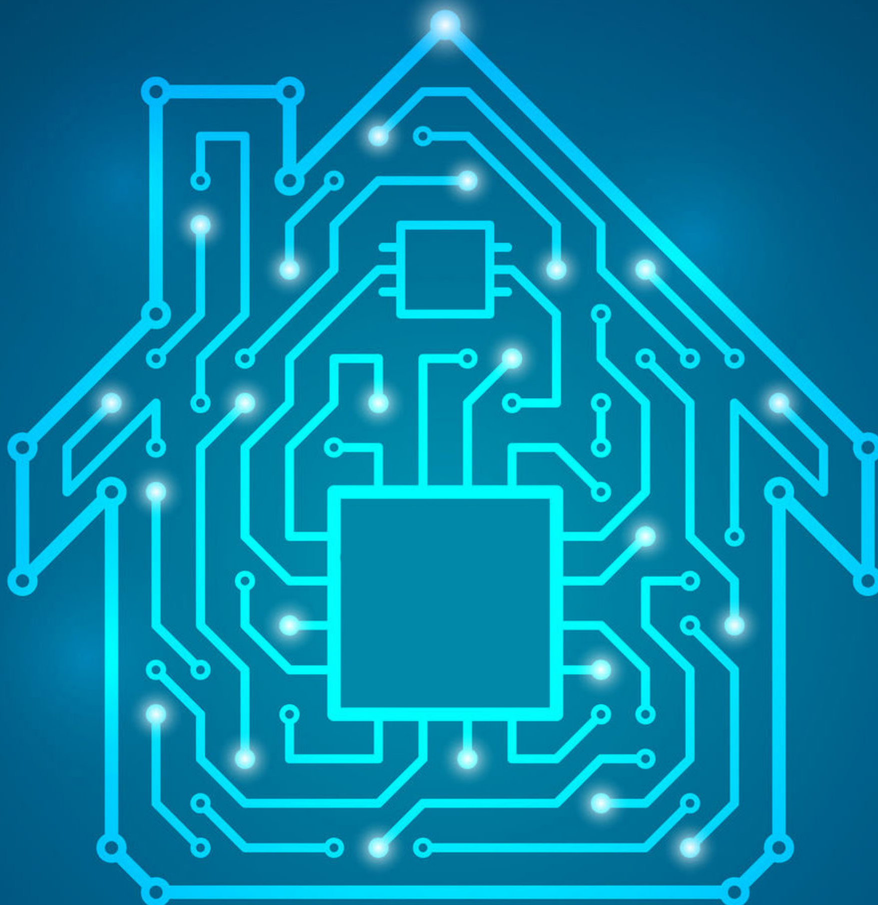
RESIDENTIAL GRID-INTERACTIVE EFFICIENT BUILDING TECHNOLOGY AND POLICY: HARNESSING THE POWER OF HOMES FOR A CLEAN, AFFORDABLE, RESILIENT GRID OF THE FUTURE



Prepared for NASEO by

Kara Saul Rinaldi, Elizabeth Bunnen, and Sabine Rogers

AnnDyl Policy Group, LLC

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NASEO National Association of State Energy Officials

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Kara, Lizzie, and Sabine

Contents

01. Introduction

Energy efficiency and renewable energy have permanently changed – and will continue to change – the future of the electric grid. In some states, renewable energy generation is creating new imbalances between energy production and demand, where variable renewable energy and customer demand do not match up, and new need for utilities to manage demand to align with least-cost energy generation. Energy efficiency can play a key role in helping address new grid challenges, but we need to break down the silos between energy efficiency, renewable energy and the growing number of behind-the-meter distributed energy resources (DERs)[1], and employ new technologies, strategies, and policies to ensure efficiency and renewables are deployed in mutually supportive ways, when and where they are needed most, to ensure energy affordability and grid reliability.

Grid modernization efforts across the country are focused on supporting resilient infrastructure and reducing energy costs while also driving broader environmental goals. States are looking to decarbonize the power sector by ramping up renewable generation, and other significant changes are underway with the increasing penetration of DERs, such as rooftop solar, electric vehicles, grid-interactive efficient appliances, and smart load-controlling technologies in homes. The grid is evolving from a linear system with one-directional energy flow to an increasingly complex and interconnected system through which energy and data flow to and from various entities (homes, utilities, third-party service providers). With this emerging grid of the future, new challenges to balance supply and demand and maintain grid stability are arising, along with new opportunities to fully integrate buildings and distributed energy resources into an electric system that is cleaner, more efficient and can better meet customer needs.

Buildings are not only large energy consumers; they also are part of the grid infrastructure. Buildings—and the residential sector in particular—can be enabled to play an important role in managing demand to support efficiency and resiliency for the grid of the future. The U.S. Department of Energy (DOE) Building Technologies Office (BTO) has defined a "Grid-interactive Efficient Building" (GEB) as "an energy efficient building with smart technologies characterized by the active use of DERs to optimize energy use for grid services, occupant needs and preferences, and cost reductions in a continuous and integrated way."[2] This report focuses on residential buildings, primarily single-family homes, and opportunities for GEB solutions in this sector.

Residential GEBs can be part of larger strategies to create a more reliable, affordable, and cleaner power system. Policy and regulatory measures that advance grid-interactive efficient homes can support grid modernization and resiliency, while working hand in hand with energy policy goals, such as Energy Efficiency Resource Standards, Renewable Portfolio Standards, Clean Peak Standards,[3] and strategic electrification that aim to reduce emissions and create a new need for demand-side flexibility.

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1 This report has adopted NARUC's definition: "A DER is a resource sited close to customers that can provide all or some of their immediate electric and power needs and can also be used by the system to either reduce demand (such as energy efficiency) or provide supply to satisfy the energy, capacity, or ancillary service needs of the distribution grid." Available at: https://pubs.naruc.org/pub.cfm?id=19FDF48B-AA57-5160-DBA1-BE2E9C2F7EA0.

2 Monica Neukomm et al., "Grid-interactive Efficient Buildings: Overview," April 2019, *U.S. Department of Energy*.

3 Each of these policy goals is discussed in greater detail in **Section 4: Policy Opportunities**.

02. Residential GEB Technologies: Current and Future Potential

The residential buildings sector is a newer participant in load shifting and other demand-side management programs. These energy reduction efforts have traditionally focused on commercial and industrial buildings where individual loads are larger and often controlled by energy managers, making it easier to target and deploy sizable load shedding and shifting potential. The residential sector, however, remains a largely untapped resource for both efficiency and flexibility. Residential buildings consume more electricity than any other sector[4] and are the largest contributor to peak demand.[5] As the electric grid evolves into a more distributed two-way power system and homes add new technologies, including electric vehicles and controllable thermal and battery storage capacity, a huge opportunity is emerging to integrate homes and behind-the-meter energy resources dynamically to optimize how energy is used and support a more reliable and resilient grid, while also creating savings and other occupant benefits. Technologies that turn a home into a grid-interactive efficient building (GEB) are a pathway to this opportunity by making homes a dynamic grid asset that can produce and/or store energy and use it efficiently and in a way that provides system benefits. The U.S. DOE BTO Grid-interactive Technical Report Series, being published concurrently with this series of NASEO-NARUC GEB briefing papers, lays out a useful framework for understanding what defines a GEB. The Overview Report identifies four key characteristics of GEBs: efficient, connected, smart, and flexible.[6]

A smart, grid-interactive efficient home will comprise the integration of the following technologies and strategies:

1. **Energy Efficiency.** Energy efficiency measures are the foundation of a smart, grid-interactive efficient home. They can reduce the baseline load of a home, lowering overall electricity use. Conventional energy efficiency measures include building envelope improvements and replacement of existing equipment and systems (e.g., appliances, lighting, HVAC, boilers) with higher-efficiency models. Energy efficiency provides a foundation for other solutions' effectiveness: minimizing the load size that requires shifting, enabling homes to hold a comfortable temperature for longer periods of time, and ensuring distributed generation and storage are right-sized.

2. **Smart Home Technology and Intelligent Control Platforms.** Smart home technologies and energy management systems have real potential to deliver energy savings and load flexibility. Increasingly commonplace in homes, these devices and solutions enable two-way communication between the home and the grid, providing a connection that allows utilities or third-party vendors to manage demand. The smart home technology ecosystem includes smart thermostats, smart appliances (washers and dryers, refrigerators, dishwashers, etc.), smart lighting and smart plugs, as well as a variety of connected devices that offer home monitoring, security, and entertainment features. Within that ecosystem, home energy management systems (HEMS) is an umbrella term that may include a combination of technologies including sensors, controls, software, and machine learning, that together offer energy management for different connected devices and end uses.[7] HEMS use data and analytics for optimization and can manage command or price signals

4 https://www.eia.gov/electricity/annual/html/epa_01_02.html

5 Monica Neukomm et al., "Grid-interactive Efficient Buildings: Overview," April 2019, *U.S. Department of Energy.*

6 Ibid.

7 Northeast Energy Efficiency Partnerships (NEEP) keeps a regularly-updated HEMS product list, available at: https://neep.org/initiatives/integrated-advanced-efficiency-solutions/home-energy-management-systems#HEMS%20Product%20List.

sent via the utility or third party to enable load shaping and flexibility in the home. Smart thermostats, for example, offer monitoring, control, and optimization of HVAC systems to take advantage of energy saving opportunities (e.g., via learned schedules and low-energy "away" modes) and can be used for demand response.[8] In addition to providing advanced control and supporting grid services, smart home technology bundles can provide numerous co-benefits to homeowners, including convenience, energy bill savings, comfort, health and safety.[9] In fact, non-energy benefits like convenience and security may be the primary motivation for many households to invest in smart home systems, while the energy management features are an additional benefit. For example, voice assistants are growing in popularity as a central smart home and energy management interface,[10] and they are creating new opportunities to engage residential customers with their energy use.[11] As HEMS advance and integrate with more technologies, these platforms can support the interconnection of solar, storage, and flexible end uses in the home to coordinate load management strategies for grid and user benefit.

3. **Storage.** The ability to store energy for later use is a key piece to making homes flexible grid assets and enabling better use of intermittent renewable energy resources, like wind and solar.

   a. *Electric battery.* While little residential battery storage has been deployed to date,[12] the technology is beginning to gain traction and becoming more accessible. According to a McKinsey analysis, "annual installations of residential energy-storage systems in the United States have jumped from 2.25 megawatt-hours (MWh) in 2014 to 185 MWh in 2018."[13] However, cost remains a significant barrier to wider deployment across the residential sector.

   b. *Thermal storage.* A water heater is a comparatively inexpensive resource for storing thermal energy that is readily available in most homes. Grid-interactive water heaters can be deployed to soak up power when the marginal price of electricity is low (e.g., if over-generation of solar occurs in the middle of the day) and shift load away from peak demand periods, without compromising occupants' access to hot water.[14] However, unlike electric batteries, thermal energy stored in water heater tanks cannot be discharged

8 Consortium for Energy Efficiency (CEE) published a 2019 program guide on smart thermostats for demand-side management, available at: https://library.cee1.org/system/files/library/13813/CEE_ConnectedThermostats_ProgramGuide_15Jan2019.pdf.

9 For a more comprehensive review of smart home technologies and the benefits and opportunities they provide to homeowners, utilities, and the grid, see the 2018 Home Performance Coalition (now Building Performance Association) Smart Home Report: http://www.building-performance.org/sites/default/files/HPC_Smart-Home-Report_201810.pdf.

10 By 2023, an estimated 28 percent of U.S. households will have smart thermostats and 36 percent will be using voice assistants as smart home control platforms according to GTM research, available at: https://www.greentechmedia.com/articles/read/connected-devices-driving-a-more-grid-responsive-home#gs.wuoee8.

11 Google recently announced a new developer program to integrate energy data with Google Assistant virtual personal assistant to be able to communicate information and personalized recommendations to customers.

12 Claire Miziolek, "The Smart Energy Home: Driving Residential Building Decarbonization," March 2019, *Northeast Energy Efficiency Partnerships*.

13 Jason Finkelstein et al., "How residential energy storage could help support the power grid," March 2019, *McKinsey & Company*. Available at: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-residential-energy-storage-could-help-support-the-power-grid.

14 According to a recent NRDC study of the demand flexibility potential of residential water heaters in California, flexible water heating has largely focused on electric resistance technology so far, but heat pump water heaters (HPWH) represent an emerging opportunity to provide thermal storage and demand flexibility in addition to their high efficiency. Pierre Delforge and Joseph Vukovich, "Can Heat Pump Water Heaters Teach the California Duck to Fly?" 2018, *NRDC*. Available at: http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M236/K009/236009513.PDF.

back to the grid or other end uses. There are other opportunities for load flexibility via thermal storage in homes. A home's thermal mass can enable load-shifting of HVAC energy usage by pre-cooling or pre-heating and allowing the temperature to float during a peak event. These strategies depend on a tight, well-insulated building envelope and can be strengthened by other load-mitigating measures such as efficient and dynamic window shading.

c. *Electric vehicles and chargers.* EV charging is a load that can be shifted off-peak or to times when renewable resources are abundant and can support shorter-term grid needs through voltage support and frequency regulation. EV batteries also offer a behind-the-meter storage option and can even send electricity back to the grid during peak hours through integrated vehicle-to-grid systems.[15]

4. **Distributed generation.** The residential solar market has grown considerably over the past decade. Today, approximately 2.7 percent of single-family households own or lease a photovoltaic (PV) system, although penetration varies widely by state.[16] California, the largest market for residential PV, added nearly 1 GW of installed capacity in 2018.[17] As this market grows, rooftop solar will need to be integrated with the other GEB strategies outlined above to ensure the solar energy use is efficient and optimized within the home, and enable coordination with the grid so that distributed generation can be used to ease stresses and improve efficiencies on the transmission and distribution systems.[18]

5. **Integration across technologies.** The coordination of the residential GEB technologies and solutions outlined above will enable more sophisticated approaches to residential demand-side management, increase grid stability and reliability, and better align energy resources with demand. HEMS could provide a centralized platform for connecting and managing all of the DERs in a home. A recent NEEP report posits in the future "HEMS could forecast the expected solar PV production based on weather conditions and determine when to use that energy, when to store it, or when to sell it back to the grid…[and] could determine the best charging behavior between different DERS (such as battery storage systems, heat pump water heaters, and electric vehicles) to optimize their use."[19] Some integrations across technologies are already available. For example, the Sense energy monitor is a HEMS product that collects data from the PV system and home electric panel allowing homeowners to see solar production and disaggregated energy usage in real time. In the future, that information could be used to inform control decisions and address grid capacity constraints.[20] However, the lack of interoperability between technologies remains a key challenge.

15 David Farnsworth et al., "Beneficial Electrification of Transportation," January 2019, *The Regulatory Assistance Project (RAP)*.

16 David Feldman and Robert Margolis, "Q4 2018/Q1 2019 Solar Industry Update," May 2019, *NREL*. Available at: https://www.nrel.gov/docs/fy19osti/73992.pdf.

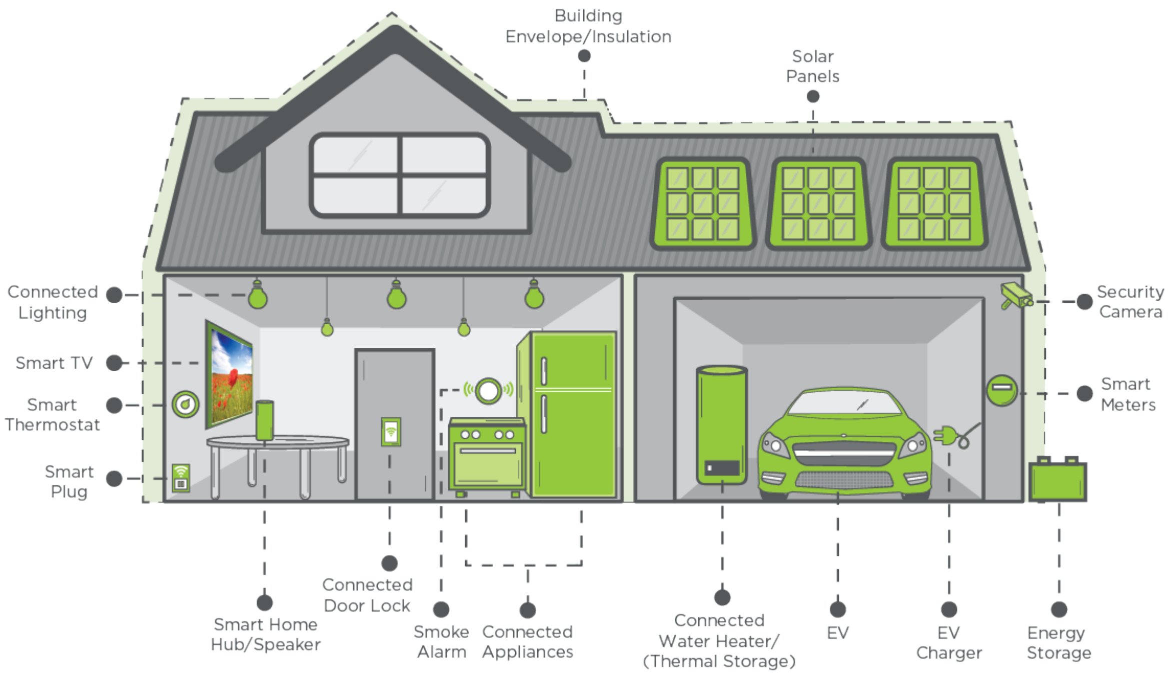
17 SEIA/Wood Mackenzie U.S. Solar Market Insight Report: 2018 Year in Review. Available at: https://www.seia.org/research-resources/solar-market-insight-report-2018-year-review.

18 While rooftop solar is the most common form of distributed generation in the residential sector, other systems include small wind turbines, natural-gas-fired fuel cells, and micro combined heat and power (micro-CHP) systems—which, to the extent they are deployed, should also be integrated with other GEB strategies.

19 Claire Miziolek, "The Smart Energy Home: Driving Residential Building Decarbonization," March 2019, *Northeast Energy Efficiency Partnerships*.

20 Scott Taylor, Sense, interview, April 2019.

Figure 1: Residential GEB Technologies (adapted from Navigant)



Source: IoE Connected Home image, Navigant, "Energy Cloud 4.0: Capturing Business Value Through Disruptive Energy Platforms", 1Q 2018, p.25.

Advancing residential GEBs will depend not only on more of these technologies and solutions being brought into homes, but also on policies and regulations that enable the full potential for load flexibility and other grid services from the residential sector to be realized. In the next decade, additions to residential load flexibility are predicted to exceed those of commercial and industrial as consumers increasingly adopt technologies that enable demand flexibility in the home and as utilities deploy advanced metering infrastructure (AMI) more widely.[21] In some cases the technology is already in place today but could be utilized more optimally and more broadly than it currently is.

Grid-connected water heaters for thermal storage are a key opportunity currently available but largely untapped for residential load flexibility.[22] Abigail Daken of the U.S. Environmental Protection Agency says making water heaters grid-interactive is a near-term, accessible opportunity that will help us transition into a practice of residential grid services and a more GEB-looking future.[23] With just 2 percent of electric water heaters currently participating in utility demand response programs, significant untapped potential exists from this resource.[24] Smart HVAC monitoring and control is another key opportunity to manage a major electricity end use in homes, and one that

21 Ryan Hledik et al., "The National Potential for Load Flexibility: Value and Market Potential through 2030," June 2019, *The Brattle Group*. Available at: https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_-_final.pdf.

22 General thoughts expressed by the following industry experts during interviews conducted in April and May 2019: Ethan Goldman (Recurve), Nick Lange (VEIC), Dan Fredman (VEIC), Abigail Daken (U.S. Environmental Protection Agency), Robin LeBaron (Pearl National Home Certification), Claire Miziolek (Massachusetts Executive Office of Energy and Environmental Affairs, formerly with Northeast Energy Efficiency Partnerships).

23 U.S. Daken, U.S. Environmental Protection Agency, interview, May 2019.

24 David Farnsworth et al., "Beneficial Electrification of Water Heating," January 2019, *The Regulatory Assistance Project (RAP)*.

has already gained significant traction in the residential space.[25] As of 2018, smart thermostats are estimated to have reached 10-15 percent penetration in the U.S.,[26] offering significant potential to manage HVAC systems more optimally and in coordination with grid dynamics.

These smart grid-interactive technologies offer new tools to target load shedding and shifting more precisely and continuously, exactly when and where it is needed, while maintaining occupant comfort and needs. Nick Lange, Senior Consultant at VEIC, describes residential GEBs as a vision for getting "easy, cost-free access to spare capacity in the system" for the benefit of the grid and its users.[27] Indeed, the future of the home-to-grid connection is one where fleets of grid-interactive efficient HVAC, water heaters, and other electric loads—along with increasing numbers of EV chargers, solar inverters, and distributed batteries—are managed using smart controls and can be deployed to enable more dynamic load shaping, allowing the utility or third party to throttle demand up and down to take advantage of clean resources and ensure the grid stays in balance and allowing consumers to manage their energy use and costs while gaining other benefits like increased comfort and resilience of their home.

Opportunity in People Potential

While this paper addresses the opportunities created by the synergies of new dynamic policy and technology, it is important not to forget the "people potential" that can be tapped in the residential sector. Unlike commercial and industrial buildings, people live in homes. They have an emotional attachment to their home, their environment, and their energy waste – "who left the lights on?" Furthermore, because residents tend to pay for their own energy bills, it is a unique place to connect people to solutions that address both their wallet, the environment, and the potential conveniences that smart technology offers. Smart technologies are providing new tools to engage people on their energy usage, and these technologies create the opportunity for diverse energy management approaches tailored to the unique needs and varying lifestyles of different people, rather than offering a one-size-fits-all approach.

Spectrum of Grid-interactivity

Different levels of grid-interactivity are possible within homes. At the most basic level, there are direct load controllers which deliver peak demand reductions by shutting off power to a single device or end use (these are not "smart" but do enable a singular grid service). At an intermediary level, individual appliances and systems with smart functionality—such as an HVAC system or water heater paired with a smart thermostat—can receive and respond to operational signals and provide energy arbitrage on a continuous basis. Advanced home-to-grid interaction will entail increasing integration and optimization across technologies via centralized HEMS that can manage signals from the utility or third party and coordinate different connected devices and end uses in home.

25 General thoughts expressed by the following industry experts during interviews conducted in April and May 2019: Ethan Goldman (Recurve), Nick Lange (VEIC), Dan Fredman (VEIC), Robin LeBaron (Pearl National Home Certification), Claire Miziolek (Massachusetts Executive Office of Energy and Environmental Affairs, formerly with Northeast Energy Efficiency Partnerships).

26 PLMA Thermostat Interest Group, "The Future of Utility 'Bring Your Own Thermostat' Programs," March 2018. Available at: https://www.peakload.org/assets/Groupsdocs/PractitionerPerspectives-UtilityBYOTPrograms-022818-Final.pdf.

27 Nick Lange, VEIC, interview, May 2019.

03. Program/Pilot Highlights

Utility Programs/Pilots

The goal of residential GEBs is the integration of multiple categories of DERs within a home to manage energy use and harness flexibility potential, making the home itself a grid asset. But moving from simple load control switches that shed load at peak times to treating the house as a system of coordinated end uses that can be deployed to help smooth out imbalances between supply and demand in real time is no easy feat. Fortunately, pilots and programs have started to explore opportunities to bundle and co-optimize these different behind-the-meter assets in real homes, providing insights and lessons learned as the full potential of residential GEB is realized.

Pacific Northwest CTA-2045 Water Heater Demonstration Project

From 2015 to 2018, Bonneville Power Administration (BPA) and Portland General Electric (PGE) led the largest smart water heater pilot to date and the first large demonstration project of heat pump water heaters (HPWH) participating in demand response (DR) events.[28] The pilot engaged manufacturers to add CTA-2045 technology[29] to their existing water heater tanks—both electric resistance and HPWH—and then recruited customers who had installed the CTA-2045-equipped water heaters to enroll in a DR program. The main objective of the pilot was to evaluate whether there is economic justification for a market transformation effort to get all electric water heaters arriving in the Pacific Northwest to have native CTA-2045 communication ports. (While a CTA-2045 enabled water heater is not a smart water heater on its own, having a native CTA-2045 port built in makes it easier and cheaper to deploy a device that makes the water heater "connected" and able to participate in a DR program.) The final report determined that with increased penetration of CTA-2045-equipped water heaters, assuming 26.5 percent customer enrollment in demand response programs, there will be "301 MW of demand response potential in Oregon and Washington by 2039" which will result in an estimated $230 million in savings through 2054 compared to the cost of building peak power plants of equivalent capacity.[30] The report also concluded that having CTA-2045 technology installed at the time of manufacturing is the most cost-effective solution to water heater control.

Glasgow, Kentucky Smart Energy Technology Pilot

In a year-long pilot from 2016 to 2017, Glasgow Electric Plant Board (GEPB) installed smart thermostats, hybrid-HPWHs, and residential battery systems for utility control to a group of approximately 330 homes (a subset of which also received advanced weatherization measures). The devices were used to call demand response events and reduce the impact of peak demand charges on customers.[31] Virtual Peaker, a software platform that integrates with internet of things (IoT) devices for demand-side management, was brought in to integrate the devices into its cloud for data collection, customer engagement, and device control. Virtual Peaker's platform integrated with the utility's AMI backhaul system to better understand the usage patterns

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28 Bonneville Power Administration, "CTA-2045 Water Heater Demonstration Report Including A Business Case for CTA-2045 Market Transformation," November 2018. https://www.bpa.gov/EE/Technology/demand-response/Documents/Demand%20Response%20-%20FINAL%20REPORT%20110918.pdf.

29 CTA-2045 is a standard communication interface—analogous to a USB port—which consists of a port that can be built in or retrofitted to an appliance, allowing a device called a "universal communication module" to plug into the appliance and make it capable of responding to demand response signals.

30 Bonneville Power Administration, "Smart Water Heater Report Errata," April 22, 2019. Available at: https://www.bpa.gov/EE/Technology/demand-response/Documents/20190422_Smart_Water_Heater_Report_errata_V2.pdf.

31 GEPB has a critical peak pricing rate structure called "Infotricity."

of each home, and it leveraged machine learning and real-time control to optimize each customer's load profile.[32] An independent evaluation found that across 67 dispatch events, the average demand reduction across the event period was 1.48 kW for homes that had all measures installed.[33]

Con Edison Smart Home Rate Demonstration Project

As part of New York's Reforming the Energy Vision (REV) initiative, Con Edison has developed a Smart Home Rate demonstration project with two tracks: (1) HEMS for central air and (2) solar plus storage. The Smart Home Rate is a time-based rate that sends price signals to smart technologies in the home to help customers save money. For Track 1,[34] Con Edison is working with a thermostat provider and using algorithms to send the day-ahead price signals from the ISO to see if the system can optimize to the price signal to balance comfort and cost savings based on what customers want. Con Edison Senior Specialist Zach Sussman says the goal is to gauge customers' engagement with this type of interaction in their home and to understand the potential to roll it out to other grid-connected smart technologies, such as home appliances and lighting. "Hopefully the whole home will be able to adjust to the customer's needs based on the price signal and how comfortable they want to be." Through Track 2,[35] Con Edison is providing a battery to customers that already have solar, to see how the solar and storage charge and discharge based on price signals. Sussman envisions that eventually the different components of these two tracks will all work together. "There's no reason you can't have a thermostat with a storage system that is precooling and then discharging into the grid, or charging based on that price signal."[36]

Indiana Michigan Power (I&M) "IM Home" program in collaboration with Tendril

IM Home is a combination residential energy efficiency and demand response program in which I&M remotely manages customer-owned smart thermostats using Tendril's cloud-based software platform for a continuous demand management approach. The software creates a thermal model for each home, then sets a day-ahead optimization schedule for smart thermostats. IM Home has been able to shift load by up to 85 percent during demand response events while maintaining customer comfort by staying within 2 degrees of set point temperature. From May to September 2018, the IM Home program ran on 2,132 thermostats in Indiana and 423 thermostats in Michigan and saved nearly 90,000 hours of cooling runtime equal to more than 263 MWh.[37] According to Jon Walter with I&M, the purpose of combining energy efficiency and demand response into one program was to maximize and streamline customer and utility benefits through a single connected device technology.[38] The Peak Load Management Alliance (PLMA) recognized I&M and

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32 Virtual Peaker Glasgow Case Study. Available at: https://www.virtual-peaker.com/request-case-study.

33 Curt Puckett, "Smart Energy Technologies – An Application Using Residential Battery Storage," June 2018, *International Energy Policy & Programme Evaluation Conference*. Available at: https://energy-evaluation.org/wp-content/uploads/2019/06/2018-puckett-paper-vienna.pdf.

34 "Track 1: Implementation of Price-Responsive Home Automation Systems" https://www.coned.com/-/media/files/coned/documents/business-partners/business-opportunities/smart-home/rev-demo---smart-home-rate-rfi-track-1.pdf.

35 "Track 2: Implementation of Price-Responsive Battery Storage Systems" https://www.coned.com/-/media/files/coned/documents/business-partners/business-opportunities/smart-home/rev-demo---smart-home-rate-rfi-track-2.pdf.

36 Zach Sussman, Con Edison, interview, April 2019.

37 https://www.tendrilinc.com/resources/press-release/plma-pacesetter-indiana-michigan-power-tendril.

38 Jon Walter, Indiana Michigan Power, "Indiana Michigan Power and Tendril for Residential Integrated DSM Approach," PLMA Load Management Dialogue presented on July 11, 2019.

Tendril with a 2019 Program Pacesetter award for their residential integrated demand side management approach.[39]

Virtual Battery Programs with a Vermont IOU, Municipal Utility, and Electric Co-op

Packetized Energy has partnered with Green Mountain Power, Burlington Electric Department, and Vermont Electric Co-op to deploy virtual battery technology: they install a smart thermostat on customers' water heaters and use their proprietary software to coordinate aggregated groups or "virtual batteries" of these connected devices for peak demand reduction and price arbitrage.[40] These pilot programs are ongoing and results are not available yet, but the goal is to ultimately include a wider range of device types, including EV chargers and smart thermostats, in the virtual batteries.

Con Edison Brooklyn Queens Demand Side Management Program

The Brooklyn Queens Demand Management (BQDM) program was initiated in 2014 to address projected capacity constraints caused by rising electricity demand in Brooklyn and Queens, and the program is set to continue through 2021.[41] From the residential sector, which accounts for approximately 30 percent of peak demand in the BQDM area, the program has achieved over 4 MW of BQDM peak load reduction through its residential direct-install lighting and bring your own thermostat (BYOT) programs.[42] Through 2018, Con Edison has spent an aggregate of $95 million on the BQDM program,[43] dramatically lower than the approximately $1 billion price tag for the traditional infrastructure investments initially proposed.[44] One of the largest non-wires solutions[45] projects in the U.S., the BQDM program, "demonstrates the ability to implement a diverse portfolio of DER technology to drive demand reduction and defer traditional infrastructure upgrades that would require a large investment."[46]

National Grid, Tiverton Non-Wires Alternative Pilot

The NWA pilot program in Tiverton, Rhode Island ran from 2012 to 2017 and included a wide variety of demand response and energy efficiency resources, such as Wi-Fi thermostats, heat pump water heater rebates and installation, and window air conditioner replacement and recycling. "Although the project never fully realized the goal of 1 MW of load reduction after five years, the Tiverton NWA Pilot did defer the Tiverton Substation and feeder upgrades."[47] In its 2019 System Reliability Procurement Report submitted to the

39 https://www.peakload.org/2019-award-winners.

40 Scott Johnstone, Packetized Energy, interview, June 2019.

41 "Brooklyn Queens Demand Management Program – Employing Innovative Non-Wire Alternatives," *Advanced Energy Economic Institute, Rocky Mountain Institute, America's Power Plan*. Available at: https://info.aee.net/hubfs/NY%20BQDM%20Final.pdf.

42 Con Edison, "BQDM Quarterly Expenditures & Program Report: Q4-2018." Available at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B608B8B5F-36DD-46DA-9069-5869CACD36D5%7D.

43 Ibid.

44 "Brooklyn Queens Demand Management Program – Employing Innovative Non-Wire Alternatives," *Advanced Energy Economic Institute*. Available at: https://info.aee.net/hubfs/NY%20BQDM%20Final.pdf.

45 Non-wires solutions (NWS), also called non-wires alternatives (NWA), are portfolios of DERs deployed in specific locations to meet grid needs and defer or eliminate the need for costlier "poles and wires" infrastructure investment.

46 Brenda Chew et al., "Non-Wires Alternatives: Case Studies from Leading U.S. Projects," November 2018, *Smart Electric Power Alliance, Peak Load Management Alliance*, and *E4TheFuture*.

47 Ibid.

Rhode Island PUC, National Grid proposed launching a successor project in the same territory to provide continued load relief.[48] Meanwhile, the demand response component of the original program has evolved into National Grid's ConnectedSolutions Bring Your Own Device (BYOD) program that allows all of its Rhode Island customers to enroll their connected thermostats and battery energy storage for an incentive.

Bring Your Own Device

Some utilities are taking advantage of increasing numbers of grid-connected devices and DERs through BYOD programs through which customers can enroll their own or third-party owned smart thermostat, water heaters, EVs—and likely many more connected devices in the future—in demand response programs for an incentive.

- *Green Mountain Power BYOD storage program.* Starting in 2018, Green Mountain Power in Vermont launched one of the first BYOD programs for residential battery storage.[49] The program allows customers to enroll their privately owned or third-party energy storage and participate in different rate structures to save money. In February 2019, GMP partnered with Renewable Energy Vermont to offer a large new upfront incentive ($850 per kW of energy storage enrolled) for customers who enroll their home batteries in the BYOD program.[50]

Maryland Energy Storage Pilot Project

In May 2019, Maryland Gov. Larry Hogan signed the Energy Storage Pilot Project Act requiring investor-owned electric utility companies in the state to solicit two energy storage projects. Pilots will look at different potential ownership models and could include residential behind-the-meter storage.[51] Maryland is looking to advance innovation in storage and in its Empower program. "Evaluating utility ownership models will help us look out for ratepayer interests, and to ensure that our energy storage programs are consistent with being a restructured State," said MD PSC Commissioner Richard."[52]

Community-Scale GEB Projects

Neighborhood-scale residential GEB projects are emerging across the country as testing grounds for implementing today's most advanced grid-interactive efficient solutions to effectively meet location-specific grid needs. These projects, both retrofit and new construction, offer frameworks for how residential GEB solutions can work at scale in real-world contexts. Importantly, data and findings from these projects can help inform future state planning and policymaking regarding opportunities for homes to become a grid resource.[53]

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48 National Grid, "2019 System Reliability Report." Available at: http://www.ripuc.org/eventsactions/docket/4889-2019-NGrid-SRPReport(10-15-18).pdf.

49 https://greenmountainpower.com/news/gmp-offers-new-bring-device-program-cut-energy-peaks/.

50 https://greenmountainpower.com/news/rev-and-gmp-partner-on-groundbreaking-opportunity/.

51 Kelly Speakes-Backman, Energy Storage Association, interview, May 2019.

52 Commissioner Michael T. Richard, Maryland Public Service Commission, interview, June 2019. MACRUC Conference.

53 Additional resources are forthcoming: Rocky Mountain Institute (RMI) is developing a comprehensive inventory of projects and best practices related to smart and connected communities with a focus on projects with multiple buildings connected to each other and the grid; NASEO will publish an in-depth case study of residential GEB projects.

Reynolds Landing neighborhood in Alabama

Alabama Power and parent company Southern Company partnered with Electric Power Research Institute (EPRI), Oak Ridge National Laboratory (ORNL), and homebuilder Signature Homes to develop a smart neighborhood of 62 high-performance homes outfitted with energy efficient systems and smart home technologies, along with a microgrid of community-scale solar, natural-gas generation and storage that powers the neighborhood and can provide excess energy back to the grid.[54,55] With the microgrid the neighborhood has the ability to island and resynchronize with the grid without any impact to the customer. The utility and research partners are looking at what the cost savings are from the utility standpoint, in terms of the operations, energy costs, and averted infrastructure costs, as well as potential cost savings for customers.[56]

Clovis grid-connected zero net energy community in California

Developer DeYoung Envision collaborated with EPRI and Pacific Gas and Electric (PG&E) to build 36 zero net energy homes, outfitted with efficiency measures, smart technologies, and rooftop solar.[57] One of the goals of the project is to monitor how integrating solar communities affects the load capacity of the overall grid.[58] EPRI's research will quantify the benefits and impacts of this residential community, such as energy savings, reduced CO_2 emissions, and increased customer choice.[59]

Jasper Community virtual power plant in Prescott Valley, Arizona

Private developer Mandalay Homes and energy storage manufacturer Sonnen partnered to create a 2,900-home project with residential storage, solar, and efficiency measures.[60] The concept, still in pre-development stage, is for aggregated residential storage to provide power and act as a peaking plant for the community, in addition to serving as a demand response resource and enabling the shift of solar power into the evening.[61]

Colorado Residential Retrofit Energy District

The Colorado Energy Office has partnered with the National Renewable Energy Laboratory (NREL), Rocky Mountain Institute, and Xcel Energy on a project designed to test new approaches to demand side management, demand response, and renewable energy integration in existing residential buildings. The project is currently in the planning phase and the team is using grid and building modeling tools to identify

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54 Alabama Power has three more Smart Neighborhoods planned for 2019 in partnership with local builders. More information available at: https://www.smartneighbor.com/pages/neighborhood.

55 Through its Advanced Energy Communities initiative, EPRI is researching the integration of customer DERs to achieve larger utility and societal goals such as decarbonization, grid hardening and grid support while enabling customer comfort, convenience and cost benefits. EPRI has partnered with utilities and developers to lead demonstration projects and analyze results.

56 Seth Coan, RMI, interview, August 2019.

57 Measures installed in the homes include: high efficiency HVAC system, smart thermostat with voice integration, radiant barrier reflective insulation and duct sealing, high quality LED smart lights, reflective roof tiles and dual pane windows, and in three homes aerobarrier envelope sealing.

58 https://aec.epri.com/content/central-californias-first-grid-connected-zne-community-clovis.

59 Chris Warren, "EPRI Works with Builders and Utilities on Advanced Energy Communities," July 18, 2018, *EPRI Journal*. Available at: http://eprijournal.com/a-blueprint-for-the-house-of-the-future/.

60 The homes were built with a high-performance building envelope designed to enable passive heating and cooling, which helps minimize load and reduced the solar capacity needed.

61 https://www.utilitydive.com/news/sonnen-prepares-its-next-step-in-aggregating-residential-storage/540760/.

the most promising packages of technology solutions that can be deployed and evaluated—looking at energy efficiency, intelligent controls, solar, and storage—and next they will develop an experimental plan for deployment.[62] According to Jocelyn Durkay, Policy Analyst at the Colorado Energy Office, the project is "an initial step to investigate how DERs can assist the state and our largest utility to meet emissions reduction and renewable generation goals in a residential retrofit context." [63]

62 Lieko Earle, *NREL*, interview, April 2019.

63 Jocelyn Durkay, Colorado Energy Office, interview, August 2019.

04. Barriers and Opportunities

Bringing to Scale—Beyond Pilots and Field Tests
The utility and program pilots and the community-scale residential GEB projects described in the previous section have been and continue to be important first steps to validate the role residential buildings can play in addressing grid challenges and carbon reduction. But in order for GEBs to be a meaningful resource, a number of them must, in aggregate, provide demand flexibility to the grid. Currently, barriers stand in the way of advancing residential GEBs at scale, but opportunities are emerging to evolve policies, regulations, and programs to capture the benefits of these resources.

Challenges and Barriers

The ideal regulatory framework for a nimble and interactive home-to-grid dynamic can be hard to achieve. In large part, viewing residential buildings with DERs as a grid asset represents a significant shift from the traditional electricity system and role of the utility. Conventional regulatory frameworks incentivize utilities to make capital investments in traditional infrastructure, such as power plants, distribution lines (poles and wires), and transformers. Under that model, utilities have control over grid resources and earn a regulator-approved rate of return on their investments.[64] Turning to GEBs as an alternative solution for grid services—and deferring or avoiding new generation, transmission, and distribution needs—requires a shift in electricity grid planning and market functions. Utilities will depend more on DERs, many of them customer or third-party owned assets, and more integrated approaches to support the combined efficiency, smartness, and flexibility of homes will be needed.

The integration of DERs into the grid needs to be addressed by utility regulators and energy policymakers because current policies are not welcoming the opportunity for GEBs to be a valuable grid resource. Current utility policy considerations are often about the control of the technologies; for example, what they control and how they can control the DERs that are changing load curves and posing new integration challenges. Former Maryland utility commissioner Ann Hoskins, now Chief Policy Officer at Sunrun, noted in a meeting before utility commissioners that the question is "not what should utilities control, but how should utilities embrace" these new DERs to optimize their use as a grid resource. "The public wants more control of their energy," noted Hoskins.[65] This section discusses challenges and barriers that will need to be addressed to make this shift.

Valuing GEBs

A fundamental barrier to advancing residential GEBs is the lack of mechanisms for valuing these technologies and the full range of benefits they provide. According to Nick Lange of VEIC, "Standing in the way of the market, the missing piece is really around the math—making the case from the regulatory/utility side about how there is durable economic value that can come through this equipment."[66] From cost-effectiveness tests, to incentive structures, to utility planning models, existing regulatory structures in many cases are not set up to account for all value streams from residential GEB solutions—benefits which accrue to the homeowner, the utility/grid, and to society.

64 Mark Dyson et al., "The Non-Wires Solutions Implementation Playbook," 2018, *Rocky Mountain Institute*.

65 Remarks by Ann Hoskins, Sunrun. NARUC 2019 Summer Policy Summit, "Creative Momentum Class for Today and Tomorrow: DERs are Changing Everything," July 23, 2019, 1:30-2:30pm, Indianapolis, IN.

66 Nick Lange, VEIC, interview, May 2019.

- ***Cost-Effectiveness Testing***
  Traditional cost-effectiveness screening practices often lead to undervaluing efficiency and other DERs, causing uneven comparisons with traditional utility infrastructure investments. Current cost-effectiveness assessments do not adequately include the costs of replacing, adding, or maintaining supply-side infrastructure especially taking into consideration risks of wildfires, hurricanes, and other natural disasters. Nor do they include numerous non-energy benefits, including water savings, job creation, or health and pollution benefits. Additionally, "on the system scale, the value of load-shifting and grid flexibility is seldom observed in cost-effectiveness screening," according to a recent Resources for the Future report.[67] Grid-interactive efficient homes, and the various DERs that comprise them, offer a number of benefits and value streams. They provide customers with improved comfort, health and safety, convenience, and bill savings; the utility and grid benefit from demand flexibility, peak reduction, increased reliability, and resiliency. Overall societal benefits include support for decarbonization and emissions reductions as well as energy security and resilience. Without a framework that captures the full range of benefits from DERs, their economic value will be overlooked and opportunities for prudent investment in these resources will be missed. Many states use one or more of the five tests defined by the California Standard Practice Manual to evaluate utility programs, but the tests are applied inconsistently and do not ensure the symmetrical inclusion of costs and benefits.[68] Undervaluing is due in large part to the use of tests that do not include hard-to-quantify impacts; include all participant costs but not all participant benefits, especially non-energy benefits; and fail to incorporate relevant state policy goals in their test.[69] The opportunity to reform cost-effectiveness tests so they capture the full range of benefits from GEB technologies which accrue to the customer, to the grid, and to society, is discussed further in the **Policy Opportunities Section**, below.

- ***Lack of Price Signals and Incentive Structures***
  Another valuation-related barrier is the absence of residential market signals for the time and locational value of energy. In most contexts, homeowners pay the same price for a kWh regardless of when it is used or how much it cost to deliver the energy at that time. Having a clear price signal for the time value of energy would incentivize load flexibility and improve the value proposition of GEB technologies. Abigail Daken of the U.S. Environmental Protection Agency says, "The biggest barrier [for residential GEBs] is that there is no way for [most] consumers to directly recoup the value that the grid gets from them moving their energy use to a different time of day."[70] The lack of incentivizing rate structures and policies around demand flexibility can also make it difficult to advance market transformation since manufacturers may not see a large enough national market to justify adding grid-interactive functionality to all of their products.[71] In terms of the locational value, "DERs have the potential to create significant value by supplying energy (or reducing net withdrawals) at locations where networks are frequently constrained and marginal losses on transmission

67 Jake Duncan and Dallas Burtraw, "Does Integrated Resource Planning Effectively Integrate Demand-Side Resources?" December 2018, *Resources for the Future*.

68 Tim Woolf et al., "The Resource Value Framework: Reforming Energy Efficiency Cost-Effectiveness Screening," August 2014, *The National Efficiency Screening Project*.

69 The National Efficiency Screening Project, "National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources," May 2017. Available at: https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_May-2017_final.pdf.

70 Abigail Daken, U.S. Environmental Protection Agency, interview, May 2019.

71 Alice Rosenberg, Consortium for Energy Efficiency (CEE), interview, May 2019.

and distribution systems are large."[72] There is a need for signals that incentivize the use of DERs where they can provide the most benefit.

Barriers in Utility Planning, Procurement, and Program Design

In many states, residential DERs are not considered an explicit asset in utility planning, meaning they are not considered on a level playing field with traditional generation resources and grid infrastructure investments. In order to evaluate the potential of DERs to meet grid needs compared to supply-side resources, and to enable investment where it makes sense, DERs should be included as a core resource in planning models. A recent RMI insight brief on demand flexibility cautions that "without proactive planning that includes demand flexibility, there is a significant risk of duplicative investment in natural-gas power plants that may become stranded as demand flexibility becomes more cost-effective and commonplace."[73] In addition to generation, demand flexibility and other grid services provided by DERs can also serve as an alternative to the expansion or upgrade of distribution and transmission systems. Regulatory structure is needed to direct utilities to properly value and source DER grid services.

For some utilities, existing incentive structures may discourage the use of residential buildings as a flexible grid asset. Without decoupling, utility profits are tied to energy sales, so they have a financial disincentive to invest in energy efficiency. Utilities have also historically earned a rate of return on investments in centralized assets, so they are incentivized to make those types of investments instead of considering where distributed resources, such as residential GEBs, could be used to meet grid needs more cost-effectively.

Another challenge is that current planning models may not be able to capture all value streams from residential GEB technologies. For example, traditional Integrated Resource Planning (IRP) models only look at the arbitrage, or time-shifting, benefits for energy storage which represent just a small portion of the overall value that storage can provide to the grid.[74] Grid-interactive water heaters, battery storage, and EV charging can be used for frequency regulation to increase grid stability over the span of seconds or minutes, and those benefits are missed if planning models do not examine system needs at those granular timeframes. Other DER benefits may be difficult to quantify (e.g., non-energy benefits, such as comfort for homeowners or grid services like reliability and resilience). A recent NARUC report examined current approaches to using the value of resilience in DER investment decision-making and found that there are currently "no standardized approaches for determining a specific value of resilience."[75] Broadly, the exclusion of certain benefits, such as those that are hard to quantify, leads to undervaluing and therefore limiting investment in the DERs that comprise GEBs.

Policymakers must take care to break down the silos between DERs and traditional EE when reviewing energy resources. Utilities that have invested significantly in wind or solar may recognize fewer benefits from investing in energy efficiency and fear creating stranded renewable energy assets. Looking at investments in traditional energy

72 Scott P. Burger et al., "Why Distributed? A Critical Review of the Tradeoffs Between Centralized and Decentralized Resources," March/April 2019, *IEEE Power & Energy Magazine*. Available at: http://www.ieee.org/ns/periodicals/PES/Articles/PE_MarApr2019_Burger.pdf.

73 Cara Goldenberg et al., "Demand Flexibility: The Key to Enabling a Low-Cost, Low-Carbon Grid," February 2018, *Rocky Mountain Institute*. Available at: http://rmi.org/wp-content/uploads/2018/02/Insight_Brief_Demand_Flexibility_2018.pdf.

74 Jeremy Twitchell, PNNL, "Energy Storage and Integrated Resource Planning," presented at NRRI Energy Storage webinar, April 10, 2019.

75 Wilson Rickerson et al., "The Value of Resilience for Distributed Energy Resources: An Overview of Current Analytical Practices," April 2019, *NARUC*.

efficiency with GEB technology assisting in the use of that efficiency is important to easing the size and speed of investment in utility-scale and aggregated DERs, while still supporting a transition from fossil fuel resources.

In procurement and program design regulatory processes can delay progress and innovative approaches. This makes it difficult to stay on top of changing system needs and opportunities and ensure that residential DERs are evaluated alongside conventional options to meet resource, transmission, or distribution needs. As William Burke, CEO of Virtual Peaker, sees it, "This is not a world where we are building power plants, so you can't just come up with a spec sheet and say I want to purchase this thing. You really need to experiment to figure out that business model."[76] If utilized, data streams from AMI and smart home technologies offer increased visibility of localized grid needs and existing behind-the-meter resources, which can inform planning models and program design. That data also provides near real-time feedback on energy savings and demand flexibility performance allowing for quicker assessment of programs. But without a process in place to be able to respond nimbly to that information, some benefits are lost.

Energy Efficiency, Demand Response, and Other DERs Are Siloed

Advancing residential GEBs entails coordination between energy efficiency (EE) strategies, demand response (DR), and the management of other DERs, like EVs and storage, but these approaches have traditionally been siloed. Utility programs and regulatory structures have generally treated EE, DR, and other DERs separately, with different budgets, metrics, and evaluation methodologies. These divisions make it difficult to incentivize the combination of mutually supportive GEB strategies and to adequately value measures that provide both efficiency and load-shaping benefits. Many grid-interactive technologies offer both energy savings and demand flexibility through their smart functionality, yet it can be a challenge for utility programs to fully value the EE and DR benefit streams of these technologies.

Existing regulatory structures and utility departmental constructs make it difficult to integrate these different technologies and solutions into a unified demand-side management approach. A recent LBNL study looked at the adoption of integrated demand side management (IDSM) at utilities—an approach that combines EE, DR, distributed generation, and storage programs into an integrated effort.[77] The study identified the division of program funding and administration and the treatment of demand side management technologies as competitors instead of complements as primary barriers. Additionally, a majority of program managers surveyed for the study identified the "lack of effective metrics for evaluating cost-effectiveness of integrated programs" as a significant regulatory barrier.[78]

Programs need to avoid double counting, but attributing savings to one side or the other can be difficult, especially since EM&V and cost-effectiveness methods vary across programs.[79] Alice Rosenberg of the Consortium for Energy

76 William Burke, Virtual Peaker, interview, June 2019.

77 Jennifer Potter et al., "Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management at Electric Utilities: A Scoping Study," February 2018, *Lawrence Berkeley National Laboratory*.

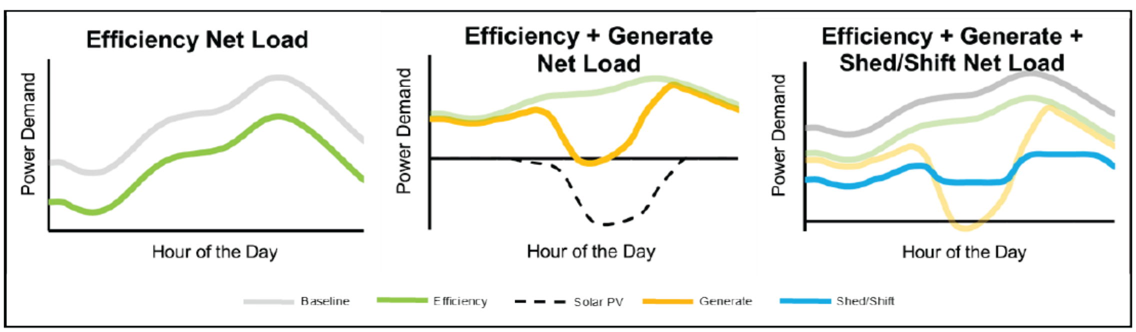
78 Ibid.

79 Brett Feldman et al., "Attribution for Integrated Distributed Energy Resources: Methodology for Attributing Benefits from Integrated Offerings to Existing Programs," 2017, *Navigant*.

Efficiency (CEE) says "many traditional voluntary energy efficiency programs are being asked to meet goals that span a much broader range of integrated demand side management (IDSM) objectives. These diverse savings goals may not be compatible with the various internal departments are structures. Further, the current metrics and evaluation approaches for claiming savings may not best reflect the evolving value streams."[80] Rosenberg works with program administrators across the U.S. and Canada and sees the existing institutional infrastructure as a common barrier for many large regulated IOUs moving towards a more IDSM framework.

Differing metrics have also kept efficiency and load shaping apart. Efficiency is concerned with reducing total kWh used, while DR and load flexibility are about moving energy usage to a different time of day in response to grid needs as well as shedding load at critical peak times. To date, EE and DR have largely been treated as separate demand-side management strategies and even seen as potentially oppositional, given load shifting does not necessarily result in net energy savings, and prioritizing load flexibility can come at the expense of opportunities to improve efficiency. At the same time, there are moments in a day when a lot of solar is on the grid, and baseload EE exacerbates the "belly of the duck," possibly being seen as having a negative value if storage is not available. However, both flexible building loads and EE are needed to support the grid of the future; a need exists to reduce both peak demand and baseload, and efficiency makes deploying flexible loads more effective.[81]

Figure 2: Grid-Interactive Efficient Building Load Curves (U.S. Department of Energy)



Source: Monica Neukomm et al., "Grid-Interactive Efficient Buildings: Overview," April 2019, U.S. Department of Energy, p.14.

Coordination should occur between these different, but complementary, approaches for homes to be an effective grid asset. Ethan Goldman, Director of Customer Solutions with Recurve, is concerned that as load shifting becomes a bigger focus, there could be a motivation to build more flexible load, for the sake of flexibility alone, at the expense of efficiency.[82] Not bringing together these different programs and strategies risks that efficiency will lose out to efforts to increase grid-connectivity and demand flexibility, when an all-hands-on-deck approach is needed to optimize energy use and work towards a cleaner, more efficient, and reliable grid that also benefits customers.

80 Alice Rosenberg, Consortium for Energy Efficiency (CEE), interview, May 2019.

81 The authors of this paper have described how DR is more effective when paired with EE measures in previous Smart Home reports: http://www.building-performance.org/sites/default/files/HPC_Smart-Home-Report_201810.pdf, http://www.building-performance.org/sites/default/files/nhpc_white-paper-making-sense-of-smart-home-final_20140425.pdf.

82 Ethan Goldman, Recurve, interview, April 2019.

Former Northeast Energy Efficiency Partnerships (NEEP) Technology and Market Solutions Senior Manager Claire Miziolek says the challenge is that some technologies "don't fit within the existing construct, even though they are totally aligned for the bigger goal."[83] For example, technologies like EVs increase load, conflicting with existing regulatory structure in many states which incentivizes efficiency based on kWh reductions alone. Yet, with grid-responsive charging strategies, EVs can reduce peak demand through load flexibility and storage, provide additional grid services, and support the more optimal use of renewable generation in addition to advancing state carbon goals by reducing vehicle emissions. Regulatory frameworks need to evolve to enable the integration of different technologies and strategies and advance overarching energy goals.

Engaging and Educating Homeowners

Industry Experts Speak to the Challenges of Educating and Engaging Homeowners

The only time somebody thinks about a water heater is when theirs is broken, and they want a hot shower and can't have one. They call up a plumber and say, 'Get me a water heater as soon as possible,' and what they get installed is whatever is on the back of the truck. So, getting a smart water heater, one that can communicate with these programs, is fairly unlikely unless the contractors are engaged, and the contractors know that the homeowner gets energy efficiency plus some benefit from the utility from installing this water heater.
William Burke, Virtual Peaker

[Our customers who participate in demand response programs] aren't always happy, and they intentionally override it. An issue with demand-side management programs is they don't do a great job of getting information out to people. People feel like they're being controlled, rather than they're controlling.
Ryan Weitzel, FLC Energy

[Any program or incentive] has to be easy—it has to be easily understandable and easy to do it. The more hoops you have to jump through, every step is going to be another reason why people won't do it.
Jeff Boone, NorthStar Comfort Services, Inc.

Engagement with customers is really key. Economic models of customers are not always accurate; just because it's in their best interest doesn't mean they will do it. That is especially difficult on the residential side.
David Parsons, Hawaii Public Utilities Commission

Homeowners are so busy trying to make a living. If efficiency and choosing the right thing become too complicated, they may not participate. There's not much margin of elasticity for residential, because they've got a schedule that's not necessarily under their control.
Carilyn Shon, Hawaii State Energy Office

Homeowners will never be experts in residential HVAC. [...] Contractors will be a trusted entity for understanding how systems work, building science, etc. Contractors are the person with their foot in the door—the ones who can sell things to customers and convey value to them.
Alice Rosenberg, Consortium for Energy Efficiency, Inc.

Anything new scares the daylights out of people. Most consumers don't think about the grid and what's best in the long run, so I think it's breaking that down into very simple marketing or messaging.
Taren O'Connor, Connecticut Office of Consumer Counsel

[In the residential sector] we need to convince our 3 million customers to be part of this—how do we market to them? How do we make sure the messaging is clear? In mass marketing, you need something catchy, like an image, to get someone's attention. Words can't do it alone.
Zach Sussman, ConEdison

If we really want to leverage the potential of grid-enabled smart homes or products for energy efficiency and demand response, we need to move from just getting [the technologies] in to getting them in, installed, managed, maintained, and used efficiently.
Beth Karlin, See Change Institute

Contractors are key to being able to aggregate cost-effectively. Convincing people to add this technology, particularly through this transition time where some appliances are grid-enabled, but then are you adding some sort of plug or downloading software—you still need to get customer attention. The amount it will cost per customer acquisition through a traditional sell is going to be so high that it won't work economically.
Scott Johnstone, Packetized Energy

To advance residential GEBs, consumers should be educated about grid-connected and smart energy management technologies to encourage adoption, optimal use, and enrollment in energy-saving and load-shifting programs. The costs and difficulty of customer acquisition and engagement are a challenge in the residential space.

83 Claire Miziolek, Massachusetts Executive Office of Energy and Environmental Affairs (formerly with Northeast Energy Efficiency Partnerships), interview, May 2019.

> *"On the commercial side, you have a building energy management system with a trained operator, whereas in homes you have millions of individuals."*
>
> *- Claire Miziolek, Massachusetts Executive Office of Energy and Environmental Affairs* [84]

Interoperability

Interoperability has long been seen as the ultimate hurdle to the smart, grid-connected, efficient home. It entails standards for seamless communication across devices within the home and between homes and the grid. Within the home, the successful integration of various smart home devices is key to optimizing energy usage across different end uses as well as making energy management simpler for homeowners. However, manufacturers that allow only proprietary devices to interact, limiting the platforms that can communicate, remains a barrier to interoperability. Elena Chrimat, co-owner of Arizona-based home performance company Ideal Energy, sees this problem with AC systems that are designed to only work with proprietary smart thermostats—the systems speak their own language and are not compatible with any other thermostats or devices. "This is a serious issue right now for us," says Chrimat.[85] This lack of interoperability across manufacturers limits customer choice and prevents the integration of different systems in the home. If homeowners have to manage each piece of their smart home individually—needing a separate app for their water heater, for example—that will make widespread adoption and scalability difficult.[86] Furthermore, customer confusion about which products work with others is likely stagnating larger growth of these connected devices.[87]

> *"If you have a system that's communicating with the utility and the grid and all the different smart devices, there is a lot of potential flexibility in the load. At this point we don't have a system that can do that—there are a lot of individual technologies, a lot of different interfaces and different communication methods."*
>
> *- Gamaliel Lodge, OptiMiser* [88]

Some experts believe that as the market for these technologies matures, interoperability will ultimately get sorted out as technology providers integrate across their APIs and industry leaders emerge. Zach Sussman of Con Edison states that the market for smart home technology is currently focused on virtual assistant technology, for example,

84 Ibid.
85 Elena Chrimat, Ideal Energy, interview, August 2019.
86 Alice Rosenberg, Consortium for Energy Efficiency (CEE), interview, May 2019.
87 Kevin Foreman, Powerley, interview, July 2019.
88 Gamaliel Lodge, OptiMiser, interview, May 2019.

virtual assistants from Amazon and Google. Increasingly, manufacturers are seeking integrations for their devices with such virtual assistant platforms due to consumer interest, and any market consolidation could lead to increased interoperability.[89] The evolution of the smartphone market is an example of this. With the iPhone and Android, initially apps were being designed for one phone but not the other, and people wanted to stick with the system they had, but over time as the two smartphones came to dominate the market, more developers began designing for both and it became easier to do so, removing the switching costs of moving from iPhone to Android or vice versa.

Not only must devices be interoperable within the home, the home's systems must also be interoperable with the grid. In terms of the home-to-grid connection, standard communications are needed to fully and cost-effectively leverage GEBs for load flexibility. Ethan Goldman of Recurve says, "We're talking about a many-to-many communication scenario with lots of different utilities and lots of different tech companies—it would be a lot easier if they all spoke the same language."[90] Industry-wide standards will help to facilitate integration and information sharing across the many different technology solution providers and utilities. Open communication standards do already exist—primarily OpenADR and CTA-2045—and they are being adopted in some markets. However, certain industry experts say these solutions are insufficient to fully engage homes and various DERs for dynamic load shaping.[91]

An integrated platform for aggregating DERs that can coordinate signals between homes and the grid and manage load shaping could be part of the answer to interoperability challenges. It is not clear yet what that ultimate ideal solution will be. However, a few different models are emerging:

- **Distributed Energy Resource Management Systems (DERMS)** are centralized software platforms that coordinate control of connected devices and DERs across many different homes, so they can all be managed from one centralized place. In the residential space, companies like EnergyHub, Powerley, Tendril, and Virtual Peaker are working to provide that solution, facilitating communications between the utility and end-use devices through cloud-based software.

- **Transactive Energy** is an alternative model in which "participants buy and sell energy and ancillary services, and negotiate between themselves through market mechanisms" using automation tools to actively engage with price points.[92] The National Institute of Standards and Technology (NIST) is studying the potential of transactive energy systems, which so far have only been implemented in very small-scale pilots and demonstration projects.

- A third option is **packetized virtual batteries,** a model put forth by Packetized Energy in which a "packet" of energy is equal to five minutes of power, behind-the-meter connected devices request energy when needed, and the virtual battery software manages the coordination of those devices through packetization and

89 Zach Sussman, Con Edison, interview, April 2019.
90 Ethan Goldman, Recurve, interview, April 2019.
91 General thoughts expressed by the following industry experts during interviews conducted in April–June 2019: Ethan Goldman (Recurve), William Burke (Virtual Peaker), Scott Johnstone (Packetized Energy).
92 Sharon Thomas et al., "Transactive Energy: Real-World Applications for the Modern Grid," April 2019, *Smart Electric Power Alliance*.

randomization. Through this model DERs are aggregated and they collectively provide load shaping and grid services "to look, walk and talk just like a grid-tied battery."[93]

Data Privacy and Cybersecurity Concerns

Concerns about data privacy and cybersecurity risks, real and perceived, could be stumbling blocks on the road to residential GEBs. Indeed, the authors of the forthcoming DOE Technical Report, "Building Energy Modeling, Sensors, Controls, and Analytics," found that one of the major challenges for smart home technologies in the residential market is privacy and cybersecurity concerns.[94]

> *"Data is an important issue – how it is being gathered, handled, and managed. Data is sensitive and data management is key. There are issues with data privacy and security, and there are trust issues on the part of consumers."*
>
> *- Scott Taylor, Sense*[95]

Cybersecurity is often cited as a concern for GEBs as well as for the smart interconnected grid of the future. Dr. Martin Keller, director of the National Renewable Energy Laboratory (NREL), points out that the IoT in homes means "more entry points for cyber risk," but that the same can be said for a technology like credit cards; in both cases Dr. Keller believes the benefits outweigh concerns, and the key is proactively managing risk.[96]

As smart home technologies collect increasingly large amounts of data, privacy concerns arise; some homeowners may be mistrustful of the technology because of concerns about data use and privacy protections. Appropriate standards for data management and security protocols are needed along with a sufficient value proposition for homeowners. "Consumers take security risks in exchange for convenience every day. They click 'accept' to log into insecure networks at hotels and coffee shops without reading the pages of fine print. What is important is that the security is standardized and sized appropriately with the risks and that there are controls and responsibilities in place," said Kara Saul Rinaldi, Vice President of Government Affairs, Policy, and Programs at the Building Performance Association. "And, the smart home has to provide a level of convenience that people are willing to trade a modicum of privacy to enjoy it."[97]

Policymakers and regulators can encourage the use of best practices among utilities and other service providers

93 Scott Johnstone, Packetized Energy, interview, June 2019.

94 Authors unknown, "Grid-interactive Efficient Buildings Technical Report: Building Energy Modeling, Sensors, Controls, and Analytics," preliminary draft, *U.S. Department of Energy*.

95 Scott Taylor, Sense, interview, April 2019.

96 Remarks by Dr. Martin Keller, NREL. DOE 2019 Better Buildings Summit, "Lunch Plenary: Hearing From the Experts: Emerging Technologies and Things to Watch," July 11, 2019, 12:30-2:00pm, Arlington, VA.

97 Remarks by Kara Saul Rinaldi, Building Performance Association. 2019 National Home Performance Conference & Trade Show, "Utility Data Access: The Utility Role in the Smart Home," April 3, 2019, 3:30-5:00pm, Chicago, IL.

based on the most up-to-date guidance and standards for protecting privacy and security. The EU General Data Protection Regulation (GDPR) is an existing standard for data privacy, which some smart home vendors in the U.S. have integrated into their technology solutions.[98] Meanwhile, NIST has developed a voluntary Cybersecurity Framework and released a profile that applies those strategies to the smart grid.[99] NIST is also currently developing a voluntary privacy framework to help organizations manage privacy risks.[100] These standards can serve as guidance for managing concerns related to data privacy and cybersecurity. The energy industry can also look to advancements in the healthcare and financial services industries that have enabled consumers to easily share data with any provider they choose while securing privacy.

Policy Opportunities (Regulatory & Legislative)

As the grid continues to evolve, new policy frameworks will need to support a nimble home-to-grid dynamic in which distributed resources integrated with the grid can be used optimally and properly valued for the services they provide. The regulatory environment can encourage or dissuade investment in residential grid-interactive efficiency. In some cases, the technology is already there to be utilized, but policies are not in place to capture its value and incentivize its use. As the market is driving down the costs of DER systems, policymakers must examine market failures that policies and regulations can address.

Integrated Demand Side Management

Integrated Demand Side Management (IDSM)—sometimes referred to as the integration of distributed energy resources (IDER)—is an approach that brings together load shaping, efficiency, and other DERs into a coordinated effort, allowing optimization of different complementary strategies to reduce load and grid inefficiencies. A recent LBNL study defines IDSM as "a strategic approach to designing and delivering a portfolio of DSM programs to customers […] that integrates various measures and technologies to improve their collective performance and/or penetration."[101]

Importantly, performance can improve when these different strategies are combined. Flexible building loads and energy efficiency reinforce each other. As the Alliance to Save Energy outlined in recent comments submitted to the U.S. DOE in response to an RFI on efficient and flexible building loads: "Energy efficiency results in smaller energy loads, which are operationally easier to shift to a different time of day" and "strong envelope performance not only reduces peak power […] it also extends the timeframe during which mechanical cooling or heating systems can be cycled off, allowing indoor temperatures to passively remain within an acceptable performance range for longer periods."[102] Karma Sawyer, program manager of the BTO Emerging Technologies program, echoed that sentiment, "If we want to shed and shift loads on a regular basis, and you want occupants to be safe through natural disasters,

98 Chris Ebert, People Power, interview, July 2019.
99 Jeffrey Marron et al., "Cybersecurity Framework Smart Grid Profile," July 2019, *NIST*. Available at: https://doi.org/10.6028/NIST.TN.2051.
100 https://www.nist.gov/privacy-framework.
101 Jennifer Potter et al., "Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management at Electric Utilities: A Scoping Study," February 2018, *Lawrence Berkeley National Laboratory*.
102 https://www.ase.org/sites/ase.org/files/final_alliance_building_load_flexibility_rfi_comments_030119.pdf.

you need a tight and well insulated building. You need active and passive measures."[103]

The 2018 LBNL study interviewed a small sample of program administrators from around the U.S. about motivations and benefits of IDSM, many of whom said "IDSM portfolios can help balance different program design objectives, such as delivering the right type of DSM so it benefits system needs while giving the customers more choice and control."[104] Through an IDSM approach, measures that provide both EE and load shaping can get extra incentives, and customers have improved access to the combination of solutions that makes the most sense for their home and provides most value to the grid. Over 90 percent of respondents in the LBNL study indicated that the benefits of IDSM portfolios include "the ability to increase the number of DSM measures that are capable of optimizing customers' end-use consumption," and half of the respondents said they "believed that IDSM enabled more customers to participate in DSM programs and generated peak demand reductions that exceeded what DR programs alone could deliver."[105]

To facilitate IDSM, policymakers can evolve the definitions and metrics for demand-side management to allow greater flexibility regarding what devices or strategies can be used to meet an energy goal. If efficiency is framed around decarbonization instead of kWh reduction, a lot more flexibility exists, and suddenly the same program can deploy strategies that might increase or shift electricity use instead of reduce it, but are ultimately all pushing towards a larger decarbonization goal.[106] For example, Massachusetts recently passed legislation broadening the definition of energy efficiency to include energy storage, strategic electrification, and other active demand management technologies.[107] By enabling those technologies to qualify for efficiency incentives, the state is broadening its strategy to reduce peak demand and leveraging investments made in a cleaner grid to cost-effectively reduce greenhouse gas emissions from thermal loads.[108]

Regulators can also direct utilities to integrate residential demand-side management programs. Some states are already making that shift. In New York, Con Edison's demand response team is part of the energy efficiency department which gives them a unique opportunity to coordinate programs and strategies, according to Zach Sussman, Senior Specialist of Energy Efficiency and Demand Management at Con Edison. Sussman says, "Looking at smart technology, demand response and energy efficiency go hand in hand, because customers get to be compensated for additionally reducing their energy demand when called for by the Company's DR programs and provide energy efficiency benefits throughout the rest of the year. If they are two separate groups, you miss opportunities—it is about how to offer joint incentives to make it work." In California, the California Public Utilities Commission (CPUC) directed utilities in 2007 to "integrate customer demand-side programs, such as energy

103 Remarks by Karma Sawyer, U.S. Department of Energy. DOE BTO 2019 Peer Review, "Integrating Building Technology with Renewables and Storage," April 15, 2019, 10:30-11:00am, Arlington, VA.

104 Jennifer Potter et al., "Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management at Electric Utilities: A Scoping Study," February 2018, *Lawrence Berkeley National Laboratory*.

105 Ibid.

106 Claire Miziolek, Massachusetts Executive Office of Energy and Environmental Affairs (formerly with Northeast Energy Efficiency Partnerships), interview, May 2019.

107 An Act to Advance Clean Energy, available at: https://malegislature.gov/Laws/SessionLaws/Acts/2018/Chapter227.

108 Presentation by Eric Friedman, Massachusetts Department of Energy Resources. DOE 2019 Better Buildings Summit, "Grid Modernization: The Role of Grid-Interactive Efficient Buildings," July 10, 2019, 1:30-3:00pm, Arlington, VA.

efficiency, self-generation, advanced metering, and demand response, in a coherent and efficient manner."[109] The CPUC IDER Proceeding (R.14-10-003) initiated in 2015 seeks to address some of the barriers and lessons learned from those efforts, including a May 2019 decision to adopt a cost-effectiveness framework for all DERs that moves the state closer to a universal framework for assessing all resources.[110]

Updating Cost-Effectiveness Testing to Appropriately Value DERs

Jurisdictions need a common, balanced, and consistently applied cost-effectiveness testing (CET) framework to ensure all supply-side and demand-side resources are evenly evaluated. The National Standard Practice Manual (NSPM) provides a framework for how jurisdictions can update their cost-effectiveness screening practices based on the following principles: treating energy efficiency as a resource, accounting for relevant policy goals, accounting for all relevant impacts, ensuring symmetry in the inclusion of different costs and benefits, using forward-looking analysis, and ensuring transparency.[111] While the NSPM, published in 2017, focuses on energy efficiency resources, the core concepts can be applied to supply-side resources and DERs, including demand response, distributed generation, distributed storage, electric vehicles, and strategic electrification technologies. A National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources (NSPM for DERs) is forthcoming in 2020. Regulators and policymakers can use both manuals for "guidance on how to develop a jurisdiction's primary cost-effectiveness test that meets the applicable policy goals of the jurisdiction."[112]

Establishing a common screening framework would also support integrated demand side management (IDSM) efforts. Currently, differing CET methodologies and a lack of effective metrics for evaluating integrated programs have been identified as a key barrier to IDSM. LBNL's 2018 study found that developing standardized cost-effectiveness metrics for IDSM programs would support the assessment of IDSM measures and help establish the value proposition to both program administrators and customers.[113] Furthermore, the parts of a residential system have less value separately than together, and effort should be made to ensure that the testing is of an interoperable set of DERs and energy efficiency. Regulators and policymakers can support the development of a common cost-effectiveness test framework that can be used to screen any combination of demand-side measures and ensure DERs are appropriately valued. This will also help to effectively incorporate residential GEB resources into utility planning.

Utility Planning

The utility planning process shapes how investments are made to meet grid needs and forecasted peak demand requirements. To proactively move towards the grid of the future, planning models should include demand flexibility and DERs as an explicit asset and weigh them evenly against traditional capital investments in generation, transmission, and distribution. With this integration, planning models should be updated in order to capture the full value streams of DERs and identify opportunities and optimal locations for these resources.

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109 https://www.cpuc.ca.gov/General.aspx?id=10710.

110 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M293/K833/293833387.PDF.

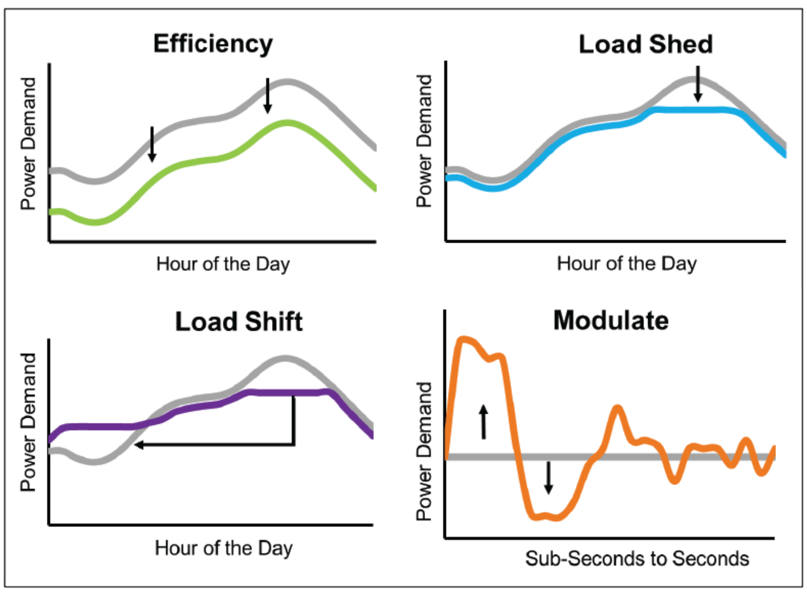
111 The National Efficiency Screening Project, "National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources" May 2017. Available at: https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_May-2017_final.pdf.

112 Ibid.

113 Jennifer Potter et al., "Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management at Electric Utilities: A Scoping Study," February 2018, *Lawrence Berkeley National Laboratory*.

- **Capturing value.** Multiple use frameworks consider the multiple use cases and benefits that an asset can provide. For example, electric batteries and virtual "batteries" of aggregated connected devices can provide load-shifting, peak demand reduction, reliability and resiliency, grid infrastructure congestion relief, and ancillary services as well as customer benefits.[114] Considering all the benefits that DERs can provide and stacking the revenues from each service would improve the economics of these resources, optimizing the use of demand-side resources, and helping to avoid unnecessary system costs. The granularity of planning models also impacts the assessed value of DERs. Frequency regulation, for example, is an important service that battery storage can provide but it is measured in seconds and so the value cannot be captured at hourly granularity.[115] Emerging planning models that examine system-level needs and capture grid service values of all resource options can help to ensure residential GEB solutions are appropriately weighed against other resource investments.

Figure 3: Building Flexibility Load Curves (U.S. Department of Energy)



Source: Monica Neukomm et al., "Grid-interactive Efficient Buildings: Overview," April 2019, U.S. Department of Energy, p.13.

Residential GEBs can provide a number of different grid services which occur across different time scales. It is important that planning models capture the value of all of these services.

- **Including DERs/load flexibility as an explicit asset.** Assessing DERs as an explicit asset in utility planning is key to capturing opportunities for load flexibility and cost-effective investments in GEB solutions, making the best use of available technologies, and avoiding unnecessary costs. Driven by aging grid infrastructure and the need for greater grid flexibility, resilience, and reliability, emerging modeling techniques for

114 Nitzan Goldberger, Energy Storage Association, "Energy storage policy," presented at NRRI Energy Storage webinar, April 10, 2019.

115 Jeremy Twitchell, PNNL, "Energy Storage and Integrated Resource Planning," presented at NRRI Energy Storage webinar, April 10, 2019.

integrated distribution system planning are beginning to assess the locational value of DERs and analyze non-wires solutions (NWS) compared to conventional infrastructure investments.[116] Regulators and policymakers could require utilities to consider NWS, including residential DERs, in the planning process in order to defer or offset traditional supply-side infrastructure investment. On the regulatory side, California, Maine, New Hampshire, New York, Rhode Island and Vermont have mandated that utilities consider NWS; California and New York also require utilities to develop NWS pilot projects.[117] RMI's 2018 Non-Wires Solutions Implementation Playbook offers examples of legislative action states have taken to drive the consideration of NWS in utility planning:

- In 2006, the Rhode Island legislature passed the Energy Conservation, Efficiency, and Affordability Act, which mandated least-cost procurement and required non-wires solution consideration for system reliability investments in the distribution network.

- In 2010, Maine passed its Smart Grid Policy Act that required DERs to be assessed to meet the goals of creating a more modern grid and reducing greenhouse gases.

- Illinois's Future Energy Jobs Act from 2016 encourages deployment of cost-effective DERs to diversify the state's energy resource mix and protect its environment."[118]

New Jersey has been undertaking a long and deliberate effort since early 2018 to advance a new Energy Master Plan and implement robust renewable energy legislation. Through Executive Order 28, Governor Murphy has set an ambitious goal of powering New Jersey through 100 percent clean energy by 2050 and initiated a planning process to develop a blueprint and specific proposals. New Jersey Board of Public Utilities Commissioner Robert Gordon noted that while smart and advanced technology is a part of that planning process, a number of important factors must be considered, including that there are not enough homes to meet demand and the available housing stock is expensive and ageing.[119] The Maryland legislature has also advanced the Clean Energy Jobs Act requiring the state to achieve a 50 percent renewable energy goal by 2030. Commissioner Michael Richard of the Maryland Public Service Commission notes that utilities should consider innovative technology, energy efficiency, EVs, and storage, observing that "while the 50 percent renewables requirement is ambitious, the full suite of tools is available or being developed that will make us successful."[120]

There is significant and growing potential for residential flexibility to be used to provide grid services and save ratepayers money. To harness this potential and take advantage of the rapid evolution of technology solutions, utilities need to be able to experiment and test different business models to figure out what works. Regulatory structures could be adapted to allow utilities to deploy pilots more quickly and enable a feedback loop that takes

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116 Lisa Schwartz, LBNL, "Overview of Integrated Distribution Planning Concepts and State Activity," presented at the Mid-Atlantic Distributed Resources Initiative, March 13, 2018. Available at: http://eta-publications.lbl.gov/sites/default/files/schwartz_madri_dsp_presentation_20180313_fin.pdf.

117 Mark Dyson et al., "The Non-Wires Solutions Implementation Playbook," 2018, *Rocky Mountain Institute*.

118 Ibid.

119 Commissioner Robert Gordon, New Jersey Board of Public Utilities, interview, June 2019. MACRUC Conference.

120 Commissioner Michael T. Richard, Maryland Public Service Commission, interview, June 2019. MACRUC Conference.

advantage of data-driven insights. Vermont, for example, has an innovative regulatory structure which has enabled the state's largest electric utility, Green Mountain Power, to launch pilots quickly and with very little paperwork, giving regulators just two weeks' notice. The pilot is still required to meet certain specifications in order to pass, but the lightweight filing process has made it possible to deploy experimental pilots, learn from them, and then develop full programs in a shorter timeframe. William Burke of Virtual Peaker says, "What is required in this new world is experimentation."[121]

Utility Incentive Structures

Opportunities exist to modernize incentive structures to support new utility business models and encourage progress towards a cleaner, more efficient, affordable grid. Decoupling rate structures is one way utilities can earn reasonable revenues while investing in strategies that create energy savings and peak reductions. Incentives that actively encourage utilities to make cost-effective investments in non-wires solutions (NWS), such as residential GEBs, could include allowing a rate of return on NWS projects or a share-of-savings incentive that lets utilities earn a percentage of the achieved savings,[122] or price structures and loading orders that put a higher value on carbon-free solutions and provide incentives for going beyond requirements.

> *"The regulatory role is exposing prices in a different way and changing the way the utility is able to recover revenue from operating these resources."*
>
> *- Ethan Goldman, Recurve[123]*

Incentive Structures: State Example

New York is an example of reforming incentive structures to advance DERs. The state's Reforming the Energy Vision (REV) initiative, launched in 2014 with the initiation of a Public Service Commission proceeding, has set out to restructure regulatory practices to promote energy efficiency, renewable energy, least cost energy supply, fuel diversity, system adequacy and reliability, demand elasticity, and customer empowerment.[1] Through the REV initiative "reformed price signals and compensation structures will reward investments that improve overall system efficiency (e.g., by managing loads to reduce peak demand), engage the private sector to invest in clean energy opportunities, and place clean and distributed energy at the core of the utility business model."[2] Under REV, the Public Service Commission has established a mechanism to transition to a new way to compensate DERs This mechanism, called the Value of Distributed Energy Resources (VDER), or the Value Stack, replaces net energy metering and compensates projects based on where and when they generate electricity.[3] Notably, this model can provide incentives for customers to install DERs where they provide the most value to the grid.[4]

1. http://www3.dps.ny.gov/pscweb/WebFileRoom.nsf/Web/E0833D2B37E8DB9685257CC4005A7EB7/%24File/gov%204.24.14%20b.pdf?OpenElement
2. https://www.ny.gov/sites/ny.gov/files/atoms/files/WhitePaperREVMarch2016.pdf
3. https://www.nyserda.ny.gov/All%20Programs/Programs/NY%20Sun/Contractors/Value%20of%20Distributed%20Energy%20Resources
4. Mark Dyson et al., "The Non-Wires Solutions Implementation Playbook," 2018, *Rocky Mountain Institute.*

121 William Burke, Virtual Peaker, interview, June 2019.
122 Mark Dyson et al., "The Non-Wires Solutions Implementation Playbook," 2018, *Rocky Mountain Institute*.
123 Ethan Goldman, Recurve, interview, April 2019.

Performance-based regulation is an emerging framework that links earnings to how well a utility achieves certain policy goals, instead of a rate of return on investment.[124] The Hawaii Public Utilities Commission (HPUC) just adopted performance-based rate tools for the state's IOUs. The rate tools include performance incentives, shared savings mechanisms, scorecards and reported metrics. HPUC is focused on DER asset effectiveness—including those in the residential sector—and creating stronger incentives for utilities to take advantage of all those capabilities.[125] Over the course of Con Edison's Brooklyn Queens Demand Management Program, described in **Section 3**, the New York Public Service Commission has adopted similar performance incentives including a rate of return on program costs and a shared savings mechanism that allows the utility to earn 30 percent of the net benefits.[126]

Advanced Rate Structures

Not all kWh have the same value to the grid under the simple metrics of supply and demand. Typically, in the middle of the night the load on the grid is low, thus the supply of energy is plentiful and cheap. At 6 p.m. in 100-degree heat when the sun is setting, reducing solar power, and office buildings and homes are both cranking their air conditioning, energy becomes precious. Time-varying rates establish a price signal that, if the price is right, will incentivize demand flexibility and encourage consumers to adopt energy-efficient and grid-responsive technologies.

Time-of-use (TOU) rates are a key policy for putting a price on the time value of energy so that customers share the value-burden with utilities and can save money on utility bills by shifting their energy use.

TOU rates could be used to incentivize the coordinated use of different GEB strategies (described in detail in **Section 2** of this paper) to reduce or shift residential load away from peak hours and to take full advantage of variable renewable generation. By establishing higher prices per kWh for peak periods and lower prices for off-peak periods, TOU rates communicate to customers when electricity is more expensive and offer cost savings for using energy when it is most cheap and plentiful. Therefore, with the right tools, customers can benefit from these rate structures while also supporting the grid.

Abigail Daken, of U.S. Environmental Protection Agency, cautions that "imposing TOU rates without giving homeowners good tools to control when they're using energy will be regressive. It will impact the most the people who can least afford energy."[127] However, when paired with progressive access to GEB solutions that enable load flexibility (e.g., providing incentives for price-responsive technologies), well-designed time-based rate structures can help residents to capture the value they create and can be an important money-saving opportunity especially for low-income customers. Ensuring equity is important (and this is discussed in more detail at the end of **Section 4**). Scott Taylor of Sense points to smart home technologies and Home Energy Management Systems (HEMS) as

124 https://www.utilitydive.com/news/is-the-perverse-incentive-beyond-the-reach-of-performance-based-regulation/521891/

125 David Parsons and Ashley Norman, Hawaii Public Utilities Commission, interview, August 2019.

126 "Brooklyn Queens Demand Management Program – Employing Innovative Non-Wire Alternatives," *Advanced Energy Economic Institute, Rocky Mountain Institute, America's Power Plan*. Available at: https://info.aee.net/hubfs/NY%20BQDM%20Final.pdf.

127 Abigail Daken, U.S. Environmental Protection Agency, interview, May 2019.

Around 14 percent of all U.S. utilities, and 48 percent of U.S. IOUs, offer residential TOU rates according to a November 2017 survey from the Brattle Group.[5] In Arizona, over half of Arizona Public Service residential customers are enrolled in TOU rates.[6] APS offers a three-tiered TOU rate with peak period, off-peak period, and super-off-peak winter prices to encourage customers to use energy when there is excess generation from solar.[7] In California, the CPUC has mandated that the state's IOUs start transitioning their residential customers to TOU rates by 2020. This will be the first U.S. system-wide default (a.k.a. "opt-out") TOU rate structure and will include 22.5 million residential customers.[8]

5. https://brattlefiles.blob.core.windows.net/files/12658_the_national_landscape_of_residential_tou_rates_a_preliminary_summary.pdf.
6. Brenda Chew et al., "2018 Utility Demand Response Market Snapshot," September 2018, *Smart Electric Power Alliance.*
7. https://www.aps.com/en/residential/accountservices/serviceplans/Pages/saver-choice.aspx
8. https://www.utilitydive.com/news/as-california-leads-way-with-tou-rates-some-call-for-simpler-solutions/532436/

important tools that can help customers better manage their energy usage as they move onto these rate structures. The Sense home energy monitor, for example, provides real-time feedback about the energy consumption of different appliances and can alert homeowners when their usage spikes during expensive peak-price hours.[128] In the future, pricing signals could be integrated into a HEMS or other centralized control platform that can manage all the loads in the house automatically on behalf of the homeowner, while staying within certain parameters based on learned patterns or preconfigured user preferences. By establishing a monetary value for demand flexibility, TOU rates can also improve the value proposition of smart home technologies and HEMS by offering a higher return on investment compared to the payback from energy savings alone. However, TOU rate design needs to be done carefully otherwise there is little or no incentive for the homeowner.[129]

Consumer awareness and education is key to making the transition to these rate structures and enabling homeowners to save money and reduce/optimize their energy consumption. Taren O'Connor, Associate Rate Specialist with the Connecticut Office of Consumer Counsel, says "The biggest barrier [for TOU rates] is getting people comfortable with the idea."[130] Brian Farhi who works for Google agrees that "there's an entire education process for consumers," and suggests that part of that process is "the outbound communication of the utilities and of the PUCs via different agencies to make sure customers are very clearly aware of changes before they happen."[131] Utilities and state agencies can also provide resources to help homeowners understand the impact of moving to new rate structures. In California, for example, PG&E offers an online Electricity Rate Plan Comparison tool that shows customers how their electric bill, based on the prior 12 months, would be affected by switching to a different rate plan.[132] In Arizona, the state's largest electric utility, Arizona Public Service, has partnered with technology solution provider OptiMiser to develop resources and train contractors on how to help homeowners navigate new rate structures. Gamaliel Lodge, lead developer at OptiMiser, says the company is building out their residential energy auditing software to be able to compare a home's load to the TOU rate structure in order to understand the financial savings possible for particular measures.[133]

128 Scott Taylor, Sense, interview, April 2019.
129 Robin LeBaron, Pearl National Home Certification, interview, May 2019.
130 Taren O'Connor, Connecticut Office of Consumer Counsel, interview, August 2019.
131 Brian Farhi, Google, interview, May 2019.
132 https://www.pge.com/en_US/residential/rate-plans/how-rates-work/find-my-best-rate-plan.page.
133 Gamaliel Lodge, OptiMiser, interview, May 2019.

- **Moving Beyond TOU Rates**
  Experts across the industry have different ideas about which rate structures will be most effective at driving incentives for more optimal energy use. Looking to the future, peak periods will change as new resources, such as renewables, storage, and EVs, are brought onto the grid. Kelly Speakes-Backman, CEO of the Energy Storage Association, says what will ultimately be crucial is "Being aware of where and when you need electricity and incenting in that way, not necessarily a static TOU rate, because peak periods are changing and shifting as well."[134] While TOU rates serve to help even out variations in supply and demand, ultimately TOU rates only matter when there is a large differentiation in the value of a kWh across different times of day or days in the year. Once there is greater flexibility on the grid with GEBs that react to needs and shift load to make the value more level, rate structures can move beyond TOU to dynamic rates that are responsive to the real costs of energy. ConEd's Smart Home Rate, described in the **Section 3** above, may be a model for dynamic rates of the future in which smart home technologies and software platforms automatically optimize according to price signals and help homeowners get the most out of complex, dynamic rates.

- **Innovative Flat Rate Billing: a "Service Plan" for Energy**
  Alternatively, some industry experts believe a flat rate for energy "as a service" will be the most effective pricing model for the grid of the future. While time-varying rates communicate the time value of energy and incentivize peak load reductions, some experts argue they are too complex and that rate structures should move beyond TOU and other models to a simple flat rate bill that reflects the actual cost and benefits that the customer with GEB/DERs is providing to the grid. A "service plan" would charge a flat fee that covers the household's entire monthly electricity consumption and allows the utility to call on the home for grid services. The idea is analogous to cellphone service plans, where customers are billed a flat monthly rate that covers all services rather than being charged by the minute or paying a higher rate for long-distance calling.

  Some experts believe customers would like the idea of zero volatility and not having to engage in active energy management around pricing in any way. Recurve's Ethan Goldman says, "I see two propositions for the customer. Master of all energy, control over everything. Or you are never going to have to think about it again, it's going to be a flat fee, it's always going to be there for you and it just works. Most people are going to go for it just works."[135] A flat-fee service plan could be a much simpler way "to drive alignment and unification of signals and incentives" for GEB solutions, according to Nick Lange, Senior Consultant at VEIC.[136] Under this model customers could use as much power as they need within certain limits in exchange for providing generation, storage, or shifting—allowing the power system to benefit from their DERs.

  New pilots are beginning to test out the idea of flat-fee pricing for power. In Vermont, Green Mountain Power utility recently launched its Resilient Home pilot program where customers can rent battery storage

134 Kelly Speakes-Backman, Energy Storage Association, interview, May 2019.
135 Ethan Goldman, Recurve, interview, April 2019.
136 Nick Lange, VEIC, interview, May 2019.

for $30 per month and then have the option of paying a fixed monthly price for all of their electricity use,[137] while the utility can use the batteries to manage the grid for carbon and cost reductions.[138]

Increased Data Access and Data Granularity

Measuring performance, modeling loads, evaluating programs, increasing grid visibility, and supporting a nimble home-to-grid dynamic all rely on data and data access. Constructing open and secure data pathways between utilities, customers, and authorized third parties will enable and maximize the benefits of GEB solutions. With access to utility data, third parties can run innovative DR programs that engage customers and achieve savings for users and the grid, and they can conduct virtual audits using disaggregated AMI data to assess savings opportunities across a portfolio of homes. As Elena Chrimat, co-owner of Ideal Energy in Arizona, explains, lack of data access creates added costs and inconvenience for services that use homeowner meter data. In order to get one-time access to a customer's energy usage data to model customer load profiles and compare them to the utility TOU rates, Chrimat's home performance contracting company is required to have the homeowner manually sign a form and then send it to someone at the utility for approval and processing.[139] Enabling secure and ongoing data access via a simple online customer verification process would increase opportunities for third parties to help homeowners manage and optimize their energy use cost-effectively.[140]

Data streams from AMI and smart technologies could be used to get information on a home's efficiency or load-shifting performance in real time, making it possible to more quickly evaluate demand-side management programs and make improvements. "With smart home devices and real-time data, we are essentially getting 100x more information at a faster rate, which allows us to significantly reduce the time that it would take to do really strong EM&V analysis on a particular program or tool or pilot," says Kevin Foreman with Powerley. If regulators embrace these technologies and faster M&V 2.0[141] methodologies, the utility industry can move more quickly to find effective ways to deploy energy-saving and load-shifting programs that take advantage of DER technological advancements.[142] More precise data also supports more robust deemed savings estimates for Technical Resource Manuals and better program design. As more is known about the realized savings from certain energy measures, combination of measures, or even types of required contractor training, those findings can better inform prescriptive programs on what measures and program aspects to incent and what energy savings value or load-shifting potential can be attributed.

Furthermore, data and direct feedback from products in a home can improve programs as well as system planning. With this increased data visibility, the key is having a regulatory structure and policy process that enables a nimble

137 Green Mountain Power offers tiered fixed monthly pricing based on a household's level of past energy usage. More information available at: https://greenmountainpower.com/product/powerwall/.

138 https://greenmountainpower.com/news/gmp-pioneers-patent-pending-system/

139 Elena Chrimat, Ideal Energy, interview, August 2019.

140 Mission:data Coalition has published a framework for comprehensive energy data sharing policy, which outlines promoting consistency in data-sharing policies and effectively balancing consumer privacy and security with convenient access, to help customers manage their energy usage and costs. Available at: https://static1.squarespace.com/static/52d5c817e4b062861277ea97/t/5a3a8c66c8302509260492b2/1513786475950/Energy-data-unlocking-innovation-with-smart-policy.pdf.

141 M&V 2.0 refers to automated measurement and verification of energy savings in a home on an ongoing basis using data streams and cloud-based analytics tools.

142 Kevin Foreman, Powerley, interview, July 2019.

response, allowing regulators and utilities to continuously improve policies and programs based on a feedback loop from smart technologies. In addition, technology can use the grid predictability, such as when it will be hot/cold or day/night, and human energy demand as a result to provide flexibility. As a way of more intelligently and cost-effectively meeting the human demands for air conditioning or light, technology can take into account time, location, and reliable projections to shift other consumer uses, such as hot water needs, laundry, etc. during those peak times. Data can be used to more precisely target load mitigation where there are stresses on the grid. Jessica Burdette of the Division of Energy Resources at the Minnesota Department of Commerce says that extreme and prolonged freezing during the polar vortex last winter caused significant stress to the natural gas and electric system resulting in some utilities sending out notices asking customers to turn down their thermostats. "As customer data collection and management gets better and technologies get better at responding to that data we may be at a place where utilities don't have to make an all call and may be able to control devices in a very concerted area."[143]

Use Open Standards to Advance Interoperability and Keep Costs Down

Given the pace of technological advancement for smart homes and DERs, it will be important to build in flexibility. Regulators and policymakers can incentivize interoperability by requiring utilities to adopt open standards for communications and data sharing with minimum standards for appropriate cyber hygiene. Open standards reduce integration costs and create flexibility to ensure technologies are future-proofed and avoid stranding assets—and they can help drive innovation. Common protocols for information sharing will help ensure that residential GEBs can be aggregated and coordinated cost-effectively to provide system benefits.

Utilities and policymakers can also make cross-manufacturer interoperability a requisite for any technology participating in utility programs. That will not only help ensure the cost-effectiveness, flexibility and scalability of GEB solutions, it will also support greater flexibility in the marketplace as consumers do not feel trapped into any given manufacturer's solution. This is similar to how cell phones must accept calls from different manufacturers' cell phones and different gaming machines can play on different television brands. However, there is also the possibility that smart home hubs will align in the same way "universal television remotes" solved the solution of interoperability between DVD and TV channels. Another possibility is that apps will be tailored as they are for Apple and other products.

Data standardization is also key to interoperability and will allow data to be aggregated in a meaningful way. Requiring the use of the national open data standard for residential energy efficiency—Home Performance eXtensible Markup Language (HPXML)—would make data transferring and gathering more seamless for demand-side management programs. HPXML is a set of common definitions for the attributes of the systems in a home, based on the Building Performance Institute's BPI-2100 and BPI-2200 data standards, and a common computing language that creates interoperability between software systems to transfer data across different market actors.[144]

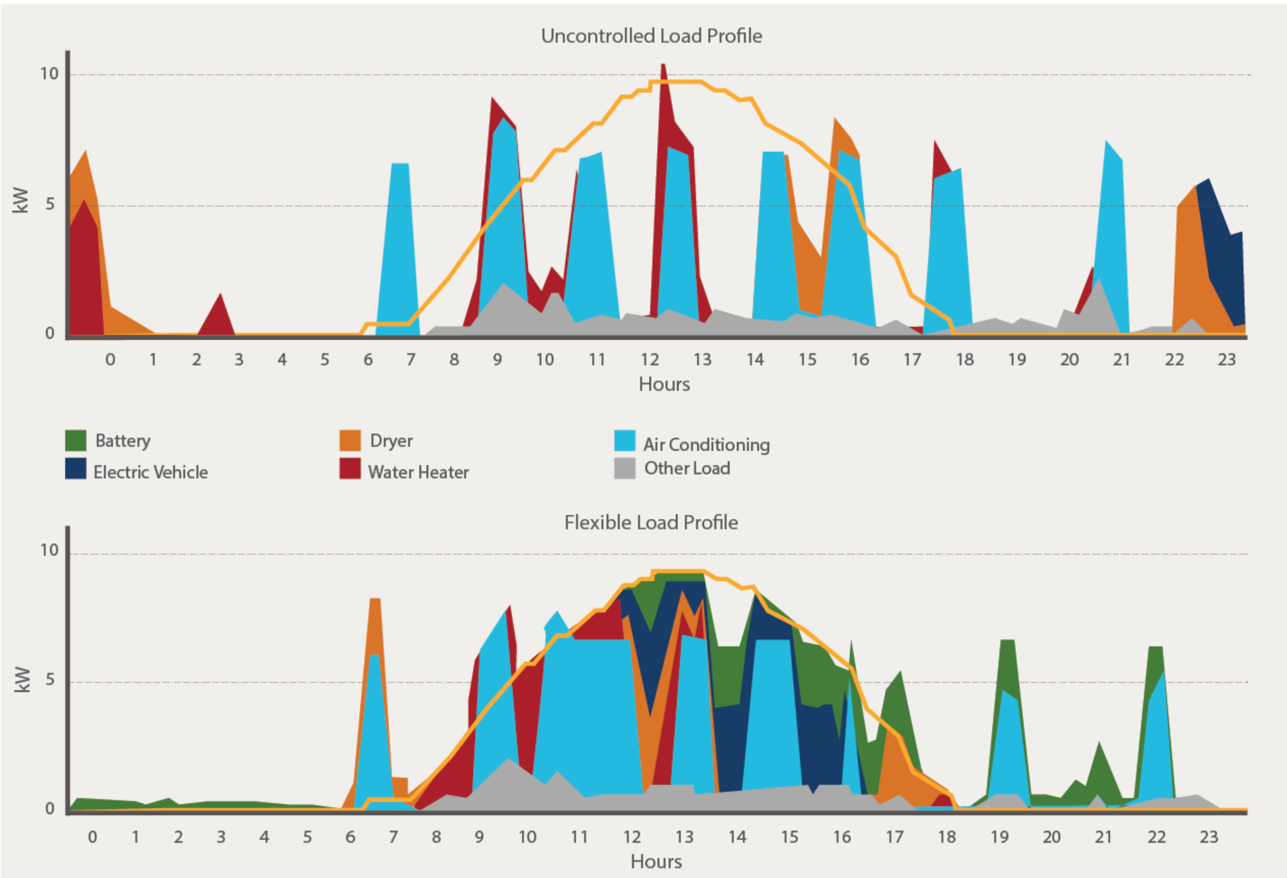
Demand Response/Load Shaping

The integration of GEB strategies in the residential sector creates new expanded opportunities for demand

143 Jessica Burdette, Minnesota Department of Commerce, interview, August 2019.

144 http://www.hpxmlonline.com/.

Figure 4: Impact of demand flexibility on residential load profile (Rocky Mountain Institute)



Source: Cara Goldenberg et. al., Rocky Mountain Institute, "Demand Flexibility: The Key to Enabling a Low-Cost, Low-Carbon Grid", February 2018.

response (DR). When efficiency measures are combined with smart controls, and different technologies are used in coordination, DR can be more effective. For example, a recent PNNL study looked at coupling HVAC control with window shading strategies and found significant incremental savings when energy-efficient cellular shades were coupled with thermostat setbacks.[145] Efficient shades can therefore be coupled with a smart thermostat or other HEMS to make DR programs or other load-shifting or shedding strategies more successful. Katherine Cort, the lead author of the report, explains that in DR programs "you get a quick response from the thermostat setback, but you can enhance savings significantly when you couple it with things that help control that load."[146]

Traditional DR has been used for critical peak reduction, where events are called during peak hours on a limited number of days out of the year. While some of these events require load shifting (as a dishwasher or industrial process is moved to a different time) much of this energy is conserved when air conditioner set points are changed

145 Katherine Cort et al., "Testing the Performance and Dynamic Control of Energy-Efficient Cellular Shades in the PNNL Lab Homes," August 2018, *Pacific Northwest National Laboratory*.

146 Katherine Cort, PNNL, interview, April 2019.

or energy using activities are curtailed.[147] This can be an important utility tool to address peak loads and avoid the need for additional generation on-peak, but it is not a solution to carbon reduction. Current approaches miss key leverage opportunities to look at the entire grid system more holistically, to not only address peaks but also valleys and different grid stresses throughout the year.

Enabled by GEB technologies, residential DR is moving beyond the load control switches that simply shut off an appliance's power when called during DR events and turning to a wider range of connected technologies and software solutions to dynamically call on demand flexibility from homes to provide grid services. While traditional DR has focused on notching out loads on critical peak days, the future of DR is load shaping, where grid-connected devices in the home can increase or decrease energy draw in response to grid needs at a given time through two-way communication with the grid, while intelligent controls help to maintain customer comfort. Smart connected appliances and DERs can receive signals directly or through a centralized HEMS platform and respond automatically to time-varying rates or real-time pricing and adjust load accordingly within a set range of customer preferences. A number of software companies offer platforms that integrate with IoT devices for demand-side management, providing real-time control for utilities and grid operators. In this way, as more homes become GEBs, residential load flexibility can be used not only to address capacity constraints on peak days, but also to reduce grid stress in more granular timeframes and help balance out supply and demand throughout the year. Harnessing residential load flexibility will support a cleaner more reliable grid.

A 2018 Wood Mackenzie Power & Renewables report forecasts 88 GW of total residential flexibility potential in the United States by 2023—more than twice the cumulative potential in 2017— based on projections for increased penetration of smart thermostats, residential solar, EV charging, and residential battery storage.[9] According to the Smart Electric Power Alliance (SEPA) 2018 Utility Demand Response Market Snapshot report, mass market programs (offered to both residential and small business customers) reported a total national enrolled capacity of 6.3 GW in 2017, with AC switch programs accounting for the largest portion of enrolled mass market DR capacity (3.4 GW), followed by thermostat, behavioral, and water heater programs.[10]

9. https://www.greentechmedia.com/articles/read/88-gigawatts-by-2023-u-s-residential-flexibility-on-the-rise#gs.dqekp4
10. Brenda Chew et al., "2018 Utility Demand Response Market Snapshot," September 2018, *Smart Electric Power Alliance.*

Consumer Engagement

Energy user apathy has long been the Achilles heel in advancing energy savings and more optimal energy management. Most homeowners and residents have little understanding about how the energy system and electric grid work, let alone actions they can take in their home to deliver benefits across that system. However, some experts point to customer engagement as a key and attainable piece in the future of reducing energy demand. Smart technologies and intelligent controls offer new opportunities to make energy usage visible to homeowners and to put it in the context of the things they really care about, such as comfort, reliability, and security. For example, a smart energy monitor can alert the homeowner when the oven is left on or an appliance may be malfunctioning in addition to providing insights on how much electricity they are using. Smart home technologies also offer more tailored energy optimization strategies that fit the unique needs and preferences of a household, while advancing

147 For an example of energy savings achieved in residential DR see the 2013 Sacramento Municipal Utility District study on residential precooling strategies with smart thermostats prior to DR events, which found a reduction in overall energy use among homes with higher levels of ceiling insulation. Available at: http://www.herterenergy.com/pdfs/Publications/2013_Herter_SMUD_ResPrecooling.pdf.

Industry Experts Offer Ideas for Educating and Engaging Homeowners

There should be some good video product for contractors to show to homeowners that says here's what GEB is, in layman terms." Jonathan Waterworth, AZ Energy Efficient Home/Southwest Sustainable Structures Inc.: "If you had state officials or DOE-sponsored videos that could be a powerful part of the presentation.
Scott Needham, Princeton Air

Contractors and real estate agents who are on the frontlines interacting with homeowners can be translators and cheerleaders for the different technologies, and help homeowners make informed decisions.
Claire Miziolek, Massachusetts Executive Office of Energy and Environmental Affairs (formerly with Northeast Energy Efficiency Partnerships)

You'll get a lot of kickback from people if they feel like they're being required to throttle their appliances up and down because their utility says so. But if they opt in and have the opportunity to save money, are shown what they're doing and how it's making the grid better and cleaner, then that's a very different thing.
Damian Hodkinson, Halco

I think developing and deploying technologies that make it simple for consumers to 'set it and forget it', and allow for some degree of control and flexibility, will be key to success. Consumers have to understand and experience the tangible value in order to create acceptance and engagement.
Kim Burke, Colorado Energy Office

I think the home performance contractor is best suited to educate homeowners. That's what we do. We're doing that for energy efficiency—envelope and mechanical—and now we're just adding more on top of that. It all starts with the whole sit-down education, this is where you're at, this is what you could do, this is why you should do it.
Jonathan Waterworth, AZ Energy Efficient Home/Southwest Sustainable Structures Inc.

Media can play an important role in making people aware and moving the needle. We're taking our cues from each other and we are reflected in our media. Our media is a reflection and a prognostication of where we're going.... It's possible to respectfully guide and be a part of the conversation.
Beth Karlin, See Change Institute

There is a need not only for a good marketing campaign but also for attractive sales materials for contractors to enable them to talk easily and comfortably about grid-interactive efficient home solutions.
Robin LeBaron, Pearl National Home Certification

Most smart home and energy management systems to date have been more engineering centric and point solution focused. Bot-enabled artificial intelligence (AI) microservices changes the game by learning the patterns of the home and serving as an intuitive digital assistant—saving energy in the background of end users' lives and proactively enabling a conversation with and control of the home via text messaging.
Chris Ebert, People Power

Get people thinking bigger picture. I think most people want to do their part, but you've got to provide an easy path for them.
Dan Thomsen, Building Doctors

Have a dialogue with the customer in a fairly lightweight manner that helps homeowners understand why they should remain in this program, and how these smart technologies are helping them without much effort on their part. I don't think homeowners want to take an active role in this. I think homeowners want to take a minimal approach, but they want to live their worldview.
William Burke, Virtual Peaker

energy savings and grid services. Ultimately, there is a lot of variation among homeowners in terms of interests and the level of control or automation that works best for them, so it is important to have a spectrum available rather than a one-size-fits-all approach. Programs designed in ways that give homeowners flexibility in the extent to which they are engaged – or not engaged – in active decision-making are more manageable for the average homeowner who spends only six minutes per year thinking about their utility bill.[148]

On the active side, behavioral DR programs are focused on engagement and tapping into the psychology of human motivation. OhmConnect, for example, is a third-party software company that enlists California IOU customers to use energy when it is cleanest and save energy when it is dirty through gamification, loss aversion, and cash incentives. Customers who reduce their energy use during a dispatched event earn points, which can be cashed out each month, while increased energy use results in lost points. Loss aversion leads consumers to engage in the program and pay attention to their energy consumption.[149] On the passive side, utilities and third parties are looking to aggregate behind-the-meter resources, such as smart water heaters or EV chargers, for flexibility services in order

148 https://www.greentechmedia.com/articles/read/customers-spend-8-minutes-a-year-interacting-online-with-their-utility.

149 Matt Duesterberg, OhmConnect, "The Importance of Consent: Policy Energy Data Access," presented at Wedgemere "Energy Data Access Policy" webinar, February 14, 2019.

to dispatch them in a way that does not impact the customer or require them to participate actively.

Whether homeowners ultimately play a more active or passive role in energy management and load shaping, across the board, experts agree that as the electric system evolves and new opportunities emerge for the residential sector, it is increasingly important to figure out how to engage and support homeowners and have an informed and trained workforce who can communicate the value of these technologies.

From a regulatory perspective, the focus should be on creating structures that enable creative solutions—carrots and sticks, and information, are not enough. According to Beth Karlin of See Change Institute, our core social motive is love and belonging and a good program will get at that in some subtle way to motivate people and influence behavior.[150] Companies have utilized these motivations to sell products for years. Now we need to sell energy savings in a similar manner. In the same way that a parent may spend $100 on 10 pizzas they don't really want because it will provide 10 percent to a school fundraiser or adults at a sporting event rush to catch tee shirts that they may never wear, energy programs can tap into human motivations to win and be a part of something bigger than themselves. The challenge is to find the motivation that drives the divergent demographics that make up our energy consuming society and motivate the same reaction: reduced energy consumption and willingness to provide grid services for the greater good.

P4P: State Examples

In 2015 the California state legislature passed SB 350 which mandated the PUC to authorize P4P programs that link incentives directly to measured energy savings[11] as well as AB 802 which required the PUC to use "the overall reduction in normalized metered energy consumption as a measure of energy savings."[12] An Oregon 2017 Executive Order directed the SEO and PUC to expand meter-based savings programs, including P4P programs, for energy efficiency. Energy Trust of Oregon is currently developing a residential P4P program that will deliver weatherization, HVAC measures, and deep energy retrofits through different aggregators. The program is anticipated to launch in 2019 and span three years.[13]

11. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350.
12. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB802.
13. https://www.oregon.gov/energy/Get-Involved/Documents/2018-BEEWG-Directive-5A-Summary.pdf.

Pay for Performance (P4P)/Measured Savings Model

Pay for performance (P4P) is a measured savings model through which incentives are given based on realized energy savings, rather than upfront payments for deemed savings attributed to a particular technology or measure. P4P can take a range of different forms—including different design features, administrators, and payment structures—but it generally entails shifting risk to a third-party service provider or aggregator whose payment depends on actual performance (i.e., measured and verifiable energy savings). This shift brings market forces to bear to discover the best solutions that deliver persistent savings. Vendors that can deliver the most energy savings with their technology, reward system, or other approach for the least cost will provide the least expensive kWh of savings.

In a P4P model, the utility doesn't look at specific measures or estimate the savings of these measures to address their demand reduction needs; the onus is on third-party program managers

150 Beth Karlin, See Change Institute, interview, May 2019.

to demonstrate with data that the savings were achieved. This model offers important flexibility to target different homes with unique approaches while ensuring accountability. To date, there are few active residential P4P programs, so the models are evolving. P4P models have largely focused on kWh saved but they could also incent based on time-based and locational savings. California utility PG&E has taken this approach with a recent request for third-party programs that serve a grid resource function and integrate EE with DR to provide savings that align with grid needs. In its November 2018 Request for Abstracts (RFA) for Third-Party Energy Efficiency Programs, PG&E requested "program designs that can target the right customers with the right measures at the right time and the right location. This entails having [third-party] program designs that are informed by data that reflects the needs of the grid which varies by the time of day, the time of year, and geographic location on the grid."[151]

> *"What Pay for Performance does is it brings accountability, and accountability means you look at the things that actually work, so the system will get more efficient."*
>
> *- Damian Hodkinson, Halco* [152]

While P4P is still being tested, new software abilities and data access mean the potential is enormous. The model offers an opportunity for incentivizing solutions delivered where and when they are needed most to support the grid of the future. Because P4P is technology-agnostic and based on outcomes rather than prescriptive measures, the paradigm could encourage GEBs' use of multi-measure approaches (different technologies and solutions) that work together to make homes a real grid resource that can flexibly provide supply and demand to the grid to reduce peaks and valleys.

Building Codes: State Example

California's newly updated 2019 Building Energy Efficiency Standards (Title 24, part 6) for residential buildings—which go into effect January 2020— include demand response compliance options, encouraging battery storage and heat pump water heaters.[14] The code also requires OpenADR for demand responsive controls and sets OpenADR 2.0 as the default communications protocol.[15]

14. https://www.energy.ca.gov/title24/2019standards/documents/2018_Title_24_2019_Residential_Standards.pdf.
15. https://www.energy.ca.gov/2018publications/CEC-400-2018-020/CEC-400-2018-020-CMF.pdf.

Building Codes and Zoning Regulations

Building codes present an opportunity to set standards for GEB solutions in the residential sector and to require that new construction be equipped with enabling infrastructure. (Examples of enabling infrastructure are measures such as pre-wiring for high-efficiency automated window shades or establishing electrical capacity so homes are EV-ready.) According to Emily Kemper of CLEAResult, "One of the single biggest things we can do to increase efficiency [in new homes] is by changing code," and in order to advance residential GEBs we "should start talking about how we incorporate the mechanisms of smart home ecosystems into code."[153]

151 https://www.pge.com/pge_global/common/pdfs/for-our-business-partners/energy-efficiency-solicitations/RFA_General_Instructions.pdf.
152 Damian Hodkinson, Halco, interview, August 2019.
153 Emily Kemper, CLEAResult, interview, May 2019.

As jurisdictions look to advance the penetration of GEB solutions in homes, building codes could be used to establish a minimum set of standards for grid-interactivity and smart energy management for all new construction. Outcome-based codes are another possible model, through which standards could be set for the required efficiency and flexibility of homes. The ability for homes to talk to the grid could allow such outcome-based codes to be pursued.[154] At the very least, smart home ecosystems and GEB-enabling infrastructure could be incorporated into stretch codes as a framework for how homes can become GEBs.

Policymakers could also include incentives for residential GEBs in zoning regulation. For example, ordinances could be created to allow a density bonus for an energy efficient building that has other DERs and can provide load flexibility. Including GEB criteria in zoning processes could encourage new construction to meet these standards in the areas where it would be most beneficial to the grid.

Residential Energy Labeling and Product Standards

Standards and labeling can serve as a goal post for GEB solutions in the residential space. Labels that certify homes and products that meet specified GEB criteria would help to communicate the value to consumers and promote greater investment in these technologies and services.

Home energy labeling is a way to provide recognition of energy efficiency, smart home technology, and DERs implemented within a home. By making those assets visible, in real estate transactions for example, labeling can help to establish a market value for residential GEBs and boost the return on investment for homeowners. While rating systems to date have primarily focused on energy efficiency, they could be expanded to recognize a home's potential to provide other grid services, including recognition of DERs and technologies that deliver load flexibility. For example, the Residential Energy Services Network (RESNET) is currently investigating how they might incorporate a determination of load flexibility into their Home Energy Rating System (HERS) Index Scores.[155]

The use of home energy labels or certifications provides energy performance information for both new and existing homes to ensure that the value of a high-performing grid-interactive home is apparent to consumers—and across the market to realtors, appraisers, and lenders. Home energy labeling could be integrated into residential utility programs to help consumers understand the value of energy efficiency combined with other GEB measures and provide them specific recommendations for how to improve their home's energy assets. Policymakers could also implement transparency laws requiring a home energy label or rating to be provided at time of sale.

Policymakers can also promote product labeling and energy standards that identify grid-interactive functionality for home appliances and systems. The U.S. Environmental Protection Agency (EPA) ENERGY STAR Program has optional connected criteria to identify products that provide grid services, energy reporting and consumer benefits through their connected functionality. While not required for earning an ENERGY STAR label, these optional criteria help to highlight products with grid-interactive efficient features. EPA is also currently developing additional

154 Jennifer Amann, ACEEE, interview, May 2019.

155 https://www.resnet.us/articles/new-working-group-on-when-energy-is-used-load-flexibility-into-hers-scores/.

optional connected criteria for large loads including water heaters, central AC and air source heat pumps, and electric vehicle supply equipment.[156]

Labeling would increase the visibility and consumer awareness of these often invisible and undervalued energy resources, helping to advance greater investment in residential energy efficiency, load flexibility, and making more homes GEBs.

Energy Policy Goals

Advancing residential GEBs can be part of larger strategy to create a cleaner, more reliable, efficient and affordable power system. GEBs can provide grid services to enhance resiliency and support grid modernization, while creating cost savings for ratepayers and supporting progress towards emissions reductions and energy policy goals.

- **Energy Efficiency Resource Standard**
  Energy Efficiency Resource Standards (EERS) set energy savings targets that must be achieved through efficiency measures. Efficiency is a foundational part of GEBs and investment in these resources will help support energy savings goals. A loading order can also be established such that cost-effective investment in energy efficiency is prioritized before investment in renewable generation as the California PUC has done. Increased efficiency reduces overall energy demand, supporting grid reliability and emissions reductions, and also helping to make renewable targets more achievable.

- **Renewable Portfolio Standard**
  A renewable portfolio standard (RPS) sets targets for the percentage of electricity generation that must come from renewable power, accelerating the transition to a cleaner, decarbonized grid. Given the variability of renewable generation, greater renewable penetration will drive increased need to actively manage demand. GEBs increase the value proposition of renewable energy installations, and vice versa. "GEBs are more important as we give up control of supply side and now we need to control demand instead," says Ethan Goldman.[157] As the sun does not always shine and the wind does not always blow, in order to meet ambitious RPS targets, a dynamic grid is needed through which demand can be shaped to absorb excess generation when there is ample solar or wind, and load shifting and storage can kick in to compensate when supply is lower. Wider deployment of GEB solutions across the residential sector will take better advantage of renewable resources through efficiency and demand flexibility, lower overall demand so less renewable generation is needed, and reduce the need for fossil fuel peaking plants—all of which will help to meet RPS requirements.

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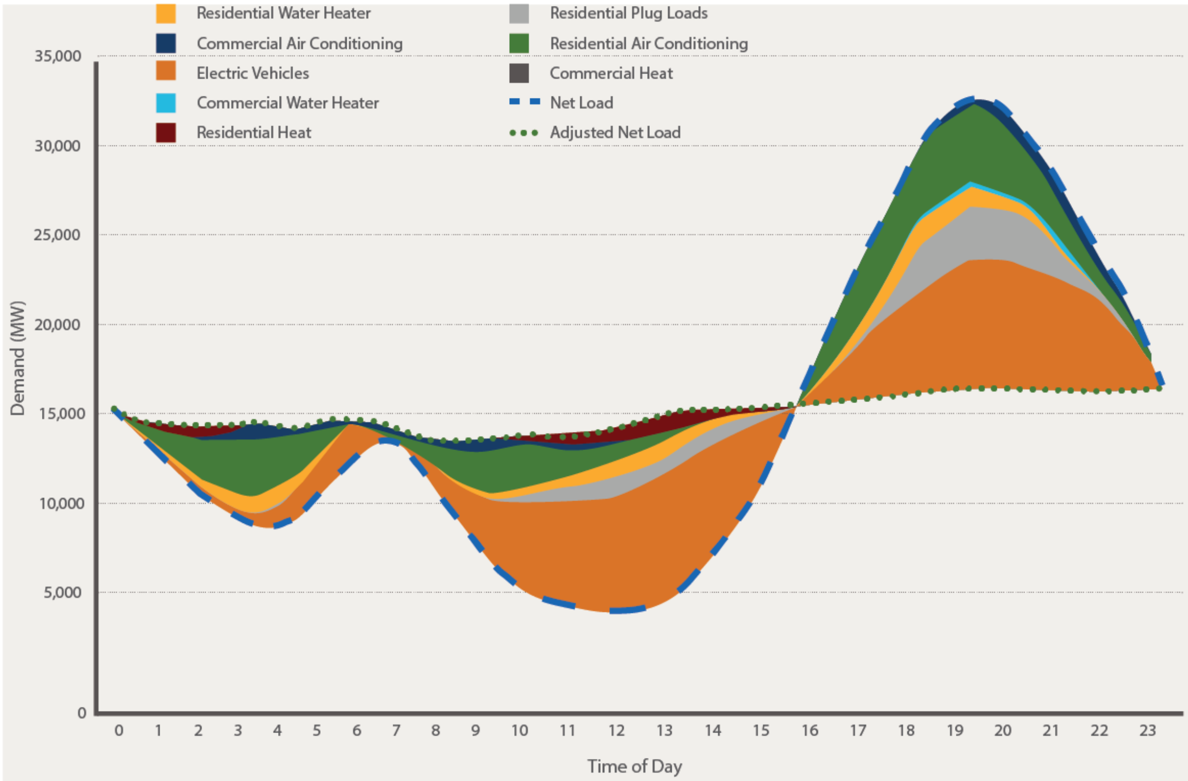
156 ENERGY STAR Program, "Connected Criteria for Large Load Products: Discussion Guide," February 2019, *U.S. Environmental Protection Agency*. Available at: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Connected%20Criteria%20for%20Large%20Load%20Products%20Discussion%20Guide.pdf.

157 Ethan Goldman, Recurve, interview, April 2019.

Figure 5: Net load and changes from demand flexibility for an average day (Rocky Mountain Institute)



Source: Cara Goldenberg et. al., Rocky Mountain Institute, "Demand Flexibility: The Key to Enabling a Low-Cost, Low-Carbon Grid", February 2018.

This graphic shows how residential loads, and EVs in particular, can have a significant impact on flattening out the net load "duck curve" to support renewable energy integration and RPS goals.

- **Clean Peak Standard**
  A Clean Peak Standard (CPS) is similar to and complements an RPS, requiring that a certain amount of power supply during peak periods come from clean resources. This reduces the need for less efficient and often more polluting power plants that are currently used to meet peak demand. Residential GEBs can be a crucial part of that clean resource portfolio by providing load flexibility to reduce demand on peak and storing intermittent renewable energy for use during peak periods.

  Implementing a CPS is a way to monetize the benefits of residential energy savings and load flexibility that occur on peak, so these monetary benefits flow back to the consumer or developer.[158] It is a performance-based standard that provides direct incentives for measures that generate, dispatch or discharge clean electricity to the distribution system during seasonal peak periods, including measures that actively reduce

158 Joanna Troy, Massachusetts Department of Energy Resources, interview, August 2019.

peak demand. In this way, a CPS is one mechanism for valuing GEBs and the benefits they provide.

Given that residential buildings are significant contributors to peak demand, an important opportunity exists to target the sector for energy reductions and load shifting to meet clean peak goals.

Clean Peak Standards: State Examples

Massachusetts passed a Clean Peak Standard last year which will go into effect in 2020. By law, utilities will have to increase purchases of clean peak resources—which include demand response resources, energy storage systems, and renewables—by at least 0.25 percent per year. The CPS is still under development, but the final regulations enacted by the Massachusetts Department of Energy Resources will require electric distribution companies to achieve a certain amount of clean peak savings. Clean Peak Energy Certificates (CPECs) will be issued to new renewables, existing renewables paired with new energy storage, new storage charged primarily from renewables and demand response resources.[16] Arizona, California, and North Carolina are considering Clean Peak Standards.[17]

16. https://www.mass.gov/files/documents/2019/08/07/Draft%20CPS%20Reg%20Summary%20Presentation%208.6.pdf.
17. https://www.utilitydive.com/news/deploying-more-renewables-now-through-an-energy-storage-centric-clean-peak/5497.

Ensuring Equity: Barriers and Opportunities for Low-Income Households

Equity is an important consideration when designing policies and programs to advance residential GEBs. As we look to homes to meet grid needs and access new benefits, ensuring that households of every income level have access to these solutions is important. Low-income households already pay a disproportionate amount of their income on energy bills,[159] and thus stand to benefit significantly from new GEB solutions' cost savings opportunities, if they can gain equitable access. Indeed, as GEBs provide system benefits, increasing grid efficiency and reducing infrastructure costs, those cost savings will help everyone. However, low-income households are least likely to have smart energy technologies in their homes, according to consumer survey data from Parks Associates.[160] Policies that advance the market for residential GEBs will also help to bring down the costs of these technologies and make them more accessible, but they cannot be relied upon for achieving equitable access alone. To ensure equity for lower income households, programs and policies should be thoughtful about addressing unique challenges and target these communities with appropriate outreach and incentives:

- **Wi-Fi access.** Lack of Wi-Fi may be an initial barrier standing in the way of low-income households in some communities taking advantage of smart energy management systems. William Burke, CEO of Virtual Peaker, says that he does hear that pushback from rural and low-income serving utilities in conversations about deploying smart home technologies.[161] However, it is important to note that the low-income population is

159 Ariel Drehobl and Lauren Ross, "Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities," April 2016, *ACEEE*.

160 Lindsay Gafford, "Smart Home: Bringing Energy Efficiency to Low-Income Households," April 17, 2019, *Parks Associates*. Available at: http://www.parksassociates.com/blog/article/smart-home--bringing-energy-efficiency-to-low-income-households.

161 William Burke, Virtual Peaker, interview, June 2019.

diverse across geographies and demographics and in some places Wi-Fi penetration rates may be higher than people assume.[162]

- **Upfront costs.** The high upfront costs of different GEB solutions can be prohibitive for low-income households, regardless of the potential payback over time. Programs could address that barrier by offering higher incentives to eligible customers or providing enabling technologies for free in exchange for participation. Con Edison, for example, has a Smart AC program that provides smart plugs to customers for free to make their window AC unit smart as long as they participate in at least one demand response event during peak summer periods.[163] On-bill financing is another strategy that could help more households overcome the high upfront costs to gain the benefits of GEB technologies.

- **Limited flexibility.** Low-income families and other vulnerable ratepayers may not have the flexibility or resources to shift their energy use, so it is important to focus on ways to prevent TOU rates from punishing those customers. Otherwise, there is a risk that these rate structures will be regressive and increase energy costs for families who can least afford it. In order to ensure that low-income families are not punished by the changing energy paradigm, and they are able to access new opportunities for energy cost savings and other benefits, there needs to be proactive support for low-income households to have access to smart energy management technologies, and relevant energy efficiency and health-related home upgrades.

- **Integrating GEB technologies with Weatherization Programs.** Weatherization and low-income programs support access to energy efficiency, but these programs should expand to include smart technologies and other new and innovative measures, so low-income homes can be a part of the shift to greater demand flexibility and integration with the grid. The linking of funds for weatherization measures, home health upgrades and GEB technologies would help to reach more low-income households. Weatherization programs could also be combined with research studies to provide technologies for free to low-income households in exchange for anonymized data-sharing. The data could then be used to track measures and better understand how these technologies are working across varied contexts—a win-win.

- **Addressing other hurdles.** Specific barriers for low-income households may vary across different localities and different demographics. Therefore, it is important to understand the unique concerns and needs of a community. For example, Con Edison market research has shown that their lower income customers value the immediacy of upfront payments from demand response program enrollment and participation. Zach Sussman, Con Edison's Senior Specialist of Energy Efficiency and Demand Management, notes, "For lower income customers, the $5 for participating in a demand response event can go much further."[164] Recognizing that some lower income households do not have access to a credit card, Con Edison has allowed customers eligible for Supplemental Nutrition Assistance Program (SNAP) benefits to enroll in their residential Smart

162 Google did a study on a Nest Learning Thermostat pilot with the low-income weatherization program in Colorado and found that 81 percent of the homes had Wi-Fi, a much higher rate than what was predicted.

163 https://www.coned.com/en/save-money/energy-saving-programs/smart-air-conditioners.

164 Zach Sussman, Con Edison, interview, April 2019.

AC demand response program without putting a credit card on file, and the utility advertises programs directly to users of a SNAP benefits tracking app ("FreshEBT" by Propel).

GEB Measures in Low-Income Programs: Utility Examples

Arizona Public Service (APS) is piloting a program to deploy thermal load shifting in low-income housing. The utility is wrapping concrete block low-income housing in continuous insulation so that the concrete becomes part of the building's thermal mass. Then they can precool the house ahead of the peak period and let the home's temperature float through that time. OptiMiser, an energy auditing software provider that works with APS, is developing its software to be able to model how inside temperature floats during the hottest days and what measures will enable a home to maintain comfort through a peak period without activating the cooling system.[18]

In Connecticut, United Illuminating conducted a low-income HPWH pilot combined with demand response. The 2018 pilot offered free Wi-Fi-connected HPWHs to income-eligible customers and gave them the opportunity to enroll in the utility's demand response program. Through the pilot, 65 HPWHs were installed in homes and 90 percent signed up for demand response. The utility is now working to make it a permanent part of its Home Energy Solutions–Income Eligible (HES-IE) program.[19]

18. Gamaliel Lodge, OptiMiser, interview, May 2019.
19. https://aceee.org/sites/default/files/pdf/conferences/hwf/2019/7d-rodrigues.pdf.

05. Recommendations for Policymakers

This paper has outlined a number of challenges and opportunities to the expansion of Grid-Interactive Efficient Buildings while highlighting the important use cases and reasons to promote GEBs. Policymakers looking to advance energy efficiency and increase the intelligent and communicating capacity of residential buildings may act to:

1. **Break down the silos between renewable energy, energy efficiency, and DERs**
    a. Advance policies that drive Integrated Demand Side Management (IDSM) to bring together residential EE, DR, and other DERs.
    b. Establish energy policy goals and minimum standards for reduced fossil energy use (RPS, CPS, EERS) while ensuring that any goals or requirements for renewables include residential energy efficiency, storage, and technology incentives.

2. **Ensure proper valuation of residential DERs (including energy efficiency)**
    a. Update cost-effectiveness tests to ensure that all costs and corresponding benefits (including non-energy) are included, taking into consideration state policy goals.
    b. Require the use of planning models that include residential DERs as a core resource and appropriately capture their value.

3. **Incentivize residential energy efficiency and load flexibility**
    a. Provide residential energy customers with advanced rate structures to establish a price signal that encourages a shift of energy use from peak to off-peak.
    b. Modernize utility incentive structures to remove disincentives and better align utility financial interests.

4. **Engage the public and design policies that work for everyone**
    a. Provide residential education about the technology options that make flexibility under advanced rate structures possible.
    b. Ensure all demographics have access to residential GEB technology solutions by considering the impacts of new policies and programs on low-income populations.
    c. Encourage and enable customer engagement and participation by providing market flexibility and information campaigns using all forms of media.
    d. Ensure the ability of residential energy users to assign a third party access to their utility data.

5. **Establish necessary infrastructure to pave the way to a grid-interactive efficient future**
    a. Complete AMI penetration across the country enabling a national infrastructure for grid-interactive energy optimization.
    b. Promote interoperability by requiring open standards for communication protocols and data sharing amongst manufacturers.
    c. Include smart technology in residential energy stretch codes for efficiency.

06. Research and Development Needs

The opportunities energy efficiency and smart technologies present are significant and must be recognized and emphasized as options to enhance grid performance, but unknowns remain. Further research is needed in the following areas:

1. **Develop and Promote Standards for Residential GEB Technologies**
    - Standards for connected capabilities and grid-interactive functionality for appliances.
    - Standards for interoperability and communications protocols for residential IoT and connected controls.
    - Understand how GEB technologies fit into new building code qualifications.

2. **Identify Security Risks and Best Practices**
    - Investigate specific cybersecurity risks for residential IoT in the energy space.
    - Formulate security protocol best practices to ensure the ability of energy users to assign a third party access to their utility data.

3. **Conduct Behavioral Science Research and Usability Studies**
    - Behavioral science research to define and remove barriers to residential end-user adoption of individual smart home technologies and comprehensive smart home retrofits.
    - User engagement and usability studies with smart home and grid-interactive technologies, addressing differences across geographies and demographics.

4. **Advance Workforce Education**
    - Develop curriculum for training home performance contractors to advance smart technology within home performance retrofits.

5. **Develop Strategies to Maximize GEB Potential of Homes**
    - Assess the potential of different retrofit measures to increase energy efficiency, grid interactivity, and demand flexibility in existing homes—including bundles of measures that can be implemented using a staged retrofit approach.
    - Develop energy optimization strategies across different technologies within homes and interactions at scale across residential DERs.
    - Utilize EM&V 2.0 strategies to use home energy monitoring in lieu of traditional EM&V to streamline program administrative efficiencies.
    - Physical and regulatory research pilots that determine the best way to maximize smart technologies' benefits to low-income homes.

6. **Quantify the Value of Residential GEBs and Benefits**
    - Advanced performance measurement to quantify the value of a house as a resource on the grid.
    - New methods and tools for valuing the hard-to-quantify benefits residential GEBs provide, including energy resiliency and non-energy benefits.

07. Conclusion

The energy grid is changing, and utility policies must change to manage this more diverse and flexible grid. Rather than fighting for control of energy, utilities and policymakers can embrace the new dynamic and find ways to allow the innovation to work for them. GEB technologies have a key role in helping address the challenges that arise from a changing grid. As this paper has illustrated from thoughtful stakeholders to pilot projects, we need to break down the silos between energy efficiency, renewable energy and DERs, and encourage policy and program innovation to deploy technology in mutually supportive ways, when and where it is needed most.

While policymakers and stakeholders seeking to increase "clean energy" look to renewable energy integration into the grid, energy efficiency as a solution is too often overlooked. The opportunities presented by energy efficiency, and dynamic efficiency with grid-enabled technologies, are significant and must be recognized and emphasized as options to enhance grid performance. The key to deploying energy efficiency as a grid-stabilizing and capacity resource is to make it smarter—to enable better coordination across DERs and co-optimize energy performance for the occupant and the grid. Through improved holistic building performance—where energy efficiency measures are combined with load flexibility, intelligent connected controls, storage and even generation resources—homes can become grid assets that enhance reliability and resilience and deliver carbon reductions.

The interdependence and the appropriate valuation of energy efficiency, load management, storage and renewable energy – together as combined resources – is important to allowing residential buildings to play a new role that includes flexible load and electricity generation to an enhanced grid infrastructure. As homes and cars create, use, and store energy, they are an integral part of the grid. Traditional utility policies look to address the system between the meter and the utility and miss an opportunity. Looking at the building itself as a part of the system will improve energy, environmental, and health outcomes for all. GEB technologies have the potential to deliver more reliable energy services at lower costs, make homes more comfortable, and allow residents to exercise better control over how and when they use energy and at what price points are comfortable for them and their families. Without supportive policies that allow appropriate valuation and flexibility, many of these efficiency resources will remain untapped, and installations of smart features will be disjointed from the value they could provide. As this paper aims to demonstrate, policymakers have many options before them including policies that will advance energy efficiency and storage implementation and increase the intelligent and communicating capacity of homes and buildings. Plans for interoperability, incentives, and maximizing data use is critical for tapping this great energy resource. By applying intelligent technology to the electricity system, residential grid-interactive efficient buildings may help drive the country toward a clean, resilient, grid-stable future.