National Association of
State Energy Officials

Grid-interactive Efficient Buildings: State Briefing Paper

NASEO-NARUC Grid-interactive Efficient Buildings Working Group

Image source: rlmartin

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Contents

Introduction

In states across the nation, the electricity system is changing, presenting challenges and opportunities for the delivery of reliable, clean, and affordable power to America's homes, businesses, and institutions. As variable renewable generation and distributed energy resources (DERs)—including energy efficiency, demand response (DR), onsite generation, energy storage, and electric vehicles (EVs)—grow, the management of electricity is becoming more complex.

Fortunately, advancing technologies open the prospect for more flexible management of building and facility energy loads to benefit occupants, owners, and the grid. Grid-interactive Efficient Buildings (GEBs) take advantage of these new capabilities to optimize energy management by using sensors, analytics, and smart controls to best serve the needs of occupants while considering the grid and external conditions (such as peak loads and weather). Greater optimization of the significant energy demand and supply functions that buildings offer—on an automated basis—has far reaching electricity policy and regulatory implications for State Energy Offices, Public Utility Commissions, utilities, and building owners and investors. GEBs can:

- Lower costs, enhance resilience, and reduce emissions
- Reduce peak loads, moderate the ramping of demand, and provide grid services
- Enhance energy efficiency and integrate distributed and renewable energy resources.

The fundamental questions that arise from this opportunity are:

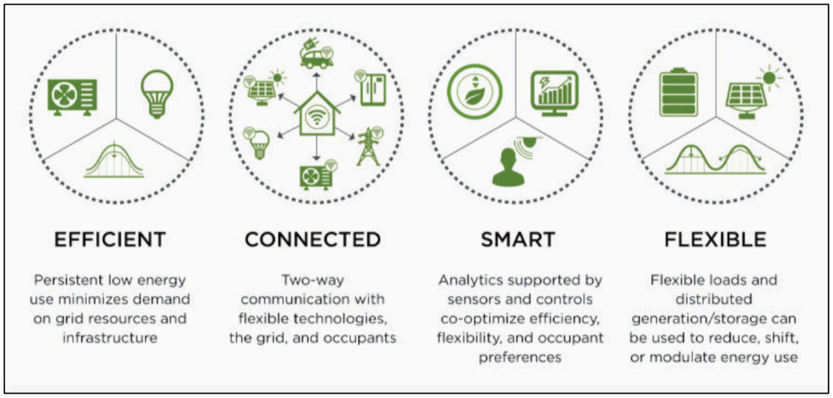
- How can facility interactions with the grid be optimized?
- How can states fashion policies, programs, and regulations to advance such optimization through GEBs?
- What are the roles for states, facility owners and operators, utilities, product and service providers, and others?

To help states approach these questions, the National Association of State Energy Officials (NASEO) and the National Association of Regulatory Utility Commissioners (NARUC) established the NASEO-NARUC Grid-interactive Efficient Building Working Group with the support of the U.S. Department of Energy (DOE) Building Technologies Office and the Pacific Northwest National Laboratory (PNNL).

This document provides a brief overview of the core aspects of a GEB and related flexible load management topics to help states and other stakeholders discern benefits of and challenges to load flexibility to meet such state objectives as affordability, cost containment and economic growth; energy reliability and resilience; and environmental stewardship.

What Are Grid-interactive Efficient Buildings?

Figure 1. Grid-interactive efficient building characteristics



EFFICIENT

Persistent low energy use minimizes demand on grid resources and infrastructure

CONNECTED

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

SMART

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

FLEXIBLE

Flexible loads and distributed generation/storage can be used to reduce, shift, or modulate energy use

Source: U.S. Department of Energy

GEBs are buildings that integrate and optimize DERs in conjunction with the electric grid to provide benefits to building owners and occupants as well as to the operation of the electricity system.[1]

As shown in Figure 1, the foundation of GEB is a high level of *energy efficiency* (EE), including passive elements, such as well-insulated and tight building shells (walls, roofs, windows, and doors), and active electrical and mechanical components like heating, cooling, lighting, refrigeration, cooking, and other electrical appliances and equipment.[2] High energy efficiency is beneficial in essentially all cases, irrespective of which, if any, other DERs are present or the degree of grid-interactive capability employed.

GEBs are *connected,* featuring two-way communication of signals between buildings (and their operators and occupants) and the grid. The signals may directly control and monitor equipment or may indicate prices and grid conditions that trigger building automation systems to act in accord with economic incentives and customer preferences. GEBs should also be *smart*, employing sensors, controls, and analytics to optimize the performance of a building to meet occupant needs and deliver grid services. And GEBs must be *flexible*, able to adjust loads and/or draw on DERs quickly to deliver optimal performance.

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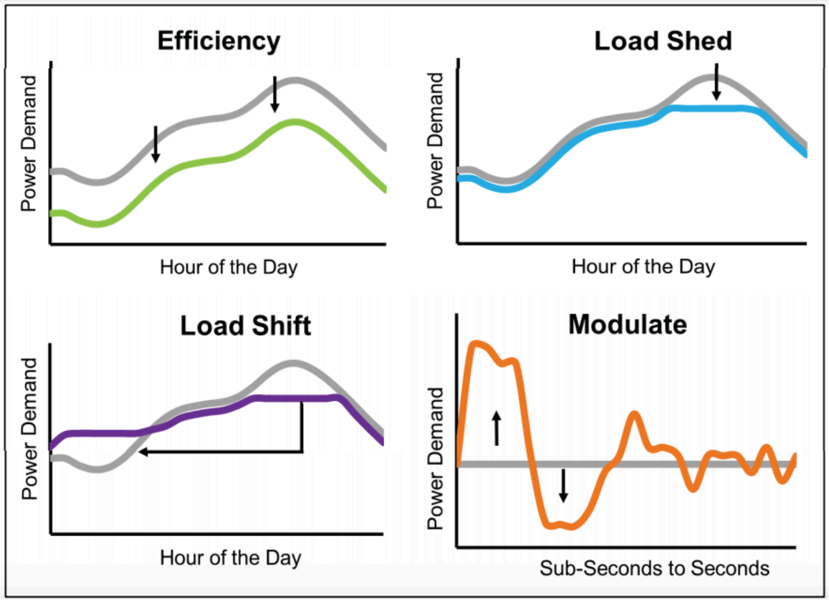
[1] U.S. DOE Grid-interactive Efficient Buildings: Overview along with a summary GEB factsheet Grid-interactive Efficient Buildings: Factsheet offer excellent overviews. This document is not meant to duplicate those resources.

[2] Benefits of energy efficiency apply to buildings' use of natural gas and other fuels (propane, oil) too but this document focuses on electricity. However, there can be GEB-pertinent interactions, such as peak demand reduction and grid-services that can be provided by onsite fuel-consuming generation, such as fossil-fueled combined heat and power (CHP) and microgrids. Also, electricity and onsite fuel use interact in some systems, such as electric loads from fans distributing heat from fuel-burning furnaces.

As shown in figure 2, GEBs can deliver several forms of demand flexibility that serve the grid. *Energy efficiency* provides ongoing reductions in energy use and power demand. *Load shedding* reduces load by curtailing one or more energy uses. This may be done to lower a building's demand charge on its utility bill or in response to a signal from its utility or grid operator during high electricity demand periods when the grid may be stressed and/or marginal costs of additional power are very high (i.e., demand response [DR]).

Figure 2. Demand Flexibility Provided by GEB



Source: U.S. Department of Energy

Load shifting flattens a building's demand curve by moving energy consumption from peak periods to other times to reduce both costs and grid stresses. Loads can also be shifted to take better advantage of renewable generation. Often load shifting is accomplished through thermal storage of energy, such as pre-cooling buildings or making ice at off-peak times to reduce daytime air conditioning loads, or scheduling water heating for off-peak periods. The decreasing cost of batteries is making electrical storage for load shifting more feasible too. Careful scheduling of electric vehicle (EV) charging and of certain industrial and commercial operations are also load shifting techniques. Second-by-second and even sub-second *modulation* of electricity use (for example, by finely controlling lighting or water heating) and injection of power to the grid (from batteries, for instance) can provide important voltage and frequency regulation to assure power quality.

Figure 3. Grid-interactive Efficient Building Load Curves

Source: U.S. Department of Energy

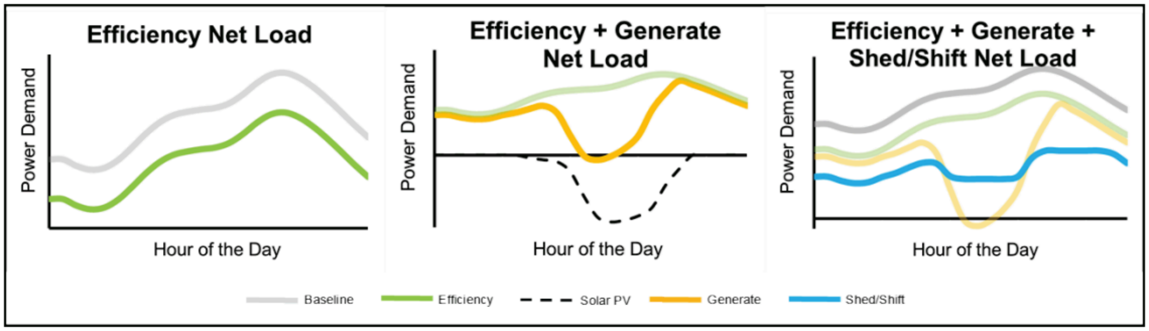


Figure 3 illustrates how multiple forms of demand flexibility—efficiency, generation, and load shedding and shifting—can combine to reduce and flatten a building's demand and moderate the rate of change in its demand (ramp rate). It also illustrates how these coordinated demand flexibility mechanisms can help to integrate variable renewable power generation, in this case solar energy.

Energy efficiency, smart load management, onsite generation (solar, fossil, or others), and energy storage can also be combined and configured as a microgrid to provide energy resilience to buildings, campuses, and communities, allowing them to operate (especially critical functions) during grid outages. Microgrid-equipped facilities need not necessarily include GEBs. However, load flexibility found in GEBs can optimize performance both when grid-connected and when operating off the grid in "islanded" mode, thus supporting facility resilience.[3]

While ideal GEBs include all of these facets and functions, different degrees of load flexibility, grid-interaction, and "smartness" still offer grid and building owner benefits—e.g., precooling buildings during off-peak periods, staging of HVAC equipment and other onsite load management, and traditional one-way demand response signals to curtail building equipment. GEBs need not be an all-or-none proposition. Indeed, a continuum exists from traditional demand response through automated demand response with smart equipment control to highly dynamic, flexible GEB.

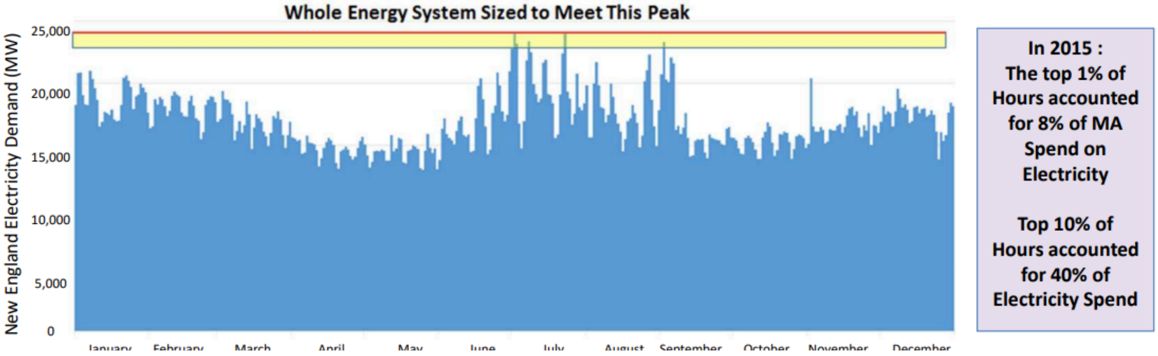
Why Should States Care About and What Can They Gain From GEB?

GEBs benefit the operation of the electric grid and owners and occupants simultaneously, thus benefiting utilities and grid operators, customers, and society at-large.

How GEBs Benefit the Grid

On the grid side, the first benefit is economic. Grid operators generally dispatch power supply in a "loading order" starting with the least expensive resources, turning toward higher marginal cost resources as demand increases. The marginal resource sets the price for wholesale power, which can become very expensive when electricity demand is very high. A relatively small number of peak hours account for a large fraction of annual electricity costs. For example, in Massachusetts, 1% of hours account for 8% of electricity spending; 10% of hours account for 40% of electricity spending (see figure 4.)[4] Shedding or shifting load from these times (which can also include use of onsite generation) lowers costs to utilities and their customers.

Figure 4: Source: Massachusetts Department of Energy Resources



In 2015 : The top 1% of Hours accounted for 8% of MA Spend on Electricity

Top 10% of Hours accounted for 40% of Electricity Spend

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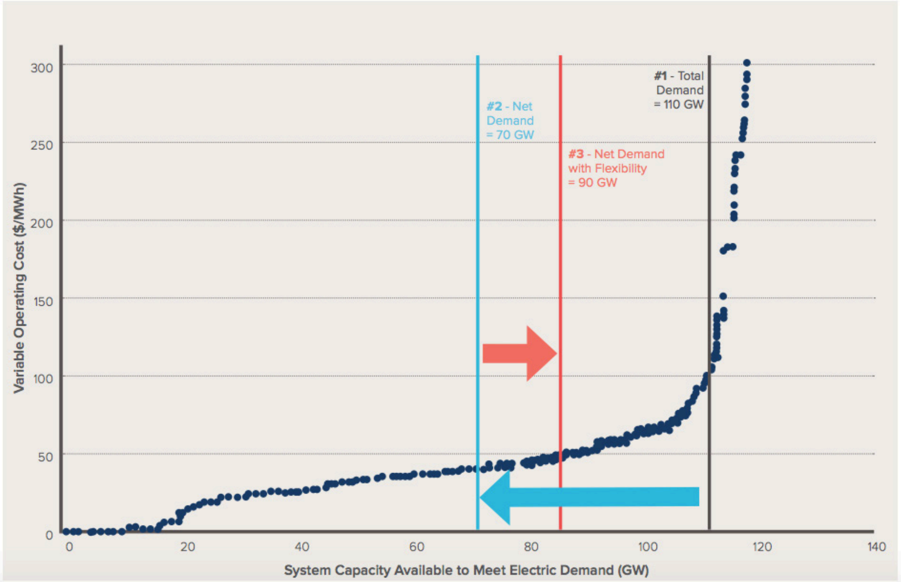
[3] With constrained onsite energy storage and power generation, which may also be variable (e.g., solar), load flexibility to balance generation and consumption, including assuring power quality, may be more critical when islanded than when grid-connected. Load flexibility may also allow better prioritization of loads during an extended outage.

[4] E. Friedman, 2019, "The Role of Grid-Interactive Efficient Buildings," Better Buildings Summit. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/Grid-Modernization.pdf

Figure 5 illustrates a representative dispatch curve for the ERCOT[5] service territory (most of Texas) showing the relationship of system capacity needs and variable operating costs.[6] The graphic illustrates how low-marginal cost renewable energy (blue arrow) reduces "net" load that needs to be satisfied by thermal power plants while load flexibility (red arrow) shifts load to when the low-cost renewable resource is available, allowing better use of renewable supply.

Figure 5: Impacts of Renewables and Demand Flexibility on the Wholesale Market



Source: Rocky Mountain Institute

Shifting, shedding, and onsite supply also reduce electric system line losses and physical stresses to grid equipment, thus lowering costs, as well as help defer or avoid replacement and upgrades to generation, transmission, and distribution capacity. Load flexibility can be incorporated into non-wires solutions (also called non-wires alternatives) in which DERs with grid software and controls reduce loads, allowing deferral or avoidance of traditional transmission and distribution (T&D) system upgrades such as lines and transformers.[7]

The Brattle Group found that a U.S. national load flexibility portfolio could deliver over $16 billion of annual savings in 2030, mostly from avoided generation capacity, followed by energy cost savings, avoided transmission and distribution capacity, and grid ancillary services (frequency regulation only in this study).[8] (See Table 1.)

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[5] Electric Reliability Council of Texas (ERCOT) is the electric grid operator serving about 90 percent of Texas' electric load. http://www.ercot.com/about

[6] C. Goldenberg, M. Dyson, and H. Masters, 2018, "Demand Flexibility: The Key to Enabling a Low-Cost, Low-Carbon Grid," Rocky Mountain Institute. https://rmi.org/wp-content/uploads/2018/02/Insight_Brief_Demand_Flexibility_2018.pdf

[7] B. Chew, E. Myers, T. Adolf, and E. Thomas, 2018, "Non-Wires Alternatives: Case Studies from Leading U.S. Projects," Smart Electric Power Alliance, Peak Load Management Alliance, and E4The Future. https://e4thefuture.org/wp-content/uploads/2018/11/2018-Non-Wires-Alternatives-Report_FINAL.pdf

[8] R. Hledik, A. Faruqui, T. Lee, and J. Higham, 2019, "The National Potential for Load Flexibility: Value and Market Potential Through 2030," The Brattle Group. https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_-_final.pdf

Table 1. 2030 Annual Benefits of National Load Flexibility Portfolio

Category	Annual Savings ($)	Percent of Total Saving
Avoided Generation Capacity	9.4 billion	57
Avoided Energy Costs	4.8 billion	29
Avoided Transmission and Distribution Capacity	1.9 billion	12
Ancillary Services	0.3 billion	2
Total	**16.4 billion**	**100**

Source: Derived from The Brattle Group

The same study estimated that in 2030 U.S. cost-effective load flexibility potential could reach 198 gigawatts (GW) or about 20 percent of national peak load. About 115 GW (almost doubling the current 59 GW of DR capability) could be achieved under existing market conditions with program expansions but another 83 GW could be available through emerging load flexibility enabled by new technologies and supportive policies, regulations, standards, and analytical approaches. [9]

Whether across the grid or in particular distribution feeders, grid flexibility provides reliability and resilience benefits by reducing stresses that can result in power quality compromise (like "brownouts") or outages, particularly during very high electricity demand periods or when natural calamities, equipment failures, accidents, or attacks damage key generation, transmission, and even distribution assets.

Should outages occur, GEBs may facilitate more orderly restoration of service. GEBs incorporating onsite generation and storage configured as microgrids may be able to continue operations through an outage. These resilience aspects are of growing salience for states, localities, institutions, businesses, and residential communities in light of recent natural calamities and concerns about energy system vulnerabilities, including to physical and cyber-attack. [10]

The lowering cost and growing penetration of both utility-scale (solar and wind) and distributed (largely solar) variable renewable generation presents opportunities and challenges to power system management. The growth in these resources and associated power sector challenges coincide with an increasing number of state, local, and private sector goals for expanding renewable and zero-carbon generation resources and reducing power sector emissions.

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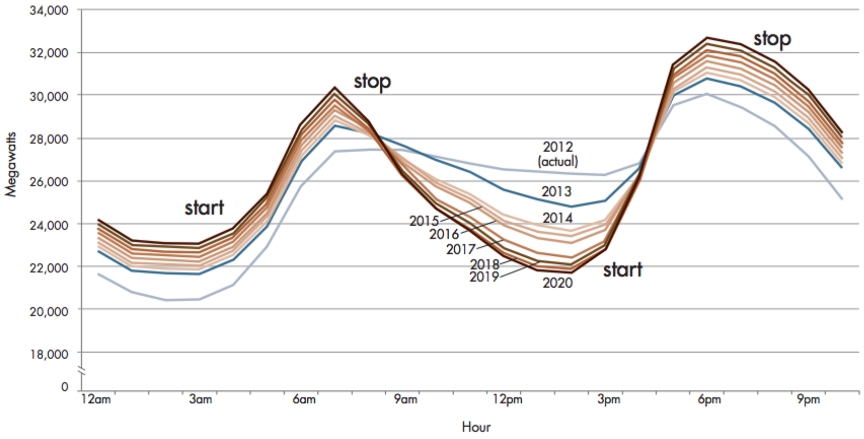
[9] Ibid.

[10] However, increasingly connected buildings and components (energy-related or otherwise) also create potential vulnerabilities to cyberattack. Cybersecurity aspects of GEBs, DERs, and the grid warrant priority attention.

Figure 6: The Duck Curve (Example from a January 11th Net Load)



Source: California Independent System Operator

The (in)famous ”duck curve” (figure 6) first appeared in California but the phenomenon is arriving elsewhere in the United States, such as parts of New England. [11] At times of high solar generation (belly of the duck), wholesale power prices can turn negative, leading to curtailment of renewable generation despite its minimal marginal cost. But as evening comes, solar generation reductions coincide with evening peak consumption, requiring a steep rise in other generation to meet demand (neck of the duck or “ramp rate”). Price volatility, steep ramp rates, and curtailed renewable generation can create fiscal and operational difficulties. They can also reduce the efficacy of clean energy policies that target greenhouse gases and Clean Air Act-regulated air pollutants by continuing reliance on higher-emitting ramping resources and requiring spinning reserves (excess online generation used to balance short-term variabilities, e.g., changing cloud cover and sudden changes in load). Regions with high levels of wind power generation also face challenges of variable renewable supply often not matching patterns of power demand.

Further complicating future grid management is the prospect of widespread electrification of transportation and of space and water heating. Electric vehicle (EV) use is expected to grow dramatically. Charging these vehicles could greatly increase loads—and stresses—locally on individual distribution feeders as well as in aggregate across utility territories, states, regions, and nationally if not well-managed. GEB technologies complemented by appropriate regulated (including rates) and market price signals could help shift EV load through managed charging to reduce peaks, moderate ramp rates, and better integrate renewable generation. GEB’s two-way power flow abilities could also allow EVs to provide grid ancillary services to balance loads and regulate frequency and voltage, turning an electric load into a grid service asset. Similarly, heat pumps for efficient space and water heating may increase electric loads when replacing natural gas, propane, or oil burning appliances though they may moderate loads as replacements for inefficient resistance heating. In either case, heat pump technologies can be grid-enabled for load shifting and, perhaps, short-term load modulation.

GEBs can mitigate these grid management challenges by shifting load through energy storage, load scheduling, and peak reduction to benefit from low marginal cost renewable generation when it is available, and to moderate ramp rates. This would provide economic, operational, and environmental benefits. Thus, GEBs can play an important role for states to meet renewable energy and emission objectives while assuring electricity affordability and reliability.

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[11] California Independent System Operator. “What the Duck Curve Tells Us about Managing a Green Grid.” California ISO, 2016, www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

How GEBs Benefit Building Owners and Occupants

From the perspective of building/facility owners, including states and other public entities, GEBs can offer customer cost savings through more effective reduction in peak loads (and lower demand charges), taking advantage of utility time-of-use rates, and additional revenues from demand response program participation while also enhancing building performance and occupant comfort.[12]

A study by the Rocky Mountain Institute (RMI) and the U.S. General Services Administration (GSA) estimated that implementation of GEB-encompassing HVAC, lighting, plug-load, renewable energy, and storage measures across the GSA-owned office portfolio could yield 165 megawatts (MW) of peak reduction and 180 gigawatt-hours (GWh) per year of energy savings, reducing energy bills by $50 million annually or about 20 percent of GSA's annual energy spending.[13] Modeled prototype GSA office buildings across six locations would save between seven and 60% on their annual energy costs and show payback periods of under four years while yielding positive net present value (NPV) results. [14] In addition to financial benefits that would accrue to GSA, implementation of the modeled GEB measures across the GSA office portfolio could provide up to $70 million annual grid (and ratepayer) cost savings from avoided generation capacity and T&D costs while also supporting resilience, load balancing, and emission reduction objectives.

Presumably, these types of GEB benefits would also apply to state, local, institutional, and private building owners. Based on interviews with state officials participating in the NASEO-NARUC GEB Working Group (see below for more detail), multiple states are interested in GEB to address state and public building needs. Some states appear interested mainly in cost reduction opportunities (such as those suggested by the RMI-GSA study) while others also point to state or public building clean energy, climate, and environmental sustainability policies and goals.

For example, Minnesota's Sustainable Buildings 2030 Energy Standard establishes carbon-emission reduction goals for new and renovated state-bond financed buildings as compared to a 2003 average building baseline.[15] The 2015-19 goal is a 70% reduction which will increase to 80% in 2020, 90% in 2025, and 100% in 2030. The program had focused on energy efficiency measures with energy use intensity (EUI—energy consumption in British thermal units (Btu) per square foot of area) as a metric. As the standard's stringency increases, GEBs can coordinate and optimize energy efficiency, renewable generation, storage, and other DERs with the grid to meet emission objectives.
The next section discusses state interests and motivations related to GEBs as elicited from a series of interviews with state officials.

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[12] Utility rebates and other incentives for energy efficiency and demand response may also be available.

[13] C. Carmichael, M. Jungclaus, P. Keuhn, K. Porst Hydras, 2019, "Value Potential for Grid-Interactive Efficient Buildings in the GSA Portfolio: A Cost-Benefit Analysis," Rocky Mountain Institute and U.S. General Services Administration. https://rmi.org/insight/value-potential-for-grid-interactive-efficient-buildings-in-the-gsa-portfolio-a-cost-benefit-analysis/

[14] Ibid. Utility incentives were included in financial analyses and NPV remained positive under varied upfront cost assumptions.

[15] See Minnesota B3 SB2030 Energy Standard https://www.b3mn.org/2030energystandard/

NASEO-NARUC GEB Working Group State Interviews

During April and May 2019, NASEO and NARUC interviewed officials of 14 states participating in the Working Group. The intent of the interviews was to understand each state's energy landscape, interest in GEBs, and what each state seeks from Working Group participation. Understanding of state interests and contexts is shaping Working Group direction and activities.

The discussions covered state contexts, including profiles of the electricity system and its market and regulatory structure; roles of the State Energy Office, Public Utility Commission, and other agencies; whether any pertinent demonstration projects or pilots are underway or planned; and whether state energy and electricity planning processes had included grid-interactive considerations. States were offered confidentiality to ensure open discussion.

The state interviews yielded a rich set of information and perspectives, some detailed and state-specific but others generalizable and thematic. The following includes some high-level points garnered from the interviews.

States want to learn about other states' experience and activities. This includes projects, policies, and regulatory actions. They want to learn about results, lessons, and insights. They are interested in tangible examples.

States are interested in GEB and resulting load flexibility to help meet broad electricity and energy system objectives. When asked about motivations for GEB, such as moderating peak demand, modernizing the grid and addressing congestion, enhancing energy resilience, or addressing emissions, many states said essentially "yes, all of the above." States are interested in such areas as renewable resource integration, microgrids and other DERs to support resilience, meeting air pollution and climate goals, and beneficial electrification and electric vehicles. They want to understand how to integrate and optimize across these dimensions to meet state objectives. Working Group states include those with surplus generation as well as ones perceiving generation and transmission constraints.

Some states are interested in GEBs and resulting load flexibility applications for state and public buildings. States have multiple motivations in this area. Some focused primarily on opportunities to reduce utility costs. Many pointed to resilience benefits that could accrue, particularly to critical public facilities. Others have state "lead-by-example" objectives for improving energy efficiency, reducing energy-related emissions, and promoting cleaner energy at state or public facilities. These interests suggest options for using public buildings as demonstration test beds for GEBs and other building energy technologies. This can be analogous to federal facility technology demonstration and validation projects performed through the U.S. General Services Administration's Proving Ground program and the Department of Defense's Environmental Security Technology Certification Program (ESTCP).[16, 17]

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[16] U.S. Department of Defense, nd, "About ESTCP," https://www.serdp-estcp.org/About-SERDP-and-ESTCP/About-ESTCP

[17] U.S. General Services Administration, 2019, "About GSA's Proving Ground (GPG)," https://www.gsa.gov/governmentwide-initiatives/sustainability/emerging-building-technologies/about-gsa%E2%80%99s-proving-ground-gpg

Many states want to understand how to value and assess the performance of GEBs (and broader DER integration) and their states' potential for implementation. States agreed that this is an area that needs more exploration. Topics for further consideration include: What is the value of a GEB and to whom? How can performance and its value be measured? How can costs and benefits be evaluated?

States noted technical challenges, but most states recognize that policy and regulatory factors can impede realization of the full benefits of load flexibility provided through GEBs. Even if technologies are readily available and implementable, what would incite building owners to change energy management to benefit the grid? What incentives are there for utilities to rely on customer- or third party-owned assets and actions to provide grid services? Among Working Group states, utility market and regulatory structures vary significantly as does the availability and use of peak demand charges, time-of-use rates, and demand response programs. Some of the states are actively exploring new utility business models. The states differ in advanced metering infrastructure (AMI) penetration and have mixed experience with grid modernization proceedings.

How or can traditional energy efficiency programs mesh with broader load flexibility? Some states are interested in expanding traditional energy efficiency programs to include other DERs, load flexibility, and electrification. This was raised with respect to utility ratepayer-funded efficiency programs but can apply to energy savings performance contracts (ESPCs), state building performance targets, and other policies and programs. There can be good opportunity for energy efficiency to work in concert and synergy with other DERs through GEB but there is also the hazard of conflict and forgone energy efficiency investment.

The state interviews suggested multiple areas for exploration and explication. They help guide the Working Group's consideration of topics for future learning, exchange, and resource development; for further research and technical assistance; and directions for state development of roadmaps, action plans, and policy and regulatory development.

Technical Aspects: Characteristics, Opportunities and Challenges

Load Flexibility: A Continuum of Capabilities

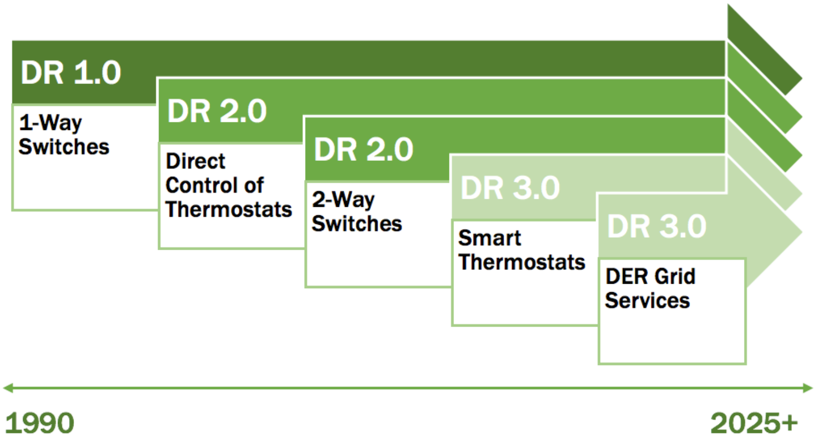
As noted previously, GEBs are not an all-or-none proposition. Not all grid-interactive load-flexible features, functions, and grid services need to be simultaneously available to provide benefits to the grid and to building owners and occupants. States and utilities as well as building owners can add such capabilities and functions based on their own contexts.

One-way grid interactivity has existed for many years as traditional demand response—DR 1.0. Traditionally, the utility or grid operator would call or signal industrial or commercial customers participating in a DR program to curtail certain loads during periods of extremely high demand or supply-side constraints. Residential customers might have devices connected to their electric water heaters or air conditioner compressors allowing utilities to curtail those devices for limited periods. Compensation to participating customers might be through seasonal or per event bill credits or, perhaps, be based on the amount of load reduced by industrial customer or through payments in a capacity market.

Traditional DR has been important but is a fairly blunt tool, providing "capacity" service to the wider grid over hours-long timeframes. More sophisticated automated DR is closer to the GEB vision of agile and precise load flexibility that can coordinate and optimize across multiple DERs to meet both occupant and grid needs. Automated DR can be more locationally targeted, such as toward specific stressed or congested portions of the grid. It can operate in faster timeframes to provide minute- and second-level flexibility. GEBs can provide multiple grid services beyond curtailment (shed) such as load shifting and modulation to provide ancillary services. Batteries and onsite generation can also feed power back into the grid to provide service. Figure 7 illustrates the evolution in sophistication of DR over time.[18]

Because there is a continuum of building-grid interactivity rather than a discrete threshold defining a GEB, states and utilities that lack or have low penetration of "smart meters" and advanced metering infrastructure (AMI) should not forego opportunities that are still available to them. While AMI can facilitate greater GEB functionality, utilities can still implement programs, such as for smart thermostats and electric water heaters, to perform load shifting and shedding functions.

Figure 7: Evolution of Demand Response



Source: Smart Electric Power Alliance

Advanced distribution management systems (ADMS) and distributed energy resource management systems (DERMS) are emerging tools for utilities to manage multiple DERs across multiple customers in the distribution system. Portfolios of buildings or facilities may be controlled as virtual power plants (VPPs) or virtual batteries in more sophisticated GEB approaches.[19, 20]

Another consideration is distinguishing DR from broader load management and load management from GEB. The "R" in DR is for "response"—response to a grid signal. Traditionally the utility or grid operator declares a grid "event" to trigger DR signals to participating customers. However, good building management systems and operators will seek routinely to reduce peaks, save energy, and co-optimize utility costs and occupant needs without grid signals. If widely practiced, good building load management could reduce the need for utilities and grid operators to declare DR events. Full-fledged GEBs would combine the functions of high quality building energy management with grid-interaction. However, grid-interaction would be two-way, smart, and also routine; done as part of

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[18] Smart Electric Power Alliance, 2017, "2017 Utility Demand Response Market Snapshot," https://sepapower.org/resource/2017-utility-demand-response-market-snapshot/

[19] M. Brown, 2019, "Solar Energy: World's First Virtual Power Plant of its Kind Coming to Utah," Inverse https://www.inverse.com/article/58821-solar-energy-one-of-the-largest-virtual-power-plants-is-coming-to-utah

[20] H. Trabash, 2019, "Hollywood's Next Star Could Be Virtual Power Plant as LADWP Closes Out Natural Gas," Utility Dive https://www.utilitydive.com/news/hollywoods-next-star-could-be-virtual-power-plants-as-ladwp-closes-out-nat/560792/

normal grid operation and optimization rather than as discrete, infrequent "DR events."
Many commercial and large multifamily residential buildings use building management systems that control energy-using systems such as HVAC, lighting, and water heating but are not grid-interactive. These systems vary significantly in their "smartness"—the sophistication of sensing, control, and analytics. There can be ways to "smarten" existing systems to make them more load flexible and even grid-interactive. The New York State Energy Research and Development Authority (NYSERDA) Real Time Energy Management (RTEM) program provides an example. (See Box 1.)

Box 1. Real Time Energy Management (RTEM) Program

NYSERDA established RTEM to improve energy management in commercial, multifamily residential, and industrial buildings. Qualifying systems continuously collect data from sensors, meters, and equipment and use sophisticated analytics (cloud-based or on-site) to identify performance optimization opportunities and energy savings[21]. The program provides cost-share incentives for eligible customers to implement RTEM systems offered by qualified vendors. The systems may be integrated into existing building management systems or, for facilities lacking such systems, wireless sensors and meters can be installed that allow monitoring and analysis. An undated (likely 2019) paper noted that $59 million of incentive supported almost 400 projects delivering an average of 12 to 15% annual energy savings.[22] The RTEM systems "also include solutions that interact with the grid to receive and react to demand response signals."[23] While as yet not fully grid-interactive, such systems can enable deeper GEB capabilities. Indeed, NYSERDA is developing a Grid-responsive Energy Management (GEM) program to build on RTEM to enable buildings to act as virtual batteries, using controls and intelligent automation to rapidly shed and shift loads.[24]

Technical Challenges

Multiple technical challenges can stand in the way of GEBs. Among them are the following:

Standards and Interoperability

A technical challenge that has arisen in furthering building automation in GEBs concerns standards and interoperability limits. A report focused on residential GEB notes that "Interoperability has long been seen as the ultimate hurdle to the smart, grid-connected, efficient home."[25] From the homeowner's perspective—whose interest in smart homes likely emphasizes amenity, safety, and security rather than energy—there can be confusion about which system components can work together and an aversion to having separate apps controlling different components. For grid interaction, open communication standards such as OpenADR and CTA-2045 exist but may be insufficient to fully engage residential GEB opportunities.[26]

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[21] NYSERDA, nd, "Real Time Energy Management (RTEM) Program," https://www.nyserda.ny.gov/All-Programs/Programs/Real-Time-Energy-Management

[22] NYSERDA, nd, "Raising the Bar for Smart Building Solutions," https://www.nyserda.ny.gov/-/media/Files/Programs/RTEM/rtem-solutions.pdf

[23] Ibid.

[24] NYSERDA, 2019, slide deck provided to NASEO https://annualmeeting2019.naseo.org/data/energymeetings/presentations/NYSERDA--RTEM-GEM.pdf

[25] K. Saul Rinaldi, E. Bunnen, and S. Rogers, 2019, "Residential Grid-interactive Efficient Building Technology and Policy: Harnessing the Power of Homes for a Clean, Affordable, and Resilient Grid of the Future." AnnDyl Policy Group, https://www.naseo.org/Data/Sites/1/anndyl_naseo-geb-report-final_20191008-003-1.pdf

[26] Ibid.

Cybersecurity

Cybersecurity is a growing concern that requires serious attention if grid-interactive functionality is to grow. The expanding Internet of Things (IoT), of both energy and non-energy-related devices and on both utility and customer sides of the electric meter, offers a burgeoning number of targets potentially vulnerable to attack by criminal groups, terrorists, national actors, and others. Attacks could be made on individual companies and institutions to steal and manipulate sensitive information or disrupt operations. IoTs can be manipulated to disrupt Internet services, such as through distributed denial-of-service (DDoS) attacks. The grid-supportive, beneficial functions of GEBs could be subverted by malefactors to disrupt and damage the grid as well. A Government Accountability Office report noted a simulation that found that a cyberattack on high-wattage smart home appliances (e.g., air conditioners) could turn them into "botnets" that could be used to manipulate demand across the grid and cause an outage by synchronously switching on all compromised devices.[27] Federal and state officials, utilities and grid operators, building owners and operators, and providers of products and services need to work together to address such vulnerabilities.

Data Availability and Customer Privacy

Utility data availability and customer privacy concerns can also be a hurdle to implementing GEB. Energy use data are critical for utilities, building owners, and operators alike if they are to optimize energy management. They are also critical to the business of DER providers and DR and other energy service aggregators to discern business opportunities, develop service offerings, and, of course, provide services to customers. Beyond data used for customer billing, utilities may not have relevant operational and time differentiated data available; or operational and billing data may be in incompatible formats not easily integrated for use in offering services. Utilities may be concerned about liabilities relating to customer privacy or accuracy of data. Their business and regulatory models may make them reluctant to share information or partner with third party energy service providers. Energy service providers may find it difficult to deal with varied procedures, legal strictures, and data formats across utilities and states. Customer data release authorizations, data exchange infrastructures, data safeguards, and incentives for utilities to make data accessible are among issues that need to be addressed to animate new markets and business offerings for grid services, including for GEBs.[28]

There are several challenges to the advancement of GEBs that have technical aspects but significantly impinge on policy, regulation, and administration. These include valuation of load flexibility, measurement and evaluation of building and system performance, and demonstration and validation of technologies to give customers, utilities, and regulators confidence that they will deliver value at acceptable cost. These will affect the policy, regulatory, and market environments for load flexibility.

Valuation of Load Flexibility

Valuation of load flexibility informs policy, regulation, and business models. What is the value of load flexibility and to whom? This and other papers have recounted grid, building owner, and occupant benefits of load flexibility, including some estimated monetized benefits of saved energy, reduced peak demand, avoided capital expenditures, and ancillary grid services. But such broad estimates are inadequate for establishing regulatory or market mechanisms for compensating flexible grid service provision or for determining the cost-effectiveness of projects and programs.

One attempt to develop "value stacks" for compensation purposes is illustrated in Box 2.

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[27] U.S. Government Accountability Office, 2019, "Critical Infrastructure Protection: Actions Needed to Address Significant Cybersecurity Risks Facing the Electric Grid," https://www.gao.gov/assets/710/701079.pdf

[28] C. Girouard, 2018, "Access to Data: Brining the Electricity Grid into the Information Age," Utility Dive https://www.utilitydive.com/news/access-to-data-bringing-the-electricity-grid-into-the-information-age/521874/

Box 2. The Value of Distributed Energy Resources

In New York, NYSERDA developed a Value of Distributed Energy Resources (VDER) system that will initially be applied to distributed renewable power sent to the grid as the state phases out net energy metering [29,30], VDER established a "value stack" consisting of five components:

1. *Locational-based marginal pricing, which is the wholesale electricity price that varies by location and time*
2. *Capacity value*
3. *Environmental value, which approximates the renewable energy certificate value*
4. *Demand reduction value, based on peak reduction value at the time power is sent to the grid*
5. *Locational adders, which are bonuses added for DERs providing power in congested distribution areas*

Although developed for distributed renewable generation exported to the grid, the approach can be made more widely applicable to DER grid services, including those provided by demand reduction and demand flexibility.

Performance Metrics

Metrics for grid flexibility are nascent. How does one indicate quantitatively how well a building is serving as a grid asset? The New Buildings Institute, in collaboration with the Rocky Mountain Institute and U.S. Green Building Council, is developing GridOptimal as a metric for "grid citizenship."[31] There are also National Laboratory investigations in this area.[32] As discussed below, such metrics could support voluntary initiatives as well as policies and regulatory program, such as inclusion of relevant metrics and indicators in building energy and environmental rating systems; building performance benchmarking and disclosure rules; building codes and performance standards; and in zoning or land use processes.

Demonstration and Validation

Pilot projects to demonstrate and validate load flexibility approaches through GEBs are pertinent across technical, policy, and regulatory realms. Potential customers, utilities, policymakers, and regulators need objective performance data to show the value and efficacy of GEBs before they will be willing to enact supportive policies and regulations or implement projects. Various grid flexibility and grid-interactive pilot projects are underway across the United States in residential, commercial, and mixed-use communities, in new and existing developments, and under varied utility regulatory structures. Still, more is needed.

At the federal level, the GSA Proving Ground program and the Department of Defense Environmental Security Technology Certification Program (ESTCP) have demonstrated and validated multiple building energy efficiency, load management, and microgrid technologies.[33, 34] There is opportunity for states, localities, and other institutions (such as colleges and universities) to establish pilot programs and test beds to demonstrate and validate grid flexibility and GEB.

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[29] VDER applies in service territories of utilities overseen by the Public Service Commission. A separate VDER approved by the Long Island Power Authority applies to Public Service Electric and Gas, Long Island.

[30] E. Thoubboron, 2018, "VDER: NY's Replacement to Net Metering," Energy Sage https://news.energysage.com/vder-ny-replacement-net-metering/

[31] New Buildings Inst., 2019, "The GridOptimal Buildings Initative," https://newbuildings.org/resource/gridoptimal/

[32] U.S. Dept. of Energy, 2019, GEB Strategy Portfolio, Conference session, Building Technologies Office Peer Review

[33] U.S. Department of Defense, op cit.

[34] U.S. General Services Administration, op cit.

Control of Load Flexibility

Another topic that crosses technical, policy-regulatory, and market realms is how GEB will be controlled. Should loads and coordination of DERs be directly controlled (or sometimes even owned) and "dispatched" by utilities or should grid-interactive DERs operate autonomously, responsive to price signals and grid conditions (such as voltage and frequency)? Under the former, utilities may have more certainty of performance, but the latter allows consumer (directly or via a third party aggregator/ service provider) to choose their level of participation based on market signals and their preferences.

Policy, Regulatory, and Administrative Matters: Drivers and Impediments

New technological capabilities are enabling the potential of GEBs but policy, regulatory structures, and market signals are needed to incite implementation. Why would a building owner provide the grid services that a GEB enables? Why would a utility invest in or rely on load flexibility resources it does not own? Are there business cases for third-party private sector GEB service provision by energy service companies (ESCOs), DR aggregators, or others? How can load flexibility benefits and value be recognized and monetized to provide financial reward for implementation?

Some opportunities for monetizing and, thus, incentivizing load flexibility depend on electric utility and grid operation governance and regulation under legislative and/or utility commission (or other authority in the case of cooperative and public power utilities) control. These include the design of electricity rates, rules on grid service markets and compensation (such as Independent System Operator capacity markets), and utility and grid operator business structures. Laws establishing energy efficiency, demand reduction, and renewable energy goals, such as energy efficiency resources standards (EERS) and renewable portfolio standards (RPS) also shape utility requirements and programs and, depending on policy design, could encourage GEB applications.

However, policies and factors outside the realm of utility regulatory purview under state energy office and other bodies' purview also shape the potential market for load flexibility, DERs, and GEBs. For example, some states and localities seeking to enhance resilience of public buildings and critical facilities are exploring and implementing microgrids, whose suites of DERs can be grid-interactive assets. Public building "lead-by-example" programs promote improved energy and environmental performance in new and existing buildings; they may also support the use of public buildings as GEB demonstration test beds. State policies and programs could stimulate Energy Savings Performance Contracting (ESPC), energy-as-a-service, and other public-private partnership structures that could include load flexibility services. State and local building energy benchmarking, disclosure, labeling, and performance policies as well as zoning and land use processes can also help craft load flexibility and GEB markets. Federal and state appliance energy standards and state and local building energy codes may also be pertinent. And voluntary certifications and labels for equipment and buildings, such as ENERGY STAR and LEED, can also play roles.

Building owner and customer perspectives and motivation to provide services

Traditional utility rate structures often include, particularly for commercial and industrial (C&I) customers, demand charges and time-of-use (TOU) rates which provide some incentive for peak reduction and load shifting. These, plus traditional DR programs, are relatively blunt tools.

Typically, demand charges are based on the highest load demanded by the customer during the month, irrespective of whether that load coincides with peak loads experienced by the wider grid or local congestion-related stresses. Thus, a customer's demand charges may have little relationship with costs imposed on the grid. Demand charges may be most appropriate to cover distribution system components needed to serve the individual customer rather than to address wider grid needs but TOU rates and DR incentives are more appropriate existing tools for mitigating system peak and ramp rate stresses.[35] There are also emerging rate and market approaches (some described below) that can incentivize load flexibility and GEB solutions.

TOU pricing offers an approximation of customers' impacts on the wider grid by dividing the day into several periods with differing rates (and adjusted seasonally as well) reflecting grid cost impacts. It incentivizes such techniques as pre-cooling buildings or heating water off-peak to reduce on-peak demand.[36] It could also stimulate other load shifting such as use of batteries to arbitrage differing rates over the course of the day and encouraging off-peak EV charging. However, TOU rate design should be sensitive to potential impacts on low-income customers.[37]

Some utilities have introduced "critical peak pricing" for certain C&I customers. Under critical peak pricing, participating customers can save additional money by curtailing (or shifting away) load during critical periods that are identified a day ahead by the utility. The utility is limited in the number and duration of critical peak pricing periods it can invoke.[38]
Another interesting approach to monetize peak reduction grid service is under development in Massachusetts through its Clean Peak Standard.[39] (See Box 3.)

Box 3. Massachusetts Clean Peaks Standard

Authorized by the 2018 Act to Advance Clean Energy, the Massachusetts Department of Energy Resources is developing a Clean Peaks Standard. Draft rules propose that Clean Peak Resources (new renewables, existing renewables paired with new energy storage, new energy storage charged primarily from renewables, and DR resources) that generate, dispatch, or discharge energy during a Seasonal Peak Period would generate Clean Peak Energy Certificates (CPECs). Analogous to how Renewable Energy Certificates (RECs) are used for Renewable Portfolio Standard compliance, retail electricity suppliers would procure CPECs to meet obligations under the Clean Peaks Standard.[40] The draft regulation also proposes a series of "multipliers" to align CPEC generation with periods of most beneficial and valuable grid impact and other desired attributes (e.g., proposed resilience multipliers and future consideration for a distribution circuit multiplier for stressed areas). Thus, a market would be created to reward peak reductions through the eligible Clean Peak Resources.

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[35] J. Shenot, C. Linvill, M. Dupuy, and D. Brutkoski, 2019, "Capturing More Value from Combinations of PV and Other Distributed Energy Resources," Regulatory Assistance Project, https://www.raponline.org/wp-content/uploads/2019/08/rap_shenot_linvill_dupuy_combinations_pv_other_ders_2019_august.pdf

[36] TOU rates in some utility territories may not necessarily comport with the impacts of rising variable renewable generation and shifting of "net" utility load when accounting for solar and wind generation patterns and impacts on evening ramp rates.

[37] J. Gheorghiu, 2019, "Colorado regulators cancel Black Hills Energy TOU pilot amid concerns for low-income customers," Utility Dive https://www.utilitydive.com/news/colorado-regulators-cancel-black-hills-energy-tou-pilot-amid-concerns-for-l/558911/

[38] For example, see Xcel Energy https://www.xcelenergy.com/staticfiles/xe-responsive/Programs%20and%20Rebates/Business/CO-Critical-Peak-Pricing-Info-Sheet.pdf, Southern California Edison https://www.sce.com/business/rates/cpp, and Baltimore Gas & Electric (AEE Institute, Rocky Mountain Institute, America's Power Plan, nd, "Case Study: Navigating Utility Business Model Reform, Maryland's Behavioral Demand Response Program—Baltimore Gas & Electric's SmartEnergy Program," https://info.aee.net/navigating-utility-business-model-reform-case-studies)

[39] Massachusetts Department of Energy Resources, nd, "Clean Peak Energy Standard," https://www.mass.gov/service-details/clean-peak-energy-standard

[40] Massachusetts Department of Energy Resources, 2019, "The Clean Peak Energy Standard: Draft Regulation Summary," https://www.mass.gov/files/documents/2019/08/07/Draft%20CPS%20Reg%20Summary%20Presentation%208.6.pdf

As previously noted, NYSERDA developed a VDER "value stack" that includes locational, temporal, and environmental value components to compensate eligible distributed renewable generation. Such an approach could be extended and adapted to include other DERs.

Whether through utility tariffs, rebates and incentives, creation of separate markets (e.g., Massachusetts Clean Peak Standard), or some combination of these mechanisms, there is a need to monetize (either as cost savings or revenues) load flexibility grid services to incite building owners to participate. These mechanisms should recognize and value the fuller "value stack" provided by load flexibility and align compensation accordingly. Such monetization is also needed for ESCOs, DR aggregators, and others to discern market opportunities.

Utility perspectives and aspects

Under traditional "cost-of-service" utility regulation, investor-owned utilities earn returns on capital investments they make as approved by their Public Utility Commission (PUC).[41] In contrast, operating expenses are usually "pass-throughs" to customers that do not earn return. What would impel such utilities to rely on non-utility owned assets to provide grid services, as would be the case with GEBs? Consumer-owner utilities (rural electric cooperatives and public power utilities) are usually under other governance structures but would also have to see advantages to moving away from conventional approaches.

Utilities and their regulators also tend to be risk-averse and favor well-demonstrated technologies and approaches.[42] This preference derives from a need for prudency to assure that customers (ratepayers) do not bear costs of excessive or unnecessary investments. However, this tendency to stick with tried-and-true approaches can impede the introduction of new technologies and business models since innovations present some risk even as they offer possibilities of large benefits. However, ironically, risk-aversion can also impose the unintended risk of being "left behind" by not innovating in the face of changing conditions.

To address these hurdles, some have proposed regulatory "sandboxes" to allow low-risk experimentation under conditions of reduced legal uncertainty.[43] Limited-scale pilot projects can allow trials of new technologies with modest risk should the project underperform. For example, the Colorado PUC authorized Xcel Energy to expend funds on two Innovative Clean Technology demonstration projects focused on GEB-relevant battery applications for peak reduction, solar integration, backup power, load shifting, and ancillary services.[44] Southern Company's Alabama Power and Georgia Power are implementing two Smart Neighborhood Initiative projects under pertinent utility commission authority.[45]

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41 Here the term Public Utility Commission is used also to refer to Public Service Commissions, State Corporation Commissions, Utilities Boards, and similar bodies.

42 Smart Electric Power Alliance, nd, "Renovate Initiative," https://sepapower.org/renovate/

43 B. Sheahan and J. Zhang, 2019, "Experiment without penalty: Can regulatory 'sandboxes' foster utility innovation?," Utility Dive https://www.utilitydive.com/news/experiment-without-penalty-can-regulatory-sandboxes-foster-utility-innov/550950/

44 E. Maurer and N Cowan, 2019, NASEO-NARUC Grid-interactive Efficient Buildings Working Group webinar presentation, Xcel Energy, https://naseo.org/event?EventID=6945

45 J. Leverette and J. Hill, Southern Company, 2019, "Southern Company's Smart Neighborhood Initiatives," NASEO-NARUC Grid-interactive Efficient Buildings Working Group webinar presentation, https://naseo.org/event?EventID=6945 It should be noted that these projects included shareholder investment expenditures.

Impelled by growing DER and load flexibility options along with increasing impacts of variable renewable generation, various states are exploring new utility business and regulatory models.[46] For example, New York State's Reforming the Energy Vision (REV) aims to fundamentally change the way utilities make money by seeking to turn electric utilities into distributed service platforms that would operate markets linking power producers and users (and "prosumers") in which DERs could fully participate.[47] Other states, such as Ohio, are considering more incremental changes in rate and regulatory structures.[48]

While a full treatment of utility business and regulatory models and pertinent state activities is beyond the scope of this paper, several approaches are noted here: allowing utility returns on certain non-capital spending, shared savings approaches, and performance-based regulation (PBR).

Starting prior to the New York REV utility reform proceeding, Consolidated Edison's (ConEd) Brooklyn Queens Demand Management (BQDM) program is perhaps the most written about non-wires solution (NWS) project to date. The New York Public Service Commission (PSC) noted that BQDM was the first time the PSC required a utility to address growth through means other than traditional utility investment.[49] The traditional solution for addressing projected peak demand in a section of Brooklyn and Queens would require about $1 billion in distribution system upgrades. Instead, in 2014 the PSC approved an alternative plan for non-traditional demand reduction investments (on both customer- and utility-sides of the meter) of $200 million plus $305 million in traditional distribution system investments. The PSC allowed ConEd to earn an authorized rate of return on project costs with the possibility of additional returns if certain performance-based objectives are met. The utility was also able to book faster depreciation in this project as compared to traditional capital investment, providing additional financial benefit to the utility.

Another example of PUCs allowing return for non-traditional investments comes from both Illinois and New York, where capitalization of software-as-a-service and cloud-based computing is allowed or under consideration to level the playing field between utility capital investment and procurement of services from a third party.[50] Analogous accounting regulatory modifications could encourage utilities to be more receptive to procuring grid services from GEBs and non-utility-owned DERs.

Oklahoma offers an example of shared-savings incentives. Two Oklahoma utilities, Oklahoma Gas & Electric and Public Service Company of Oklahoma, significantly increased energy efficiency investments and energy savings after the Oklahoma Corporation Commission authorized shared savings and lost revenue adjustment mechanisms as incentives.[51] The shared savings incentive compensates the utilities based on total net benefits of the energy efficiency program and total energy

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[46] America's Power Plan, nd, "Ratemaking and Utility Business Models," https://americaspowerplan.com/power-transformation-solutions/ratemaking-and-utility-business-models/

[47] New York State, 2016, "Reforming the Energy Vision," https://www.ny.gov/sites/ny.gov/files/atoms/files/WhitePaperREVMarch2016.pdf

[48] Public Utility Commission of Ohio, 2018, "Power Forward: A Roadmap to Ohio's Electricity Future," https://www.puco.ohio.gov/industry-information/industry-topics/powerforward/powerforward-a-roadmap-to-ohios-electricity-future/

[49] AEE Institute, Rocky Mountain Institute, America's Power Plan, nd, "Case Study: Navigating Utility Business Model Reform, Brooklyn Queens Demand Management Program—Employing Innovative Non-wires Alternatives," https://info.aee.net/navigating-utility-business-model-reform-case-studies

[50] AEE Institute, Rocky Mountain Institute, America's Power Plan, nd, "Case Study: Navigating Utility Business Model Reform, Regulatory Accounting of Cloud Computing—Software as a Service in New York & Illinois," https://info.aee.net/navigating-utility-business-model-reform-case-studies There are significant differences in returns depending on procurement approaches (pre-pay versus pay-as-you-go) having to do with treatment of amortization.

[51] AEE Institute, Rocky Mountain Institute, America's Power Plan, nd, "Case Study: Navigating Utility Business Model Reform, Oklahoma's Energy Efficiency Incentives—Shared Savings-Based Performance Incentive Mechanisms," https://info.aee.net/navigating-utility-business-model-reform-case-studies

savings achieved. Stakeholders asserted that absent these incentives, the two utilities would not have offered any energy efficiency programs. Shared savings could incentivize utilities to support GEB-provided services.

While traditional cost-of-service utility regulation incentivizes capital investment as an input, PBR incentivizes outcomes. Utility compensation and profit depends on performance against policy goals, such lowering costs, reducing outages and improving reliability, improving customer service and satisfaction, and enhancing environmental performance.[52, 53] A prominent model is the United Kingdom's RIIO (an acronym of Revenue = Incentives + Innovation + Outputs). Under RIIO, multi-year rate plan design details, combining portions of capital and operating expenditures as a single regulatory asset, performance incentives, and an innovation fund work together to promote cost-effectiveness, improved service, environmental performance, and innovation.[54] Hawaii offers an example of a state that is developing PBR framework that will include revenue adjustment mechanisms for cost control, performance incentives for additional revenues, and earnings sharing mechanisms between the utility and ratepayers.
[55]

Varying state regulatory frameworks will likely affect utility and third-party business models and approaches to ownership and control of DER- and GEB-provided grid services (as well as attractiveness of engaging such resources to begin with). Specific details can matter a lot. For example, in some jurisdictions, regulations may incentivize utilities to own and operate some DERs, such as distributed batteries. In others, where electric distribution utilities are not allowed to own generation assets, batteries may be defined as "generation" (because they send power to the grid) and, thus, are not allowable as utility assets. Modernization and clarification of policy and regulatory details amid changing technologies and the business approaches they can enable is important.

Utility planning and programs

The organization of utilities and their internal operations—including planning and program delivery—can also affect the prospects for GEB.

Utility planning processes are often disjoint. Integrated Resource Planning (IRP) focuses mostly on generation resources and is usually not well aligned with distribution system planning. Demand-side resources may or may not be considered in IRPs. Some states, particularly some with restructured utilities under independent system operator (ISO) grid management, do not do IRPs. Also, consumer-owned utilities often are not subject to IRP requirements. Utility regulators often have little visibility into distribution planning. In addition, there may be separate transmission planning processes and separate plans for energy efficiency programs. Alignment of different levels and forms of utility and grid planning, and more explicit inclusion of distribution-level resources, including DERs and GEBs,

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[52] M. Newton Lowry, T. Woolf and L. Schwartz, 2016, "Performance-Based Regulation in a High Distributed Energy Resources Future," Lawrence Berkeley National Laboratory https://emp.lbl.gov/sites/all/files/lbnl-1004130_0.pdf

[53] Extensive treatment of PBR is found in D. Littell, et al., 2017, "Next-Generation Performance-Based Regulation: Emphasizing Utility Performance to Unleash Power Sector Innovation," National Renewable Energy Laboratory, https://www.nrel.gov/docs/fy17osti/68512.pdf

[54] AEE Institute, Rocky Mountain Institute, America's Power Plan, nd, "Case Study: Navigating Utility Business Model Reform, UK's RIIO—A Performance-Based Framework for Driving Innovation and Delivering Value," https://info.aee.net/navigating-utility-business-model-reform-case-studies

[55] Hawaii Public Utilities Commission, 2019, "Summary of Phase 1 Decision & Order Establishing a PBR Framework," https://puc.hawaii.gov/wp-content/uploads/2019/05/PBR-Phase-1-DO-3-Page-Summary.05-23-2019.Final_.pdf

can permit better recognition of load flexibility and GEB value and opportunities.[56, 57] Examples of forward movement in this realm include initiatives in California, Hawaii, Minnesota, Nevada, and New York, such as Minnesota's Integrated Distribution Planning requirements and Hawaii's Integrated Grid Planning process.[58, 59]

Another issue affecting utility implementation and use of DERs is that utility-supported programs may be siloed. Often utility energy efficiency and demand response programs have uncoordinated goals and dockets and have separate responsibilities, budgets, and staff. Few utilities have integrated these programs.[6061] At times their goals can be at odds. For instance, there is less load to curtail during DR events in highly efficient buildings than in less efficient buildings—a good thing for the grid but a greater challenge for a DR program seeking to meet narrowly-defined numerical DR resource targets. Another example: there is always some energy loss associated with energy storage, so storage does not maximize energy savings.

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 in complement through GEB.

Energy Service Businesses

Energy Savings Performance Contracts (ESPCs) are a form of public-private partnership that has delivered over $50 billion of cost-effective upgrades over the last 30 years to U.S. federal, state, local, and institutional (e.g., hospitals, universities) facilities.[62] In an ESPC, an energy service company (ESCO) develops and delivers projects whose guaranteed energy savings (sometimes water and operations and maintenance are also included) cover all project costs, allowing the customer to effect upgrades without tapping their own capital budgets.

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[56] M. Newton Lowry, M. Makos, J. Deason and L. Schwartz, 2017, "State Performance-Based Regulation Using Multiyear Rate Plans for U.S. Electric Utilities," Lawrence Berkeley National Lab https://eta.lbl.gov/sites/default/files/publications/multiyear_rate_plan_gmlc_1.4.29_final_report071217.pdf;
L. Schwartz and J. Homer, 2019, "PUC Distribution Planning Practices," Lawrence Berkeley National Laboratory and Pacific Northwest National Laboratory, https://emp.lbl.gov/publications/mid-atlantic-distribution-systems-and;
A. Cooke, J. Homer, L. Schwartz, 2018, "Distribution System Planning – State Examples by Topic," Pacific Northwest National Laboratory and Lawrence Berkeley National Laboratory https://epe.pnnl.gov/pdfs/DSP_State_Examples-PNNL-27366.pdf;
J. Homer, A. Cooke, L. Schwartz, G. Leventis, F. Flores-Espino and M. Coddington, 2017, "State Engagement in Electric Distribution Planning," Pacific Northwest National Laboratory, Lawrence Berkeley National Laboratory and National Renewable Energy Laboratory https://emp.lbl.gov/publications/state-engagement-electric

[57] The NARUC-NASEO Comprehensive Electricity Planning Task Force is working to help states align resource and distribution planning. https://www.naruc.org/taskforce/

[58] J. St. John, 2019, "Hawaiian Electric's Landmark Integrated Grid Planning at the Crossroads," Greentech Media https://www.greentechmedia.com/squared/dispatches-from-the-grid-edge/minnesotas-integrated-distribution-plan-the-midwest-model-for-grid-edge-int

[59] J. St. John, 2018, "Minnesota's Integrated Distribution Plan: The Midwest Model for Grid Edge Integration?" Greentech Media https://www.greentechmedia.com/squared/dispatches-from-the-grid-edge/minnesotas-integrated-distribution-plan-the-midwest-model-for-grid-edge-int

[60] J. Potter, E. Stuart, P. Cappers, 2018, "Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management at Electric Utilities: A Scoping Study," Lawrence Berkeley National Laboratory https://emp.lbl.gov/publications/barriers-and-opportunities-broader

[61] D. York, G. Relf, and C. Waters, 2019, "Integrated Energy Efficiency and Demand Response Programs," American Council for an Energy-Efficient Economy https://aceee.org/research-report/u1906

[62] National Association of Energy Service Companies, nd, "National Association of Energy Service Companies," https://www.naesco.org/

ESCOs and ESPCs (and related utility energy service contracts—UESCs) can play important roles in expanding load flexibility if monetizable business cases can be made. Generally, ESPCs can take advantage of demand reduction utility bill savings. TOU and real-time pricing can also offer savings that can be incorporated into ESPC guarantees if such rate options are available and measurement and verification (M&V) of energy (and demand) savings are time differentiated. In principle, other revenues for grid services could also be included.

However, inclusion of other grid service savings and revenues can be difficult. Variable and uncertain savings may not be confidently predictable so may be too risky for an ESCO to guarantee. Appropriate objective metrics and M&V must be available. Expertise on both the ESCO and customer side is needed to understand the opportunities and financial risks. There may also be a need to clarify and perhaps modify authorizing legislation and pertinent policy to allow ESPCs to include what are now unconventional grid services.

More experience with GEBs and application of appropriate metrics would provide more confidence in performance. Conservative load flexibility-related savings assumptions and mechanisms to mitigate financial performance risk due to unexpected changes in future utility rate structures would be useful to stimulate ESCOs to work with customers to implement GEB.

While GEBs can have significant local distribution system effects, the major benefits of load flexibility will require aggregation of many buildings and projects. Expanding GEBs to scale could be accomplished bilaterally by utilities (and their contractors) with individual building owners and households, as may be done for conventional DR programs. However, there can be opportunities for DR aggregators and other businesses to offer grid-flexibility services beyond "DR 1.0" participant aggregation. Some of these businesses may operate as contractors to utilities while others may independently operate as market and regulatory frameworks may allow.

An important consideration for unleashing market forces and private initiative is too assure that customer utility data are, with customer permission, readily accessible to service providers. Issues of privacy, data security, and liability may be present.

Other policy and program mechanisms and considerations

Various other buildings- and energy-related policies can potentially help advance the use of load flexibility and development of GEBs.

As previously noted, many NASEO-NARUC GEB Working Group state participants indicated strong interest in GEB opportunities for state and public buildings. Some focused on potential cost savings and others on "lead-by-example" policies for enhancing public building energy and environmental performance. There was also strong interest in building and facility resilience and microgrids to allow critical facilities to operate during periods of power system stress and outage.

States and localities that have established resilience banks, green banks, and similar funding mechanisms could support the incorporation of load flexibility in projects that they fund. Where resilience is a focus, load flexibility combined with DERs configured as microgrids serve both on-site resilience during an outage and help reduce grid stresses that can lead to outage and other disruption. GEBs may also support more orderly restoration of service.

Minnesota's Sustainable Buildings 2030 Standard was previously mentioned. It is one of various state and local lead-by-example programs meant to improve public building energy and environmental performance. GEB functionality can help meet the objectives of these policies while providing greater and broader benefits than not incorporating grid-interaction.

A number of cities and states have implemented energy benchmarking and disclosure policies for large commercial and, sometimes, multifamily residential buildings. These policies generally rely on the ENERGY STAR Portfolio Manager tool and energy use intensity (EUI, in Btu per square foot) as a metric. Jurisdictions can consider adding a “grid friendliness” metric as envisioned by the GridOptimal initiative (previously mentioned) or other measures of building demand “peakiness” and carbon-intensity/emissions impacts (which are the motivations for many state and local benchmarking policies).

Several jurisdictions, including the State of Washington, New York City, and Washington, DC recently enacted existing building performance standards for energy and greenhouse gas performance.[63, 64, 65] These laws will establish standards focused proximately on energy efficiency but aimed at greenhouse gas impacts of building energy use. Including load flexibility through GEB would help jurisdictions and building owners meet these policies’ intent.

Building energy rating systems and labels could be an approach to encourage GEBs. For example, the Residential Energy Services Network (RESNET) is examining inclusion of temporal use of energy and load flexibility in the HERS Index.[66] The evolving GridOptimal metric or similar efforts can be used to complement LEED, ENERGY STAR, and other voluntary building certification and recognition programs.

Similarly, for appliances and equipment, grid-interactive capability can be considered in premium labels. For example, ENERGY STAR is examining “grid-awareness” as an optional criterion for some appliances.[67] Beyond voluntary labels, grid-connectivity could also be included in appliance and equipment standards, such as in the Washington State HB 1444 Appliance Efficiency Standards bill which has a provision mandating new electric storage water heaters to include a DR communication port meeting the CTA-2045 or equivalent interface standard. [68]

In California, the Title 24 building energy code includes some nascent recognition of time differentiation of energy use and load flexibility. Since its 2005 update, Title 24 has included time dependent valuation (TDV) in cost-effectiveness determinations, recognizing “that energy efficiency measure savings should be valued differently depending on which hours of the year the savings occur,

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[63] Council of the District of Columbia, 2018, “CleanEnergy DC Omnibus Amendment Act of 2018,” http://lims.dccouncil.us/Legislation/B22-0904

[64] Urban Green Council, 2019, “All About NYC’s Historic Buildings Emission Law “ https://www.urbangreencouncil.org/content/projects/all-about-nyc%E2%80%99s-historic-building-emissions-law; New York City Council, 2019, “Int 1619-2019” https://legistar.council.nyc.gov/LegislationDetail.aspx?ID=3995448&GUID=87CA3AFF-038B-4ADF-A6F2-5CC758A20F6C&Options=ID%7CText%7C&Search=

[65] Washington State Legislature, 2019, “House Bill 1257 – 2019-20,” https://app.leg.wa.gov/billsummary?BillNumber=1257&Initiative=false&Year=2019

[66] RESNET, 2019, “New Working Group on When Energy is Used/Load Flexibility Into HERS Scores,” https://www.resnet.us/articles/new-working-group-on-when-energy-is-used-load-flexibility-into-hers-scores/

[67] A. Daken, 2019, “Grid-aware Water Heaters and the ENERGY STAR Specification: Would optional criteria be helpful? What would they be?” U.S. Environmental Protection Agency https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20and%20Connected%20Water%20Heaters%20Stakeholder%20Meeting_%203%2020%202018_final.pdf

[68] Washington State Legislature, 2019, “Second Substitute House Bill 1444,” http://lawfilesext.leg.wa.gov/biennium/2019-20/Pdf/Bills/Session%20Laws/House/1444-S2.SL.pdf

to better reflect the actual costs of energy to consumers, to the utility system, and to society." [69] The latest Title 24 update also includes an Energy Design Rating (EDR) compliance path that would allow crediting of load management through battery storage of photovoltaic generation.[70]

A further tool is zoning and land use regulation where, as appropriate, approvals, variances, density bonuses, and other items can be offered for developments and land use changes that include load flexibility and GEB components. Perhaps zoning mechanisms could be used to encourage GEB and non-wires solutions in areas where electric distribution systems are stressed and where hosting capacity analyses show greater value for DER implementation.

Actions States Can Take

As discussed above, there are many policy, regulatory, and programmatic issues in play; some that impede realizing the fruits of load flexibility while others can nurture the opportunities. States can take stock of their situations and contexts; examine their potential for load flexibility and GEB benefits; learn lessons from their and others' experiences, including policy and regulatory as well as physical pilots and demonstrations; and they can identify and address needs and gaps.

This section looks forward to steps that states can take to advance their opportunities to benefit from GEB. It draws significantly from materials presented in the August 13, 2019 NASEO-NARUC GEB Working Group webinar by an expert at the Lawrence Berkeley National Laboratory (LBNL) and, somewhat modified, featured in a GEB session and workshop on September 16, 2019 at the 2019 NASEO Annual Meeting.[71, 72] A version of these materials will also appear in a forthcoming State and Local Energy Efficiency (SEE) Action paper focused on state and local actions to advance load flexibility and grid-interactive capabilities and applications.

Those materials, this paper, and a forthcoming scoping for a GEB roadmapping kit will serve as complementary resources to help states identify and move forward with action steps suitable to their own contexts.

Table 2, in condensed form, and Table 3, more extensively, suggest numerous actions that states and localities can consider. The lists are not comprehensive nor do they suggest that all actions should be undertaken. States should tailor actions based on their own situations. However, several activities corresponding to the three major categories of activities are likely universally applicable:

1. *Gather information and identify opportunities*
2. *Develop and implement strategies to integrate demand flexibility*
3. *Accelerate adoption*

Tables 2 and 3 also identify the types of entities that can take actions. These include State Energy Offices, Public Utility Commissions, and other state agencies and localities, including both bodies with

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[69] California Energy Commission, 2017, "Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2019 Time Dependent Valuation (TDV) Data Sources and Inputs," docketpublic.energy.ca.gov/PublicDocuments/16-BSTD-06/TN216062_20170216T113300_2019_TDV_Methodology_Report_21517.pdf

[70] RESNET op cit.

[71] Session materials available on the NASEO GEB resources page https://naseo.org/issues/buildings/naseo-geb-resources

[72] L. Schwartz, 2019, "NASEO-DOE Webinar - Action Steps for States: Moving Towards a Future with Demand Flexibility," https://naseo.org/event?EventID=6927

policy and regulatory purview (e.g., agencies responsible for building codes, environmental regulation, zoning and land use, economic development) and those that operate buildings and facilities (e.g., general services departments, school districts, public colleges and universities, housing authorities, public hospitals, corrections departments). They also include utilities, grid operators (including independent system operators [ISOs] and regional transmission organizations [RTOs]) and, of course, building and facility owners. For all the listed potential actions, multiple entities can have roles.

It makes sense for states to start by taking stock of their situations and priorities. This may be done as part of or prior to embarking on a roadmapping exercise. What are state electricity and energy system needs and objectives? What are the opportunities and potential for load flexibility and GEBs to help meet those objectives? Which policies, programs, planning processes, and regulations support or impede load flexibility implementation? Are there physical or policy/regulatory pilot projects in-state or elsewhere that offer relevant experience and lessons? What are roles for public agencies and private stakeholders? Have other steps supportive of load flexibility already been undertaken?

States and localities should be informed and deliberate in considering actions to support load flexibility implementation through GEBs. States should consider developing a roadmap to identify and address opportunities and hurdles to advancing load flexibility. While there is no single right format or formula for roadmapping, there are some common steps to consider. These steps are analogous to those recommended for developing state energy plans in the NASEO's State Energy Planning Guidelines.[73] The following Guideline steps are modified for roadmapping:

Step 1: Establish a Requirement and Scope for a Roadmap
Step 2: Convene the Roadmapping Team
Step 3: Develop a Vision for the Roadmap
Step 4: Conduct Data Collection and Projection Analyses
Step 5: Garner Public Input and Feedback
Step 6: Establish Goals and Recommended Actions to Meet the Vision
Step 7: Draft the Roadmap
Step 8: Finalize, Adopt, and Implement the Roadmap
Step 9: Conduct Outreach and Education
Step 10: Monitor Progress and Update the Roadmap

The roadmap should identify barriers and gaps to be overcome (some listed in Table 3). It will likely identify and recommend policy, programmatic, and regulatory options to pursue (see Table 4). These can include, among others, research and studies, attention to analytic methods and standards, altering planning processes, physical and policy/regulatory pilot projects, state or public building policies, promoting voluntary actions, and revising regulations (meaning not only utility rates and rules but, possibly, other types of regulation, such as building codes and performance standards, appliance standards, building benchmarking and disclosure rules, and environmental regulations). Some actions may be done administratively by agencies and/or directed via Governors' Executive Orders. Some may occur through PUC proceedings. Others may require state legislation. Local legislation and executive actions are required for city and county level actions. And private voluntary initiatives should not be underestimated. The roadmap should identify priorities, time-frames, and sequence of actions too.

This topic will be elaborated in a separate GEB roadmapping scoping document.

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[73] NASEO, 2018, "NASEO's State Energy Planning Guidelines: Guidance for States in Developing Comprehensive Energy Plans and Policy Recommendations" https://naseo.org/Data/Sites/1/sepguidelines_2018_final.pdf

Table 2: Key Actions States and Localities Can Take to Advance Demand Flexibility (condensed)

	Who can take action?							
	Gov. Office	**PUC**	**SEO**	**Other Agencies***	**City/County**	**Utilities**	**RTO/ISO**	**Bldg. owners****
1. Gather Information and Identify Opportunities								
• Consider how demand flexibility can support goals	●	●	●	●	●	●	●	●
• Inventory options and select opportunities for early action	●	●	●	●	●	●	●	●
• Participate in pilot projects and share best practices		●	●	●	●	●		●
2. Develop and Implement Strategies to Integrate Demand Flexibility								
• Develop a roadmap to advance demand flexibility	●	●	●	●	●	●	●	●
• Develop mechanisms to allow building owners, operators and occupants to earn compensation for providing grid services		●	●			●	●	●
• Conduct outreach and education about opportunities and benefits		●	●	●	●	●	●	●
3. Accelerate Adoption								
• Assess and remove barriers to demand flexibility in buildings providing grid services***	●	●	●	●	●	●	●	●
• Update economic valuation methods for DERs as energy assets for utility programs, plans and procurements***		●				●		●
• Establish practices for robust and cost-effective assessments of demand flexibility performance***		●	●	●	●	●	●	●
• Regularly assess and report on progress	●	●	●	●	●	●	●	●

**For example, state departments or agencies responsible for general services, building codes, environment, economic development, transportation, and financing authorities*

***Best opportunities for owners and operators of privately owned buildings to support state and local activities*

****Subject of forthcoming SEE Action reports.*

Source: Derived and modified from L. Schwartz, Lawrence Berkeley National Laboratory[74]

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[74] L. Schwartz, op cit.

Table 3: Key Actions States and Localities Can Take to Advance Demand Flexibility

	Who can take action?							
	Gov. Office	PUC	SEO	Other Agencies*	City/County	Utilities	RTO/ISO	Bldg. owners**
1. Gather Information and Identify Opportunities								
Consider how demand flexibility can support goals								
• Catalog ways demand flexibility can help achieve energy-related goals (e.g., resilience and reliability, energy affordability, emissions, energy efficiency, integrating variable renewable generation, electrification, energy security, grid modernization) and other aims (e.g., economic development, critical infrastructure)	●	●	●	●	●	●	●	●
• Establish team to consider how demand flexibility can contribute to achieving these goals	●	●	●	●	●	●	●	●
Inventory options and select opportunities for early action								
• Catalog existing pilots, standards, programs, procurements, policies and regulations that address demand flexibility		●	●	●	●	●	●	●
• Consider ways to further integrate demand flexibility (e.g., lead by example, building operator training, energy savings performance contracting, benchmarking and transparency, DER incentives, smart cities, performance standards for existing buildings, state building energy codes and appliance standards)	●	●	●	●	●	●	●	●
• Identify planning processes that can address demand flexibility goals (e.g., integrated resource planning, efficiency and other DER planning, planning for distribution systems, transmission expansion, grid modernization, transportation electrification, resilience, energy security) and initial integration steps		●	●	●	●	●		
• Identify DER requirements that may need updating to enable demand flexibility (e.g., revising energy efficiency resource standards to also target peak demand savings, modernizing demand response requirements, requirements for participating in electricity markets)	●	●	●	●	●	●	●	
Participate in pilot projects and share best practices								
• Identify opportunities to collaborate on test beds for individual buildings, campuses, and commercial developments to gain experience, validate demand flexibility performance, and demonstrate value to the utility system and building owners and operators		●	●	●	●	●		●
• Conduct pilots for public buildings and campuses to test demand flexibility technologies and microgrids		●	●	●	●	●		●
• Test approaches for hard to reach audiences, including low-income households and small and medium commercial buildings		●	●	●	●	●		●
• Share results across the jurisdiction and in regional and national forums		●	●	●	●	●		●

	Who can take action?							
	Gov. Office	PUC	SEO	Other Agencies	City/County	Utilities	RTO/ISO	Bldg. owners
2. Develop and Implement Strategies to Integrate Demand Flexibility								
Develop a roadmap to advance demand flexibility								
• Engage key stakeholders (e.g., third-party program administrators, DER service providers, DER aggregators, contractors, consumer representatives, trade associations for building owners and operators, energy service companies) and use public meetings to discuss strategies	●	●	●	●	●	●	●	●
• Establish principles (e.g., related to cost-effectiveness, consumer and utility system benefits, equity, resilience)	●	●	●	●	●	●		
• Create a comprehensive and collaborative approach with steps to advance demand flexibility through programs, planning processes, standards, policies and regulations (e.g., through a Governor's executive order, MOU across agencies, multistate partnership)	●	●	●	●	●	●	●	
• Estimate benefits and costs to determine cost-effective achievable potential of demand flexibility for residential and commercial buildings and best opportunities for action		●	●	●	●	●	●	●
• Make a public commitment toward achieving this potential with specific multiyear targets	●	●	●	●	●	●		
• Develop interim and long-term metrics for measuring progress	●	●	●	●	●	●	●	
• Update roadmap on a regular schedule (e.g., every three years)	●	●	●	●	●	●	●	●
Develop mechanisms to allow building owners, operators and occupants to earn compensation for providing grid services								
• Establish multiyear funding assurances for utility programs. Establish payment methods for DER aggregators and customers		●				●		●
• Consider performance-based incentives for utilities to encourage use of buildings as energy assets toward meeting generation and delivery needs		●				●		●
• Review retail electric rates for embedded incentives and disincentives for demand flexibility in residential and commercial buildings		●				●		●
• Work across states to encourage wholesale electricity markets to enable buildings to provide a broader suite of grid services by updating participation requirements and compensation methods		●	●				●	●
Conduct outreach and education about opportunities and benefits								
• Partner with utilities, utility consumer groups, energy services companies, DER aggregators, building owner and management organizations, trade associations, and other stakeholders to develop and disseminate educational materials		●	●	●	●	●	●	●
• Create user-friendly, online resources such as how-to guides and establish online forums that answer common questions			●	●	●	●	●	●
• Organize webinars and in-person trainings with utilities and stakeholder groups			●	●	●	●	●	●

	Who can take action?							
	Gov. Office	PUC	SEO	Other Agencies	City/County	Utilities	RTO/ISO	Bldg. owners
3. Accelerate Adoption								
Assess and remove barriers to demand flexibility in buildings providing grid services*								
• Identify technical barriers (e.g., requisite building technologies and utility systems, cybersecurity, lack of integrated design and system approaches)		●	●	●	●	●	●	●
• Identify financial barriers (e.g., cost-effectiveness, inadequate compensation through utilities or markets, upfront cost)	●	●	●	●	●	●	●	●
• Identify regulatory, market and other institutional barriers (e.g., restrictions on DER aggregation and participation, lack of compensation mechanisms, data access provisions and data privacy concerns, siloed DER programs, procurement provisions)	●	●	●	●	●	●	●	●
• Identify other barriers (e.g., split incentives for building owners and tenants, lack of motivation and energy focus for building operators, workforce training needs)	●	●	●	●	●	●	●	●
• Determine which barriers are critical to address and prioritize / develop strategies to overcome them	●	●	●	●	●	●	●	●
Update economic valuation methods for DERs								
• Update economic valuation methods for DERs (e.g., as energy assets, providing grid services, reducing capacity needs) in utility programs, plans and procurements*		●				●		●
Establish practices for assessments of performance								
• Establish practices for robust and cost-effective assessments of demand flexibility performance*		●	●	●	●	●	●	●
Assess and report on progress								
• Regularly assess and report on progress	●	●	●	●	●	●	●	●
• Track and report to stakeholders annually on metrics identified in the roadmap		●	●	●	●	●	●	
• Identify new opportunities to improve demand flexibility implementation and performance and update the roadmap		●	●	●	●	●	●	●
• Use a variety of channels to share information, such as presentations at established events, social media, and online dashboards and maps		●	●	●	●	●	●	●
• Provide recognition for building owners and operators, government agencies, utilities and regional grid operators for outstanding projects and programs that advance demand flexibility	●	●	●	●	●	●	●	●

**For example, state departments or agencies responsible for general services, building codes, environment, economic development, transportation, and financing authorities*

****Subject of forthcoming SEE Action reports.*

Source: Derived and modified from L. Schwartz, Lawrence Berkeley National Laboratory[75]

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[75] Ibid.

Table 4: Potential Demand Flexibility Barriers

Technical, economic, achievable potential not characterized (e.g., by market sector, operating mode, grid services provided)
Consumer value proposition not well-known
Rate design, program incentives, market compensation mechanisms may not be aligned for demand flexibility (e.g., inadequate inclusion of time and locational value)
Disincentives, lack of financial motivation for utilities to use buildings as energy assets
Building energy rating, labeling, targets, performance policies and programs, etc. based on total energy and/or energy use intensity (EUI), not on demand flexibility
Insufficient metrics, tools to evaluate building demand flexibility performance
Benefit-cost analysis methods for grid modernization investments (e.g., AMI, advanced distribution management systems, DER management systems) inadequate
Insufficient integration of demand flexibility programs in utility, state, jurisdiction (e.g., EE, DR, RE, storage programs uncoordinated)
Lack of coordination between utilities and RTOs/ISOs (e.g., double-counting potential and conflicting rules, roles and responsibilities)
Constraints on third-party aggregation of DERs
Enhancements needed to economic valuation methods for planning and analysis
Data access provisions and data privacy concerns
Interoperability hurdles for software and equipment
Barriers to entry for DERs to compete in organized wholesale markets for energy, capacity and ancillary services, even if DERs can meet grid service requirements
Demand flexibility poorly or not recognized in distribution system planning, resource planning, transmission planning, energy efficiency, and other utility planning processes
DER-specific issues:
Storage – Unmonetized value streams; may not be recognized as offering multiple grid services; utility ownership restrictions; market v. rate-based service; duration and cycling requirements
Distributed generation – Interconnection standards and procedures; standby rates; compensation; treatment in state resource standards and organized wholesale markets; facility owner unfamiliarity
Demand response – Lack of defined need; valuation and pricing; dispatchability; AMI not deployed
Energy efficiency – split incentives (e.g., landlord-tenant, builder-owner); upfront costs; payback period and owner tenure; information gaps; savings calculation methodologies

Source: Derived and modified from L. Schwartz, Lawrence Berkeley National Laboratory[76]

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[76] Ibid.

Table 5: Some Opportunities to Overcome Barriers

- **Studies** — e.g., consumer preferences, cost-effective achievable potential
- **Pilots** — e.g., test new rate and program designs, develop performance data
- **Enhanced analytical methods and practices** — e.g., for valuation, performance assessment, labelling/ratings
- **State and public facilities** – e.g., lead-by-example building standards and procurement, resiliency and public purpose microgrids valuation and integration
- **Model standards** — e.g., for data access and privacy; interoperability
- **Programs for residential and commercial buildings** — e.g., programs and incentives to pilot or implement grid-interactive functionality; incentives for grid-interactive building management systems
- **Financial incentives for utilities** — e.g., performance incentive mechanisms; shared savings; multiyear rate plans (performance-based regulation)
- **Energy and electricity system planning** – e.g., include demand flexibility, flexibility in distribution system planning; integrate distribution, resource, and transmission planning; include demand flexibility in state energy plans
- **Building energy codes** – e.g., "GEB-ready," time dependent valuation in cost-effectiveness, load management provisions
- **Appliance standards** – e.g., grid-interactive features, time dependent valuation of cost-effectiveness
- **Zoning** – e.g., land use incentives and concessions for grid-interactive developments to reduce distribution system stresses and investment needs
- **Voluntary programs, certifications, and labels** — e.g., building and products certifications and labels (LEED, ENERGY STAR, etc.) consideration of grid-interactive features and functionality
- **Governor's executive orders** — e.g., start new programs, coordinate across state agencies, set targets
- **PUC proceedings** — e.g., rate design updates, utility financial incentives, grid-service markets, regulatory "sandboxes", funds for innovation and pilot projects
- **State legislative action** — e.g., remove barriers to third-party aggregation while preserving consumer protection, mandate data access for consumers and their designated third parties, establish electricity system and environmental policies (such as "clean peaks"), authorize supportive State Energy Office and PUC actions

Source: Derived and modified from L. Schwartz, Lawrence Berkeley National Laboratory [77]

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[77] Ibid.

Conclusion

Advancing technologies and a changing electricity system present challenges and opportunities for the delivery of reliable, clean, and affordable power to the nation's homes, businesses, and institutions. DERs and variable renewable generation are making the grid more complicated to manage. Electrification of transportation and many heating loads is in prospect. And states and utilities must address economic, energy resilience and security, and environmental imperatives.

Fortunately, new technologies provide options for flexible management of building and facility energy loads. Through GEBs—using sensors, analytics, and smart controls—energy optimization can be pursued to simultaneously benefit building occupants and owners and the grid alike. These possibilities have far reaching policy and regulatory implications for State Energy Offices, Public Utility Commissions, utilities, and building owners and investors.

Flexible load management can lower costs, enhance energy resilience, improve efficiency, and reduce emissions. It can mitigate peak loads and ramping rates, provide grid services, and integrate distributed and renewable energy resources.

As stated at the outset of this document, the fundamental questions that arise from this opportunity are:

- *How can facility interactions with the grid be optimized?*
- *How can states fashion policies, programs, and regulations to advance such optimization through GEBs?*
- *What are the roles for states, facility owners and operators, utilities, product and service providers, and others?*

The NASEO-NARUC Grid-interactive Efficient Building Working Group was established with the support of the U.S. Department of Energy (DOE) Building Technologies Office and the Pacific Northwest National Laboratory (PNNL) to explore these questions and provide states a forum for learning and exchange.

This document offers a short overview of GEB and related flexible load management topics followed by discussion of state interests and potential benefits from GEBs. It reviews a range of technical opportunities and challenges as well as policy, regulatory, and administrative drivers and impediments, illustrating options for overcoming some hurdles.

There are many things—some listed herein—that states and localities can do to support implementation of GEBs and broader load flexibility to help meet policy goals and targets. This document recommends that states develop roadmaps to understand their states' options and opportunities and develop steps forward to achieve the promise that GEBs can offer.

Appendix 1: NASEO-NARUC Grid-interactive Efficient Building Working Group

Fourteen states, through their State Energy Offices, Public Utility Commissions, and/or Consumer Counsels, are currently members of the Working Group.

The *GEB Working Group* co-chairs are:

- Kaci Radcliffe, Energy Analyst, Oregon Department of Energy (NASEO member)
- Hanna Terwilliger, Economic Analyst, Minnesota Public Utility Commission (NARUC member)

Working Group States:

Colorado	Michigan	South Carolina
Connecticut	Minnesota	Tennessee
Florida	New Jersey	Virginia
Hawaii	New York	Wisconsin
Massachusetts	Oregon	

NASEO contacts: Rodney Sobin rsobin@naseo.org and Maddie Koewler mkoewler@naseo.org
NARUC contacts: Danielle Sass Byrnett dbyrnett@naruc.org and Charles Harper charper@naruc.org

Appendix 2: GEB Resources

Available at https://naseo.org/issues/buildings/naseo-geb-resources

- K. Saul Rinaldi, E. Bunnen, and S. Rogers, "Residential Grid-interactive Efficient Building Technology and Policy: Harnessing the Power of Homes for a Clean, Affordable, Resilient Grid of the Future" (October 2019)
- The Brattle Group, "The National Potential for Load Flexibility: Value and Market Potential Through 2030" (June 2019)
- C. Goldenberg, M. Dyson, and H Masters, "Demand Flexibility: The Key to Enabling a Low-Cost-, Low-Carbon Grid," Rocky Mountain Institute (February 2018)
- Rocky Mountain Institute and U.S. General Services Administration, "Value Potential for Grid-interactive Efficient Buildings in the GSA Portfolio" (2019)
- Southwest Energy Efficiency Project
  - J. Brant, "Grid-Interactive Efficient Buildings: Providing Energy Demand Flexibility for Utilities in the Southwest" (2019)
  - N. Kellogg, "Smart-Tech Housing Developments in the Southwest: Grid-Integrated and Energy Efficient" (2019)

- **U.S. Department of Energy GEB**
  - Grid-interactive Efficient Buildings: Factsheet
  - Grid-interactive Efficient Buildings: Overview
  - Technology reports (pending)
    - *Heating, ventilation, and air conditioning (HVAC); water heating; and appliances*
    - *Lighting*
    - *Building envelope and windows*
    - *Sensors and controls, data analytics, and modeling*

- **SEE Action Network** (series of three resources, pending Fall 2019)
    - *Introduction for State and Local Governments*
    - *Assessing Value*
    - *Assessing Performance*

- **Webinars**
  - NASEO-NARUC Grid-Interactive Efficient Buildings Working Group: GEB and Automated Demand Response
    April 10, 2019 - Rodney Sobin (NASEO), Monica Neukomm (U.S. DOE), Mary Ann Piette (Lawrence Berkeley National Laboratory)
  - Better Buildings Residential Network (U.S. DOE): Connected Homes and the Grid - Flipping the Switch on the Script
    July 25, 2019 - Alice Rosenberg (Consortium for Energy Efficiency), Rodney Sobin (NASEO), Kara Saul Rinaldi (AnnDyl Policy Group)
  - NASEO-DOE Webinar - Action Steps for States: Moving Towards a Future with Demand Flexibility
    August 13, 2019 - Lisa Schwartz (Lawrence Berkeley National Laboratory)

  - NASEO Webinar: Grid-Interactive Efficient Buildings (GEB) – Case Examples *August 27, 2019* - Neil Cowan and Eric Maurer (Xcel Energy) and Justin Hill and Jim Leverette (Southern Company)

- **2019 NASEO Annual Meeting: Grid-interactive Efficient Buildings Roundtable**
  - NASEO-NARUC State Working Group Roundtable and Workshop Overview - Rodney Sobin (NASEO)
  - State Interviews - Hanna Terwilliger (Minnesota Public Utilities Commission), Kaci Radcliffe (Oregon Dept. of Energy)
  - Grid-Interactive Efficient Buildings: Value Propositions and Sectoral Perspectives - Joanne Morin (Massachusetts Dept. of Energy Resources)
  - The Economics of Grid-interactive Efficient Buildings (GEBs) - Cara Carmichael (Rocky Mountain Institute)
  - Residential Grid-Interactive Efficient Building Technology and Policy - Kara Saul Rinaldi (AnnDyl Policy Group)
  - NYSERDA - RTEM & GEM - Rodney Sobin (NASEO) [on behalf of NYSERDA]
  - Workshop Handout: Actions States Can Take - Rodney Sobin (NASEO)
  - Next Steps - Hanna Terwilliger (Minnesota Public Utilities Commission), Kaci Radcliffe (Oregon Dept. of Energy)

- **2019 NASEO Energy Policy Outlook Conference**
  - Grid-interactive Efficient Buildings - David Nemtzow (U.S. DOE)
  - Buildings-to-Grid: Critical Issues for Decision Makers - Natalie Mims Frick (Lawrence Berkeley National Laboratory)

- **2018 NASEO Annual Meeting (Detroit)**
  - Grid-Interactive Efficient Buildings: Energy Efficiency & Grid Optimization - David Nemtzow (U.S. DOE)
  - What's Next for Energy Efficiency: Grid Interaction - Chris Baker (The Weidt Group)
  - Grid Interactive Efficient Buildings - Jan Berman (PG&E)

- **Smart Neighborhood** - James Leverette (Southern Co.)