Grid Modernization: The Role of Grid-Interactive Efficient Buildings

Wednesday, July 10th, 2019
1:30–3:00 pm
Grid-interactive Efficient Buildings Summary
Better Buildings Summit

Monica Neukomm
Building Technologies Office, DOE
www.energy.gov/eere/buildings/geb
Key Characteristics of GEB

**EFFICIENT**
Persistent low energy use minimizes demand on grid resources and infrastructure

**CONNECTED**
Two-way communication with flexible technologies, the grid, and occupants

**SMART**
Analytics supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences

**FLEXIBLE**
Flexible loads and distributed generation/storage can be used to reduce, shift, or modulate energy use
Grid-interactive Efficient Building

- Different technology options than EE
- Interaction between technologies increase in importance
- Greater focus on cyber and interoperability than needed for EE
- Disruptive technology considerations
- Greater focus on occupant needs
- Need for new ways to assess and validate performance and value
- Optimization/Integration considerations outside traditional building technologies
- Different regulatory issues than EE
**Definitions**

| Grid-interactive Efficient Building (GEB) | An energy efficient building with smart technologies characterized by the active use of DERs to optimize energy use for grid services, occupant needs and preferences, and cost reductions in a continuous and integrated way |
| Demand Flexibility | Capability provided by DERs to reduce, shed, shift, modulate or generate electricity; energy flexibility and load flexibility are often used interchangeably with demand flexibility |
| Smart Technologies for Energy Management | Advanced controls, sensors, models and analytics used to manage a range of energy assets, while responding to changing ambient and grid conditions, saving energy and meeting occupants requirements |
Demand Flexibility Provided by GEB
# Potential Grid Services Provided by Demand Flexibility in Buildings

<table>
<thead>
<tr>
<th>Grid Services</th>
<th>Potential Avoided Cost</th>
<th>Potential Market Size Addressable by Demand Flexibility in Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generation Services</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation: Energy</td>
<td>Power plant fuel, operation, maintenance, and startup and shutdown costs</td>
<td>Large</td>
</tr>
<tr>
<td>Generation: Capacity</td>
<td>Capital costs for new generating facilities and associated fixed operation and maintenance costs</td>
<td>Large</td>
</tr>
<tr>
<td><strong>Ancillary Services</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contingency Reserves</td>
<td>Power plant fuel, operation, maintenance, and associated opportunity costs</td>
<td>Moderate</td>
</tr>
<tr>
<td>Frequency Regulation</td>
<td>Power plant fuel, operation, maintenance, and opportunity costs associated with providing frequency regulation</td>
<td>Small</td>
</tr>
<tr>
<td>Ramping</td>
<td>Power plant fuel, operation, maintenance, and startup and shutdown costs</td>
<td>Small</td>
</tr>
<tr>
<td><strong>Delivery Services</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non Wires Solutions</td>
<td>Capital costs for transmission &amp; distribution equipment upgrades</td>
<td>Moderate</td>
</tr>
<tr>
<td>Voltage Support</td>
<td>Capital costs for voltage control equipment (e.g., capacitor banks, transformers, smart inverters)</td>
<td>Small</td>
</tr>
</tbody>
</table>
# Mapping Flexibility Modes to Grid Services

<table>
<thead>
<tr>
<th>Flexibility Mode</th>
<th>Grid Services</th>
<th>Description of Building Change</th>
<th>Key Characteristics</th>
</tr>
</thead>
</table>
| **Efficiency**   | Generation: Energy Generation: Capacity T&D: Non-Wires Solutions | Persistent reduction in load. Interval data may be needed for M&V purposes. This is not a dispatchable service. | Duration: Continuous  
Load Change: Long term decrease  
Response Time: N/A  
Event Frequency: Lifetime of equipment |
| **Shed Load**    | Contingency Reserves | Load reduction for a short time to make up for a shortfall in generation. | Duration: Up to 1 hr  
Load Change: Short term decrease  
Response Time: <15 min  
Event Frequency: 20 times per year |
|                  | Generation: Energy Generation: Capacity T&D: Non-Wires Solutions | Load reduction during peak periods in response to grid constraints or based on time-of-use (TOU) pricing structures. | Duration: 2 to 4 hrs  
Load Change: Short term decrease  
Response Time: 30 min to 2 hrs  
Event Frequency: <100 hrs per year/seasonal |
BTO’s grid-interactive efficient buildings portfolio

**VALUATION**
How do *time & the interaction of flexibility options* impact value?
Identify values to stakeholders, quantification of national value.

**TECHNOLOGY OPTIONS**
Which *end use technologies* provide solutions to specific grid needs?
Prioritize technologies / solutions based on grid services.

**OPTIMIZATION**
How to maintain or improve services while *optimizing for flexibility*?
Solutions that meet grid operator & building occupant needs.

**VALIDATION**
Do technologies *perform as predicted* and meet grid & occupant needs?
Verification of technologies / strategies, increasing confidence in the value of energy flexibility.
MONICA NEUKOMM
monica.neukomm@ee.doe.gov

Building Technologies Office, U.S. DOE
www.energy.gov/eere/buildings/geb
Seth Coan
Rocky Mountain Institute (RMI)
Grid Modernization:
The Role of Grid-Interactive Efficient Buildings

Smart and Connected Communities
A multi-building energy management approach

| July 10th |

Transforming global energy use to create a clean, prosperous, and secure low carbon future.
Key Questions / Objectives of Study

What is a Smart and Connected Community?

Value propositions of Smart and Connected Communities

Right stakeholders and right business models

Source: https://huntingtonbeachca.gov/residents/sustainable-hb/advanced-energy-community/
Defining SCC by the energy management approaches employed, e.g.

**Working definition:** A SCC incorporates integrated energy management strategies at the multi-building scale, optimizes energy resources across buildings and provides multiple services to the grid.

1. While overlaps between these strategies exist (e.g. Solar is a Renewable Energy Generation strategy and also part of a GEB approach) the categorization of strategies presents the integral approaches to smart and connected communities.
<table>
<thead>
<tr>
<th>Stakeholder / Ownership</th>
<th>Placement of Assets **</th>
<th>Configuration</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility driven</td>
<td>In front of meter</td>
<td>Shared resources</td>
<td>• Grid benefits first</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Consumer benefits second</td>
</tr>
<tr>
<td>Owner/ third party driven</td>
<td>Behind the meter</td>
<td>• Shared resources,</td>
<td>• Consumer benefits first</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Building level resources</td>
<td>• Grid benefits second</td>
</tr>
</tbody>
</table>

** Note: For utility driven projects, there are examples of projects with assets and devices such as BAS or smart thermostats that are behind the meter and under partial control by the utility for demand response or ancillary services.
## Value Propositions of Smart and Connected Communities

Increasing levels of integration unlocks additional value

<table>
<thead>
<tr>
<th>Integration hierarchy</th>
<th>Energy Conservation</th>
<th>Demand Management</th>
<th>Ancillary Services</th>
<th>Resilience</th>
<th>GHG Emissions Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>EE+RE</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>EE+RE+Storage</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>EE+RE+Storage+GEBs (single building)</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>EE+RE+Storage+GEBs (multi-building)</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

○ = Low  ● = High
# Business Case for Smart and Connected

What is the additional value of employing energy strategies that connect multiple buildings?

<table>
<thead>
<tr>
<th>Value Propositions</th>
<th>Value of SCC (multi-building approach)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CAPEX savings</strong></td>
<td>• First cost savings with centrally installed systems (e.g. RE, district thermal, energy storage) by meeting higher % of annual loads per unit of installed capacity</td>
</tr>
<tr>
<td><strong>Energy conservation</strong></td>
<td>• Economies of scale with multiple building energy upgrades</td>
</tr>
<tr>
<td></td>
<td>• Ability to leverage EPSC contracts for energy upgrades</td>
</tr>
<tr>
<td></td>
<td>• District thermal approaches have inherent energy efficiencies</td>
</tr>
<tr>
<td><strong>TOU price arbitrage</strong></td>
<td>• When aggregating load, may be able to change rate schedules</td>
</tr>
<tr>
<td></td>
<td>• For behavioral changes especially in residential, benefits come from automated control</td>
</tr>
<tr>
<td><strong>Demand charge reduction</strong></td>
<td>• Greater diversity in loads; can achieve greater demand charge reduction per unit of installed DER capacity</td>
</tr>
<tr>
<td></td>
<td>• By aggregating the loads of multiple buildings behind one meter, demand charges are reduced (community peak is lower than sum of individual peaks)</td>
</tr>
<tr>
<td><strong>Demand response and ancillary services</strong></td>
<td>• Can aggregate load to participate in a wider variety of demand response programs and events</td>
</tr>
<tr>
<td></td>
<td>• Can participate in wholesale markets to augment the value stack of aggregated resources</td>
</tr>
<tr>
<td><strong>Resiliency</strong></td>
<td>Greater islanding capability per unit of installed capacity</td>
</tr>
<tr>
<td><strong>GHG Reduction</strong></td>
<td>• Can meet higher % of annual loads with on-site renewables per unit of installed capacity</td>
</tr>
<tr>
<td></td>
<td>• Can dispatch aggregated resources to reduce consumption during times of greatest emissions intensity on the grid</td>
</tr>
</tbody>
</table>
**Reynolds Landing**

**Project Type:** Residential, New Construction  
**Location:** Birmingham, Alabama  
**Phase:** Operational as of 2017  
**Project Size:** 62 single family homes

**Key Takeaways**
- Utility driven project to research microgrid and DR program for non-wires alternatives
- Optimizing microgrid for TOU, DR, voltage and frequency regulation, and resilience

**Energy Efficiency Measures**
- Rated 45 on the HERS scale  
- 2x6 exterior walls with R24 blown in fiberglass  
- Carrier Green Speed, 20 SEER heat pump  
- wi-fi integrated heat pump water heater  
- triple pane windows, and LED lighting  
- NEMA 1450 plug in each garage

**Microgrid**
- 400-kW solar PV array,  
- 400-kW natural gas generator  
- 600-kWh battery storage system

**Controls**
- Microgrid controller, Seismic Shock  
- Home energy management, Voltron by ONL
**Project Type:** Commercial, Retrofit  
**Location:** Fort Collins, Colorado  
**Phase:** Operational as of 2012  
**Project Size:** Regional; 10 -15% of FCU distribution

**Key Takeaways**
- Reduce load by almost 5 MW
- Can do more with more buildings, & different use types
- What took 1 year to stand up in 2012 could take a few weeks today
- Partnerships with shared benefits are critical to success

Source: Spirae
Virtual Power Plants – Commercial Non-contiguous

DERMS vendors and aggregators creating VPP, portfolio solutions and allocating benefits

Key Takeaways
- Aggregate resources and dispatch capacity into demand response programs
- Projects pencil out as tariff structures, wholesale and retail programs, and incentives become more granular to account for actual cost of energy

STEM
- Storage as a service model
- Large enterprise customers, e.g. JC Penny, AMC Theatres, Whole Foods, and Home Depot
- Deployed 550 lithium ion batteries (15 kW to 5 MW)

Advanced Microgrid Solutions (AMS)
- Hybrid Electric Buildings Portfolio
- Irvine Co, Walmart and others for 30 MW

Axiom and Ice Energy
Thermal Energy Storage

Leap
- 90MW Stake in California’s DRAM
- Distributed Energy eXchange (DEX) API
GSA Case Study

GSA is interested to incorporate GEB into portfolio as a result of RMI analysis of the value

Findings show there are cost effective opportunities to reduce operating costs by up to 1/3 through measures with sub 4 year paybacks.

1. **Investment in fully controllable systems**: Many GSA buildings have LEDs, but fully controllable fixtures provide much more value

2. **Staging of large building loads**: Like electric heating, AHU fan motors, and plug loads. Staged loads are an untapped source of demand savings and require little-to-no new equipment.

3. **Consistent demand management and peak shaving**: Year-round demand management delivers greater value than demand response program participation in most scenarios

4. **Battery storage and solar PV**: Make economic sense in most locations. Falling first costs make these technologies more important for future projects

5. **Persistent savings**: GEBs measures enable load flexibility, delivering savings, even as rate structures change

6. **Substantial energy impacts**: These measures can reduce building energy consumption by up to 40% and peak demand by up to 80%

Report will be released publicly in the next month, and can be found free on RMI’s website.

GSA GPG is releasing an RFI and seeking collaborators later this fall to test the real-world value and implementation methods.
More Smart and Connected Community projects are being developed as values are being recognized.

Stay tuned for RMI/NREL white paper on Smart and Connected Communities.
Contact

Seth Coan
Manager

P  +1 202.459.6232
M  +1 404.775.2175
E  scoan@rmi.org

1750 K St. NW | Washington, DC | 20006

Creating a clean, prosperous, and secure low-carbon energy future
Eric Friedman
Massachusetts Department of Energy Resources
BETTER BUILDINGS SUMMIT:
THE ROLE OF GRID-INTERACTIVE EFFICIENT BUILDINGS

JULY 10, 2019

MASSACHUSETTS DEPT. OF ENERGY RESOURCES
ERIC FRIEDMAN
DIRECTOR, LEADING BY EXAMPLE PROGRAM
OVERVIEW

- Emissions and Clean Energy Goals
- Policies, Programs & Strategies
- Challenges
Energy Goals
1. Reduce and stabilize energy costs
2. Continue our commitment to a clean energy future
3. Ensure a safe, reliable, and resilient energy infrastructure
LEADING BY EXAMPLE

- Robust clean energy goals for state government operations
- Portfolio includes:
  - 80 million sq. ft. of buildings
  - 3,000+ light duty vehicles
- MA State government:
  - Consumes over 1 billion kWh of electricity
  - Uses more than 7 million gallons of gasoline & diesel
  - Emits almost 1 million tons of GHGs

### Technical and Financial Assistance
- Feasibility studies
- Implementation grants
- Project guidance

### Data Tracking & Analysis
- Collect annual energy & cost data
- Report on progress
- Identify priority sites for energy efficiency
- Demonstrate cost-effectiveness of strategies

### Communications & Outreach
- LBE Council meetings
- Email updates
- Awards & recognition
Global Warming Solutions Act
- 25% GHG ↓ by 2020
- 80% GHG ↓ by 2050
- 80 by 50 Study
MASSACHUSETTS ENERGY USE AND EMISSIONS BY SECTOR
Comprehensive Energy Plan (CEP) Overview

- Executive Order No. 569, Establishing an Integrated Climate Change Strategy for the Commonwealth, directed DOER to undertake a Comprehensive Energy Plan (CEP) that includes:
  - Energy demand projections for electricity, transportation and thermal conditioning
  - Strategies for meeting these demands in a regional context
  - Modeling and Analysis of policies to reduce GHG emissions on cost and reliability from now to 2030
  - Policy guidance on strategies to balance costs, emissions and reliability

Published Dec. 12, 2018
1) Focusing primarily on the electric sector has diminishing returns, increasing rates with while realizing only modest decreases in GHG emissions.

2) Electrifying the thermal and transportation sector leverages investments made in a cleaner electric grid.

3) Conservation and peak demand reduction important as use of electricity for heating and transportation grows.

4) Energy efficiency and peak demand reduction are important for keeping electricity rates affordable, as demand for electricity in the thermal and transportation sector increases.
Electric Vehicles Grid Impact

Figure 28. Energy consumed by the transportation sector in Massachusetts

Figure 45. Electric load in the Sustained Policies scenario compared with the Baseline

In the Sustained Policies scenario, we assume that policies are implemented such that the charging of electric vehicles is focused in two main periods: while Massachusetts residents are at work and school, and again at night. Figure 46 displays the assumed load shape for electric vehicle charging.

Figure 46. Assumed load shape for electric vehicle charging
CEP Policy Priorities and Strategies

Thermal Sector

- Leverage investments made in the clean energy sector through electrification
- Promote fuel switching from more expensive, higher carbon intensive fuels to (electric air source heat pumps and biofuels)
- Reduce thermal sector consumption
- Drive market/consumer demand for energy efficiency measures and fuel switching
- Invest in R&D for clean heating fuels such as renewable gas and biofuels that can utilize investments already made in heating infrastructure

Electric Sector

- Prioritize electric energy efficiency and peak demand reductions, including Clean Peak Standard
- Increase cost-effective renewable energy supply
- Support grid modernization and advanced technologies, including microgrids and storage
- Develop policies to align new demand from the charging of EVs and heating/cooling with the production of clean, low-cost energy.
- Include cost-effective demand reduction and additional energy efficiency initiatives in our nation-leading energy efficiency programs and plans

Transportation Sector

- Increase the deployment of EVs and charging infrastructure
Non-Linear Pathway toward Decarbonization

Grid Interactive Buildings

Renewables

Demand Reduction

Efficiency

Electrification Energy Storage
CLean Energy Targets

Renewable Portfolio Standard 55% by 2050
Alternative Portfolio Standard 12.5% by 2050
Clean Energy Standard 80% by 2050
RENEWABLE ENERGY: CLEAN ENERGY PROCUREMENTS

- Hydroelectric - New England Clean Energy Connect 1200 MW / 9.5 TWh

- Offshore wind - Vineyard Wind 800 MW Awarded & Approved

- Second solicitation for offshore wind out.

- DOER recommended another 1600 MW of offshore wind
RENEWABLE ENERGY: BEHIND THE METER

90,000+ installed projects, 2,300+ MW

Solar in all 351 cities and towns

After SMART incentive program is completed, over 4,000 MW of solar in Massachusetts
ELECTRIFICATION OF BUILDINGS & TRANSPORTATION
BUILDING ELECTRIFICATION-HEAT PUMPS

- Alternative Portfolio Standard (APS)
  - Incentives for renewable thermal technologies that increase efficiency and reduce fossil fuels
  - E.g. CHP, Biomass, solar thermal, GSHP, ASHP
  - Certificates for useful thermal energy–paid over time except for small projects
  - Goal is full electrification for new buildings
  - Targeting fuel oil, propane for existing buildings

- Mass. Heat Pump Projects
  - 627 Heat Pump projects installed after 1/1/2015 applied for AECs (majority were ASHP)
  - MassCEC grants for 258 Ground Source Heat Pump Installations
  - MassCEC ASHP Grants to 20,000 homes and VRF grants to 110 projects
<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>2020 Emissions</th>
<th>2050 Emissions</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL</td>
<td>170</td>
<td>170</td>
<td>0%</td>
</tr>
<tr>
<td>PROPANE</td>
<td>145</td>
<td>145</td>
<td>0%</td>
</tr>
<tr>
<td>GAS</td>
<td>120</td>
<td>120</td>
<td>0%</td>
</tr>
<tr>
<td>ELECTRIC RESISTANCE</td>
<td>205</td>
<td>60</td>
<td>85%</td>
</tr>
<tr>
<td>ELECTRIC COLD CLIMATE AIR SOURCE HEAT PUMP</td>
<td>65</td>
<td>20</td>
<td>85%</td>
</tr>
<tr>
<td>ELECTRIC GROUND SOURCE HEAT PUMP</td>
<td>45</td>
<td>15</td>
<td>85%</td>
</tr>
</tbody>
</table>

**Pounds of emissions to deliver 1 MMBtu of heat into a space**

85% Less
BUILDING ELECTRIFICATION - ZNE

2008 ZNEB Task Force Report

- Enhance Energy efficiency
- Expand renewables incentives
- Asset rating pilots
- Education and workforce development
- State Government Pilots

Pathways to Zero Grant Program

- $1.9 million for feasibility studies, integrated design, construction
- 16 new and existing residential and C&I building projects
Electric Vehicles

- Multi state EV goal - 300,000 EVs on road by 2025 (up from 18,000) in MA
- 2018 ZEV Action Plan adopted by 9 states: education, infrastructure, incentives, fleets and collaboration with dealers
- 2018 Commission on the Future of Transportation in the Commonwealth report -- Substantially reduce greenhouse gas (GHG) emissions from transportation sector in order to meet Commonwealth’s Global Warming Solutions Act (GWSA) commitments

- MA Mor-EV Rebate Program through 9/30
- $60 million utility program approved to fund 100% of applicable EVSE infrastructure upgrades and some equipment incentives
- Targeting 3500+ stations
PEAK DEMAND REDUCTION
# National Leader in Energy Efficiency

- **#1 eight years in a row** for energy efficiency programs and policies

- Three Year Energy Efficiency Plans consistently have the most aggressive goals in U.S.
  - $9.3 billion in benefits
  - Electric savings goals to reflect expansion in programs like fuel switching and peak demand
  - Highest gas savings goals to date
**Peak Demand: Energy Efficiency**

![Graph showing projected summer peak demand with and without EE and PV savings](image)

*Note: Summer peak demand is based on the "90/10" forecast, which accounts for the possibility of extreme summer weather.*

Peak Demand: Energy Storage

- Energy Storage Initiative
  - 2016 State of Charge Study
  - $20M Advancing Commonwealth Energy Storage (ACES) Grant
  - 26 projects for 32 MW / 85 MWh

2015
- 3 PROJECTS
- 1.4 MW /
- 0.45MWh

2019
- 232 PROJECTS
- 190 MW / 470 MWh
  (operating & in development)
PEAK DEMAND: SOLAR + STORAGE

- Launched 11/26/2018
- 1st in nation solar + storage incentive
- Storage compensated via
  - variable adder based on ratio of storage to solar capacity
  - Duration of storage
- Minimum performance standards to ensure grid benefits
Energy Storage Adder Formula

\[
\text{Energy Storage Adder} = \left( \frac{\text{ESkW}}{\text{PVkW}} \right)^{\left( \frac{\text{ESkW}}{\text{PVkW}} \right) + \exp \left( 0.7 - \left( \frac{\text{ESkW}}{\text{PVkW}} \right) \right)} \right) \times 0.8 + \left( 0.5 \times \ln \left( \frac{\text{ESkWh}}{\text{ESkW}} \right) \right) \times \text{Base Adder}
\]

Where ESkW represents the nominal rated power of the energy storage system and ESkWh represents the nominal rated useful energy of the energy storage system.

Formula Outputs

Creating A Clean, Affordable, and Resilient Energy Future For the Commonwealth
2018 legislation tasked DOER with establishing a Clean Peak Standard (CPS)

- First in the nation program
- Aligns clean energy generation and zero emission demand resources with periods of peak electricity in most cost-effective manner while reducing emissions
- Encourage integration of energy storage and clean generation
- Enable continued deployment of renewable generation by flattening electric load curve
- Any eligible resource will generate Clean Peak Certificates (CPC)
CLEAN PEAK STANDARD

- Qualified Clean Peak Resources eligible to generate CPCs during Seasonal Peak Periods until 2051
- New RPS Class I eligible resources in operation on or after 1/1/19
- Qualified Energy Storage Systems
- Demand Response Resources
- Existing RPS Class I / Class II resources that are paired with a Qualified Energy Storage System on or after 1/1/19
CLEAN PEAK STANDARD

- Proposing to match CPS seasons with demand:
  - Spring: March 1 – May 14
  - Summer: May 15 – September 14
  - Fall: Sept. 15 – November 30
  - Winter: December 1 – February 28

- Clean Peak Windows will be 4 hours weekdays, excluding holidays and will be different for each of the 4 seasons

  - Summer and winter
    - Highest daily peaks
    - Highest costs
    - Highest emissions
  
  - Other Value Multipliers
    - Actual system peak
    - Resilience
    - Other TBD
UTILITY ENERGY EFFICIENCY PLANS
2019-2021
• **Green Communities Act (2008)** requires all cost-effective energy efficiency and demand reduction

• **An Act to Advance Clean Energy (2018):**
  – Expands allowable energy efficiency investments to include active demand management (including storage), strategic electrification, and fuel switching to clean energy sources
  – Broadens electric efficiency plans to “energy” efficiency plans
  – Changes Department of Public Utilities cost-effectiveness review to sector-level
**Key Changes to Energy Efficiency Plan**

**Fuel Switching**: customers will be provided information on cleaner fuel options for heating with new incentives for customers to fuel switch to air source heat pumps and other renewable heating options.

**Active Demand Reduction**: Programs that help offset the most expensive hours of the year through load reduction and active dispatch including energy storage.

**Energy Efficiency Plans**
- **Electric Efficiency Plans**
  - MWH Reduction
  - MW Reduction
- **MMBtu Reduction** (electric, oil, propane, etc.)
- **MWH Reduction** (excluding fuel switching)
- **Peak Demand Reduction** (Summer, Winter), including *active* demand
2019-2021 THEMES: FUEL SWITCHING

- Consumer education through fuel-neutral heating and hot water recommendations during in-home assessments
- Significant increases in incentives for cold climate heat pumps (air and ground source)
- Residential and Commercial
- Offsetting higher emitting fuels like oil and propane

Heat Pump Goals

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Customers</td>
<td>37,993</td>
</tr>
<tr>
<td>Low Income Customers</td>
<td>6,082</td>
</tr>
<tr>
<td>C&amp;I Units</td>
<td>17,890</td>
</tr>
</tbody>
</table>
Active Demand Reduction

- Continue to focus on energy efficiency, while pivoting reducing energy usage during times when demand and costs are highest.
- **Active Demand Reduction Programs** include residential direct load control, energy storage, C&I load curtailment.

### Statewide Goal 2019-2021

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<tbody>
<tr>
<td>Summer MW Total</td>
<td>693</td>
</tr>
<tr>
<td>Winter MW Total</td>
<td>544</td>
</tr>
<tr>
<td>Active Summer MW</td>
<td>200</td>
</tr>
<tr>
<td>Active Winter MW</td>
<td>50</td>
</tr>
</tbody>
</table>

In 2015:
The top 1% of Hours accounted for 8% of MA Spend on Electricity
Top 10% of Hours accounted for 40% of Electricity Spend
# Active Demand - Residential

<table>
<thead>
<tr>
<th>Program Parameters</th>
<th>Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Connected Thermostat</strong></td>
<td>![Thermostat]</td>
</tr>
<tr>
<td>• 13 to 17 events per summer</td>
<td></td>
</tr>
<tr>
<td>• 3 hours per event</td>
<td></td>
</tr>
<tr>
<td>• $20 for signing up</td>
<td></td>
</tr>
<tr>
<td>• $25 per year for staying in the program</td>
<td></td>
</tr>
<tr>
<td><strong>Battery</strong></td>
<td>![Battery]</td>
</tr>
<tr>
<td>• 30 - 60 events per summer,</td>
<td></td>
</tr>
<tr>
<td>• 2 - 3 hours per event</td>
<td></td>
</tr>
<tr>
<td>• $225/kW-summer</td>
<td></td>
</tr>
<tr>
<td>• $50/kW-winter</td>
<td></td>
</tr>
<tr>
<td><strong>Electric Vehicle</strong></td>
<td>![Electric Vehicle]</td>
</tr>
<tr>
<td>• 2 to 8 events per summer</td>
<td></td>
</tr>
<tr>
<td>• 3 hours per event</td>
<td></td>
</tr>
<tr>
<td>• Eversource – Charger Control – R&amp;D</td>
<td></td>
</tr>
<tr>
<td>• National Grid – Vehicle Control – Claiming Savings</td>
<td></td>
</tr>
</tbody>
</table>
# Active Demand – C&I

<table>
<thead>
<tr>
<th>Program Parameters</th>
<th>Typical Application</th>
</tr>
</thead>
</table>
| **Targeted Dispatch** | • 3 - 8 events per summer  
• 3 hours per event  
• **$35/kW-summer**  
• Eversource only: Targeted Storage **$100/kw-summer** |
| **Daily Dispatch** | • 30 - 60 events per summer,  
• 2 - 3 hours per event  
• **$200/kW-summer** |
| **Winter Dispatch** | • 5 events per winter  
• 3 hours per event  
• **$25/kW-winter** |
CHALLENGES

- Upfront Costs vs. long-term benefits
  - e.g. TLEDs vs. lighting fixtures with controls

- Higher cost of electricity

- Complexity and cost of retrofitting existing buildings, esp. C&I

- Getting price signals right for dispatchable assets
  - e.g. upfront vs. performance based incentives

- C&I Building Operator skillset related to advanced controls/technologies

- Consumer awareness and resistance
  - e.g. new technology and privacy perceptions
THANK YOU
Demand Reduction

Storage
Demand Reduction: Energy Efficiency
Demand Reduction: Demand Response

Load Shifting

Peak Shaving

Automated Demand Response
Manual Demand Response
Automated Demand Response
Free Programs

VS

[Image of a beer mug]  [Image of a kitten]
Storage
Battery Storage: Exterior
Battery Storage: Interior
Systems Integration
Reducing Grid Load through Digitalization

Grid Modernization: The Role of Grid-Interactive Efficient Buildings
Table of contents

- History of Automation in Building Energy Management
- Creating Standards for Energy Consumption
- The Role of Building Automation in Energy Conservation
- The Fourth Industrial Revolution and Building Controls
- Challenges in Adoption
- Examples of Successful Implementation
History of Automation in Building Energy Management

- The first commercially available thermostat was developed in 1883 to alert boiler operators of dropping room temperatures.

- This was improved in the design of a multi-zone automatic temperature control system by 1895.

- While controlling space comfort was the original goal of these inventions, it wasn’t until the 1970s that energy efficiency was an important aspect of building comfort controls.
Creating Standards for Energy Consumption

• ASHRAE 90 1975\(^1\) was developed in 1975 after two energy crisis in 1973 and 1979. The standard stipulated heating and cooling recommendations and describes energy efficient control strategies.

• Since then, over 10 national and international building codes have been designed and adopted.\(^2\)

• If energy reduction strategies were not implemented in the 1970s, the US would have consumed 207 quadrillion BTUs (quads) by 2007\(^3\). Because of new policies and building control strategies, the US only consumed 101 quads that same year.

• This is further supported by the Energy Information Administration’s (EIA) Commercial Building Energy Survey (CBECS)\(^4\) reports:

<table>
<thead>
<tr>
<th></th>
<th>1992</th>
<th>2012</th>
<th>delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Sqt (bn sqft)</td>
<td>67.9</td>
<td>84.9</td>
<td>25%</td>
</tr>
<tr>
<td>Site Electricity (trillion BTU)</td>
<td>2,609</td>
<td>4,241</td>
<td>62%</td>
</tr>
</tbody>
</table>

\(^1\) American Society of Heating, Refrigerating and Air-Conditioning Engineers
\(^2\) The Energy Star Program
\(^3\) U.S. Energy Information Administration
\(^4\) Commercial Building Energy Survey (CBECS)
The Role of Building Automation in Energy Conservation

• It is estimated that HVAC and Controls faults account for 29% of excess building energy use or close to 5% of national energy consumption.

• In a cross section of recent projects in the last two years, we have observed simultaneous heating in cooling at least once every five days and fans running during unoccupied periods at least once every four days.

• Using this type of analysis, up to 20% of peak load could be curtailed to improve grid services.
  • Automated Fault Detection and Diagnostics (FDD) can inform users when equipment runs outside of standard operational boundaries.
The Fourth Industrial Revolution and Building Controls

• Industrial Revolutions7
  1. Used water and steam to increase production of commodities
  2. Focused on electric power to create mass production of the products we need most
  3. Utilized electronics and information technology to automate production

• The Fourth industrial revolution is building on the third using advanced data analytics to make more informed decisions, faster and more intelligently

• Using advanced analytics empowers users to prioritize occupant comfort while optimizing building performance and ultimately reducing the load on the nation’s electric grid
Challenges in Adoption

• A majority of current facility staff are fearful of the new technology. It can be cost prohibitive and its often feared as a replacement strategy rather than an enhancement.

• The Bureau of Labor Statistics (BLS) estimates an HVAC technician shortage of 115,000 employees to meet the demand within the next four years.
  • With the reduction in workforce, its more imperative to focus on getting more with fewer resources.
### Examples of Successful Implementation

**75,000 connected buildings and counting**

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fault detection and diagnostics</td>
<td>220 predefined smart-building analytics rules</td>
</tr>
<tr>
<td>Cloud-based transparency and decision making</td>
<td>400 m+ data-values collected and analyzed each day</td>
</tr>
<tr>
<td>Sustainability reporting and KPI tracking</td>
<td>521 m+ tons of CO₂ emissions reduced by our customers</td>
</tr>
<tr>
<td>Energy cost reduction from repaired faulty conditions</td>
<td>$50,000+ estimated savings for only three of my 40 customers</td>
</tr>
</tbody>
</table>

*Siemens 2019*
References

4. https://www.eia.gov/consumption/commercial/
Questions?
Thank You!

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Contact Us

▪ Speakers
  ▪ Seth Coan, *Rocky Mountain Institute*  scoan@rmi.org
  ▪ Eric Friedman, *MA Dept. of Energy Resources*  eric.friedman@state.ma.us
  ▪ Sara Neff, *Kilroy Realty*  sneff@kilroyrealty.com
  ▪ Eric Harting, *Siemens*  eric.harting@siemens.com

▪ Moderator
  ▪ Monica Neukomm, *DOE*  monica.neukomm@ee.doe.gov