Electricity Markets & Policy
Energy Analysis & Environmental Impacts Division
Lawrence Berkeley National Laboratory

If One GEB is Good, a Community of GEBs is Better

David Nemtzow, U.S. Department of Energy
Cindy Regnier, Kristina LaCommare, Natalie Mims Frick, Jason MacDonald, Lawrence Berkeley National Laboratory

August 2022

2022 ACEEE Summer Study on Energy Efficiency in Buildings proceedings printed with permission.

The U.S. Department of Energy’s Energy Efficiency and Renewable Energy's Building Technologies Office, supported this work under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

If One GEB is Good, a Community of GEBs is Better

David Nemtzow, U.S. Department of Energy
Cindy Regnier, Kristina LaCommare, Natalie Mims Frick, Jason MacDonald, Lawrence Berkeley National Laboratory

ABSTRACT

Energy efficient, connected, grid-interactive, smart and flexible buildings are key to decarbonization, lowering energy use and improving the nation's electricity grid. The U.S. Department of Energy's *Connected Communities* initiative works to demonstrate how coordinated groups of highly efficient buildings combined with other distributed energy resources (DERs), such as electric vehicle (EV) charging, batteries, storage, demand response and photovoltaic (PV) generation can reliably and cost-effectively serve as grid assets by strategically deploying efficiency and demand flexibility while reducing carbon emissions. In 2021, DOE competitively awarded $61 million to a diverse portfolio of 10 pilot projects to promote grid-interactive efficient buildings (GEBs) working together to reliably and cost-effectively serve as grid assets while decarbonizing. Two of the main tenets of the program are measuring the communities' energy and carbon performance and understanding how to replicate project successes in other communities.

This paper begins with a discussion of what Connected Communities are (including a brief history) and their many benefits, including reduced carbon emissions and increased building efficiency and demand flexibility. Next, it provides an overview of the 10 projects, highlighting the diversity of approaches to measure success and replicate the projects: geographic locations; building types; utility, regulatory, market environments; and building vintages that will be used to test the ability of buildings to serve as grid resources. It concludes with a discussion of anticipated project impacts and the metrics that will be used to evaluate the Connected Communities projects.

What is a Connected Community?

A Connected Community is "a group of grid-interactive efficient buildings (GEBs) with diverse, flexible end use equipment and other distributed energy resources (DERs) that collectively work to maximize building, community, and grid efficiency" (DOE 2022a, DOE 2022b, 2022c). The objective of the demonstration project is to show that groups of high efficiency buildings with DERs can cost-effectively provide grid services and reduce carbon emissions. Figure 1 below provides a graphical illustration of the characteristics of a Connected Community (LBNL 2022).

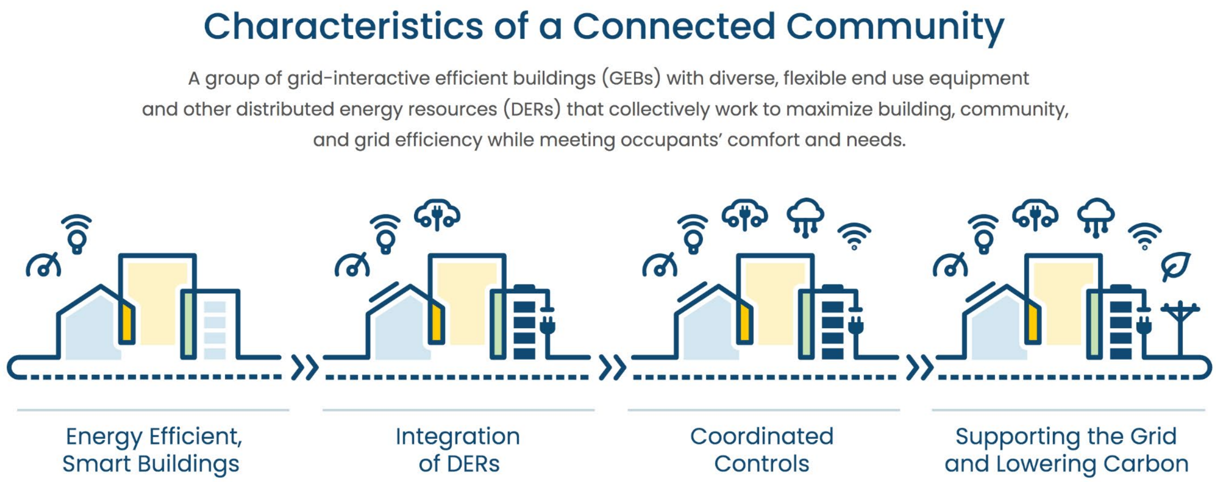

Figure 1. Characteristics of a Connected Community

Connected Community Benefits

Connected Communities offer a plethora of potential benefits, listed below.

- Reduce carbon emissions—Recent research by Berkeley Lab and DOE found that efficiency and demand flexibility in GEBs have the potential to reduce national carbon dioxide emissions by approximately 80 million tons, or about 6% of total power sector emissions, by 2030 (Satchwell et al. 2020). Greater emissions reductions can occur when additional DERs such as PV, EVs and batteries are included in GEBs and Connected Communities.
- Reduce peak demand and electricity consumption—In the same study, Berkeley Lab and DOE found that efficiency and demand flexibility in GEBs can reduce peak demand by up to 43.5 GW and save 622 TWh of electricity by 2030 (Satchwell et al. 2020). Inclusion of resources that provide flexible storage in GEBs and Connected Communities can provide even greater peak demand savings.
- Shedding or shifting energy use—Connected Communities can optimize across buildings to decrease consumption by curtailing electricity use from end-uses such as lighting or cooling, or time-shift consumption by increasing the power draw from the grid to store electricity generated on-site for later use.
- Improved integration of new (especially variable) resources and loads—Connected Communities deploying demand flexibility in conjunction with other DERs can aid in integrating higher levels of renewable energy generation, and better integrate EVs and other new electric loads, by contributing to grid services needed for these purposes.
- Increased affordability— By cost-effectively reducing energy use and peak demand, and participating in utility programs and regional electricity markets for a broad range of grid services, Connected Communities can help keep down electricity costs for residential and commercial consumers (SEE Action 2020).
- Reliability and resilience—Reducing aggregate peak demand by adjusting buildings'/communities' load profile across different timescales, makes the electricity system less vulnerable to stress-related outages. Reducing generation, transmission and distribution capacity needed for recovery from disruptions improves system resilience.

Distributed generation, storage, and microgrids also may be able to provide critical electricity services for buildings during outages. In addition, energy-efficient buildings can maintain habitable conditions for residents for longer periods and help preserve commercial operations (SEE Action 2020).

- Reduce costs (beyond energy cost reductions)—A Connected Community, in addition to coordinating diverse, flexible building loads, can potentially share infrastructure and energy assets to achieve economies of scale, improve system efficiency, reduce operations, and maintenance and capital costs (LBNL 2022, DOE 2022c).

Connected Communities were in large part inspired by two earlier "Smart Neighborhoods", one in Hoover, AL and one in Atlanta, GA, which were developed by the Southern Company in partnership with DOE, Oak Ridge National Laboratory (ORNL), and home builders, manufacturers and others. The Hoover Smart Neighborhood used a very broad array of grid-interactive efficient, renewable, storage, microgrid and related DER technologies in 62 newly constructed single-family homes; based on data from the first year of habitation, ORNL determined that these homes on average used 44% fewer kiloWatthours than would a comparable (but not "smart") all-electric home, resulting in 7,167 kWh and $931 annual savings per home on an equivalent sq. ft. basis. The Atlanta one used several similar (but more limited) technologies in 46 newly constructed town homes; based on data from the first year of habitation, ORNL determined that these town homes on average purchased 42% fewer kWh than would have a comparable (but not "smart") all-electric home, and 30%(winter) - 62% (summer) lower maximum hourly kW demand than baseline. (Southern Company 2019, Nemtzow 2021, DOE 2018)

Connected Communities Pilot Projects and Impacts

DOE awarded 10 demonstration pilot projects under the Connected Communities Funding Opportunity Announcement (DOE, 2020). These projects represent a diverse set of buildings (across building type, vintage, cost environment, utility/regulatory environment, etc.) group of buildings that will reliably and cost-effectively serve as grid assets by strategically deploying efficiency and demand flexibility in concert with distributed energy resources (DERs). Table 1 provides an overview of these pilot projects.

Table 1. Connected Communities Pilot Projects

Project Lead	Location	Building Types	New or Retrofit	DERs and/or DF
Post Road Foundation	1 CC in rural NH and 2 CCs in ME (e.g., Holton, Madison)	New Hampshire: 250 Single family homes, 5-10 Commercial Maine: each with 100 single family homes, 50 Commercial, 5 Industrial	Retrofit	DERs: BSS, PV, EVCI DF: BSS, HVAC

Project Lead	Location	Building Types	New or Retrofit	DERs and/or DF
IBACOS, Inc.	Raleigh, NC	Residential: 500 new and 500 existing, mix of single family and multi-family, and mix of owner occupied and rental, variety of vintages and efficiency levels	New and retrofit	DERs: BSS, EVCI, PV DF: smart grid-connected WHs, thermostats, PV, ASHPs, smart off-peak ventilation systems
SunPower Corporation	Menifee, CA	2 Residential communities with ~120 single family homes each	New	DERs: PV, CES, RESU, EVCI DF: HVAC, WH, EVs, smart appliances
Ohio State University	Columbus, OH	20 university buildings	Retrofit	DERs: BSS, PV, EV, CHP, wind DF: HVAC, lighting, duct static pressure reset, plug loads
Open Market ESCO LLC	MA	Up to 20 apartment communities representing >2,000 homes.	Retrofit	DERs: PV, BSS, EVCI DF: smart thermostats, smart, connected appliances, plug-load controls
Portland General Electric	Portland, OR	500 single family homes, 40 multi-family residential buildings, 40 small commercial, and 1 large business	Retrofit	DERs: BSS, EVCI, PV DF: grid-connected smart appliances (HVAC, WH)
Slipstream Group, Inc.	Madison, WI	15 existing city facilities. Primarily office buildings, public assembly, or maintenance facilities	Retrofit	DERs: BSS, EVCI, PV DF: TBD

Project Lead	Location	Building Types	New or Retrofit	DERs and/or DF
Edo Energy	Spokane, WA	50-75 existing residential and 25-50 existing commercial buildings	Retrofit	DERs: BSS, EVCI, PV DF: PV, HVAC, HPWH, smart thermostats, smart lighting
Pacificorp	Salt Lake City, UT	700 multi-family homes, commercial buildings, industrial building, EV bus depot, and EV test track	New and retrofit	DERs: BSS, EVCI, PV DF: HVAC, HPWH, adaptive lighting
Electric Power Research Institute	Seattle, WA; New York City, NY	600+ new and existing multi-family homes	New and retrofit	DERs: BSS, EVCI, PV DF: Heat pumps, HPWHs

ASHP=air source heat pump; CC = Connected Community; BSS = battery storage system; CES = community energy storage; EVCI = electric vehicle charging infrastructure; DF = demand flexibility; HPWH = heat pump water heaters; PV=solar photovoltaic; RESU = residential energy storage unit; WH = water heaters; TBD = to be determined

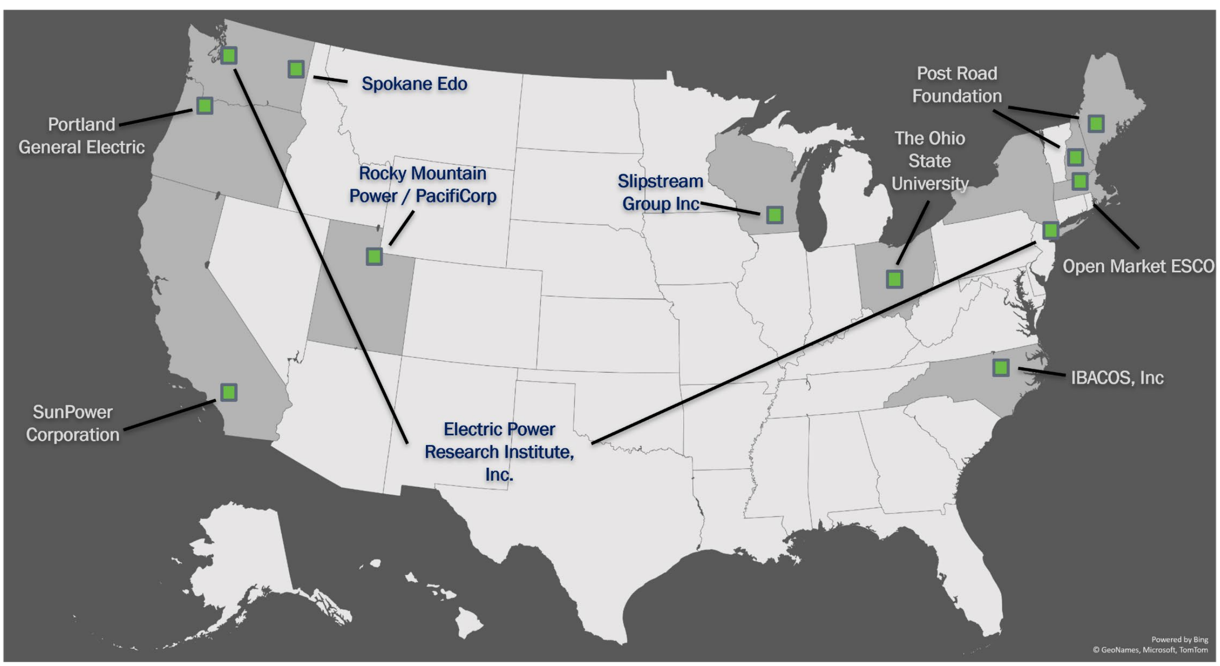

Figure 2. Geographic distribution of the 10 pilots selected

The following sections provide further detail into the project specifics, including their energy efficiency, grid services, demand flexibility technologies, DERs, project team and utility program approaches. The projects were selected for diversity - not just from a geographic perspective, but also in terms of new construction and existing buildings, utility type (IOU, POU, etc.), building types and ownership models (own, rent) and more. Several of the projects also had a focus on including low and medium income (LMI) households to improve diversity in terms of program approaches.

Post Road Foundation: Evaluating Transactive Energy for Rural America

This demonstration represents a transactive energy project that uses a Transactive Energy Service System (TESS) for load flexibility. This project represents 3 distinct CCs, one in New Hampshire and two in Maine. The New Hampshire CC will include 250 single family homes, 5-10 commercial buildings somewhere in the New Hampshire Electric Cooperative (NHEC) territory. In Maine, each CC will include 100 single family homes, 50 commercial buildings, and 5 industrial buildings within a municipality. The locations of these 3 CCs and 570 total buildings are still to be determined.

This work will be led by the Post Road Foundation, who will develop the tool for analyzing the TESS with help from Stanford's SLAC National Accelerator Laboratory who will apply their experience in developing the enhanced TESS and experience with cybersecurity and privacy standards. Other partners include Knowledge Problem who will develop the electric storage bidding functions and performance and testing protocols, the NHEC who will host a CC, and the Efficiency Maine Trust who will help with recruitment and retention for the CCs in Maine. The average total load is 1,500 kW or 200-500 kW per CC and the estimated flexible load under this demonstration is up to 7.5 MW or 2.5 MW per CC in New Hampshire based on 250 10kW batteries and up to 1.1 MW per CC in Maine based on an estimate of two-thirds of the total peak HVAC load during the winter months.

If successful, this pilot will be the first demonstration of a TESS with more than 100 buildings and multiple DERs in a rural setting. The overarching goal of this project is to demonstrate enhanced TESS benefits through economic viability at scale, support electrification, and reduce carbon emissions. The TESS will use real-time market-based price signals to coordinate energy and storage across buildings and DERs. The enhancement of the TESS comes from the idea of "prices from devices" building from work done by SLAC instead of the more common "prices to devices." Under this model, devices respond to prices from an order book based on market conditions such as load on the feeder, wholesale prices or carbon prices that would make it more attractive to consume DERs and reduce load during periods when these prices are high or load is peaking.

IBACOS, Inc.: Advanced Clean Communities Collaborative (AC3)

This project consists of 500 new construction and 500 existing residences in North Carolina with a mix of single family and multi-family, owner occupied and rental, and a variety of vintages and efficiency levels. A portion of the multi-family units are designated affordable housing targeted for LMI (low to moderate income) customers. The project team consists of a developer (Meritage Homes), an energy service company or ESCO (Elevation Home Energy Solutions), utility program designer/implementer (Tierra), utility (Duke Energy) and modeling and controls team (E3, NREL and Energy Hub). Each new home is targeted to meet or exceed DOE's Zero Energy Ready Home criteria and will include 4 kW of PV, EV charging wiring, and include an option for the homeowner to buy a 20 kWh battery. Approximately 25 of the existing homes will each be targeted for 6 kW PV systems and 20 kWh battery systems, along with connected EV home charging systems. The community will have 3.8 MW of flexible load overall to participate in grid service offerings managed through EnergyHub's distributed energy resource management system (DERMS) platform. Combined, the community is predicting 5,400 MWh of annual energy savings due to increased energy efficiency (30% new construction, 10-15% existing home savings), with another 3,300 MWh of solar generation representing more than 2,750 MTCO2e emission reductions. A full range of grid services will benefit both bulk and local transmission and distribution systems, including summer and winter peak demand side capacity, system peak capacity/energy, local transmission and distribution (T&D) capacity, load shifting and curtailment to manage variable renewable generation, frequency and voltage support.

A variety of innovative demand flexibility and grid services approaches are included across the community to provide the desired grid impacts. The new construction homes will include 'smart' grid-connected DER technologies such as water heaters, thermostats, solar PV, ASHPs (with backup electrical resistance heating for the coldest periods), and smart off-peak ventilation systems. Existing homes will include smart thermostats and connected water heaters. Overall, the DER technologies will be managed from a 'rate optimized' approach, providing price responsive automated grid services. A novel focus of this project will be piloting winter peak DER management opportunities to help defer winter peak utility capital investments. Duke's 2020 Integrated Resources Plan (Duke 2020) forecasts that by 2035 there may be a gap of 1,187 MW between winter and summer peak needs, due to increased electrification. Development of strategies to manage these emerging winter peaks will be a strategic effort for this, and similar territories, for decades to come.

SunPower Corp.: Connected Residential Communities with Enhanced Resiliency and both Customer and Utility Attributes

This project is led by SunPower Corporation as the solar and home energy management system provider and represents two, new construction, all-electric residential microgrid communities to be built by KB Homes in Riverside County, California. Southern California Edison (SCE) is the partnering utility with UC Irvine and Schneider Electric assisting with the microgrid simulation, implementation, and controls. The team is aiming to build zero-energy ready homes (ZERH) that will save 38%-57% from energy efficiency compared to a dual-fueled home in the same climate zone. The total peak load of the two communities is estimated at 1.0-1.2 MW and the project team expects 200-700 kW in flexible load to be available from smart heat pump water heaters, HVAC, EVs, smart thermostats, and other smart appliances such as dishwashers and washers and dryers. One of the microgrids (located in the Durango development) will be equipped with behind-the-meter rooftop PV with a 6.8 kW home energy storage battery while the other microgrid (located in the Oak Shade development) will have net-metered rooftop PV and a 1 MW community energy storage battery that will be available for both communities.

An important goal for this project is to demonstrate reliability and resilience, cost-effectiveness, and benefits to customers and the utility from Connected Community microgrids. The planned community-scale battery will serve to support both Connected Communities in island mode to meet critical loads and also potentially provide a service to the grid during extreme weather events with up to 500 kW available to the utility.

The grid services they hope to provide include capacity relief from demand response, emergency load transfer, and voltage and frequency regulation. Participation in the CAISO day-ahead, real-time and ancillary markets for DERs >500 kW will be explored. As well, bidirectional flow of the EVs with vehicle-to-load and vehicle-to-grid is also planned for this demonstration. In order to do so, contracts with SCE will be needed to allow the residential storage units to participate in a DR or virtual power plant (VPP) type program as well as for the community scale battery to provide a grid service during extreme weather events and for participation in the day-ahead bulk power markets.

Ohio State University-ENGIE Connected Community: Automated Building Control with Knowledge of Distributed Energy Resources and Electrical Systems for Grid Offerings

The Ohio State University-ENGIE Connected Community seeks to leverage the operations of 20 existing campus building in Columbus, OH orchestrated with distributed energy resources for energy efficiency, demand management, and grid service provision. The 20 buildings, representing a diverse set of vintages and uses (commercial, multi-family, etc.), seek to achieve a 35% energy reduction target relative to a 2017 baseline. This reduction to the 10.3 MW peak load will be partially achieved through optimal coordination with available DER and a combined heat and power (CHP) plant. Demand flexibility through HVAC setpoint management, duct static pressure resets, smart ventilation, lighting, and chiller/boiler dispatch should achieve an impact of greater than 0.75W/sf for peak reduction and grid services provision. In addition to the buildings, the community will include a 105MW CHP plant, a central chiller plant, a goal of 10MW of PV, 29 EV charging stations (300kW), and 50MW of wind power under a power purchase agreement. These resources will be coordinated ENGIE's Smart Institution software platform, a cybersecure, AI-based orchestrated controller that utilizes a model predictive control approach. The grid services targeted by the community include the full suite of bulk-level market-based services: frequency regulation, synchronous reserve, energy, and capacity.

The key innovations of project keep an occupant comfort focus to demand reduction and flexibility in mind. The AI-based coordination approach explicitly includes comfort optimization. The project will use robust methods to survey and measure the occupant experience (e.g. IEQ, productivity, wellbeing, building services attitudes and behaviors) to quantifiably improve it. This will inform the development of another key outcome, a business model for academic and other institutional and campus energy management.

Open Market ESCO, LLC.: Gateway Cities Unplugged: (em)Powering Affordable Housing

This project aims to transform existing affordable and mixed-income multifamily housing communities into grid assets through aggregation at both portfolio and apartment community levels. Led by OpenMarket ESCO LLC, a division of WinnCompanies, demonstrations at up to 6 housing communities in Lowell, Massachusetts, representing approximately 1,000 households, will strategically deploy efficiency, demand flexibility, renewable generation, and energy storage. Across the portfolio a 30% energy efficiency reduction is the target, prioritizing technologies that enable automated load shifting, such as communicating thermostats and heat-pump water heaters. DER deployment will include around 3 MW of PV, 1.3 MW of battery storage systems, and EV charging infrastructure with greater than 50 locations. The grid services that this project will target include load shaping to mitigate PV intermittency, increased PV hosting capacity, participation in ISO-NE forward capacity and day-ahead markets, utility DR programs, and peak shaving for retail bill reduction. Occupants in these underserved communities will see benefits in energy savings, comfort, resilience, and their environmental footprint.

A key goal of this project is to demonstrate financeable pathways for existing affordable multi-family housing to transition to GEBs. This will be accomplished through automating load flexibility with the development and/or enhancement of cloud-based, smart meter, and Internet of Things (IoT) platforms to integrate energy storage, PV, building automation, and other connected device controls. Additionally, the demonstrations will pilot new approaches to "Resiliency as a Service" for vulnerable communities to optimize the design and financing of on-site battery storage to provide 24-hour backup of targeted loads.

Portland General Electric: SmartGrid Advanced Load Management & Optimized Neighborhood (SALMON)

Located in North Portland, Oregon in the Overlook/Arbor Load community, this demonstration project is led by the local utility, Portland General Electric (PGE), who will be partnering with the Energy Trust of Oregon, the Northwest Energy Efficiency Alliance, Community Energy Project, National Renewable Energy Laboratory, and OSI. The community will benefit from previous efforts to establish this community as a PGE SmartGrid TestBed site. The community will include more than 580 buildings – 500 residential single-family homes, 40 multi-family homes, 40 small commercial buildings, and one large business. The DERs envisioned for this community include 110 rooftop PV units with inverters, 60 energy storage units, and 24 level 2 EVSE charging stations with assistance from the Northwest Energy Efficiency Alliance. The entire Connected Community represents an underserved community facing gentrification and striving to maintain its historic diversity. The participants will be recruited using an outreach campaign with the help from the Energy Trust of Oregon.

The overarching goal of this project is to demonstrate DERs as resources in both distribution and transmission bulk capacity markets to address capacity constraints from a feeder as well as resource constraints associated with hydropower. The plan is to implement advanced grid services such as voltage management, frequency response, and bulk service provisions. The flexible technologies include grid-enabled controls for all major end-use loads including HVAC and water heating as well as incentivizing solar and energy storage and managed EV charging.

Slipstream Group, Inc.: Connecting Communities for Sustainable Solutions

This project team will partner with the City of Madison, WI to demonstrate two phases of community scale approaches. In the first phase the pilot focuses on municipal buildings as a connected community. The second phase builds upon the lessons learned from the city-owned buildings to upgrade approximately 15 existing commercial buildings into grid-interactive efficient buildings with coordinated controls. Energy efficiency measures include retrocommissioning, LED lighting and controls integrated with HVAC controls, where temperature and ventilation resets occur based on unoccupied conditions as sensed by the lighting system. A total annual energy efficiency savings of 39% over existing use is anticipated. DERs include PV, battery storage (80 kW) and EV charging infrastructure (20 units). The automated coordinated controls will be implemented through a Demand Response Management System (DRMS). Grid services include continuous monthly peak reduction, peak load shed and load shift.

A key feature of this project is the use of off the shelf, commercially available technologies to demonstrate the new value streams and business models available through grid services. The demonstration also features applications through publicly owned and privately held facilities, demonstrating the business case for each. The project will specifically focus on developing scalable business models from both the utility and aggregator perspectives. The utility business model will align both demand response and energy efficiency utility incentive programs into a cohesive model. The aggregator business model will focus on developing a turnkey installation approach under a single vendor, with a GEB toolkit to facilitate adoption, and integrated financing options applicable to both public and private sector buildings. The project partners include Slipstream Group Inc., Madison Gas & Electric, City of Madison, RMI, ACEEE and bluEvolution.

Edo Energy: Spokane Connected Communities Project

Located in Spokane, WA this project creates a community approach in an existing residential and commercial area, inclusive of the Spokane EcoDistrict with building types varying in terms of age, sector and technology sophistication. A total of 75 to 125 buildings will be recruited from existing single family and multi-family residential and commercial buildings with a mixture of those with and without a building automation system (BAS). Avista Utilities (an Investor Owned Utility) leads this effort, and participates in technology solutions development, customer recruitment and engagement and business model development. Spokane Edo leads program planning and supports implementation, along with McKinstry and PNNL. Urbanova will support market analysis and customer engagement. The target buildings include over 300 kW of PV, 30 to 40 EV chargers, as well as the EcoDistrict's battery storage, thermal storage, and an all-electric central plant. Energy efficiency strategies include monitoring-based commissioning (Cx) and strategic energy management for commercial facilities and retrofits (e.g. heat pumps, water heaters, envelope wrap) for residential, resulting in a total of 440-900 MWh of energy savings.

This community's distribution feeder has a current peak load of 55 MW and is approaching load constraints. The Edo community has a peak between 5 to 10 MW, and load flexibility will offer 1 to 2.5 MW (depending on season, time of day), as a non-wires alternative to provide grid services to manage capacity constraints, power quality needs and adjacent feeder obligations. Flexible load technologies include rooftop units, built up HVAC systems, connected lighting and electric and heat pump water heaters for commercial buildings, and air conditioners, heat pumps, water heaters and smart thermostats for residential. Grid services will also provide load shaping, increase distribution efficiency, provide volt-ampere reactive (VAR) and voltage management, improve resiliency and enhance relief and outage recovery.

The coordinated controls will be administered by the Active Energy Management Operations Center (AEMOC) by Avista Utilities. The VOLTTRON distributed sensing and control software platform will be deployed in an integrated platform with OpenDSP to facilitate coordinated grid service controls (PNNL 2022). This project presents a unique utility and private sector partnership with a share-value business model to provide building grid services. The team will also conduct market analysis and behavior research to test prices and incentive packages for scale and will develop a playbook to enable others to replicate and scale these approaches.

Pacificorp: Utility Managed Distributed Energy Resources Intelligent Community

Rocky Mountain Power, a subsidiary of Pacificorp, will lead an effort to stand up a connected community in Salt Lake City, Utah in partnership with Pacific Northwest National Laboratory, Utah State University, Wasatch Group, GIV Group, Utah Transit Authority, Packsize International, OSI, and Sonnen. This project will implement a utility-managed DER control program among a diverse set of building types, including a downtown complex of mixed-use retail and apartments, a university laboratory, a mass transit center, manufacturing building, and residential homes. These buildings are in various stages of development with some in operation, some currently under construction, and others where the team can influence the design. The buildings are all-electric and will have advanced energy-efficiency technologies with efficient heat pump-based HVAC (both central and mini-splits) and domestic hot water, adaptive building envelope, and advanced lighting achieving a minimum of 30% energy efficiency compared to the baseline of typical buildings.

The innovative utility business model approach will explore strategic aggregation and deployment of DER bundles in wholesale electricity markets and collect data that can support Integrated Resource Planning exercises. This approach will optimize the use of DERs and demand flexibility technologies to address peak load management, frequency support, and contingency reserves through the effective integration of intermittent renewable resources. The DERs include an estimated 6.2 MW of solar PV, 13 MWh of battery storage, and >230 electric vehicle chargers. The flexible technologies will vary by site but include HVAC and heat pumps and tankless electric hot water heaters and possibly adaptive lighting.

Electric Power Research Institute: DESIRED – Deep Efficiency and Smart Grid-Integrated Retrofits in Disadvantaged Communities

This project uniquely involves two separate main locations - one in Seattle, WA, and the other in New York City, NY. In Seattle, the project consists of at least 300 units total of multi-family residences, spread over several communities, and at least 300 units spread over additional multi-family communities in New York City. The project team includes the utility Seattle City Light, EPRI, Sentient, Community Roots Housing, Vistar Energy and the Gas Technology Institute. A key attribute of the project is the focus on affordable decarbonization of the building stock, leveraging efficiency, DERs and demand flexibility to lower energy costs, while increasing the availability of DERs. Notably this project attempts to bring these values to LMI housing, including new and existing multi-family developments. The planned grid services will support local distribution resources for reserve capacity, and also include bulk system services.

The Seattle project will include both packaged terminal heat pump technologies and centralized heat pump systems, as well as low-GWP CO_2 heat pump water heaters and 120V electrical water heaters. Community solar PV, batteries and EV charging round out the planned DERs. The New York City project will include mini split HVAC systems, and cold-climate window heat pumps. Both include attic insulation and air sealing, windows, high efficiency lighting, and high efficiency appliances. Energy efficiency savings of 30% are targeted for both the new and existing construction sites. The coordinated controls strategies will emphasize customer energy cost savings, which are important to the LMI community, through use of a cost threshold while still managing grid services provision. A grid marginal carbon emissions signal will also be incorporated into the controls to influence load shifting, reducing grid carbon emissions. Energy storage is planned to be used in TOU arbitrage, to further support energy cost management. Additional efforts will focus on resilience strategies, including the use of bi-directional EV charging to support the community.

Anticipated Project Impacts

As part of the Connected Communities pilot project agreements, all projects are required to produce and collect data to demonstrate the ability of the project to provide the efficiency, load flexibility, and the grid services targeted. This will be quantified through a measurement and verification process utilizing an evaluation protocol. In order to measure quantity and quality of actual load change or energy services, or both, it is anticipated that all buildings will be equipped with interval metering infrastructure and analytics, and analogous infrastructure on the grid side. Each project should produce the types of data listed in Table 2.

Table 2. Connected Communities Pilot Project Evaluation Topics and Key Questions

Evaluation Topic and Key Question[1]	**Sub Questions**
1. Customer Impact and Benefits What was the benefit of the demonstrated solution to the customer? [owner/occupants]	1a. What was the customer's motivation, and perception of value (was/is it worth it) for participating? 1b. What was the customer's experience, including comfort and productivity etc., including specific DERs - EVs, solar, etc.? 1c. What would be the financial impacts to the customer?
2. Grid Services and Energy Impacts What was the benefit of the demonstrated community scale solution to the grid? [provider, utility/ISO]	2a. What was the physical and financial magnitude of the grid service? 2b. How consistently was the grid service provided? 2c. How much did the individual DERs contribute to the magnitude of the grid service? 2d. How much did the community's energy (electricity and other sources) change over time as a result of providing the grid service and energy efficiency?

[1] Key stakeholders for each evaluation method are shown in brackets.

3. Benefit-Cost Analysis Were the benefits for each category of program participant obtained cost effectively? [particularly for the utility(ies)/grid operator(s)]	3a. What are the net benefits and net costs for each category of participants (in dollars)? 3b. What is the benefit-cost ratio for each category of participants (calculated by dividing the present value of life cycle benefits by the present value of life-cycle costs)?
4. Business Model Can the business model be replicated by the private sector? [e.g. grid services aggregator, other relevant stakeholder business models]	4a. What products/services are being offered to customers and what operational and/or development processes support delivery of the products/services? 4b. How satisfied are customers with their participation in the project and what changes to the project were made to improve customer satisfaction? 4c. What are the business model's strengths, weaknesses, opportunities, and threats?
5. GHG Emissions What was the GHG benefit of the demonstrated solution? [general]	5a. What were the GHG savings associated with the demonstrated solution?
6. Resilience How did the demonstrated solution afford resilience?	6a. At what scale was resilience incorporated? 6b. What was the nature of the resilience that was provided? 6c. How was the resilience provided? 6d. What quantity of resilience was provided?

In addition to the required evaluation, some of the pilot project may evaluate other aspects of performance. Additional analysis might include topics such as:

- Performance of specific technologies as relates to grid services provision
- Performance of specific controls applications as relates to grid services provision
- Aspects of certain program design elements (e.g. influence of utility rates, incentives)

Similarly, Berkeley Lab and DOE anticipate that after project implementation begins, and evaluation data is available, we will conduct cross-cutting analysis on the projects to identify trends in savings and implementation (e.g., demand flexibility, GHG emissions reduction, peak load reduction, alternative and emerging business models).

As the pilots begin to move forward, Berkeley Lab, as the U.S. DOE-designated national coordinator, will identify opportunities to provide assistance to the project teams on relevant topics such as technology, cybersecurity, interoperability, customer recruitment and engagement, controls, business models, and program design. Where possible, the resources that Berkeley Lab develops, such as case studies, papers or guidance documents will be available for use as an industry, academic, governmental and public resource and be curated among other resources to support scale and adoption through the ConnectedCommunities.lbl.gov website (LBNL 2022).

References

Duke Energy. 2020. *Duke Energy Carolinas Integrated Resources Plan* https://desitecoreprod-cd.azureedge.net/_/media/pdfs/our-company/irp/202296/dec-2020-irp-full-plan.pdf?la=en&rev=f907071cc4dc4651b25ab93ca6f3d8f0.

Lawrence Berkeley National Lab (LBNL). 2022. Connected Communities. https://connectedcommunities.lbl.gov/ Accessed March 2022.

Nemtzow, David. 2021. *CEC IEPR Commissioner Workshop on Grid-Interactive Efficient Buildings: A National (and California?) Roadmap for GEBs* www.energy.ca.gov/event/workshop/2021-10/session-1-2021-iepr-commissioner-workshop-grid-interactive-efficient Accessed June 2022.

Satchwell, A., M.A. Piette, A. Khandekar, J. Granderson, N.M. Frick, R. Hledik, A. Faruqui, L. Lam, S. Ross, J. Cohen, K. Wang, D. Urigwe, D. Delurey, M. Neukomm, and D. Nemtzow. 2021. A National Roadmap for Grid-Interactive Efficient Buildings. US DOE Report, May. https://gebroadmap.lbl.gov/ Accessed March 2022.

Southern Company. 2019. How Southern Company's Smart Neighborhoods® Are Transforming the Smart Home Industry. www.southerncompany.com/newsroom/business-leadership/smart-neighborhoods-are-transforming-the-smart-home-industry.html Accessed June 2022.

State and Local Energy Efficiency Action Network. 2020. Grid-Interactive Efficient Buildings: An Introduction for State and Local Governments. Prepared by: Lisa Schwartz and Greg Leventis, Lawrence Berkeley National Laboratory. https://emp.lbl.gov/publications/grid-interactive-efficient-buildings

Pacific Northwest National Laboratory (PNNL). 2022. VOLTTRON. https://www.pnnl.gov/volttron, https://volttron.org/ Accessed June 2022.

U.S. Department of Energy (DOE). 2018. Buildings and the Grid 101: How Are Building Technologies Office Partners Researching and Validating in the Field? www.energy.gov/eere/buildings/articles/buildings-and-grid-101-how-are-building-technologies-office-partners-0 Accessed June 2022.

U.S. Department of Energy (DOE). 2022a. Funding Opportunity Announcement: Connected Communities. https://www.energy.gov/eere/solar/funding-opportunity-announcement-connected-communities. Accessed March 2022.

U.S. Department of Energy (DOE). 2022b. Grid-Interactive Efficient Buildings. https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings Accessed March 2022.

U.S. Department of Energy (DOE). 2022c. Meet DOE's Newest Connected Communities of Grid-interactive Efficient Buildings. www.energy.gov/eere/buildings/articles/meet-does-newest-connected-communities-grid-interactive-efficient-buildings. Accessed June 2022.