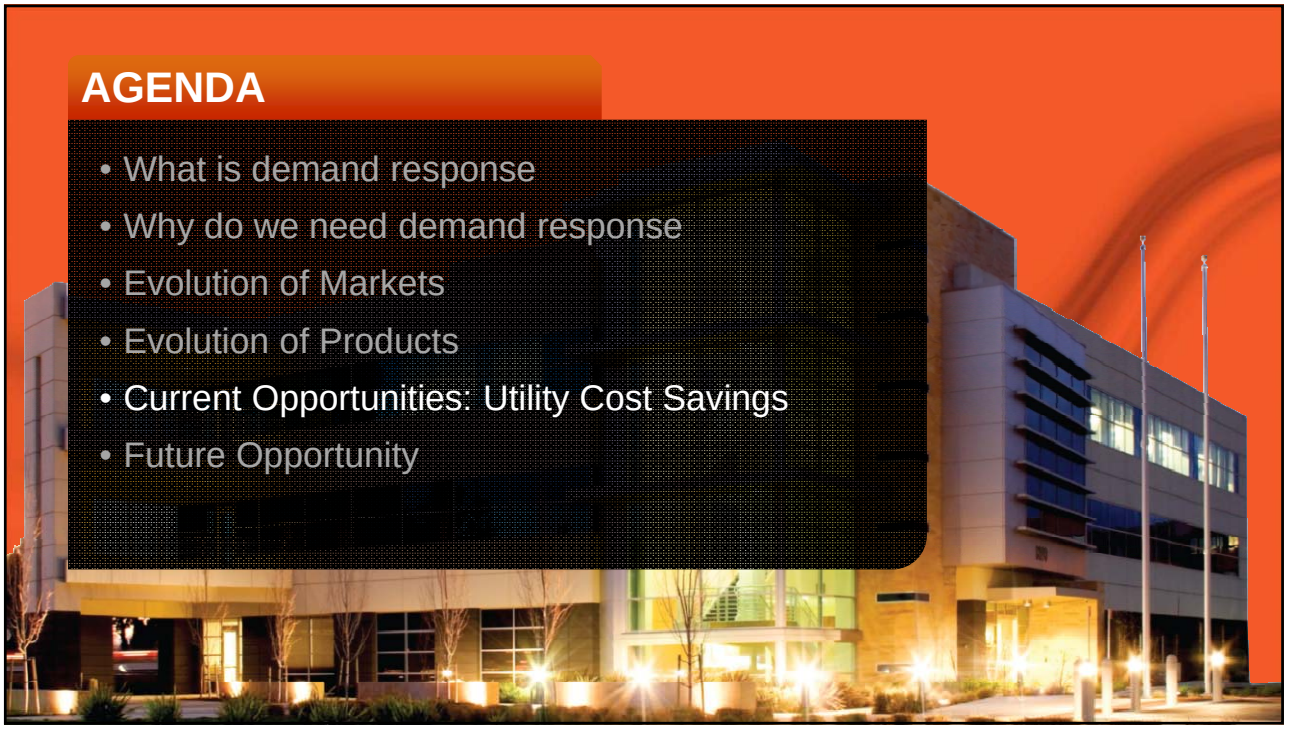

Deregulation & Markets
Regulated market
Deregulated market
POWERCO
Transmission
Generation
Distribution
GENCO
TRANSCO
DISTCO
Operated by Utility
Operated by RTO

What's the Difference for DR?

- Regulated states:
  Utility is the only opportunity
- De-regulated states:
  Utility and grid operator opportunities
- Both:
  Opportunities to reduce costs by controlling demand
- Grid operator/de-regulated markets:
  Opportunities to generate revenue

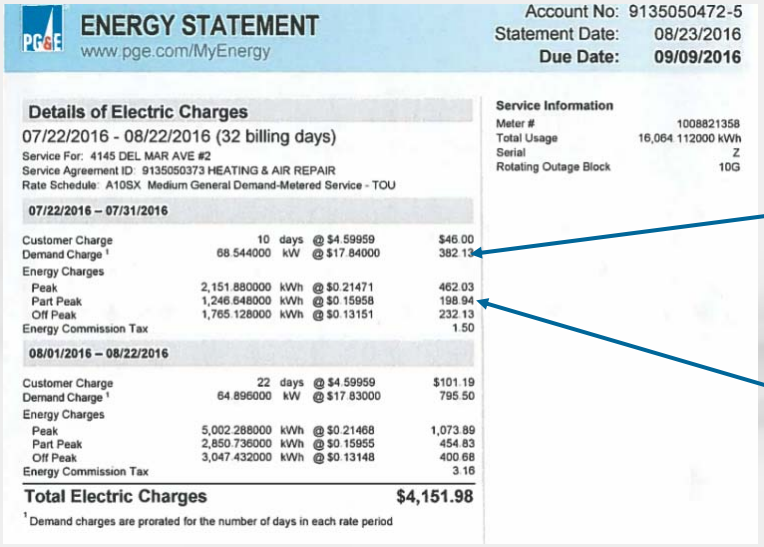
Market Differences

	?	DR Aggregation
Revenue		
Cost savings	Demand Response Demand Reduction Tariff Management Energy Conservation	Peak Load Management Demand/Capacity Reduction Power Purchasing Energy Conservation
	Regulated markets	Deregulated markets


AGENDA
• What is demand response
• Why do we need demand response
• Evolution of Markets
• Evolution of Products
• Current Opportunities: Utility Cost Savings
• Future Opportunity


IN ALL POWER MARKETS
Cost savings opportunities are available from your local electric utility.

Most basic is just lower your demand



ENERGY STATEMENT
www.pge.com/MyEnergy

Account No: 9135050472-5
Statement Date: 08/23/2016
Due Date: 09/09/2016

Details of Electric Charges
07/22/2016 - 08/22/2016 (32 billing days)
Service For: 4145 DEL MAR AVE #2
Service Agreement ID: 9135050373 HEATING & AIR REPAIR
Rate Schedule: A10SX Medium General Demand-Metered Service - TOU

Service Information

Meter #	1008821358
Total Usage	16,064.112000 kWh
Serial	Z
Rotating Outage Block	10G

07/22/2016 – 07/31/2016

Customer Charge	10 days	@ $4.59959	$46.00
Demand Charge [1]	68.544000 kW	@ $17.84000	382.13
Energy Charges			
Peak	2,151.880000 kWh	@ $0.21471	462.03
Part Peak	1,246.648000 kWh	@ $0.15958	198.94
Off Peak	1,765.128000 kWh	@ $0.13151	232.13
Energy Commission Tax			1.50

08/01/2016 – 08/22/2016

Customer Charge	22 days	@ $4.59959	$101.19
Demand Charge [1]	64.896000 kW	@ $17.83000	795.50
Energy Charges			
Peak	5,002.288000 kWh	@ $0.21468	1,073.89
Part Peak	2,850.736000 kWh	@ $0.15955	454.83
Off Peak	3,047.432000 kWh	@ $0.13148	400.68
Energy Commission Tax			3.16

Total Electric Charges **$4,151.98**

[1] Demand charges are prorated for the number of days in each rate period

Based on summer demand

Based on consumption during on-peak hours

Utility DR Opportunity

Large commercial customers

LG&E and KU also offer a demand response program at no additional cost to large commercial customers who can support automated load management reductions.

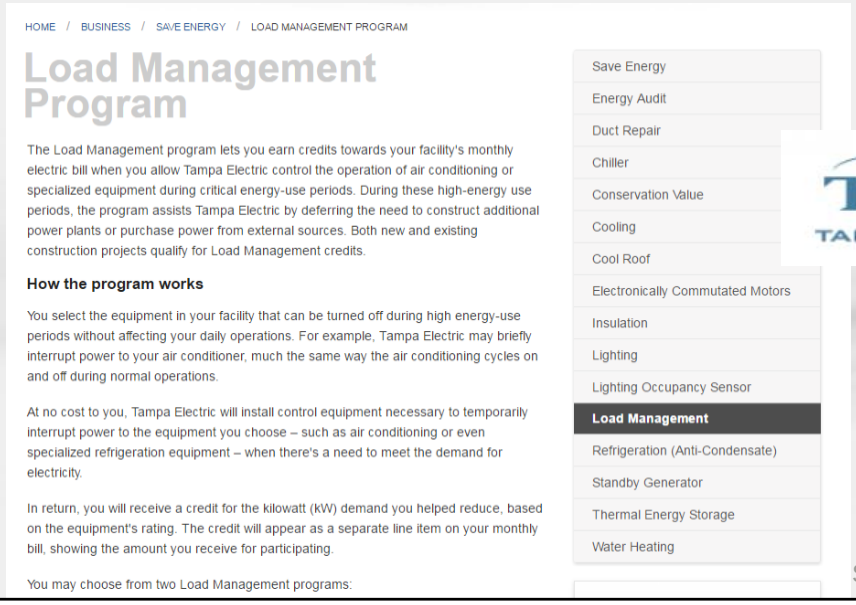
Customers can earn monetary incentives participating in our Commercial Demand Conservation program. We help participants customize energy-reduction plans that help lessen the overall demand on the electric system for brief periods of time on particularly hot days during the summer. This helps lower energy consumption so utilities can better manage peak-load on its electric system.

This program offering is available through a partnership with EnerNOC – a leading provider of energy intelligence software and demand response solutions. Participating customers must commit to curtailing at least 50 kilowatts per dispatch event and can earn up to $25 per kilowatt-year based on their energy reductions. Events may be scheduled in the months of June, July, August and September.

LG&E®

Source: www.lge-ku.com

Utility DR Opportunity

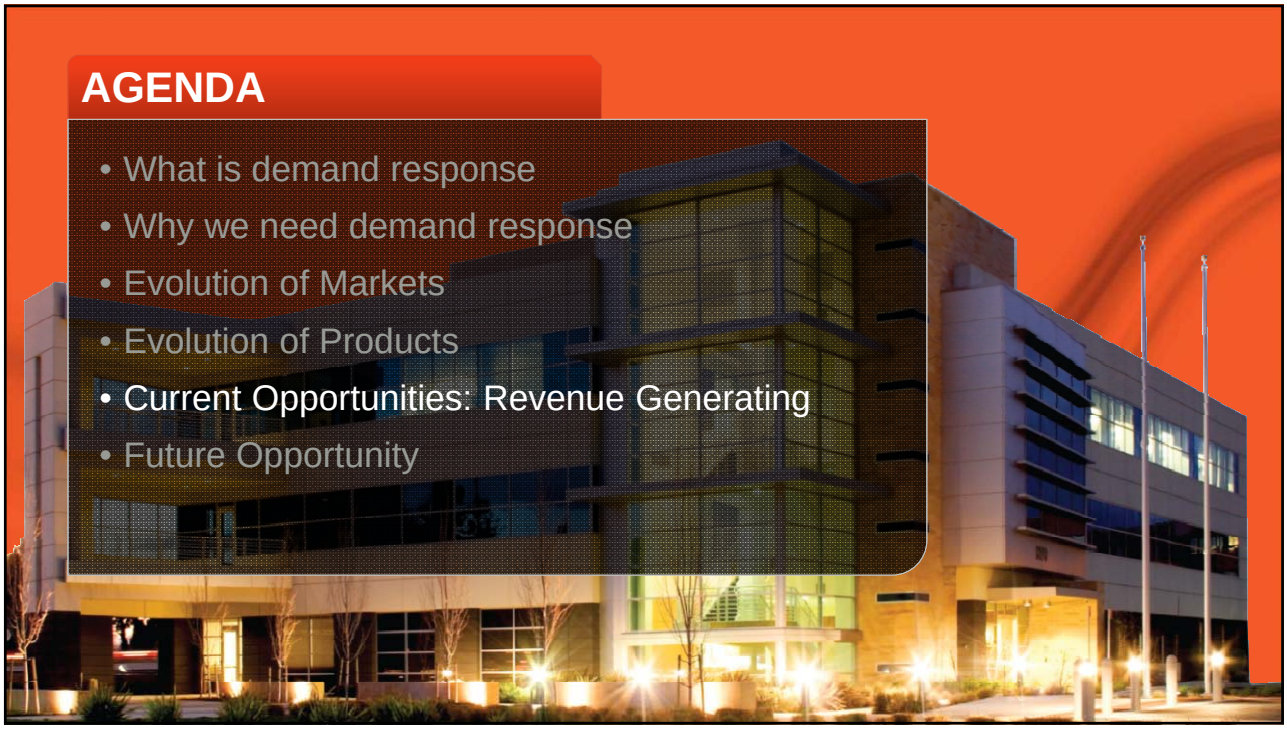


Source: www.tampaelectric.com

Summary

DR for Local Utilities

Type	Availability	Structure	Opportunity Size (estimate)	Cash Flow	Partner
Demand Management	Monthly	No Contract	$2 - $30 per kW month	Savings to Bill	Utility
Utility DR	Utility Dependent	Contract Likely	$20 - $30 per kW annually	Savings to Bill	Utility



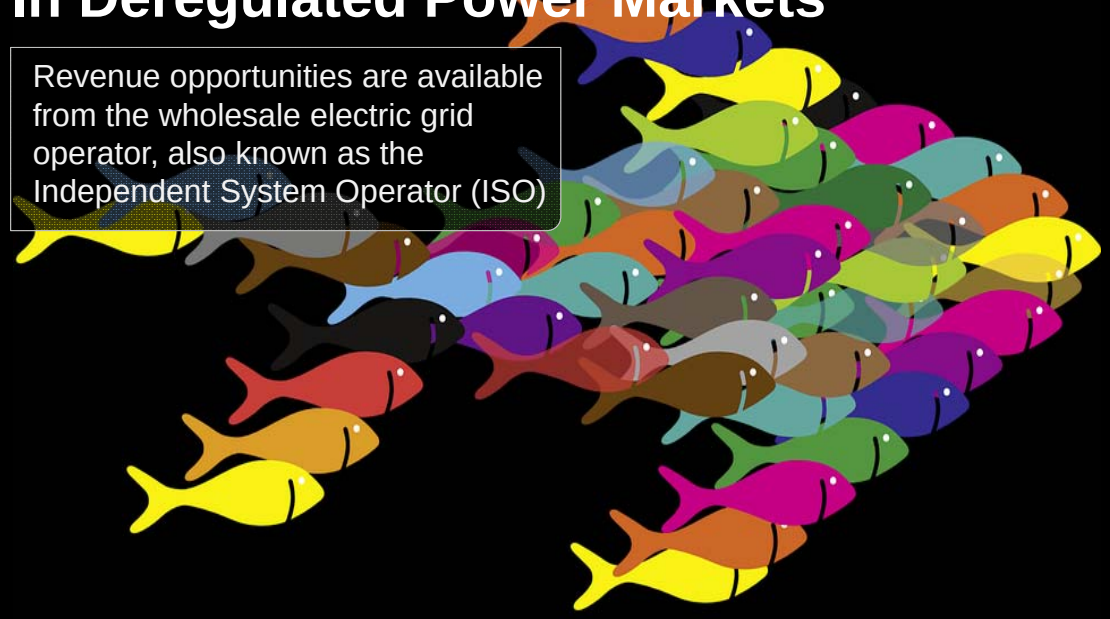
Grid Products and Their Solutions

Grid Products	Response Time	Traditional Solutions	Alternative Solutions
Capacity	Hourly Schedule	• Nuclear • Coal • Hydro • Combined Cycle • Gas Peaker	• Controllable building loads • Batteries • Thermal storage • Compressed Air • Pumped storage • Flywheels
Energy	Hourly Schedule		
Ancillary Services			
30 Minute Reserves	30 Minutes		
10 Minute Reserves	10 Minutes		
Load Following	5 Minutes		
Regulating Reserves	2-4 Seconds		
Frequency Response	0.2-0.5 Seconds		

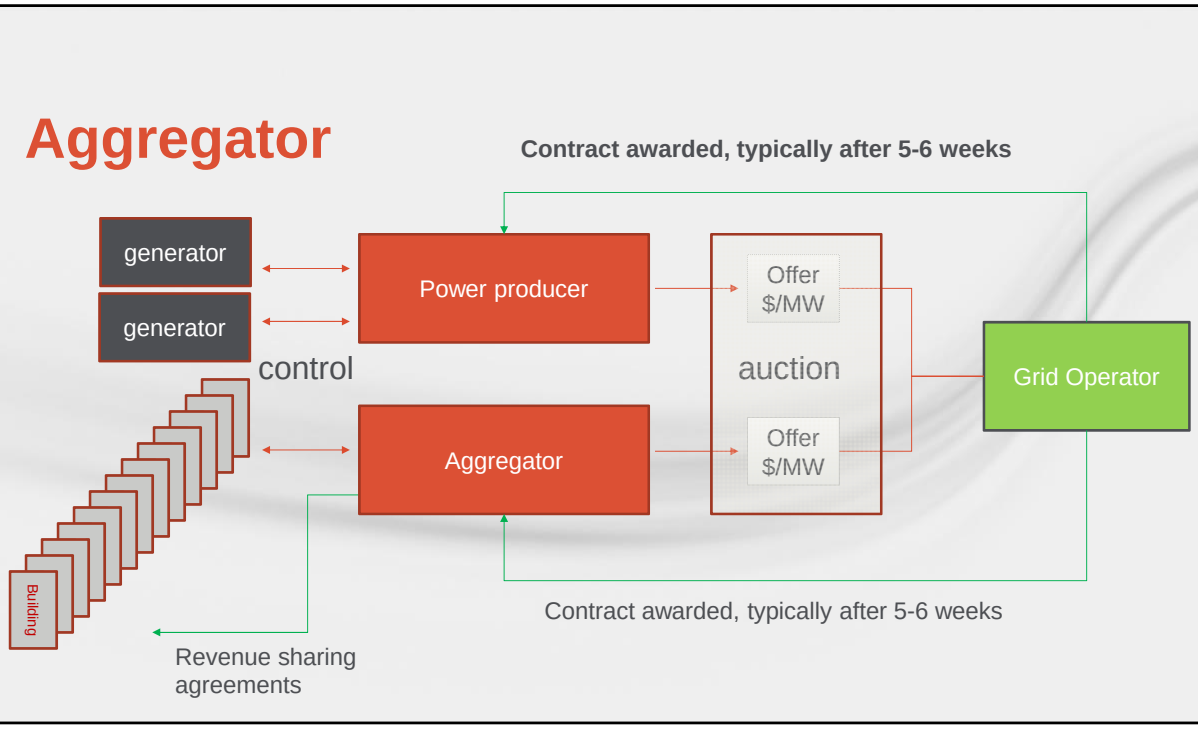
Behind the meter solutions

In Deregulated Power Markets

Revenue opportunities are available from the wholesale electric grid operator, also known as the Independent System Operator (ISO)



Aggregator

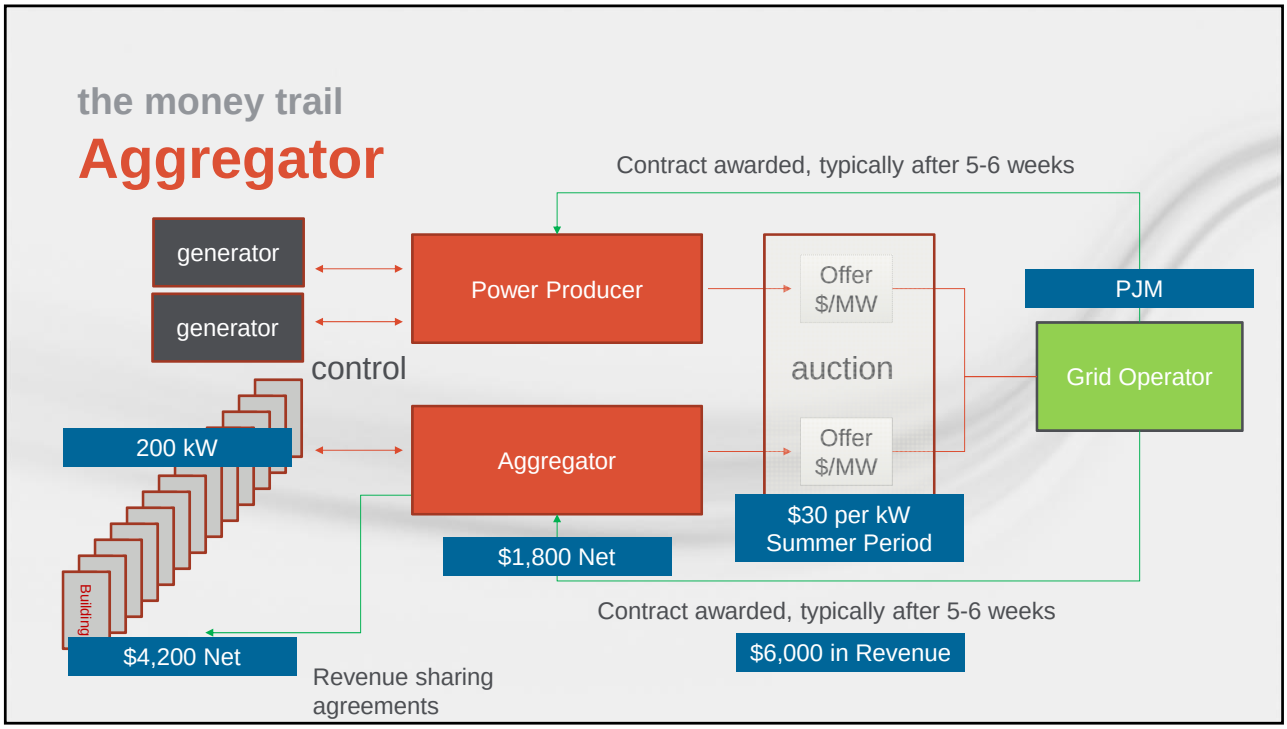


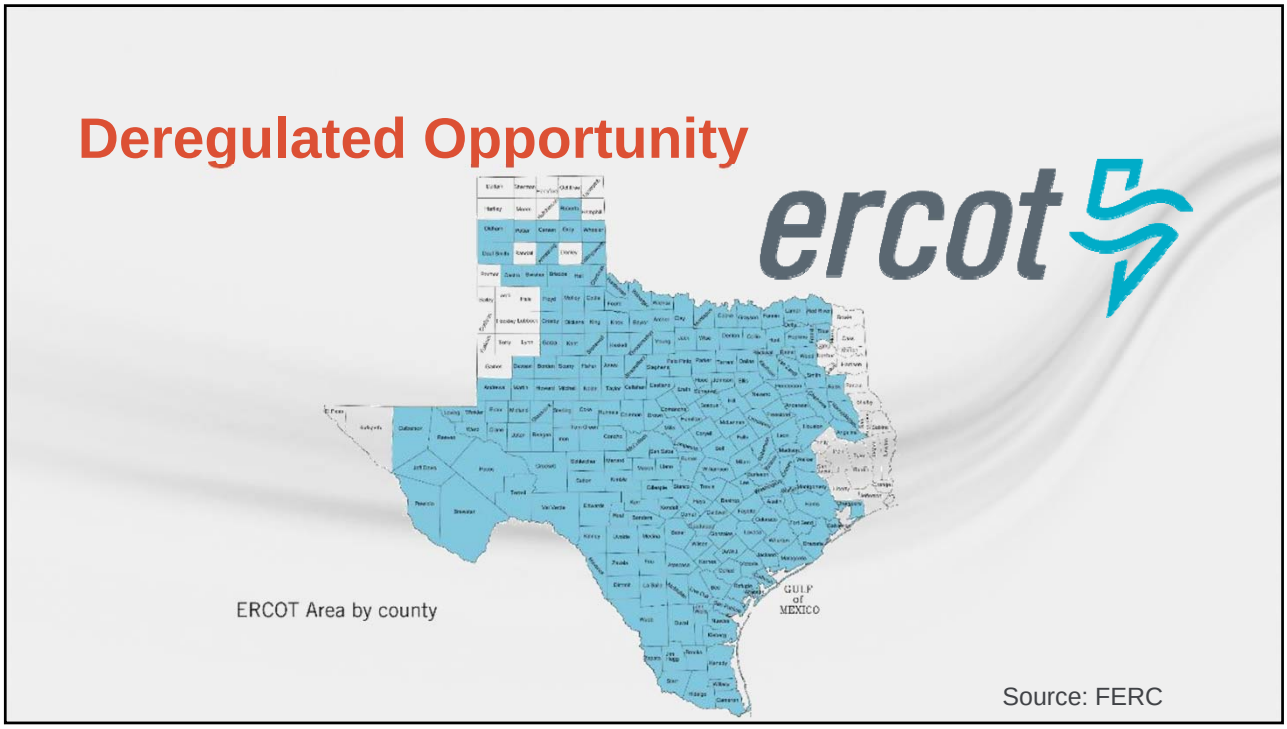
DEREGULATED DR OPPORTUNITY

pjm®

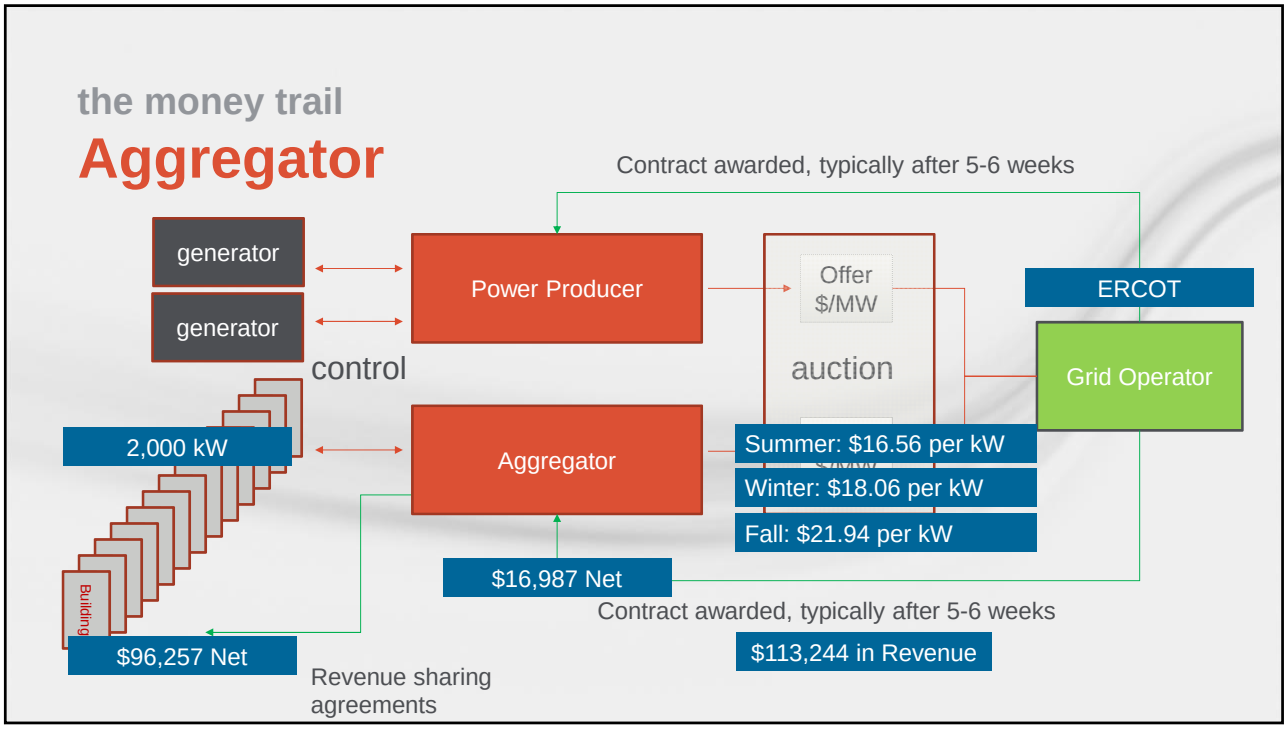
Pennsylvania school

- Contract: 70 percent of DR revenue
- 200 kW summer participation
- Plan: shutting off lights and cycling chillers
- Net ~$4,200 annually


the money trail
Aggregator
Contract awarded, typically after 5-6 weeks
generator
generator
control
Power Producer
Offer $/MW
auction
PJM
Grid Operator
200 kW
Aggregator
Offer $/MW
$30 per kW Summer Period
$1,800 Net
Building
$4,200 Net
Revenue sharing agreements
Contract awarded, typically after 5-6 weeks
$6,000 in Revenue


Deregulated Opportunity
ercot
ERCOT Area by county
GULF of MEXICO
Source: FERC


Dallas manufacturer
• Contract: 90% of DR revenue
• 2,000 kW 24-hour load response
• Plan: Deploy back-up on-site generators
• Net ~$94,000 annually


the money trail
Aggregator
Contract awarded, typically after 5-6 weeks
generator
generator
control
Power Producer
Offer $/MW
auction
ERCOT
Grid Operator
2,000 kW
Aggregator
Summer: $16.56 per kW
Winter: $18.06 per kW
Fall: $21.94 per kW
$16,987 Net
Contract awarded, typically after 5-6 weeks
$113,244 in Revenue
Building
$96,257 Net
Revenue sharing agreements

Summary

Grid Operator DR with Revenue

Type	Availability	Structure	Opportunity Size (estimate)	Cash Flow	Partner
Grid Demand Response	All Year	Contract	$15 - $50 per kW per period	Revenue	Aggregator

AGENDA

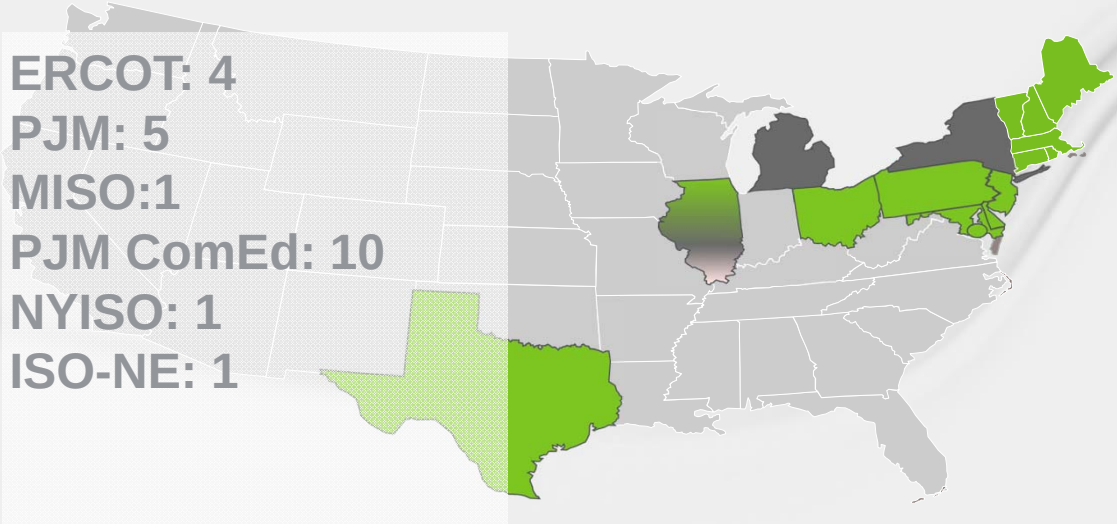
- What is demand response
- Why we need demand response
- Evolution of Markets
- Evolution of Products
- Current Opportunities: Supplier Cost Savings
- Future Opportunity

Grid Operator Charges

Wholesale electric grid operators assess costs to end-users based on the building's demand during their system peak(s)

Coincidental Peaks Events

ERCOT: 4
PJM: 5
MISO:1
PJM ComEd: 10
NYISO: 1
ISO-NE: 1



Billing of Grid Operator Charges

- Costs of coincidental peak demand are charged through the electricity supplier
- Many times presented as a fixed $/kWh rate
- Limits price transparency and visibility to opportunity

Peal Load Management

Reduce Capacity Charges

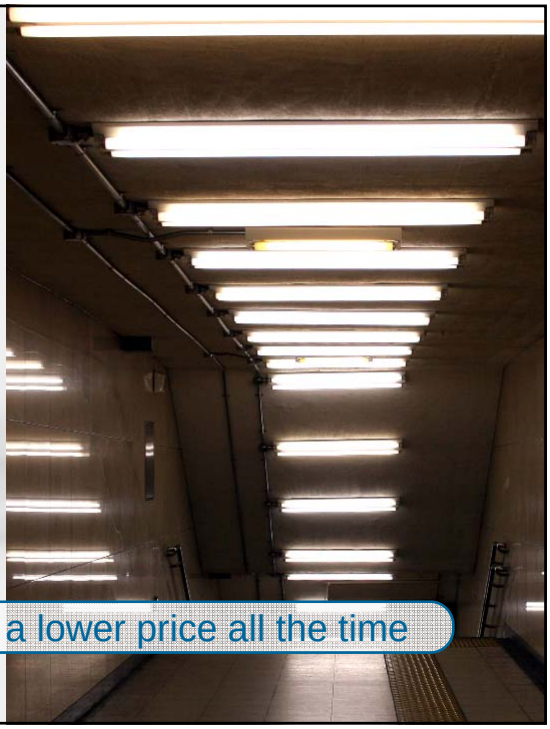
Passive methods avoid or reduce energy demand

- For example from 3-6 pm in the summer
- Thermal storage – automated, no compromise
- Chiller retrofit – compressor change out
- Last year's lighting retrofit

Peak Load Management
Reduce Capacity Charges

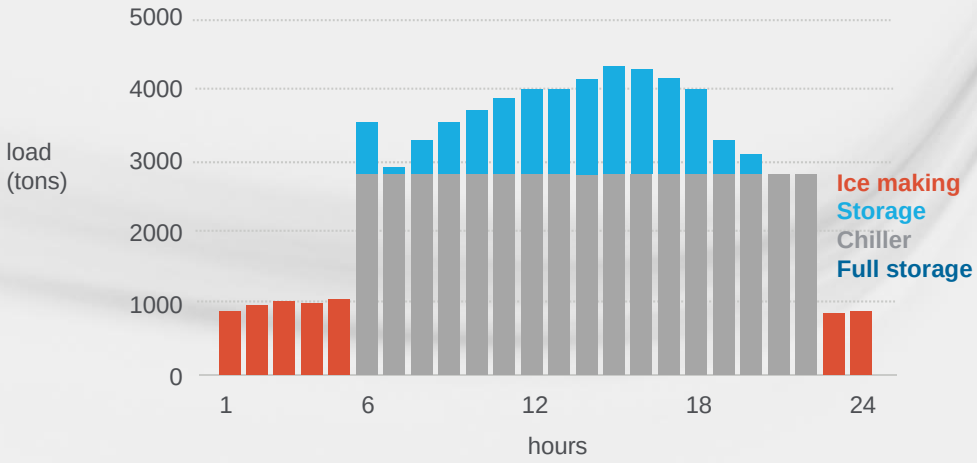
Proactive/reactive methods – operational, not equipment based

- Shutting off equipment
- Demand/Amp limiting chillers
- Turning off lights
- Process control



Curtailment, interruptible rates – a lower price all the time

Reduce Capacity Charges

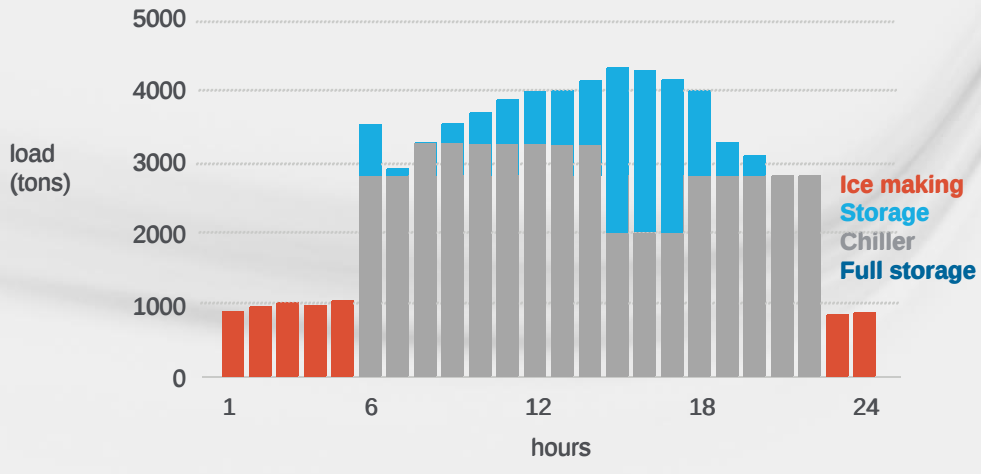


Reduce Capacity Charges

Avoid or reduce energy demand – every day

- On peak rates
- e.g. 3-6 pm in summer
- 6-10 am in winter
- Thermal storage – automated, no compromise
- Chiller retrofit – compressor change out, upgrades
- Last year's lighting retrofit

Reduce capacity charges

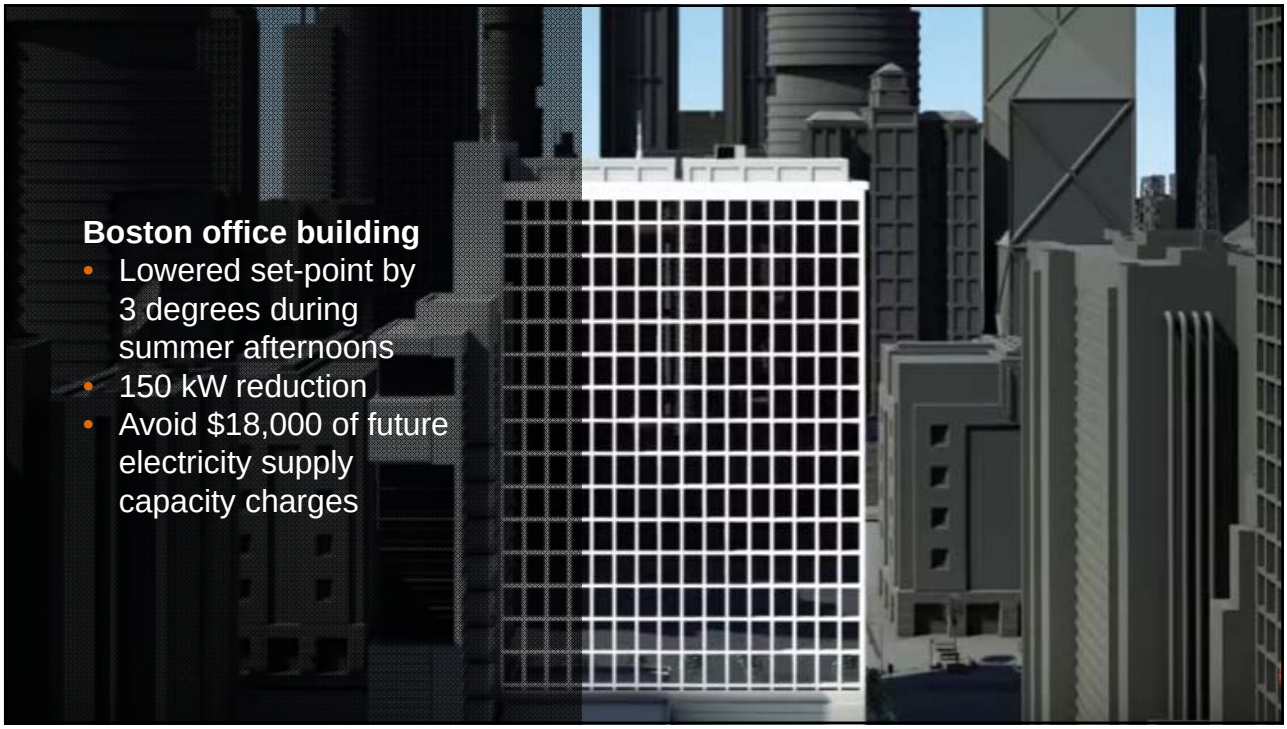


Reduce capacity charges

Proactive/reactive methods – in response to signal or hunch
Shutting off equipment

- Demand/amp limiting chillers
- Turning off lights
- Controlled duty cycling
- Process control
- Conserving stored energy

Onsite power generation
Curtailment, interruptible rates – a lower price all the time



Year	Annual Usage (kWh)	Coincidental Peak (kW)	2017 Capacity Cost (kW Month)	Annual Cost	$/kWh
2015	2,870,000	820	$15.00	$147,600	$0.0514
2016	2,870,000	658	$15.00	$118,440	$0.0412

- Reduced demand 162 kW on August 12, 2016 3:00 – 4:00 PM
- Saved $29,160 on their 2017 electricity supply costs.

summary

Grid Operator DR for Cost Management

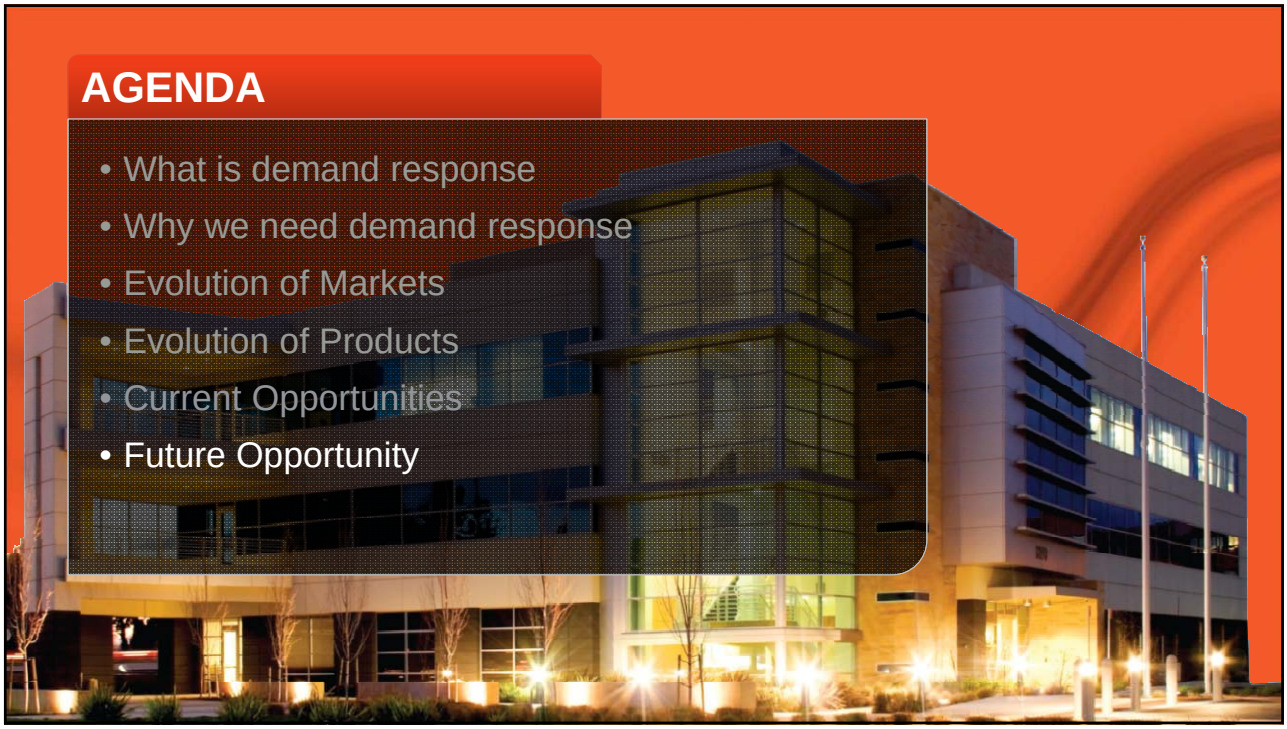
Type	Availability	Structure	Opportunity Size (estimate)	Cash Flow	Partner
Grid Cost Management	Summer	No Contract	$15 - $150 per kW annually	Savings to Supply Bill	Consultant

summary

Demand Response Opportunities

Type	Availability	Structure	Opportunity Size (estimate)	Cash Flow	Partner
Demand Management	Monthly	No Contract	$2 - $30 per kW month	Savings to Bill	Utility
Utility DR	Utility Dependent	Contract Likely	$20 - $30 per kW annually	Savings to Bill	Utility
Grid Demand Response	All Year	Contract	$15 - $50 per kW per period	Revenue	Aggregator
Grid Cost Management	Summer	No Contract	$15 - $150 per kW annually	Savings to Supply Bill	Consultant

AGENDA



- What is demand response
- Why we need demand response
- Evolution of Markets
- Evolution of Products
- Current Opportunities
- Future Opportunity

Buildings Vs. Generation as a Resource

FERC 719 Says Buildings Can Participate

Every Commission-approved independent system operator or regional transmission organization that operates organized markets based on competitive bidding for energy imbalance, spinning reserves, supplemental reserves, reactive power and voltage control, or regulation and frequency response ancillary services

…. must accept bids from demand response resources in these markets for that product on a basis comparable to any other resources, if the demand response resource meets the necessary technical requirements under the tariff….

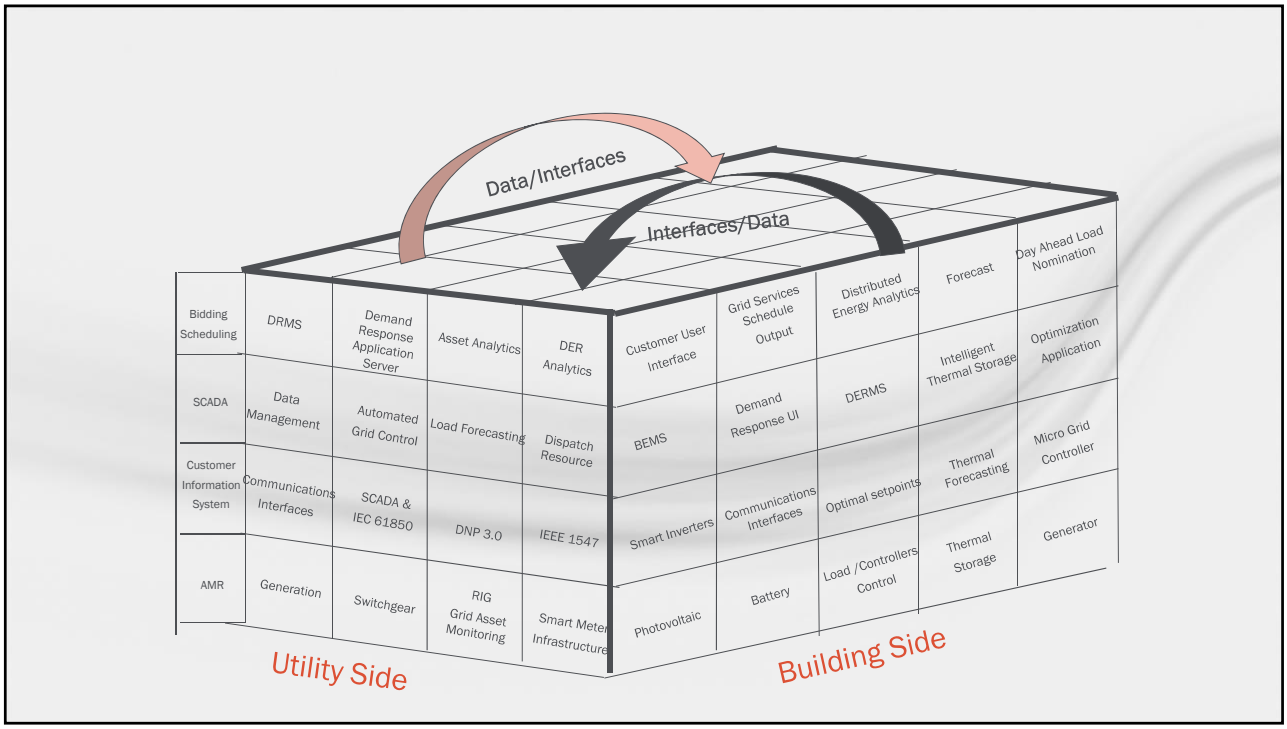
Load Acting as a Resource

Grid Products	Response Time	Traditional Solutions	Alternative Solutions
Capacity	Hourly Schedule	• Nuclear • Coal • Hydro • Combined Cycle • Gas Peaker	• Controllable building loads • Batteries • Thermal storage • Compressed Air • Pumped storage • Flywheels
Energy	Hourly Schedule		
Ancillary Services			
30 Minute Reserves	30 Minutes		
10 Minute Reserves	10 Minutes		
Load Following	5 Minutes		
Regulating Reserves	2-4 Seconds		
Frequency Response	0.2-0.5 Seconds		

Behind the meter solutions

Storage and Onsite Systems

	Frequency Response 0 – 30 seconds	*Regulation 4 seconds – 5 minutes*	*Spinning Reserve 10 mins – 105 mins*	*Non Spinning Reserve 10 mins – 105 mins*	*Other*
ERCOT	Primary frequency response is not an Ancillary Service Market Product. All online Generation Resources must have their turbine governors in service and unblocked.	Regulation is deployed through ERCOT's EMS system. The MW requirement for each hour of the day is determined monthly. The amount of MWs procured is based on the amount historically deployed and the amount of time in which	ERCOT maintains a 10 minute eserve service of at least 2300 MW. This is for normal conditions and can go up to 2800 MW. Demand side resources can provide up to 50% of this MW requirement. It may be provided from the following: ➢ Unloaded Generation Resources that are On-line, ➢ Resources controlled by high set under-frequency relays, or ➢ Direct Current (DC) tie-line response. The DC tie-line response must be fully deployed within fifteen (15) seconds on the ERCOT System after the under frequency event. These reserves are maintained by ERCOT to restore the frequency of the ERCOT system within the first few minutes of an event that causes a significant deviation from the standard frequency. Load following energy and Non-spin reserves will be deployed as a practicable and if necessary to minimize the use of the 10	Like Regulation the MW requirement for Non-spinning reserves is calculated for each hour of the day each month. Historical wind forecast errors and load forecast errors are used in determining the MW values. Non-spinning reserve service is a 30 minute product and is provided by : ➢ Off-line	Primary frequency response is not an Ancillary Service Market Product. All online Generation Resources must have their turbine governors in service and unblocked.



Summary

- Things we can do today, with systems we already have
  - Save money/make money by manipulating energy use
  - Pool with others through aggregators
  - Partner with energy experts to predict and respond to peak events before they occur
- Things we can improve today
  - Install and upgrade equipment and controls
  - Install energy storage and energy generation assets

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Trane *Engineers Newsletter LIVE:* Demand Response in Commercial Buildings
APP-CMC064-EN QUIZ

1. This ENL classified motivation for demand response into three categories; stability, reliability and financial.
    a. True
    b. False

2. Less than 1 percent of the customers in the industrial segment contribute over 54 percent of overall demand reduction.
    a. True
    b. False

3. Which of the following are revenue opportunity programs currently available?
    a. Emergency standby
    b. Economic curtailment
    c. Stabilization
    d. Mandatory curtailment

4. In a regulated market the utility is vertically integrated meaning they own, control and are responsible for generation, transmission and distribution of electricity.
    a. True
    b. False

5. Coincidental peak is a customer's demand during a grid operator's peak event or events.
    a. True
    b. False