Demand Response in Commercial Buildings
Presenters: Matt Bye, Susanna Hanson, Trevor Joelson and Chuck Lanager with Jeanne Harshaw (host)
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
 Stranger biographies

**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.
Demand Response in Commercial Buildings
Trane Engineers Newsletter Live Series

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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
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- Future Opportunity

Power:
Generated, Transmitted, Distributed
Power:
Generated, Transmitted, Distributed

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.”
Demand Response Definition

- Expected consumption
- Increase in price
- Reduction in consumption
- Growing need for flexibility in consumption

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
- What is demand response
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Grid Operators Need Demand Response

- Maintain system reliability
- Delay system expansion
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

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
Renewables’ Impact on Grid Financials

Players and Their Parts

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

Key State Regulatory and Legislative Energy Storage Policies and Actions

(As of Q3 2010)

- **California**: Energy Storage Framework and Placement Planning
- **Washington**: Energy Storage (13.008)
- **New York**: Renewing the Energy Vision
- **Massachusetts**: E-12 MM Energy Storage Initiative
- **New Jersey**: Investigation into Energy Storage
- **North Carolina**: Duke Energy Storage Pilot
- **Oregon**: Energy Storage Program (SB 1098)
- **Pennsylvania**: Act 43 of 2010

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Demand Response in Commercial Buildings
AGENDA

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

Market Segment Characteristics

<table>
<thead>
<tr>
<th></th>
<th>residential</th>
<th>commercial</th>
<th>industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers enrolled</td>
<td>93%</td>
<td>61%</td>
<td>20%</td>
</tr>
<tr>
<td>Energy savings (MWh)</td>
<td>51%</td>
<td>32%</td>
<td>6%</td>
</tr>
<tr>
<td>Actual peak demand savings (MW)</td>
<td>21%</td>
<td>54%</td>
<td></td>
</tr>
<tr>
<td>Customer incentives (dollars)</td>
<td>29%</td>
<td>23%</td>
<td>43%</td>
</tr>
</tbody>
</table>

- 9.3 million customers enrolled
- 1.4 million MWh energy savings
- 12,700 MW actual peak demand savings
- $1.2 billion customer incentives

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demand response

Residential Programs

- Water heater
- HVAC
- Passive
- Utility driven

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

<table>
<thead>
<tr>
<th>Lodging</th>
<th>Healthcare</th>
<th>Office Space</th>
<th>Warehouse</th>
<th>Education</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>158,000</td>
<td>157,000</td>
<td>1,012,000</td>
<td>796,000</td>
<td>389,000</td>
<td>3 Million+</td>
</tr>
</tbody>
</table>

Aggregated fleets of buildings could provide nearly 188GW of peak reduction potential.

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

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...

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

Lodging 300 kW
Hospital 500 kW
Office Space 100 kW
## AGENDA
- What is demand response
- Why do we need demand response
- Evolution of Markets
- Evolution of Products
- Current Opportunities
- Future Opportunity

## Grid Products

<table>
<thead>
<tr>
<th>Grid Products</th>
<th>Response Time</th>
<th>Traditional Solutions</th>
<th>Alternative Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>Hourly Schedule</td>
<td>• Nuclear</td>
<td>• Controllable building loads</td>
</tr>
<tr>
<td>Energy</td>
<td>Hourly Schedule</td>
<td>• Coal</td>
<td>• Batteries</td>
</tr>
<tr>
<td>Ancillary Services</td>
<td></td>
<td>• Hydro</td>
<td>• Thermal storage</td>
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<td>30 Minute Reserves</td>
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<td>10 Minutes</td>
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<td>• Pumped storage</td>
</tr>
<tr>
<td>Load Following</td>
<td>5 Minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulating Reserves</td>
<td>2-4 Seconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency Response</td>
<td>0.2-0.5 Seconds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **traditional demand response**
- **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

Involuntary

Then

Business hours
6 pm to 8 am, M-F
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

Hourly electricity demand and real-time energy prices in the PJM Interconnection
Saturday, July 13 - Friday, July 19, 2013

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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

Regional Transmission Organizations

Source: Energy Velocity
February 2014
Retail electricity restructuring by state

Deregulation & Markets

Regulated market

Deregulated market

POWERCO

Generation

Transmission

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

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### Market Differences

<table>
<thead>
<tr>
<th>Revenue</th>
<th>DR Aggregation</th>
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<tbody>
<tr>
<td>Cost savings</td>
<td>Demand Response</td>
</tr>
<tr>
<td></td>
<td>Demand Reduction</td>
</tr>
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<td></td>
<td>Tariff Management</td>
</tr>
<tr>
<td></td>
<td>Energy Conservation</td>
</tr>
</tbody>
</table>

**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
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.

Source: www.lge-ku.com
Utility DR Opportunity

Load Management Program

The Load Management program lets you earn credits towards your facility's monthly electric bill when you allow Tampa Electric to control the operation of air conditioning or specialized equipment during critical energy-use periods. During these high-energy-use periods, the program allows Tampa Electric by deferring the need to construct additional power plants or purchase power from external sources. Both new and existing construction projects qualify for Load Management credits.

How the program works

You select the equipment in your facility that can be turned off during high energy-use periods without affecting your daily operations. For example, Tampa Electric may briefly interrupt power to your air conditioner, much the same way the air conditioning cycles on and off during normal operations.

At no cost to you, Tampa Electric will install control equipment necessary to temporarily interrupt power to the equipment you choose - such as air conditioning or even specialized refrigeration equipment - when there's a need to meet the demand for electricity.

In return, you will receive a credit for the kilowatt (kW) demand you helped reduce, based on the equipment's rating. The credit will appear as a separate line item on your monthly bill, showing the amount you receive for participating.

You may choose from two Load Management programs.

<table>
<thead>
<tr>
<th>Type</th>
<th>Availability</th>
<th>Structure</th>
<th>Opportunity Size (estimate)</th>
<th>Cash Flow</th>
<th>Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Management</td>
<td>Monthly</td>
<td>No Contract</td>
<td>$2 - $30 per kW month</td>
<td>Savings to Bill</td>
<td>Utility</td>
</tr>
<tr>
<td>Utility DR</td>
<td>Utility Dependent</td>
<td>Contract Likely</td>
<td>$20 - $30 per kW annually</td>
<td>Savings to Bill</td>
<td>Utility</td>
</tr>
</tbody>
</table>

Summary

DR for Local Utilities

Source: www.tampaelectric.com
AGENDA

• What is demand response
• Why we need demand response
• Evolution of Markets
• Evolution of Products
• Current Opportunities: Revenue Generating
• Future Opportunity

Grid Products and Their Solutions

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<td></td>
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</table>
Revenue opportunities are available from the wholesale electric grid operator, also known as the Independent System Operator (ISO) in Deregulated Power Markets.

Aggregator

Contract awarded, typically after 5-6 weeks

Revenue sharing agreements

Power producer

Offer $/MW

Auction

Grid Operator

Offer $/MW

Contract awarded, typically after 5-6 weeks
DEREGULATED DR OPPORTUNITY

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

Power Producer

Grid Operator

PJM


generator

generator

control

200 kW

$4,200 Net

Revenue sharing agreements

$1,800 Net

Contract awarded, typically after 5-6 weeks

Contract awarded, typically after 5-6 weeks

Offer $/MW

Offer $/MW

$30 per kW Summer Period

$6,000 in Revenue

Deregulated Opportunity

ERCOT Area by county

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
- Generator control
- 2,000 kW
- $96,257 Net Revenue sharing agreements

Power Producer
- Offer $/MW
- Summer: $16.56 per kW
- Winter: $18.06 per kW
- Fall: $21.94 per kW
- $16,987 Net

Aggregator
- Contract awarded, typically after 5-6 weeks

ERCOT
- Grid Operator
- $113,244 in Revenue
- Contract awarded, typically after 5-6 weeks
Summary

Grid Operator DR with Revenue

<table>
<thead>
<tr>
<th>Type</th>
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<th>Structure</th>
<th>Opportunity Size (estimate)</th>
<th>Cash Flow</th>
<th>Partner</th>
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</thead>
<tbody>
<tr>
<td>Grid Demand Response</td>
<td>All Year</td>
<td>Contract</td>
<td>$15 - $50 per kW per period</td>
<td>Revenue</td>
<td>Aggregator</td>
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</tbody>
</table>

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

![Graph showing reduce capacity charges over time](image)
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

![Graph showing load (tons) over hours]

- Ice making
- Storage
- Chiller
- Full storage
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

Boston office building
• Lowered set-point by 3 degrees during summer afternoons
• 150 kW reduction
• Avoid $18,000 of future electricity supply capacity charges
<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Usage (kWh)</th>
<th>Coincidental Peak (kW)</th>
<th>2017 Capacity Cost (kW Month)</th>
<th>Annual Cost</th>
<th>$/kWh</th>
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<tbody>
<tr>
<td>2015</td>
<td>2,870,000</td>
<td>820</td>
<td>$15.00</td>
<td>$147,600</td>
<td>$0.0514</td>
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<tr>
<td>2016</td>
<td>2,870,000</td>
<td>658</td>
<td>$15.00</td>
<td>$118,440</td>
<td>$0.0412</td>
</tr>
</tbody>
</table>

- 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**

<table>
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<tr>
<th>Type</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Grid Cost Management</td>
<td>Summer</td>
<td>No Contract</td>
<td>$15 - $150 per kW annually</td>
<td>Savings to Supply Bill</td>
<td>Consultant</td>
</tr>
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</table>
### Demand Response Opportunities

<table>
<thead>
<tr>
<th>Type</th>
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<td>Monthly</td>
<td>No Contract</td>
<td>$2 - $30 per kW month</td>
<td>Savings to Bill</td>
<td>Utility</td>
</tr>
<tr>
<td>Utility DR</td>
<td>Utility Dependent</td>
<td>Contract Likely</td>
<td>$20 - $30 per kW annually</td>
<td>Savings to Bill</td>
<td>Utility</td>
</tr>
<tr>
<td>Grid Demand Response</td>
<td>All Year</td>
<td>Contract</td>
<td>$15 - $50 per kW per period</td>
<td>Revenue</td>
<td>Aggregator</td>
</tr>
<tr>
<td>Grid Cost Management</td>
<td>Summer</td>
<td>No Contract</td>
<td>$15 - $150 per kW annually</td>
<td>Savings to Supply Bill</td>
<td>Consultant</td>
</tr>
</tbody>
</table>

### 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

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

### Storage and Onsite Systems

<table>
<thead>
<tr>
<th>ERCOT</th>
<th>Frequency Response 0-30 seconds</th>
<th>Regulation 4 seconds – 5 minutes</th>
<th>Spinning Reserve 10 mins – 105 mins</th>
<th>Non Spinning Reserve 10 mins – 105 mins</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERCOT</td>
<td>Primary frequency response is not an Ancillary Service Market Product. All online Generation Resources must have their turbine governors in service and unblocked.</td>
<td>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 reserve service of at least 2300 MW. This is for normal conditions and can go up to 2600 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</td>
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</tr>
</tbody>
</table>

Behind the meter solutions
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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- Coil Selection and Optimization
- Ice Storage Design and Control
- All Variable-Speed Chiller Plant Operation
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