Grid-Interactive Efficient Buildings (GEBs) Tri-Region Status Report

January 2020

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About NEEP

Founded in 1996, NEEP is a non-profit whose goal is to assist the Northeast and Mid-Atlantic region to reduce building sector energy consumption three percent per year and carbon emissions 40 percent by 2030 (relative to 2001). Our mission is to accelerate regional collaboration to promote advanced energy efficiency and related solutions in homes, buildings, industry, and communities. We do this by fostering collaboration and innovation, developing tools, and disseminating knowledge to drive market transformation. We envision the region's homes, buildings, and communities transformed into efficient, affordable, low-carbon, resilient places to live, work, and play. To learn more about NEEP, visit our website at http://www.neep.org.

Disclaimer: NEEP verified the data used for this white paper to the best of our ability. This paper reflects the opinion and judgments of the NEEP staff and does not necessarily reflect those of NEEP Board members, NEEP Sponsors, or project participants and funders.

Executive Summary

The Grid Interactive Efficient Buildings (GEBs) concept was introduced by the U.S. Department of Energy's Building Technologies Office (BTO). The basis of the concept is the vision of a future in which buildings operate dynamically with the grid to make electricity more affordable and integrate distributed energy resources (DERs) while meeting the needs of building occupants. For the purpose of this report, GEBs are defined as buildings that integrate and continuously optimize DERs for the benefit of building owners and occupants, as well as the grid[1].

Although GEBs are becoming more recognized by policymakers and utilities in Northeast, Midwest, and Southwest regions as critical to the realization of a more reliable, affordable, and clean energy system, the concept is not currently widely known or understood. Today's trends show that behind-the-meter distributed energy resources (DERs), which include energy efficiency, demand response, solar PV, electric vehicles (EVs), and battery storage, are typically valued, scheduled, implemented, and managed separately. That being said, some states have begun to link their energy efficiency investments in homes and buildings with demand response and energy storage to provide grid reliability services. States like Colorado, Massachusetts, and New York are revising their existing regulatory frameworks for delivering electricity, and are introducing legislation that would create more integrated environments for their customers to participate in energy efficiency, demand response, and distributed generation.

Common drivers for currently deployed initiatives relevant to GEBs within the Northeast, Midwest, and Southwest regions include meeting federal and state climate change and emissions targets, economic improvement, environmental stewardship, demand flexibility, whole building energy optimization, customer satisfaction, and keeping up with changing technologies.

The report shows that the major GEBs-related technologies that are currently deployed in all three regions fall into the categories of load management and energy efficiency. Other GEBs-related technologies that are being implemented include distributed generation, building energy modeling, microgrids, and cybersecurity. To support the ongoing advancement of these initiatives, research and development (R&D) institutions have been carrying out extensive studies in this area that are typically funded by federal and state government, manufacturers, and direct university grants. In the Northeast region, based on a sample set of 20 R&D institutions, most of the research is focused on distributed energy resources, building efficiency, energy storage, simulation, and building energy modeling.

Today's electric grids are currently being modernized in an effort to counter the challenges associated with the growth of peak electricity demand, the increase in renewable electricity generation, and the degradation of transmission and distribution infrastructure. The roadmaps for grid modernization, in many Northeast, Midwest, and Southwest states have been outlined in their respective grid modernization plans. This report reveals that most states without formal grid modernization plans do at least have grid modernization goals in place towards which they are working. A study of current grid modernization plans from all three regions reveals that most

[1] U.S. DOE's Grid Interactive Efficient Buildings Fact Sheet. https://www.energy.gov/sites/prod/files/2019/04/f62/bto-geb-factsheet-41119.pdf

plans propose the implementation of advanced metering infrastructure, bi-directional communication systems, meter communications networks, direct load control devices, and distribution automation systems.

For all three regions, there are many technology, marketing, policy, and information barriers that currently prevent the GEBs evolution from taking place more quickly. As shown in the report, all GEBs stakeholders – federal, state and local government, regulatory and policy organizations, utilities, vendors, consumers, R&D organizations, financial institutions, and advocacy and environmental groups – have a role to play in order to overcome these barriers.

Based on the research that was conducted for the Northeast, Midwest, and Southwest regions, it is evident that GEBs deployment can yield many benefits – maintained affordability, enhanced resilience, reduced emissions, reduced peak loads, moderated ramping of demand, additional grid service, enhanced energy efficiency, and integrated distributed and renewable energy resources. However, research has also shown that most states are in the very rudimentary stages of understanding GEBs and their associated benefits. Hence, recommended actions that all three regions can undertake to advance the GEB strategy and highlight the role that buildings play in energy system operation and planning include: educating and training regional GEBs stakeholders on the benefits of approaching behind-the-meter planning with a GEBs vision in mind; gathering, sharing, and archiving updated GEBs information; and conducting in-depth studies on how utilities, government, manufacturers, vendors, and R&D institutions can work together to realize the benefits of GEBs.

It should be noted that not all sections of this report include information from all three regions. This report was prepared by the Northeast Energy Efficiency Partnerships (NEEP) and combines separate studies that were conducted by the Midwest Energy Efficiency Alliance (MEEA) and the Southwest Energy Efficiency Project (SWEEP). All regional organizations shared common goals and methodologies, but the extent of each region's scope varied. SWEEP's research findings have also been published in its own regional GEBs report[2].

[2] Grid-Interactive Efficient Buildings: Providing Energy Demand Flexibility for Utilities in the Southwest: http://www.swenergy.org/pubs/grid-interactive-efficient-buildings-report

Introduction

The energy industry in the United States is rapidly evolving – the installation of smaller generation plants is becoming a trend, renewable energy generation is expanding, coal-generated electric plants are being retired, and modern interconnected and energy-efficient technologies are being developed. To keep pace with these changes, utilities are capitalizing on both the opportunities and challenges they present, and are putting plans in place to modernize the grid.

As the grid transforms, buildings are in a unique position to assist in the actualization of grid modernization goals. In recognition of this the U.S. Department of Energy's Building Technologies Office (BTO) introduced the concept of Grid Interactive Efficient Buildings (GEBs) – a concept that envisions a future in which buildings operate dynamically with the grid to make electricity more affordable and integrate distributed energy resources while meeting the needs of building occupants.

The Rocky Mountain Institute (RMI) estimates that the demand flexibility available in buildings has the capability to reduce peak energy demand by eight percent in the United States, avoiding $9 billion per year in utility capital investments. RMI also estimates that flexible buildings can supply an additional $4 billion per year in value to the electric grid by shifting energy usage to lower cost hours of the day and providing energy services back to the grid.[3] Thus, the opportunity for integrated and flexible buildings to play a pivotal role in grid modernization is a very tangible and cost-effective one.

Purpose

The purpose of this report is to highlight the advancement of GEBs in the Northeast, Midwest, and Southwest regions of the U.S. Based on regional research that was conducted over the last eight months, this report focuses on the following:

- Current GEBs status, drivers and barriers;
- Current GEBs research and development (R&D) initiatives;
- Priorities for GEBs R&D and opportunities for coordination and collaboration.

This report will also provide recommendations for how states, utilities, building technology researchers (academia and non-academia), building technology manufacturers, national laboratories, and other GEBs stakeholders can help to accelerate research, development, testing, and adoption throughout the regions.

The Definition of a Grid Interactive Efficient Building

Grid Interactive Efficient Buildings (GEBs) integrate and continuously optimize distributed energy resources (DERs) for the benefit of building owners and occupants, as well as the grid. GEBs utilize analytics and controls to optimize energy use for occupant patterns and preferences, utility price signals, weather forecasts, and available on-site generation and storage.

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[3] Dyson, Mark, James Mandel, et al. "The Economics of Demand Flexibility: How "flexiwatts" create quantifiable value for customers and the grid." Rocky Mountain Institute, August 2015.

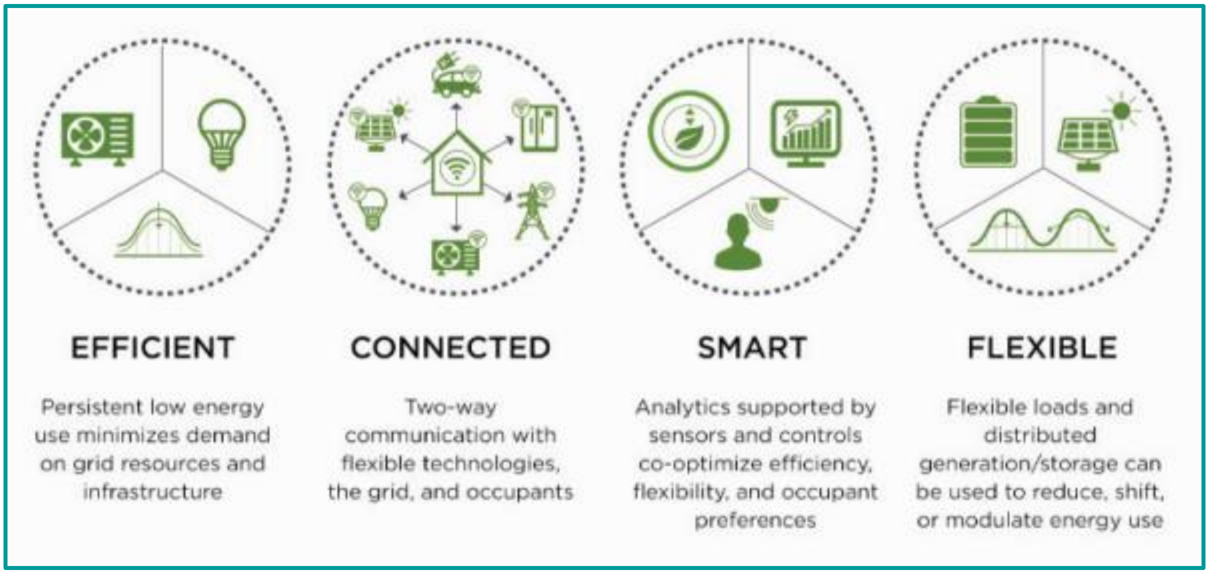


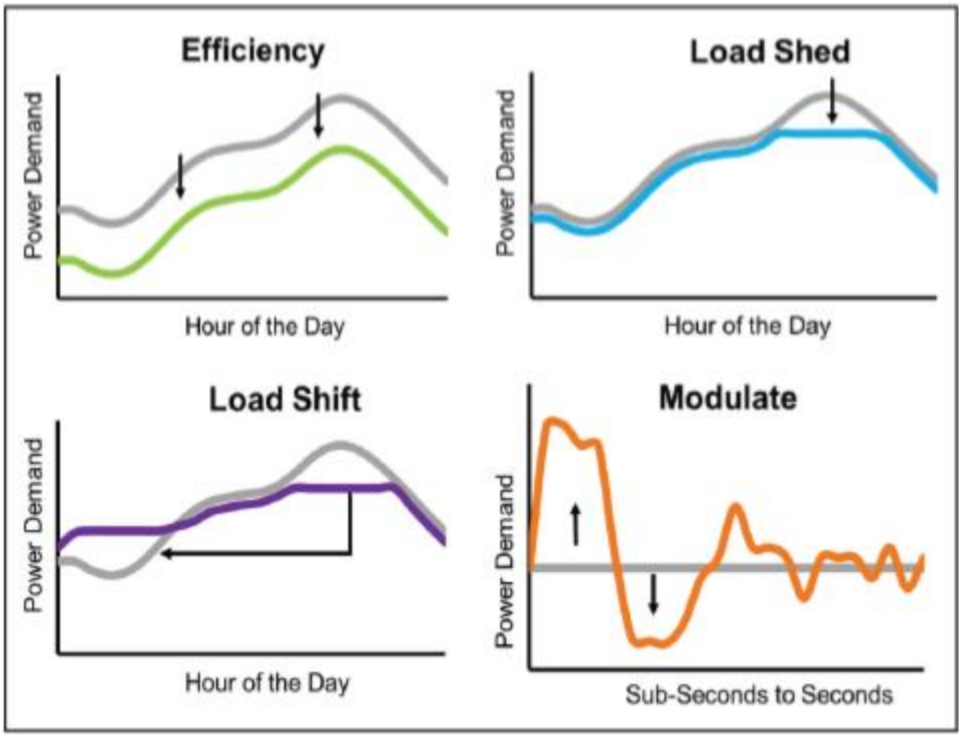
Figure 1: GEB Key Characteristics

GEBs have four key characteristics, as shown in Figure 1. GEBs are energy efficient – they contain high-quality walls and windows, high-performance appliances and equipment, and optimized building designs are used to reduce both net energy consumption and peak demand. GEBs are connected – they have the ability to send and receive signals, a characteristic that is required to respond to grid needs that are time dependent. GEBs are smart – they use analytics supported by sensors and controls that are necessary to optimally manage multiple behind-the-meter DERs in ways that are beneficial to the grid, building owners, and occupants. Finally, GEBs are flexible – their building energy loads can be dynamically shaped and optimized across behind-the-meter generation, electric vehicles (EVs), and energy storage.

According to the U.S. Department of Energy, there are five demand-side management strategies that can be implemented in buildings to manage load:

1. **Efficiency**: the ongoing reduction in energy use while providing the same or improved level of building function.
2. **Load Shed:** the ability to reduce electricity use for a short time period and typically on short notice. Shedding is typically dispatched during peak demand periods and during emergencies.
3. **Load Shift:** the ability to change the timing of electricity use. In some situations, a shift may lead to changing the amount of electricity that is consumed. Load shift in the GEB Technical Report Series focuses on intentional, planned shifting for reasons such as minimizing demand during peak periods, taking advantage of the cheapest electricity prices, or reducing the need for renewable curtailment. For some technologies, there are times when a load shed can lead to some level of load shifting.
4. **Modulate:** the ability to balance power supply/demand or reactive power draw/supply autonomously (within seconds to sub seconds) in response to a signal from the grid operator during the dispatch period.

5. **Generate:** the ability to generate electricity for on-site consumption and even dispatch electricity to the grid in response to a signal from the grid. Batteries are often included in this discussion, as they improve the process of dispatching such generated power.



GEB Benefits to Building Occupants and Owners

Continued Focus on Energy Savings

Energy efficiency has long been recognized by utilities as a cost-effective load management strategy. Efficient appliances, equipment, and whole-building energy optimization reduce both overall energy consumption and peak demand. Energy efficiency measures combined with load flexibility, including demand response and storage, can further reduce utility bills by shifting peak load costs. GEBs go beyond efficiency by harnessing the flexibility of their equipment and loads, deploy that flexibility as a new value stream, and provide solutions to grid needs.

Improved Functions: Resilience & Comfort

Smart devices connected to the internet offer building occupants a new level of functionality and convenience. Some 200,000 smart devices are being connected worldwide every hour, and the U.S. market is growing at roughly 20 percent annually[4]. Homes and offices that include these connected devices can produce new levels of

[4] Projected hourly new devices from Gartner, Inc., Nov. 2015; http://www.gartner.com/newsroom/id/3165317. Size of U.S. market from Statista, Inc. "Energy Management Smart Home Revenue in Selected Countries Worldwide in 2015." (2015); http://www.statista.com/statistics/484511/global-comparison-energy-management-smart-home-revenue-digital-market-outlook/. Projected growth in U.S. market Parks Associates and Consumer Electronics Association. "Smart Home Ecosystem: IoT and Consumers."

comfort while providing building owners and operators added control and flexibility through room-level heating and cooling capabilities, tunable lighting, smart devices and appliances, and automated building management. Additionally, buildings with advanced controls can integrate DERs and prioritize critical loads for resiliency while increasing comfort and minimizing energy waste.

Research Methodologies

The types of research methodologies used for this report were different for NEEP, MEEA, and SWEEP, and were chosen based on each Regional Energy Efficiency Organization's (REEO's) individual deliverables to U.S. DOE. The methodologies included questionnaires, surveys, interviews with government organizations, utilities, manufacturers and R&D organizations, engagement with national groups, and web research.

NEEP and MEEA conducted their research using the following approaches:

- Engagement with national groups
- Questionnaires
- Interviews with government organizations, utilities, manufacturers, R&D organizations
- Web Research

SWEEP's research was primarily conducted through interviews with Southwest-based utilities (with a focus on demand side management programs). SWEEP also captured information for its report via online searches and utility demand-side management reports.

GEBs Research Findings

Through implementation of the GEBs strategy, U.S. DOE hopes to integrate and continuously optimize DERs to advance the role that buildings can play in energy system operations and planning. To support this effort, NEEP, MEEA, and SWEEP conducted research within the Northeast, Midwest, and Southwest regions to capture each respective region's current status of GEBs, currently deployed GEBs technologies, major regional smart grid and grid modernization initiatives, potential role of GEBs to meet regional grid modernization needs, and currently deployed GEBs initiatives. The extent of research conducted for this report varied according to each region's scope and methodologies.

Current Regional Status of GEBs

The Status of GEBs in the Northeast Region

In the Northeast region, state awareness of the GEBs concept is not ubiquitous. While most states that are aware of the concept understand its benefits and are working towards integrating their buildings with the electric grid, they are still in the infancy stages of managing their building energy holistically. That being said, there are currently many technologies being deployed, researched, and developed that support the GEBs concept. Most states have expressed that if the electric grid continues to be modernized to support the

(2014); http://www.parksassociates.com/bento/shop/whitepapers/files/Parks%20Assoc%20CEA%20Smart%20Home%20Ecosystem%20WP.pdf. No Federal source exists for this information; these are considered reliable industry sources.

integration of distributed energy resources (DERs) and to take advantage of cutting-edge technologies, measures will have to be put in place to accelerate the rate at which buildings currently integrate with the grid.

The Status of GEBs in the Midwest Region

The level of awareness of GEBs in the Midwest is very similar to that in the Northeast. MEEA's research has indicated that GEBs-related technologies are currently being deployed as part of energy efficiency and load management programs run by the utilities. Illinois, Ohio, and Minnesota have either ongoing or completed stakeholder meetings to identify pathways for a modernized grid in their state.

The Status of GEBs in the Southwest Region

Even though the GEBs concept is steadily advancing in the Southwest, GEBs-related technology deployment is seldom initiated with the sole purpose of advancing the GEBs concept. This is much like the Northeast and Midwest. Rather, GEBs-related technologies are instituted to support energy efficiency, load management and renewable energy priorities. But since GEBs technologies are able to offer precise timing and sensitivity to changes in the grid that can hardly be matched by any other means, SWEEP projects that they will become a mainstay of its efficiency and grid-related efforts.

Currently Deployed GEBs Technologies

Grid integrated buildings leverage many technologies in order to support a holistic and optimized blend of energy efficiency, energy storage, distributed energy generation, and load-flexible technologies and controls. These technologies mainly include: integration of distributed generation, energy storage technologies that provide load shifting, smart controls and other technologies that provide load flexibility, building energy efficient technologies, building energy modeling, microgrids, and cybersecurity systems. For the Northeast, Midwest, and Southwest regions, most of the currently deployed GEBs-related technologies fall into the following categories:

Demand flexibility

Demand flexibility technologies adjust a building's load profile across different timescales. Energy flexibility and load flexibility are often used interchangeably with demand flexibility. Examples include smart EV charging, appliances and plug load devices with smart control, and smart energy intensive equipment (HVAC, pool pumps, refrigerators etc.)

Energy Efficiency

Energy efficiency means using less energy to provide the same service. For buildings, energy efficient technologies target the following strategies: operational, electrical, envelope, and site. They range from efficient lighting, heating, cooling, and ventilation technologies to building management system technologies that provide whole building solutions.

Building Energy Modeling

Building energy modeling is the virtual or computerized simulation of a building that focuses on energy consumption, utility bills, and life cycle costs of various energy related items such as air conditioning, lights, and hot water. Building energy modeling supports building design, planning, and valuation.

Distributed generation

Distributed generation refers to a variety of technologies that generate electricity at or near where it will be used. These technologies include combined heat and power systems, solar photovoltaic panels, wind turbines, hydropower, biomass combustion or co-firing, solid waste incineration, fuel cells fired by natural gas or biomass, and backup generators.

Cybersecurity and microgrids are not considered technologies but play a role in the realization of the GEBs concept:

Microgrids

A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

Cybersecurity

Cybersecurity protects systems, networks, and programs from digital attacks. For buildings, this will mean multiple layers of protection spread across computers, networks, programs, and data. Successful cybersecurity management systems accelerate key security functions like detection, investigation, and remediation.

GEBs Technologies Currently Deployed in the Northeast Region

Through a questionnaire and online research, NEEP gathered information that GEBs-related technologies are currently deployed by 10 states in the Northeast. This information is captured in the graph below.

It should be noted that two of the 10 states represented in this graph – Massachusetts and New York – currently deploy all of the depicted technologies. It should also be noted that all states deploy distributed generation, load shifting, load flexibility, and energy efficiency technologies, while few states show marked deployment of building energy modeling and cybersecurity technologies.

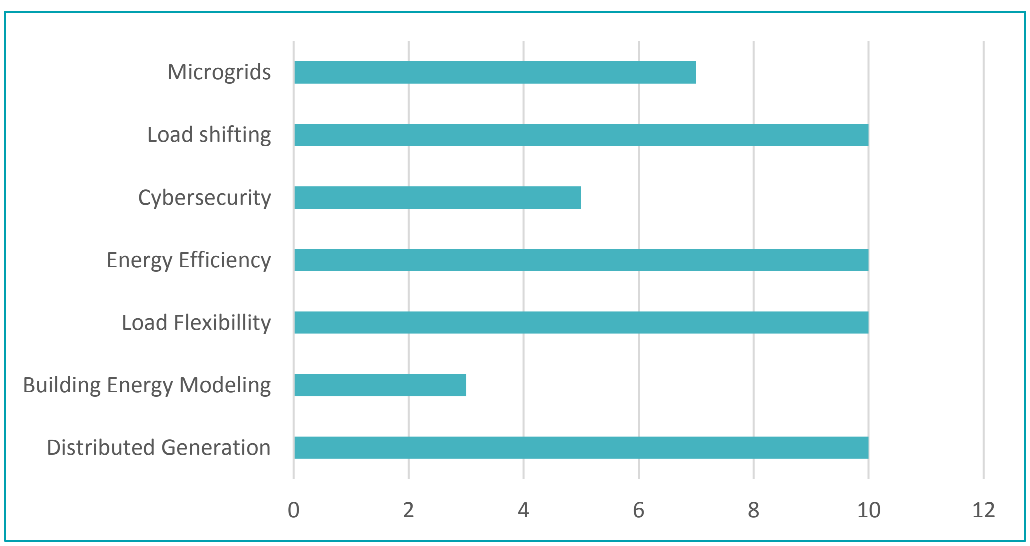


Figure 2: Number of states in the Northeast that currently deploy GEBs technologies

GEBs Technologies Currently Deployed in the Midwest Region

Based on information gathered from state agencies and utilities in the Midwest, MEEA's research has shown that most of the technologies deployed fall into the categories of energy efficiency, load shifting, load flexibility, and distributed generation.

GEBs Technologies Currently Deployed in the Southwest Region

Demand flexibility is the most common driver for the deployment of GEBs-related technologies in the Southwest region. For this report, SWEEP's research focused on demand-side management (DSM), which can be achieved through load shifting, load shedding, or load modulating programs. Many utilities in the Southwest run load shifting programs, but load shedding programs are rare in residential and small commercial approaches, and load modulating programs are still largely in their infancy. Major utilities in the Southwest are using grid-interactive buildings as a resource to help with the integration of variable renewable generation and to provide other grid services that create value for customers.

Major Regional Smart Grid and Grid Modernization Initiatives

A modernized grid aims to mitigate the stress that is usually put on the electric grid due to growing peak electricity demand, transmission and distribution infrastructures constraints and increasing renewable energy generation. Over the last decade or so, many states have put initiatives in place to modernize their grids. However, in more recent years, many factors like growing volumes of renewable energy, increasing amounts of data, and powerful new software have been driving the need for more structured grid modernization approaches.

Major Smart Grid and Grid Modernization Initiatives in the Northeast

In the Northeast, structured approaches to grid modernization vary from comprehensive plans to initiatives that target specific aspects of grid modernization. For example, in 2014, Massachusetts' Department of Public Utilities issued grid modernization orders that solicited plans from the state's utilities. Two major utilities – National Grid and Eversource – responded to these orders with grid modernization plans in 2015. Similarly, in New York, in response to the New York Public Service Commission's vision (Distributed System Platform "DSP" vision) for a more dynamic and integrated grid, Con Edison released its Distributed System Implementation Plan (DSIP) in 2016. Meanwhile, in New Jersey, the utilities – Atlantic City Electric, Jersey Central Power & Light, and PSE&G New Jersey – do not have actual grid modernization plans but a variety of investments and incentive programs.

Most grid modernization plans and efforts in the Northeast focus on the following initiatives:

- Advanced Metering Infrastructure
- Bi-directional communication systems
- Smart Meters
- Meter Communications Networks
- Meter Data Management Systems
- Time-based rate programs
- Direct Load control devices

- Distribution automation systems
- Cybersecurity

Based on a sample set of 11 grid modernization plans from 11 different Northeast states, the following graph shows how many plans include these initiatives. Information on grid modernization plans by state can be found on the NC Clean Energy Technology Center's website[5].

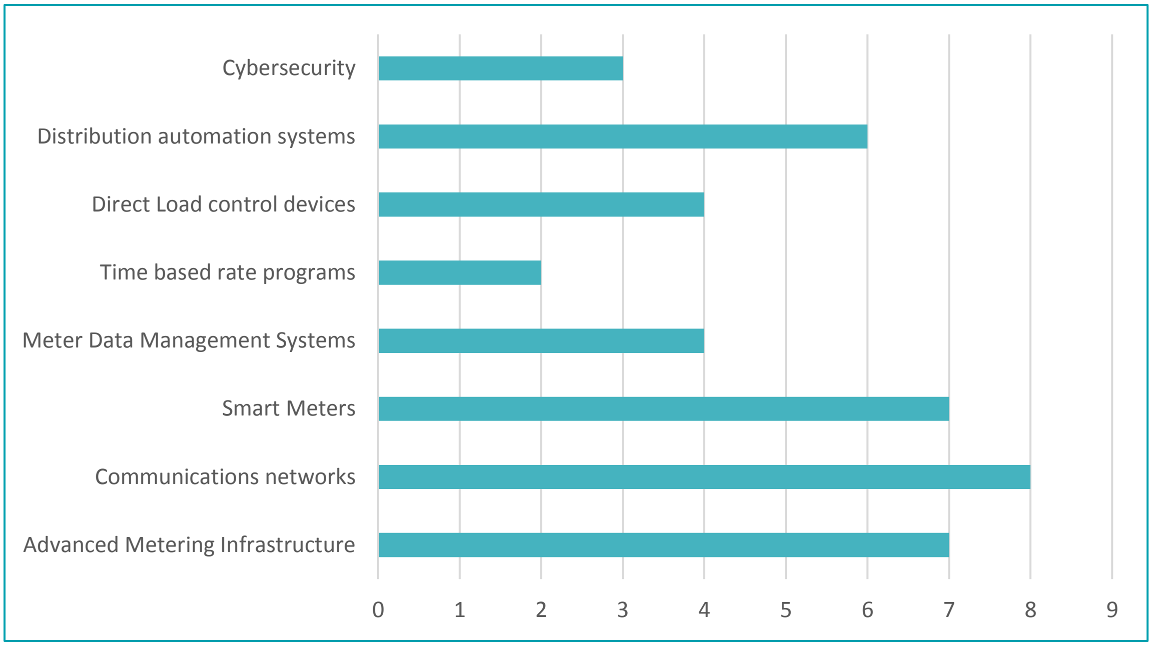


Figure 3: Number of Grid Modernization plans that include specific initiatives

Major Smart Grid and Grid Modernization Initiatives in the Midwest

Grid modernization in the Midwest is also steadily advancing in increased investments and comprehensive resource planning. Many Midwest states have recently finalized their grid modernization plans to develop foundational knowledge, identify challenges and opportunities, and explore policy, market-based, and technological solutions. For example, the Minnesota Public Utilities Commission is exploring policy to promote distribution system investment and time of use rate offerings, and has a 2025 Energy Action Plan to develop indicators and action plans to advance strategies for clean and efficient technologies which came about as part of a larger stakeholder-led initiative called E21[6]. Michigan recently launched its grid modernization initiatives via the MI Power Grid Program, which focuses on customer engagement, integrating emerging technology, and optimizing grid performance and investments. Also, the Ohio PUC has the PowerForward[7] initiative, which is

[5] The Fifty States of Grid Modernization. https://nccleantech.ncsu.edu/2019/02/07/the-50-states-of-grid-modernization-grid-modernization-action-increases-by-60-in-2018/

[6] https://e21initiative.org/

[7] https://www.puco.ohio.gov/industry-information/industry-topics/powerforward/

addressing the future of electricity in the state; and Illinois mandated the creation of a stakeholder group called the Smart Grid Advisory Council[8].

Based on the research that MEEA conducted for this report, most grid modernization plans and efforts in the Midwest focus on the following initiatives:

- Advanced Metering Infrastructure Deployment
- Bi-directional Communication Systems
- Smart Meters
- Meter Communications Networks
- Distributed Energy Resources
- Performance-based Ratemaking
- Direct Load Control Devices
- Transmission and Distribution Automation
- Conservation Voltage Reduction

Major Smart Grid and Grid Modernization Initiatives in the Southwest

Grid modernization is a large priority in the Southwest region. Utilities are beginning to utilize grid-integrated appliances and other devices to facilitate grid modernization and minimize costs, as well as reduce greenhouse gas emissions. An in-depth study of grid modernization in the Southwest region was not conducted for this report. However, more information on grid modernization plans in the Southwest region can be found on the NC Clean Energy Technology Center's website.

The Potential Role of GEBs to meet Regional Grid Modernization Needs

GEBs have the potential to advance the role that buildings play in response to regional grid modernization. To fully appreciate the role that buildings can play, many states believe that there is a need to understand all of the players that contribute to achieving the modern grid and how GEBs can optimally work in conjunction with them.

The Potential Role of GEBs to meet the Grid Modernization Needs of the Northeast

Most states in the Northeast have similar grid modernization goals. They aim to make their grids more reliable, secure, affordable, economical, efficient, environmentally friendly, and safe. While many of these states do not fully understand what GEBs are, or how they fit into the big picture of grid modernization, they do believe that they are well positioned to advance the role that buildings play in meeting their grid modernization needs. Utilities and government agencies have voiced that two important factors would accelerate the rate at which buildings can become optimal grid assets – having the right technologies in place and getting the right stakeholders on board. Both of these are elaborated on in the next section.

Major Smart Grid and Grid Modernization Initiatives in the Midwest

For the Midwest, the potential of GEBs to meet state grid modernization goals is similar to the Northeast region.

[8] https://codes.findlaw.com/il/chapter-220-utilities/il-st-sect-220-5-16-108-6.html

Major Smart Grid and Grid Modernization Initiatives in the Southwest

Similar to the Northeast and Midwest, utilities in the Southwest are well positioned to advance GEBs within their region. They are beginning to find innovative ways to utilize GEBs appliances and other GEBs-related technologies to facilitate grid modernization and minimize costs, as well as reduce greenhouse gas emissions.

Regional GEBs-Related Initiatives

Through state programs, utility programs, and focused R&D, many states in the Northeast, Midwest and Southwest are undertaking initiatives that support the integration of buildings with the electric grid. This section covers the purpose of these initiatives, the stakeholders involved in these initiatives, how and by whom the initiatives are being funded, the level of commercial and residential focus of these initiatives, and specific GEBs technologies as they relate to individual initiatives. The next section of this report highlights several examples of these initiatives by region.

Purpose of these initiatives

Program administrators and implementers would like to see a more holistic approach towards the integration of GEBs-related technologies in the future and have expressed that such an approach would be inevitable if buildings are to keep up with the rapidly evolving grid. Most have expressed that integrating current initiatives will ultimately save resources for both utilities and their customers, but the major drivers for these initiatives would not change. These include:

- Meeting federal and state climate change and emissions targets
- Environmental stewardship
- Customer education
- Customer satisfaction (mainly safety, resilience, and comfort)
- Demand flexibility
- Whole-building energy optimization
- Keeping up with changing technologies

Who is involved in these initiatives?

Many key players involved in GEBs-related initiatives include:

- Government – federal, state, and local
- Policy and regulation – PUCs (Public Utility Commissions), FERC (Federal Energy Regulatory Commission), NERC (North American Electric Reliability Commission), NARUC (National Association of Regulatory Utility Commissioners)
- Utilities – IOUs (Investor owned utilities), Publics, and RTOs (Regional Transmission Organizations)
- Consumers – commercial and residential
- Vendors – technology and service
- R&D Organizations – universities, colleges, and other R&D institutions
- Others – advocacy groups, environmental groups, finance firms, EPRI (Electric Power Research Institute)

How are these initiatives being funded?

Based on research that has been conducted for this report, most individual GEBs-related initiatives are funded by one or more of the following entities:

- Federal government
- State government
- Public Utility Commissions (or equivalent)
- Utility ratepayer programs
- Manufacturers

Level of commercial and residential focus of these initiatives

Many utilities and state government agencies have indicated that they try to operate fairly and offer a comparable number of residential and commercial programs. Depending on their annual goals and deadlines however, utilities change their focus so at any given time, the number of residential initiatives may exceed the number of commercial initiatives and vice versa. Research and development institutions have also indicated that their focus on each sector fluctuates and is dependent hugely on where their funding comes from.

Specific GEBs technologies as they relate to individual initiatives

GEBs-related initiatives involve the research, development, demonstration, and deployment of many technologies. The technologies being researched and developed are discussed later on in the report. This section gives an account of the technologies that are currently being demonstrated and deployed by demonstration projects and utility programs in the Northeast, Midwest, and Southwest.

Load flexibility programs

Load flexibility programs focus on reducing, shedding, shifting modulating or generating electricity. The following technologies are commonly deployed in load flexibility programs in:

- Connected Lighting
- Thermal storage
- Thermostat setpoints
- Refrigeration setpoints
- Battery storage
- Multi-speed and variable speed motors
- EV charging
- Dynamic Glazing
- Advanced sensors and controls
- Software for optimizing building design and operation
- Interoperable building communication systems

Energy Efficiency programs

The technological potential for reducing energy consumption and carbon emissions in the buildings sector is considerable. Many energy programs that focus on energy efficient buildings deploy the following GEBs-related technologies:

- High efficiency lighting devices
- Smart appliances
- High efficiency heat pumps
- Thermal storage
- Thin insulating materials
- Dynamic Glazing
- Advanced sensors and controls
- Software for optimizing building design and operation
- Interoperable building communication systems

Distributed Energy Generation programs

Programs to encourage the deployment of distributed generation have been active for quite some time. More recently however, there has been a focus on technologies that integrate renewable energy resources by managing energy demand for an adequate balance of supplied energy and loads. The following list covers the major distributed generation technologies that are currently in deployment:

- Wind turbines
- Photovoltaics
- Fuel cells
- Hydroelectric power
- Biomass power
- Geothermal power
- Distributed energy resource management systems

Whole building energy modeling programs

States deploy whole-building energy modeling technologies to help ensure that predicted energy performance during design is achieved once a building is in use. Based on the research conducted for this report, only a few states have programs that support whole-building energy modeling. The technologies used in whole-building energy modeling include:

- Data collection meters
- Building energy management systems
- Computer based data analysis software
- Computer based simulation software

Product demonstration programs

Many utilities conduct demonstration projects to show how new products and services can capture latent value to the grid, and how new business models can monetize and distribute that value across third parties, utilities, and customers. Demonstrated technologies include:

- Aggregated behind the meter energy storage
- Integrated electric vehicle charging and battery storage systems
- Distributed generation interconnection systems
- Commercial battery storage

- Ice storage (thermal storage technology)
- Phase change material (thermal storage technology)
- Digital queueing of electric loads
- Dynamic load management

Deployed technologies that may not be program-based

Microgrid Technology

Microgrids are a group of interconnected loads and distributed energy resources with clearly defined boundaries that act as a single, controllable entity and can connect and disconnect from the grid to operate in both grid-connected or island mode. Many states in the Northeast offer microgrid programs as they recognize microgrid technology as a solution to many of the challenges facing the electric grid.

Cybersecurity Technology

Cybersecurity is the practice of protecting systems, networks, and programs from digital attacks. Common technologies used to protect vulnerable building devices are firewalls, DNS filtering, malware protection, and antivirus software and email security solutions. Many utilities in the Northeast understand that there is an increasingly critical need to have cybersecurity technologies on board as the level of data moving between the grid and the customer increases. Utilities are currently investing in predictive cybersecurity models and are increasing customer awareness on residential and commercial building safety.

Advanced Evaluation, Measurement and Verification – important GEBs program tools

Evaluation, measurement, and verification (EM&V) is a set of practices and protocols to test the impact of energy efficiency measures, projects, and programs. EM&V is not in itself a GEBs-related technology, but its methods help regulators to ensure that energy efficiency program administrators are meeting their targets, ratepayer funds are being spent wisely, and energy efficiency programs are cost effective. The use of deemed savings or stipulated metrics to measure energy savings had been prevalent for several years. More recently however, with new data analytics technologies that allow for measurement savings at the meter, energy savings are being calculated with advanced M&V or M&V2.0 methods. Technologies used for M&V2.0 include:

- High-resolution smart meters
- Communicating smart thermostats
- Nonintrusive load-submetering devices
- Energy management and information systems
- Cloud-based data access software
- Cloud-based data analysis software
- Data modeling software

It should be noted that some states in the Northeast are currently conducting pilot programs to test and compare the predictive accuracy of M&V2.0 tools. Connecticut conducted its commercial testing pilot in 2017 and 2018, and commenced a residential pilot in 2019.

Examples of Current GEBs-Related Initiatives by Region

This section highlights examples of GEBs-related initiatives by region.

GEBs-Related Initiatives in the Northeast Region

Load Management Programs

Advancing Commonwealth Energy Storage (ACES) Program

This Massachusetts program is part of a two-phase, $10 million-dollar Energy Storage Initiative (ESI) that was announced in 2015 by the Baker-Polito Administration. The ESI aims to advance the energy storage segment of the Massachusetts clean energy industry by expanding storage technology markets, assigning value to storage benefits, accelerating the development of storage technologies, and attracting and supporting energy storage companies throughout the Commonwealth. In the first phase of this initiative, MassCEC partnered with DOER on an energy storage study, State of Charge, to obtain a broad view of energy storage technologies that would inform future policy and programs. In the second phase of this initiative, energy storage demonstration projects were solicited through the ACES RFP with the design of the RFP informed by recommendations from the study.

Massachusetts' ACES program promotes leadership and innovation in energy storage deployment and business model demonstration. ACES is the state's first substantial investment in energy storage projects and is designed to significantly catalyze the market. While technology demonstration programs are common, this program is unique in its business model demonstration objectives.

New York State Energy Research and Development Authority's (NYSERDA) Energy Storage Program

The NYSERDA Energy Storage Program offers a single up-front payment at a fixed incentive amount per kilowatt hour (kWh) of usable energy storage for projects up to five megawatts (MW). The incentives vary throughout the state and the NYSERDA energy storage incentive dashboard provides the incentive amount by region. Eligible participants include small businesses, large commercial and industrial businesses, demand-metered customers installing standalone storage or adding storage to a completed solar project, and PSEG Long Island customers in Nassau or Suffolk County. In order to receive the energy storage incentive, interested parties must work with participating contractors who will apply for the incentive on their behalf.

Con Edison's SmartCharge New York Electric Vehicle Program

In 2017, Con Edison and FleetCarma, a connected car technology provider specializing in plug-in electric vehicle applications, began the SmartCharge New York electric vehicle program to incentivize off-peak charging of plug-in electric vehicles. The program is designed to attract plug-in electric vehicle owners who regularly charge their vehicles in New York City and Westchester County by offering incentives for participation, including a free FleetCarma device that provides EV drivers with feedback on how they compare to other EV owners and how to earn rewards for charging during more preferable times for the electricity grid. Through the program, Con Edison will gain insights on how the increasing number of EVs will impact its electric-delivery system. Con Edison will use that information to guide investments in its system and maintain its industry-leading reliability.

NYSERDA's Air Source Heat Pump Program

One example of a full-scale load management program is the Air Source Heat Pump (ASHP) program that NYSERDA started in 2017. With $10.9 million in incentives available to participating installers for the installation of program-qualified ASHP systems in residential sites, the program aims to offer New Yorkers a cleaner, more efficient alternative to conventional heating options. Incentives of $500 per system were available on a first-come, first-served basis and installers could decide how best to use the incentives to maximize growth of their ASHP business.

Flexible Rate Programs

Con Edison's Time-of-Use Rates Program

In the summer of 2018, one of New York's utilities, Con Edison started its Time-of-Use Rates Program as a way to avoid brownouts and blackouts during hot weather. For this program, residential consumers are charged significantly extra for electricity during times of peak demand and rewarded with sharply reduced rates during non-peak demand hours. From June 1 through September 30, electricity during the "off-peak" hours of midnight to 8:00 a.m. costs customer 1.54 cents per kilowatt/hour. During the "peak" hours of 8:00 a.m. to midnight, the rates increase to 21.80 cents. Rates are even higher during the "super-peak hours" of 2:00 to 6:00 p.m. on summertime weekdays. Full-service Con Edison residential customers who switch to the time-of-use rates are required to remain with the program for one year and those who then return to the standard residential rate are then ineligible for time-of-use rates for 18 months.

Owners of electric vehicles who try the time-of-use rates for one year at no risk. After 12 months, Con Edison compares what the vehicle owner should pay under time-of-use rates with what was billed under the standard residential rate. If the former is higher than the latter, Con Edison credits the customer's account with the difference.

Eversource's Time-of-Day Rate 7 Program

Eversource's Time-of-Day Rate 7 Program became effective on July 1, 2018. Through this program, Eversource encourages its customers to use most of their electricity before noon and after 8:00 p.m. during the week, and anytime on weekends.

National Grid's Time-of-Use Rate Programs

National Grid offers Time-of-Use programs to commercial, industrial, and residential customers. Its Time-of-Use (G-3) program is primarily available for large commercial and industrial customers with demand greater than 200 kW. During peak hours, from 8:00 a.m. to 9:00 p.m. daily on Monday through Friday (excluding holidays) customers pay a 1.618¢/kWh distribution rate. For off-peak hours, from 9:00 p.m. to 8:00 a.m. daily Monday through Friday, and all day on Saturdays, Sundays (and holidays), customers pay a 0.865¢/kWh distribution rate.

National Grid's Residential Voluntary Time-of-Use rate (SC-1 VTOU) program allows Upstate NY customers the opportunity to reduce their energy costs by shifting their EV charging – and other appliance use – to the off-peak hours of 11:00 p.m. to 7:00 a.m. (excluding weekends and holidays). After the first year on this rate, National Grid reconciles the total amount paid with what a customer would have paid on the standard, non-time-of-use SC-1 rate. If the customer would have paid less on the SC-1 rate, National Grid provides a one-time bill credit for the difference. This reconcilement only occurs at the end of the first year and not in subsequent years. If a customer owns a plug-in electric vehicle (PEV) and receives supply service from National Grid, then that customer has the option of receiving a one-time comparison of one year of charges on the SC-1 VTOU rate versus the SC-1 standard tariff rate.

Distributed Generation Programs

MassCEC's Mass Solar Loan Program

In January 2015 DOER announced its partnership with the Massachusetts Clean Energy Center (MassCEC) as the program central administrator for the Mass Solar Loan Program. This program was launched in an effort to use credit enhancement to encourage solar lending, thereby facilitating homeowner access to attractive solar loans and providing new business opportunities for local lending institutions. Today, the Mass Solar Loan program includes three incentives: the Interest Rate Buy Down incentive, the Loan Loss Reserve incentive, and the Income-Based Loan Support incentive. Eligibility is based on total household income determined by the Total Income line of the tax return (Line 6 2018 – Form 1040) of the federal income tax filing for the most recent year available.

Rhode Island's Distributed Generation Standard Contracts Program

The Distributed Generation Standard Contracts Program (DG Program) supports the development of new, locally-based renewable energy projects. Enacted in 2011, this program requires electric distribution companies to enter into long-term contracts at a fixed price (with terms of up to 20 years) for 40 MW of newly developed distributed generation projects in the Rhode Island load zone by December 30, 2014. The 40 MW DG program is "carved-out" of the 90 MW Long-Term Contracting Standard for Renewable Energy (LTC) capacity obligation. Although the LTC obligation is "adjusted by capacity factor," the DG program is not. Therefore, a 10 MW facility with a 30 percent capacity factor would be counted as providing 10 MW to the minimum DG capacity obligation. As with the LTC projects, the electric distribution company is required to purchase capacity, energy, and attributes - not simply Renewable Energy Credits (RECs). Unlike the LTC projects, DG projects must be interconnected to the Rhode Island distribution system, so that contracted resources physically meet Rhode Island loads through direct delivery to the Rhode Island distribution system. The DG program created a simple, standard contract for project developers to obviate the need for negotiating complex contracts with the utility. The Distributed Generation Standard Contracts Board sets annual ceiling prices for categories of different renewable energy technologies.

New Hampshire's Renewable Energy Fund Programs

Through its Renewable Energy Fund Programs, New Hampshire stimulates investment in low emission renewable energy generation technologies within the state. These programs include:

The Competitive Grant Program

As required by RSA 362-F: 10, XI, the New Hampshire Public Utilities Commission (PUC) issued an annual request for proposals (RFP) to fund renewable energy projects. The RFP for fiscal year 2019 (FY19) was issued on October 1, 2018 for certain non-residential renewable energy projects located in New Hampshire that are eligible to generate certain renewable energy certificates (RECs) and not eligible to receive funds from other REF incentive programs. The PUC received three proposals requesting a total of $1.45 million in grant funds. Two projects were selected for funding: a heat recovery system for an existing biomass-fueled electricity generator which captures waste heat to heat greenhouses, and a wood-chip fueled co-generation system that will be used to dry wood chips and generate electricity for on-site use. The two projects selected received $950,000 in funding through grant contracts approved by the Governor and Executive Council on May 15, 2019.

The Low-Moderate Income Solar Program

The New Hampshire Clean Energy Jobs and Opportunity Act of 2017, included a funding allocation requirement for a program intended to reduce market barriers to solar energy participation by low and moderate income (LMI) residential customers. Working closely with stakeholders and the net metering working group, a new LMI competitive grant program was designed and implemented during FY18.

On February 2, 2019, a FY19 RFP was issued seeking proposals for community solar photovoltaic (PV) projects providing direct benefits to New Hampshire LMI residential electric customers. The PUC received four proposals requesting a total of $700,000 in grant funds for projects with a combined estimated value of $1.3 million. Three community solar projects were selected to receive $500,000 total in grant funding, and were approved by the Governor and Executive Council on May 15, 2019.

Solar Rebate Programs

With the help of New Hampshire's Solar Rebate Programs, 14 MW of solar PV was interconnected during calendar year 2018. During FY19, the incentive levels of the residential solar program remained at $0.20 per watt, up to a maximum $1,000, and $0.40 per watt, up to a maximum $50,000 for commercial and industrial (C&I) installations. On July 3, 2019 the C&I solar rebate program was closed to new applications with a waitlist totaling approximately $20,000. The construction cycle for large C&I projects is, on average, approximately one year.

Wood Pellet Rebate Programs

During FY19, the incentive levels for the wood pellet furnace and boiler programs remained at 40 percent of eligible project costs, up to a maximum $10,000 for residential installations and $65,000 for C&I installations. To encourage larger and more economical wood pellet deliveries, the residential program offers a supplemental rebate adder of $100 per ton for fuel storage systems larger than the three-ton minimum requirement, up to a maximum of $500. The C&I program offers additional incentives for the installation of a thermal storage tank and/or production meter to track thermal generation for REC certification.

Energy Efficiency Programs

Massachusetts' MassSave Program

In Massachusetts, the MassSave program initiative was created in response to the 2008 Green Communities Act that mandated the acquisition of all cost-effective energy efficiency and stimulated program administrators (PAs) in Massachusetts to rethink the way energy efficiency programs were designed and delivered. This initiative that is still up and running and is sponsored by Massachusetts' natural gas and electric utilities and energy efficiency providers, including National Grid, Eversource, Liberty Utilities, Unitil, Columbia Gas of Massachusetts, Berkshire Gas Company, Blackstone Gas Company and Cape Light Compact. These sponsors work closely with the Massachusetts Department of Energy Resources to provide a wide range of service, incentives, trainings, and information promoting energy efficiency that help residents and businesses manage their energy use and related costs. Having implemented successful energy efficiency programs for over 25 years, participating PAs built upon their successes, experience and strengths to help avoid any disruption that would usually occur with completely new program delivery.

Vermont's Energy Efficiency Utility Program

Vermont's Public Utility Commission (PUC) oversees the development, performance, and funding of Vermont's Energy Efficiency Utility (EEU) Program. The EEU Program works to provide energy efficiency services to residential and business electricity, natural gas, and thermal-energy-and-process-fuel consumers throughout Vermont.

Under this program three EEUs to deliver energy efficiency services:

- Efficiency Vermont - delivers energy efficiency services throughout most of the state
- City of Burlington Electric Department (BED) - provides energy efficiency services in its service territory
- Vermont Gas Systems, Inc. (VGS) - provides natural gas energy efficiency services in its service territory

National Grid's Massachusetts Energy Efficiency Programs

National Grid offers energy efficient solutions for Massachusetts homeowners, renters, and landlords. These energy savings programs include home energy checkups, home heating, home cooling, lighting, appliance and electronics, renters and multifamily properties, new home construction, connected solutions, residential innovations and additions, and income-eligible services.

Rhode Island's Energy Efficiency Programs

Rhode Island's Energy Efficiency Programs offer homeowners, renters, businesses, and municipalities a variety of opportunities to save energy and reduce utility bills. These programs include:

- Energy Efficiency for Residents
- Energy Efficiency for Businesses
- Energy Efficiency for Farmers
- Energy Efficiency for Public Entities
- Energy Efficiency for Income-Eligible Customers

Con Edison's Energy Efficiency Programs

Con Edison' Energy Efficiency Programs offers its customers – renters, homeowners, and business owners – various energy efficiency rebates and incentives. These incentives apply to heating and cooling equipment, home appliances, LED lighting fixtures, prescriptive variable frequency drives and more.

District of Columbia Sustainable Energy Utility's Energy Efficiency Programs

The District of Columbia Sustainable Energy Utility (DCSEU) offers energy efficiency programs for both its residential and business customers. The programs offer rebates and technical assistance that apply to lighting, appliances, major renovation and new construction projects.

Microgrid Programs

MassCEC's Expressions of Interest – Community Microgrids Program

The Massachusetts Clean Energy Center (MassCEC) currently runs a Community Microgrids Program that seeks to catalyze the development of community microgrids throughout Massachusetts to lower customer energy costs, reduce greenhouse gas (GHG) emissions, and provide increased energy resilience. This program intends to award funding for feasibility assessments to advance proposed microgrid projects through the early project origination stages and attract third party investment to these opportunities. Applicants for the feasibility assessment grant must either have the capacity to carry out the feasibility study with a pre-identified team of their own, or may opt to receive a technical and financial assessment from a technical consultant contracted by MassCEC to perform such assessments.

MassCEC is soliciting Expressions of Interest (EOIs) from groups interested in participating in feasibility assessments for community microgrid projects across the Commonwealth. Respondents may include municipalities and their public works departments, electric distribution companies, municipal light plants, emergency services departments, owners of critical infrastructure such as hospitals and financial institutions, self-organized groups of commercial building owners, developers or any other actor that either owns property within a potential microgrid or can demonstrate that they represent stakeholders with the capability of developing a community microgrid.

Connecticut's Microgrid Program

Under its Public Act 12-148, Section 7, Connecticut created a Microgrid Program to help support local distributed energy generation for critical facilities. This act required the Department of Energy and Environmental Protection (DEEP) to establish a pilot of the Microgrid Program. It was created as a result of multiple episodes of severe weather that caused widespread power outages for extended periods and is designed to help create ways to ensure that critical buildings remain powered during electrical grid outages.

Under the Microgrid Program, grants were awarded to recipients to support critical facilities and were generally split between small, medium, and large municipalities if possible. In 2016, the program's bond funding was expanded to provide matching funds or low-interest loans for an energy-storage system or clean distributed-generation projects for a Microgrid. In August 2017, DEEP issued a request for applications for Round 4 of the Microgrid Program. Of the nine applications submitted for Round 4, three were awarded grants totaling approximately $13.1 million.

Cybersecurity Programs

While NEEPs research did not identify any official cybersecurity programs in the Northeast, regulatory bodies and utilities within the region have acknowledged that they are very much aware of the increasing need to address cybersecurity threats to their utilities' corporate and field environments.

Connecticut's Cybersecurity Action Plan

On April 6, 2016, Connecticut's Public Utilities Regulatory Authorities (PURA) published the Connecticut Public Utilities Cybersecurity Action Plan (Action Plan). When developing the Action Plan, participating utilities were given the option to use a usual adjudicatory proceeding style, or to collaborate informally for change to affect the outcome of the Action Plan. The utilities agreed to meet annually with a representative from PURA and Connecticut's Division of Emergency Management and Homeland Security, and to report on their cyber defense programs, registered attacks on their systems, and cybersecurity corrective measures.

New York's Cybersecurity Audits

New York's cybersecurity efforts have shown that a lack of jurisdictional authority does not need to be a barrier to developing an understanding of system-wide resilience and cybersecurity efforts. The New York Public Service Commission's Office of Utility Security conducts regular audits and performance of its regulated utilities. The role of the office in improving the security of the distribution system does not stop there. It arranges for information sessions with regulated and non-regulated utilities to create opportunities for the whole sector to discuss emerging issues and best management practices. The Commission is also part of the New York Utility Security working group which is a collaboration between the Commission, the New York Independent System Operator, the New York Power Authority, utilities, and other government offices. By combining the collective efforts of organizations working on different elements of grid physical and cybersecurity, the working group seeks to advance collaborative practices to secure the grid.

GEBs-Related Initiatives in the Midwest Region

Distributed Generation Programs

Illinois Power Agency's Adjustable Block Program

Illinois Power Agency's Adjustable Block Program (ABP) covers all distributed solar project under 2 MW. Under the ABP program, qualifying customers and developers installing distributed solar receive 15-year fixed-price renewable energy certificate (REC) contracts, paid out over a five-year period, which significantly improve the economics and payback periods for distributed solar technologies. If this program is successful, it will lead to hundreds of MW of solar in next few years. This is one of several initiatives to reach Illinois goal of 25 percent renewable generation by 2025.

Energy Storage Programs

ComEd's Community Energy Storage pilot program

ComEd's Community Energy Storage (CES)[9] pilot is being conducted in Beecher, Ill., approximately 40 miles south of Chicago. The pilot focuses on improving power reliability for customers experiencing multiple interruptions. One of the first utilities in the nation to install CES, ComEd will also evaluate the potential of this technology to serve as a proactive tool to drive continuous improvement in service reliability. It features a 25 kWh lithium-ion battery, the CES unit was installed near the existing ComEd equipment that provides power to the homes of Beecher customers selected for the pilot.

Flexible Rate Programs

Illinois mandates utilities to offer customers the option of market-based hourly pricing through utility procurement from wholesale energy markets operated by either the Midcontinent Independent System Operator (MISO) for Ameren Illinois customers or PJM for ComEd customers. The law requires residential hourly

[9] https://www.comed.com/News/Pages/NewsReleases/2017_03_16.aspx

pricing programs to be administered by non-utility third parties. Ameren Illinois Power Smart Pricing program uses day-ahead hourly prices, whereas the ComEd Hourly Pricing program uses hourly real-time prices. Since 2007 ComEd and Ameren IL residential hourly pricing programs have seen cost savings of 22 percent and 16 percent respectively.

Xcel Energy's Time-of-Use (TOU) Rate Program

Xcel Energy[10] in Minnesota has proposed a pilot to test time of use rates for residential customers. The pilot would explore if the peak period should be longer since demand spikes immediately after the peak period ends. It would also focus on integration of renewable energy based on Xcel Energy's projection to increase its wind and solar generation for 2024 and 2030 energy resource planning. This two-year pilot will potentially engage 17,500 customers to use Minnesota's wind power. Xcel Energy's market research reveals that there is a substantial need for customer education on variable pricing. The on-peak period of 3:00 p.m. to 8:00 p.m. will be priced at $0.258/kWh in the summer and $0.226/kWh in the winter. The off-peak periods will be 6:00 a.m. to 3:00 p.m., and 8:00 p.m. to 12:00 a.m. and will be priced at $0.121/kWh in the summer and $0.106/kWh in the winter. The super off-peak period will be midnight to 6am and its year-round price will be $0.057/kWh. The pilot expects to help deploy 400 MW of new demand response (DR) by 2023.

Consumers Energy's Peak Power Savers Program

Consumers Energy in Michigan hosts a Peak Power Savers Program[11] for its residential customers. It is designed to help customers get lower rates during non-peak hours every day and earn additional savings by reducing energy consumption on designated energy saving days. Customers get even lower rates during critical peak hours. They are notified via text, email or phone, and reminded to reduce energy use from 2:00 p.m. to 6:00 p.m.to save even more money. Customers on the Peak Rewards plan during energy saving days receive 95c for every kWh reduction during peak period.

Consumer Energy's Savers Club Program

Consumers Energy launched Energy Savers Club, a pilot program designed to reduce the energy load on Swartz Creek substation. This was a non-wire alternative (NWA) pilot focusing on energy efficiency to help with deferred utility infrastructure investment. The Swartz Creek substation was selected as the targeted location due to its observed potential need for capacity upgrades in future years (not immediate). The substation transformer at Swartz Creek had experienced peak loadings of 92 percent, 94 percent, 80 percent, 79 percent, and 85 percent from 2012 through 2016. The load appeared to be highly dependent upon the weather as no system changes (large transfers or large, new customers) had been observed. A traditional substation capacity increase would be implemented after an observed overload.

Swartz Creek substation was chosen due to the fact that historical loads had been observed close to capacity, but never over. Piloting an NWA at this location was an opportunity to test an NWA solution's feasibility without risking the equipment or customer reliability due to an observed overload the prior year. It addresses the role that intentional targeting of EE and DR programs to specific capacity-constrained geographies can play in managing load and deferring capacity-related investment. The area included in this project is mainly

[10] https://www.utilitydive.com/news/has-xcel-minnesota-designed-the-ideal-residential-time-of-use-rate/513235/
[11] https://www.consumersenergy.com/residential/rates/electric-rates-and-programs/rate-plan-options/time-of-use-rate-plans

suburban/rural and includes a little less than 4,000 residential and 300 commercial accounts. The program utilized education and awareness, program participation behavior change, and customer satisfaction.

Load Flexibility Programs

Indiana Michigan Power's Home Energy Management Program

I&M's Home Energy Management (HEM) Program is a load management program for residential customers. It's designed to achieve peak demand reduction and operate on an ongoing basis to reduce customer energy use. The program utilizes smart, Wi-Fi connected thermostats to manage customer HVAC systems to reduce usage during peak load events and to reduce overall energy consumption through more efficient operating conditions. Similarly, for the Work Energy Management (WEM) Program for commercial and industrial (C&I) customers, customers can reduce their energy use during peak demand by using WEM equipment. I&M deploys switches, sensors, control systems, near-real- time communication channels, and back office control software algorithms to manage customers' loads. I&M also has an Electric Energy Consumption Optimization program that automatically controls distribution system devices that have historically acted independently. I&M is currently actively exploring utility scale battery microgrid and emerging distribution management technologies.

DTE Energy's CoolCurrents Program

DTE Energy's CoolCurrents[12] program helps residential customers save on their electric bills during the summer. The utility installs a small wireless box that is mounted near a customer's separately metered CoolCurrents meter. Customers, after enrolling, allow DTE to adjust their central air conditioner on very hot days when demand for electricity is very high. The AC cycles off for 15 minutes, every 30 minutes for no more than eight hours daily. Special discount rates are offered to senior citizens and to customers who enroll in its Time of Day rate program. The program provides more reliable service to all customers on days when the demand electricity is high due to extreme weather.

ComEd's Internet of Things (IoT) Program

ComEd has become one of the nation's first utilities to provide access to an Internet of Things (IoT) apps that enable automatic response of smart appliances such as smart thermostats to real-time conditions when time-varying prices fluctuate. A Smart Meter Connected Device (SMCD) service is also available which provides near real-time usage data and estimated electricity cost information to energy-management equipment. However, IoT is at an early stage and its full potential is yet to be determined.

Microgrid Programs

ComEd's Bronzeville Community Microgrid

In Illinois, the ICC approved ComEd's microgrid demonstration in Chicago's Bronzeville neighborhood. Phase I of the project will include 2.5 MW of load and require reconfiguration of an existing feeder and installation of battery storage and solar PV. It will directly serve approximately 490 customers. Phase II of the project will add approximately 570 customers and an additional 4.5 MW of load and 7 MW of DERs, enough to meet the peak electricity demand of customers within the microgrid footprint and maintain service when the microgrid is

[12] https://newlook.dteenergy.com/wps/wcm/connect/dte-web/home/service-request/residential/pricing/rate-options

islanded from ComEd's grid. The completed project will serve approximately 1,060 residential, commercial, and small industrial customers. ComEd is leveraging DOE's 2 grant awards to develop the Community microgrid.

Ameren's Champaign Microgrid

Ameren is testing a multi-sourced microgrid in Champaign, Illinois. It has the capacity to produce 1,475 kilowatts, enough to power more than 190 homes. The leased generation assets located on site include a 100kW Northern Power Systems wind turbine, 125 kW Yingli solar array, 1000kW Caterpillar natural gas generator, and 250kW S&C Electric Company battery storage.

GEBs-Related Initiatives in the Southwest Region

Load Shedding Programs

Rocky Mountain's Cool Keeper Program

Rocky Mountain Power's Cool Keeper program is available to all residential and small commercial customers with central air conditioning in the Wasatch front. The program is not available in rural parts of the company's service territory due to the lack of communications infrastructure. The switches cycle air conditioners on and off in approximately 15 minute intervals. In addition to capacity resources, Rocky Mountain Power has begun to use the Cool Keeper program to provide contingency services and frequency regulation. Events can last up to four hours each between 2:00 p.m. and 9:00 p.m. on weekdays between May 1 and September 30. In 2018 no event lasted for more than 36 minutes.

Fort Collins Utilities' Peak Partner Program

Fort Collins Utilities run the Peak Partner program where utilities either install smart web-programmable thermostats or water heater control switches in a customers' homes at no cost to them. For the thermostat program, the utility cycles the customer's HVAC system at 50 percent of its maximum output during conservation events.

Load Shifting Programs

Load-shifting DR programs in the Southwest often utilize smart thermostats or air conditioning switches to allow the utility company to change the set point on thermostats or cycle air conditioning units for a certain period. In these programs, the utilities are shifting usage from times of peak demand on the hottest summer days; however utilities in the region have been exploring using load shifting to provide other services to the electric grid. The new services utilities are exploring include smoothing the ramp associated with the loss of renewable energy generation when the sun goes down and helping to stabilize the electric grid during times when generating resources are down for maintenance.

Public Service of New Mexico's Power Saver Program

The PNM Power Saver program runs using either a utility-controlled air conditioning switch or a utility-installed smart thermostat. The program is available to all residential and small commercial customers with central air conditioning or a central heat pump. During events, the switches run air conditioning units at 50 percent of the prior hours' operating time. The thermostats change the temperature setting on the customer's thermostat. The program is generally used to provide peak load reduction; however, the company has begun to utilize the resource to help minimize the ramp associated reduced solar generation or to help during emergency events when a transmission line or generator come offline. Events can last up to four hours each between 1:00 p.m. and 8:00 p.m. on weekdays between June 1 and September 30. In 2018 all events ran for four hours from 3:00 p.m. to 7:00 p.m. or 4:00 p.m. to 8:00 p.m.

Xcel Energy Colorado's Saver Switch Program

Xcel Energy Colorado launched its residential air conditioning switch program, known as the Saver Switch, in 2000. The company now estimates it has switches installed in approximately 50 percent of the single-family homes in its service territory. The Saver Switches operate via the paging network. When the company calls events, the switches cycling each air conditioner on and off in 15-minute intervals. The AC Rewards program is a bring-your-own thermostat program available to owners of Ecobee and Honeywell thermostats with central air conditioners that began in 2017. The program works by adjusting the temperature set point of the thermostat during peak events. The company is also planning to pilot residential battery storage and managed electric vehicle charging, but the details of both programs are still under development Events are traditionally four hours in length from 2:00 p.m. to 6:00 p.m. or 4:00 p.m. to 7:00 p.m. on weekday afternoons. The company is experimenting with shorter duration events in its AC Rewards program.

NV Energy's PowerShift Program

NV Energy has been running residential and small commercial demand response programs since 2001. The current PowerShift offering began in 2016. The company installs smart thermostats in customer home and businesses. On event days, two-hour demand response events are phased across the fleet of thermostats, so events last approximately three hours and 10 minutes. Immediately before an event each home is pre-cooled by a few degrees. During an event the company increases the set point by four degrees.
In the summer of 2019 NV Energy also began using its PowerShift program to alleviate local distribution constraints. NV Energy has also begun piloting company control of behind-the-meter battery storage devices. Community events can last up to six hours each on weekdays between June 1 and September 30. The average event time is two hours.

Arizona Public Service (APS) Cool Rewards Program

The Cool Rewards program began in 2018. It is a bring-your-own smart thermostat program. The program works by changing the thermostat temperature by 2-3 degrees and includes precooling prior to the event.
The Storage Rewards programs is looking to install up to 40 behind-the-meter batteries at residences in targeted areas of the company's service territory that have high solar production or on feeders that are facing capacity constraints. The company would own and operate the batteries. Customers must be on a rate with a demand charge to qualify. The batteries are charged mid-day when solar production is high and discharged during peak demand or the evening ramp. The Reserve Rewards program is looking to install up to 200 heat pump water heaters in residences that already have electric water heating in targeted areas of the company's service territory that have high solar production or on feeders that are facing capacity constraints. Customers must be on a time-of-use rate or a rate with a demand charge to qualify. The company will control water heating to use energy in the afternoons when solar production is high, while reducing energy usage during the evening ramp or at times of peak demand. Cool Rewards events can last up to two hours each on weekdays between June 1 and September 30. The average event time is two hours.

Load Modulating Programs

Rocky Mountain's Cool Keeper Program

Beginning in 2018, Rocky Mountain Power began using its Cool Keeper Program to provide frequency response services. As discussed above, the utility-controlled air conditioning switches respond immediately, and the company has demonstrated that the resource can respond to very detailed utility requirements. Similar to the load shedding program described above, the frequency regulation events generally last for a short duration and have no impact on the comfort of customers. Using the Cool Keeper program to provide this grid service means the company does not need to utilize existing fossil fuel resources to provide the service.

Geo-Targeting Programs

Xcel Energy Colorado's Geo-Targeting Pilot

Xcel Energy Colorado will implement a geo-targeting pilot as part of its 2019-2020 DSM Plan. In this pilot, the company plans to defer the need for investment in a new distribution transformer and associated feeder upgrades through targeted deployment of energy efficiency and demand response. On the feeder in question, the company projects the need for both a new transformer and feeder in 2023, at a cost of $10.1 million, due to load growth in this localized area.

The company estimates it will need three MW of load reduction by 2026 to avoid the need for the transformer. To defer this investment, energy efficiency and DR will be used to keep feeder peak load below the current thermal limit of the distribution system. In addition to targeted energy efficiency in this area, the company plans to use its existing air conditioning switches to provide peak load reduction at times of feeder peak, dispatching resources only within the area in question instead of throughout its service territory.

Current R&D related to GEBs technologies and market development

This section pertains to the Northeast region only.

NEEP was able to capture information on GEBs technologies from R&D institutions in the Northeast via emails, phone discussions and online research. From a sample set of 20 R&D institutions, only 13 (65 percent) conducted research on GEBs technologies. The following GEBs topics are being researched by these 13 institutions:

- Building efficiency
- Building simulation and modeling
- Building cybersecurity
- Distributed Energy Resources
- Building controls
- Building storage
- Building communication technologies
- Microgrids

The following graph shows how many R&D institutions conduct research on these GEBs topics.

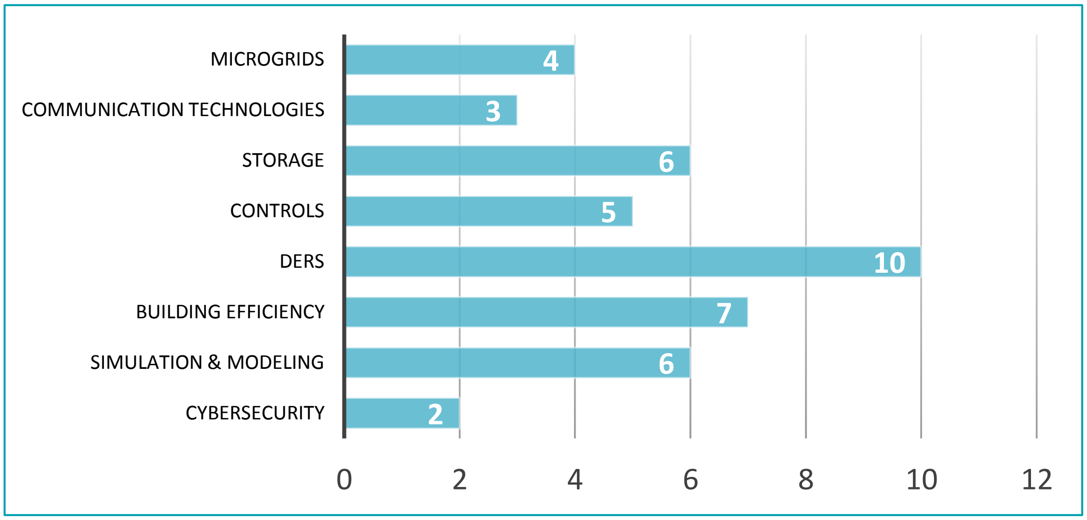


Figure 4: GEBs-related research in Northeast institutions

While the majority of GEBs technologies are being researched independent to a grid-to-building approach, there is evidence some R&D is focused on advancing holistic grid-interactive, efficient buildings. For example, New York University (NYU) is currently conducting research on how buildings behave during demand response. Using machine learning and data analysis, the NYU Civil & Urban Engineering Department is developing modeling software to better tap in to building characteristics and improve how buildings can respond during peak events. The research seeks to overcome some of the shortcomings of smart meter data, which is very accessible in the modern day but can be difficult to dissect and understand. Through enhanced modeling, NYU researchers seek to create digital models of buildings that can enable grid interactivity floor by floor – rather than whole building response – to improve timing and responsiveness of building technologies during peak events. Their modeling will be incredibly useful for new construction GEBs, but proves to be more difficult for older buildings that have much less well documented building characteristics.

Current Learning from GEBs-related Initiatives

Although many lessons being learned from GEBs-related initiatives are similar for the Northeast, Midwest, and Southwest regions, this section represents mostly a perspective from the Northeast region.

For many program administrators, state government planners, researchers and developers, the GEBs concept is very novel. They have expressed that many technologies that support this concept and currently being researched and deployed, but there is still much to be learned and implemented. For current and impending GEBs related initiatives, the following thoughts have been expressed:

- There is a need to educate employees of government organizations, utilities, manufacturers, and R&D institutions about the GEBs concept.
- There is a need for program administrators and implementers to be trained to think holistically about demand side management, incorporating energy efficiency, demand response and renewable energy. Right now the majority of development addresses energy efficiency; GEBs R&D needs to be well aligned with demand response to better serve that purpose.
- There is a need for programs at utilities to be less siloed, meaning that program leadership, program planning and program implementation must all reflect a more integrated approach.

- There is a need for program execution to stick to projected timelines as technology deployment is not currently keeping up with technology changes.
- There is a need for off-the-shelf technologies that are smart, communicative and interoperable.

GEBs Research: Analysis

Key Barriers That Impede Regional GEBs Technology Deployment

Many states embrace the vision of buildings evolving to become capable and willing partners with the modernized grid. However, there are many technology, financial, marketing, policy and information barriers that currently prevent this evolution from taking place more quickly. This sections gives an account of the key barriers that impede GEBs technology development in the Northeast and Midwest regions.

Key barriers that impede GEBs Deployment in the Northeast

Technology Barriers

The GEBs concept requires buildings to use smart technologies (e.g. smart meters, appliances, sensors and controls) to utilize multiple distributed energy resources including solar photovoltaic, wind, combined heat and power, energy storage, demand response, electric vehicles, microgrids, and energy efficiency in an integrated way to optimize energy use for grid services and building occupants.

While most states have buildings that deploy many of these technologies, the reality is that traditional buildings do not interact with the grid or exchange energy data information. Hence, many currently have a siloed approach when deploying these technologies and are only now becoming familiar with technologies that support interconnectedness, automation and interoperability.

Furthermore, many new technologies that support whole building integration tend to be unfamiliar and unproven. Utilities therefore questions their reliability, and are reluctant to invest in them. Because new technologies need to support grid stability, utilities usually have to stress-test these technologies by running pilot projects. This usually results in inflated technology implementation costs, since each utility operates in a unique environment and technology vendors are usually required to customize each deployment.

Marketing Barriers

Many utilities in the Northeast have expressed that the knowledge of new and available technologies does not get to them quickly enough, especially when it comes to the more sophisticated technologies that are required to realize the GEBs concept. One problem they have stated is that many of the specific technologies that are needed for interconnected, automated, interoperable GEBs applications do not yet exist – and this is because many manufacturing companies do not yet quite understand the concept and the accompanying future trends that would be needed to bring such technologies to market. For technologies making their way to the market, their barriers to adoption include:

- High cost of technology production
- The value of the technology is not yet known
- The application of the technology is not yet known
- The technology does not align with established work processes and procedures
- The technology has not been proven

- The technology is not quite suitable for clients

Regulatory and Policy Barriers

Many states in the Northeast have expressed that in order to effectively plan for the level of technology integration that the GEBs concept suggests, many regulatory hurdles will have to be crossed. More stringent regulations will be needed to address issues like:

- Lack of integrated program funding
- Siloed program management
- Lack of integrated EM&V regulatory rules
- Inconsistent metrics for evaluating cost-effectiveness of integrated programs
- Lack of advanced metering to provide near real-time data and price signals to customers
- Lack of robust cybersecurity guidance on both a federal and state level.

Information Barriers

Many states in the Northeast have expressed that one of the most widespread barriers to realizing the GEBs concept is insufficient information. While utilities lack information on proven technologies, equipment, and building management simulation software from manufacturers and developers; manufacturers have expressed that they would like utilities to be more transparent about their technology needs so that they can better customize their technology offerings. Similarly, utilities have stated that it would be beneficial to learn from R&D organizations what technologies are coming down the pipes, while R&D organizations would like to find out more about utility programs needs so that they can better steer their R&D topic choices. States have expressed that they are currently working on their customer relationships, and per customers' requests, will be providing them with more information on incentives, program choices, cost-saving opportunities, available services and potential returns on investment.

Key barriers that impede GEBs Deployment in the Midwest

Financial Barriers

There is a growing need to develop processes and best practices to integrate DERs into the current power system in the Midwest region. There are also numerous policy considerations that must be addressed to upgrade the electrical grid to help this transition. Even though there are large number of pilots that are underway, there is no universally accepted methodology employed to verify and compare the results across multiple studies. Without rigorous framework studies to quantify the value of DER programs, they become prone to semantic interpretations that might lead to missing or double counting costs and benefits. Better emission data transparency is needed to help decision makers and operators to optimize building operation. A shift from energy cost saving to carbon reduction would help GEBs penetration greatly. Aggregating buildings and building level energy load can help minimize cost and provide greater impact on energy saving. New metrics have to be developed to accurately capture the benefits of grid flexibility and using buildings as grid asset.

Cyber Security and Data Privacy Barriers

In the Midwest, cybersecurity and data privacy are growing concerns for customers. Internet of things (IOTs) for both energy and non-energy benefits are prone to cyber-attacks. The IOTs can be manipulated to affect and damage the grid. Stakeholders from different backgrounds need to work together to address these vulnerabilities as energy use data is critical for utility and building owners to help them optimize energy use. They are also critical for DER deployment during demand response events. This information is especially useful for aggregators to discern business opportunities, develop service offerings, and, of course, provide services to customers. Utility business model and regulations make them reluctant to share this information with third party energy service providers.

Education Barriers

In the Midwest, education and awareness are the key for GEBs. It is essential to provide clear and consistent messaging for different stakeholders. Customers and stakeholders need education on the value and the services that GEBs can provide. The information shared for different stakeholders should be tailored to meet their individual set of needs. With cities having carbon reduction goals, GEBs can be used as a pathway to reduce emissions.

Regulatory Barriers

To help greater penetration of GEBs in the Midwest, there is a need for rate structure and design reforms. Progressive rates help owners leverage the market. Customers should have the ability to lock rates long enough to align equipment investment.

Technology interoperability and communication

The biggest concern for building automation is the limitations on communication and interoperability. Currently many smart grid connected services in the market do not operate together and hence customers and homeowners are confused as to which equipment should operate together.

Policy Barriers

The manner in which utilities operate internally is a major barrier for GEBs in the Midwest. Integrated resource planning (IRP) focuses on generation resource planning, and demand response programs are sometimes not considered IRPs. Consumer-owned utilities are not subjected to IRPs. Utility regulators have much less visibility into distributed planning and the utility transmission planning process is separate from energy efficiency programs. Integrating energy efficiency and distributed resource programs will provide better recognition of load flexibility and will offer a much better chance to showcase value of GEBs. Often utility energy efficiency and demand response programs have uncoordinated goals and dockets; and have separate responsibilities, budgets, and staff. As states look to add electricity storage and, prospectively, grid-interactivity goals to energy efficiency, demand response, and renewable energy requirements, there is risk of disjointedness and sometimes conflict if such programs are not well-designed and coordinated. However, well-crafted policies, regulations, and programs could allow these multiple DERs to work complementary through GEBs.

Information Barriers

In the Midwest, pilot projects and innovative programs run by utilities are poised to help demonstrate and validate load flexibility through GEBs. The results of GEBs studies, similar to studies that were conducted for this report are key to educating policy makers and regulators. Across the U.S., various grid flexibility and grid-interactive pilot projects are underway in residential, commercial, and mixed-use communities; in new and existing developments; and under varied utility regulatory structures. It would be helpful if the best practices from these projects are shares across regions and sectors.

Regional similarities and differences

Across the Northeast, Midwest, and Southwest, the GEBs approach is still developing and its potential to provide services to the grid in each region is not yet fully known. However, independent GEBs-related technologies are already being deployed in these parts of the country, and their advancement and integration towards grid flexibility seems like an inevitable next step for all three regions.

Demand response appears to be a high priority in all three regions, and as such, many current regional GEBs initiatives are seeking ways to offset peak demand through technologies that support bi-directional communication between utilities and buildings. While some states are still in the process of implementing programs that proliferate the number of devices connected to the grid, such as NYSERDA's Air Source Heat Pump Program, others are already deploying load shaping programs that permit utilities to cycle devices already installed and therefore manage loads during peak events, such as in Xcel Energy Colorado's Saver Switch Program. Programs with more nuanced interoperability with technologies such as EVs are still largely in their pilot stages, but other mechanisms such as time-of-use rate programs are being deployed in each region and have been effective in mitigating stress on the grid during peak hours of the day.

Advanced Metering Infrastructure has largely been identified as a prerequisite to other technological solutions, as it is necessary in many cases to enable bidirectional communication between utility and customer. In almost all state energy plans in the Northeast and Midwest, further deployment of metering and analysis infrastructure is a common goal towards building a smarter and more responsive grid - perhaps fitting with the concept "You can't manage what you don't measure." However, even though AMI has been a key component of state energy plans that were reviewed for this report, the level of commitment to the technology varies by state. In some states, market penetration for the deployment of smart meters is slowing - for example, regulators in Massachusetts have rejected proposals for AMI deployment over the concern that utilities did not sufficiently make the business case. On the other hand, Minnesota has authorized increased rollouts to help meet their grid modernization goals. Despite the inconsistencies, tens of millions more AMI meters are expected to be deployed in the coming years as utilities continue with grid modernization efforts.

The key barriers to GEBs advancement that are identified by the Northeast and Midwest regions bear both similarities and differences. The common barriers are regulatory, policy, and information barriers. While technology and market barriers are two additional key barriers that are highlighted for the Northeast, cyber security, education and financial barriers are key for the Midwest.

It should be noted that since all categories of currently deployed GEBs-related initiatives are not covered by each region, an in-depth comparison of these initiatives was not conducted for this report. While common categories like distributed generation, energy storage and energy efficiency are recognized for both the Northeast and Midwest regions, the Southwest region has not included distributed generation as part of their intended scope for this project. Also, microgrid programs and cybersecurity programs are included as categories of Northeast GEBs-related initiatives; however (as each region had different scopes, approaches and targeted organizations for this report), that is by no means an indicator that the Midwest and Southwest regions do not currently conduct similar initiatives.

Recommendations

Top priorities for additional GEBs R&D going forward to meet regional needs

Investments in R&D advance science, generate fresh ideas, develop technologies, and emerge new products, services, and processes. Alongside the grid becoming increasingly complex and states seeking to advance the role buildings can play in energy system operation and planning, investment in GEBs-related R&D is either currently happening or at the forefront of state government and utility planning decisions. Based on the research that was conducted for this report, this section covers the top priorities for additional GEBs R&D to meet the needs of the Northeast and Midwest regions going forward.

Many states invest heavily in R&D projects for two main reasons: to meet state and local mandates and to stay up to date with cutting-edge technology solutions. In particular, utilities like Con Edison (NY) find that R&D pays off by making operations safer, more efficient, and more reliable, while also keeping them relevant.

For most of the utilities that were interviewed for this report, the concept of GEBs is quite novel. Hence, while many of their projected R&D investments overlap with the GEBs concept, GEBs has not been holistically considered when choosing topics for near-term R&D. When asked what future R&D topics should be prioritized so that buildings can optimally respond to a modernized grid, utilities and state government representatives suggested the following:

Modeling

Most utilities suggest that the following R&D modeling initiatives should be prioritized in the future:

- Understanding exactly what type of interaction is needed between building energy performance and electrical load modeling frameworks.
- Figuring out the modeling requirements for real-time operating systems. For example, what control systems are capable of responding to reliability events and what the response times should be expected?
- Understanding how modeling capabilities can span from design and site plans to operations.
- Modeling load aggregation and characterizing accompanying controls.
- Figuring out how whole-building models can reflect more granularity than is currently available.
- Creating frequency regulation and peak avoidance models for EV charging in residential vehicles.
- Figuring out the effect of new technologies on the distribution system.
- Analyzing demand charges versus energy charges for better optimization.
- Connecting comprehensive grid models and methods for load and resource balancing consideration of DERs, demand response and energy storage.
- Creating probabilistic models for load forecasting under dynamic pricing.
- Improving resilience and security, models for cyber-physical design methods, metrics and analytical methods.
- Creating standard models for life cycle analyses of GEBs.

Analytics/ Data

Most utilities suggest that the following R&D data and analytics initiatives should be prioritized in the future:

- Predicting how real grids will behave over time from simulation analytics.

- Figuring out how to effectively share building data with building operators in a way that will help them to work optimally.

Building Management

Most states suggest that there needs to be a better understanding of the optimal level of intelligence that is needed when sending signals from the grid to buildings, so that buildings can respond more actively to the grid. Hence, for data communication to help improve building management, R&D initiatives that will answer the following questions are recommended:

- What level of data granularity is needed?
- What geographic scale is suitable?
- What type of customer software would be best?

Communications and Interconnectivity

Most states suggest that the following R&D communications and interconnectivity initiatives should be prioritized in the future:

- Figuring out how infrastructure needs to be upgraded to improve communication infrastructure for multiple communications.
- Figuring out how to improve interconnection methods and technologies for managing and extracting information from large and disparate data flows.

Standards, Procedures and Protocols

Prioritization of the following R&D standard, procedures and protocols initiatives has been recommended by most states:

- Creating standards and associated metrics for equipment performance, standards for communications interoperability.
- Creating standardized methods for collecting and managing distribution-level operations data.

Evaluation, Measurement and Verification

Most utilities suggest that the following R&D measurement and verification initiatives should be prioritized in the future:

- Establishing a standardized protocol framework that can be widely used to identify the best EM&V methods for energy efficiency, demand response and direct load control, based on an individual system's unique resources and attributes.

Key opportunities for regional coordination and/or collaboration

Driven by environmental concerns and higher expectations around customer service, state governments are pushing new regulations to meet aggressive emissions targets and consumer habits are changing rapidly. Utilities feel the impacts of these competing pressures and very often rely on different types of collaboration to help drive major decisions. However, utility program administrators have expressed that current collaborations, although useful, are not enough. Furthermore, in order to focus on the critical aspects of GEBs-related programs as they work towards the vision of buildings operating more dynamically with the grid, both state government and utility stakeholders have iterated that collaboration will be key. Beneficial collaborations should include, but should not be limited to:

- Between utilities
- Across utility business units
- Between utility and manufacturers
- Between utility and R&D institutions
- Between manufacturers and R&D institutions
- Between utility and customers
- Between utility and utility and service providers

Stakeholders have expressed that creating regional collaborative opportunities in the following areas would be most beneficial:

Sharing best practices and lessons learned

Many states indicate that platforms that allow individual states to share their best practices and lessons learned will help other states to avoid error redundancy and expedite program successes.

Cost sharing

For most states, cost-sharing is on the top of their lists when they consider the benefits of regional collaboration. Since the cost for technology research, workforce development and training/educating customers can get very expensive, many utilities and government organizations are keen on participating in collaborations that will help them to reduce cost.

Information sharing

Sometimes finding specific information on equipment performance, building energy modeling, analytical tools and other GEBs-related technologies and solutions can be quite onerous. Hence Northeast states have indicated that having a centralized repository for the region, where such information can be stored, will be of huge benefit to them. The repository should include reports, websites, manuals, journals and other relevant documents.

Sharing barriers and strategies

Many states in the Northeast have indicated that it would be beneficial to learn about the hurdles that other states have encountered while trying to roll out their GEBs-related programs, and what strategies they used to overcome them. This would help to reduce trial and error and will assist with time and cost effectiveness in the long haul.

Sharing effective policies

Most utilities and state government organizations have their unique set of organizational rules and procedures that outline how things should be done. However, not all policies lead to employees' delivery of consistent, high caliber performance. Hence, Northeast states think that it would be beneficial to create opportunities for utilities and government organizations in the region to share policies that have been effective within their respective workplaces.

Sharing effective GEBs technologies

When it comes to technologies that support the GEBs concept, states in the Northeast are at varying stages of deployment – for most, technologies like building controls, efficient heat pumps and distributed energy resources are commonly deployed. However, very few states have advanced deployment of technologies like two-way communication platforms and whole building energy management systems. Regional knowledge of which technologies effectively support the GEBs concept – whether independently or collectively– will benefit individual Northeast states.

Conclusion

Based on the research that was conducted for the Northeast, Midwest and Southwest regions in the U.S., it is evident that GEBs deployment can yield many benefits – lower costs for consumers, enhanced resilience, reduced emissions, reduced peak loads, moderated ramping of demand, additional grid service, enhanced energy efficiency, and integrated distributed and renewable energy resources. However, research has also shown that most states are in the very rudimentary stages of understanding GEBs and their associated benefits. Hence, for all three regions, the following recommended actions should be taken to advance a GEBs strategy and the role that buildings play in energy system operation and planning.

1) **Educate and train** regional GEBs stakeholders on the benefits of approaching behind-the-meter planning with the GEBs vision in mind. This can be done via webinars, workshops, online and in-person training, brochures, and webpages dedicated to GEBs.

2) **Gather, share and archive updated information** on the following GEBs topics:
   - Progress amongst states in all respective regions
   - Best practices and lessons learned
   - Barriers and strategies
   - Effective policies
   - Resources like reports, websites, manuals and journals

3) **Conduct in-depth studies** on how utilities, government, manufacturers, vendors, and R&D institutions can work together to realize the benefits of GEBs so that energy efficiency, demand response, renewable energy, electric vehicle, and battery storage programs can be valued, scheduled, implemented, and managed holistically.