TENNESSEE VALLEY AUTHORITY

IMPLEMENTATION GUIDE

Grid-interactive Efficient Building Solutions

VERSION ONE: 02/2022

Acknowledgments

This booklet, created by the Tennessee Valley Authority (TVA), is an informational compilation of existing concepts, examples, resources and considerations, gathered to provide a digestible reference resource for Valley communities and local power companies (LPCs) as they explore implementation of connected community solutions. This booklet is not meant to prescribe the details of how an individual community should implement a specific solution.

Grid-interactive Efficient Building Solutions support one of the Valley's identified focus areas: Energy and Environmental Justice. See the Tennessee Valley Connected Communities Roadmap for more information.

Introduction

Engage Stakeholders

Explore Solutions

Deploy and Operate

Resources

Introduction

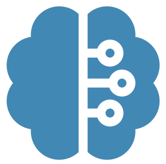
Grid-interactive Efficient Buildings (GEBs)

By connecting smart, flexible building technologies (heating, ventilation and air conditioning [HVAC], lighting, electric vehicle [EV] charging, onsite solar, battery storage, etc.) to each other and to information about occupant preferences and electrical grid needs, your smart home system or building-to-grid software can do even more.

For example, when a GEB system receives a signal about a strain on the power grid (peak demand hours or a demand response event), your smart meter or Building Automation System (BAS) can coordinate and optimize your building's technologies for greater energy efficiency. This might allow your smart thermostat to shift up or down a few degrees, to your predetermined comfort level, allowing for a reduction in energy use, that still meets your comfort level. This enhances the resilience and adaptability of our power grid, while maintaining your needs and preferences, and potentially saving you money in the process.

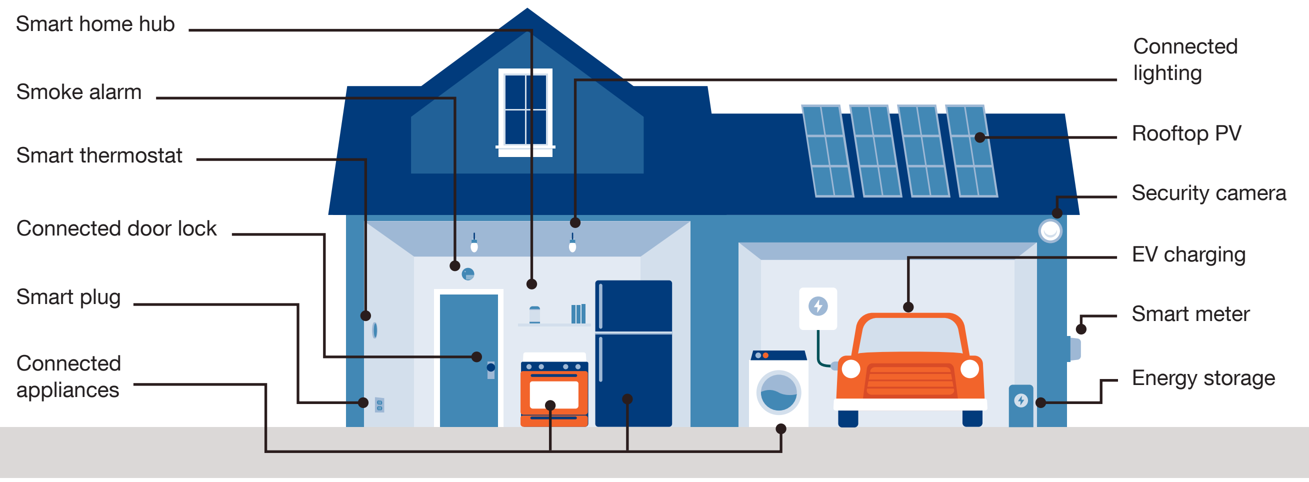
With this combination of technology, information sharing and connectedness, GEBs are a prime example of a connected community solution in the energy space.

For more information, see additional resources.

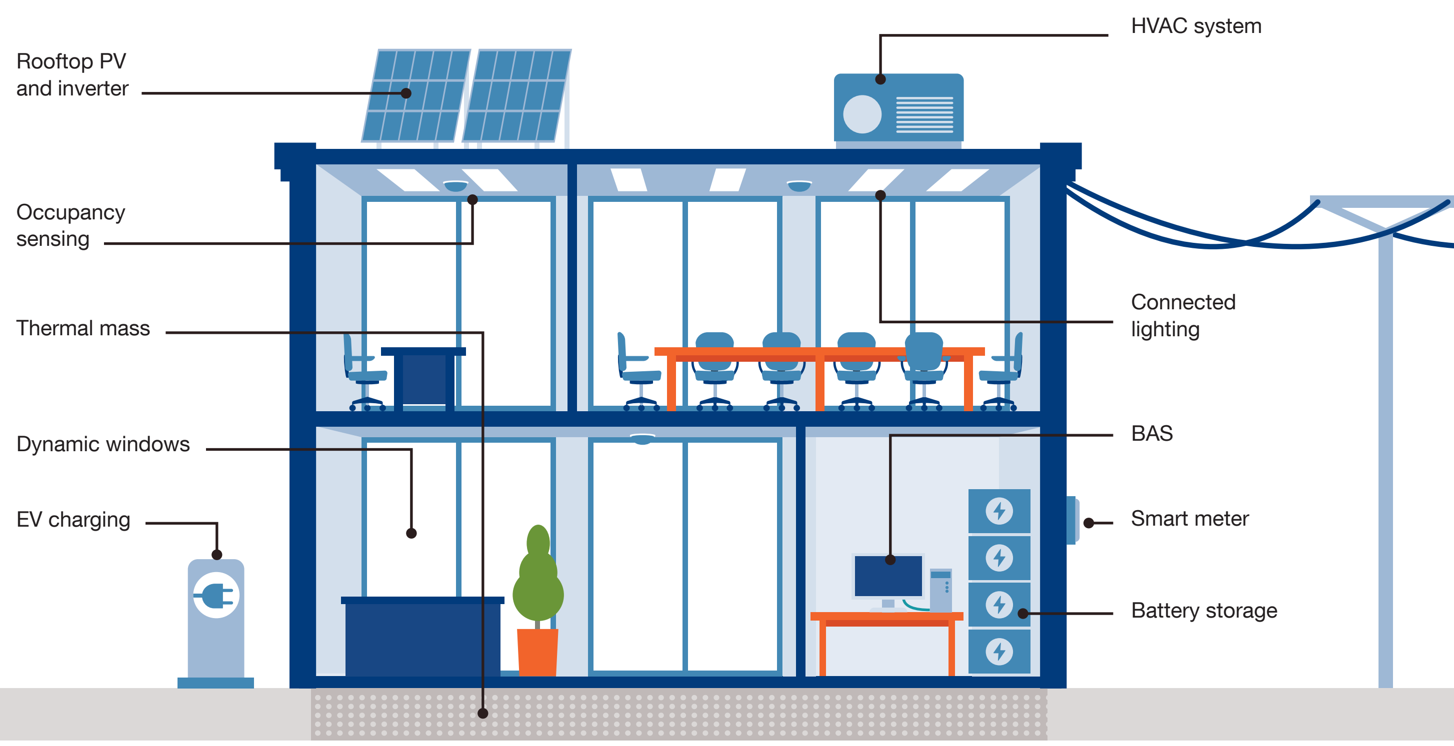


GEBs make smart devices smarter.

RESIDENTIAL EXAMPLE



COMMERCIAL EXAMPLE



Implementation Framework and Key Questions

The implementation framework below and reviewed in the Connected Communities Guidebook outlines the process and key questions to be used to approach the adoption of energy technology solutions.

While this guide focuses on GEBs, this implementation framework can be similarly applied for any solution your community is exploring.

1

Engage key stakeholders
What key stakeholders should I engage and what roles should they play?

Confirm community need
How do I best identify and confirm my community's need?

2

Explore solutions/approaches
What solution or approach options are available?

Identify ownership approach
Who will lead the solution implementation?

Identify funding approach
What funding options are available?

Plan for feasibility and risk
What additional risks should I consider?

3

Deploy solution
What are the leading practices around deploying a solution?

Launch ongoing operations
How do I ensure ongoing success of the solution after deployment?

Potential Impacts

Individual Benefits

Optimization of building technologies creates energy and cost savings. Smart HVAC and lighting enable greater occupant comfort from lower effort than traditional systems. In commercial buildings, GEBs can increase operational efficiency by quickly giving facility managers information greater control over systems. With increased operational efficiency and decreased electricity costs, GEBs can provide significant value to building owners.

Community Benefits

By actively managing electricity use in coordination with grid needs, GEBs can alleviate reliability issues created by distributed energy resource (DER) adoption and peak demand. Power system benefits include avoided generation capacity costs, reduced energy costs (fuel, variable operations and maintenance and line losses), ancillary services (i.e., fast-response services to keep the grid balanced in real-time), avoided transmission capacity costs and avoided CO_2 emissions. GEBs can also be orchestrated as a group instead of individual buildings, expanding connectivity and information to potentially compound benefits.

Like other distributed energy solutions, utilizing GEBs to advance and maximize community benefit requires broad promotion and adoption of GEBs within a neighborhood or community.[3]

BUILDINGS IN THE UNITED STATES ACCOUNT FOR

75%

of total electricity use

and 80% of peak power demand.[1]

The DOE has a goal to reduce this by

300%

by 2030 relative to 2020 levels.[2]

GEBs can address individual and community-level problems, and support sustainability and reliability while reducing the need for costly electricity infrastructure.

CASE STUDY

Georgia Power partnered with PulteGroup and US DOE to create Atlanta's Smart Neighborhood.

Each townhome has solar panels on the roof, in-home battery storage, optimal insulation, latest heating and cooling systems, LED lights, chargers for electric cars and smart home system features.

Georgia Power is working with Southern Company Research and Development, Oak Ridge National Laboratory and EPRI to analyze and optimize energy saving solutions to improve home energy usage and energy technology integration with grid.

The GEBs allow for flexibility in load they provide as well as benefiting the overall grid.

Learn more >

46

newly built connected smart townhomes.

42%

less energy

than similar new construction.

62%

reduction

in their collective demand on the warmest days.

Engage Stakeholders

Identify Key Stakeholders

Identifying and engaging a variety of relevant stakeholders is a critical component to implementing a connected community project.

Stakeholders Roles

The chart on the right identifies potential stakeholders and their roles for exploring and implementing GEBs. Stakeholder engagement will vary based on the project. Consider these key questions in your stakeholder selection:

- What are their building energy interests/needs?
- How would they benefit from adoption of building energy technologies?
- How could they contribute to implementing a pilot or program?
- How does this project align with their priorities?

GEBs can be implemented in: new or existing buildings; urban development; residential or commercial district planning; and through building codes and standards.

KEY STAKEHOLDERS AND THEIR POTENTIAL ROLES

	ADVOCATE	CUSTOMER	ADVISOR	DEPLOYER
Building portfolio owners, developers, facility managers, residents, businesses		✓		
Local governments, congressional budget offices	✓	✓		
Smart technology hardware manufacturers, software providers, system integrators	✓			✓
Architects, engineers, urban development planners, code officials	✓		✓	
Local power companies	✓		✓	✓
Universities or research institutes			✓	✓
Installers				✓

Engage Stakeholders

Confirm the Community Need

The energy needs of a community and the interest in building owners to pursue a solution that addresses the identified energy needs must be validated.

KEY QUESTIONS TO ANSWER

Community Surveys

Community surveys educate key stakeholders and gauge interest in adoption of flexible technologies for energy savings, better user control of devices and DERs.

Surveys shed light on interests and needs from building owners, facility managers, etc. that can reap direct benefits for their operations and drive forward the community's adoption of solutions such as GEBs.

1. Is there interest in smart devices or flexible assets for demand management?
2. Does need and opportunity exist to support equity using GEBs?

Demand Forecasting

Utilities can use data on current and forecasted peak demand to understand if, when and where further demand management may be needed.

Analyses and forecasts of grid capacity to meet demand and host DERs, conducted by or in partnership with a local power company will inform the locations and degree of need.

3. Where is demand growing?
4. Where is peak demand nearing limits now or in the future?

KEY QUESTIONS TO ANSWER

Development Planning and Building Stock Assessment

Between development planning and power companies, the value of GEBs in existing and future building stock can be assessed.

5. How could GEBs be considered for new construction?
6. Are there candidates for GEB retrofits in the current building stock?

Hosting Capacity Analysis

Utilities can assess current and forecasted capacity to add DERs at various points on the grid.

7. Where is capacity to host DERs constrained now and in the future?
8. What system upgrades would be needed to expand hosting capacity?

CASE STUDY

Supporting Equity with GEBs

In Vermont, those living in traditional mobile and manufactured homes spend 66% more of their income on energy than owners of stick-built homes. To create more affordable, healthier housing, Efficiency Vermont launched their Zero Energy Modular home program. Vermont residents can take advantage of income-based incentives and low-interest 30-year financing for a modular home built for energy efficiency, durability and net zero energy costs thanks to rooftop solar. Read more >

Explore Solutions

Select Solutions

Communities should explore solutions and select the promotion of GEBs in a way that best fits your needs and abilities.

For more information, see additional resources.

SOLUTION OPTION

Pilot Program

Targeted GEB deployments to learn about feasibility and impact.

EXAMPLES

- **Smart Neighborhood Project** *Birmingham, AL*
- **Zero Energy School Building: Discover Elementary** *Arlington, VA*

STAKEHOLDERS

- Funding providers
- Research institutions
- Local power companies
- Smart technology providers
- Participating building owners

SOLUTION OPTION

Incentives and Technical Support

Providing incentives/technical guidance to support the deployment of GEB projects.

EXAMPLES

- **Duke's Solar Choice net meter smart thermostat incentive**
- **Green Mountain Power Bring Your Own Device Program**

STAKEHOLDERS

- Organizations providing incentive (often the local power company or local government)
- Technology providers
- Participating building owners

With sufficient adoption from individual buildings, building energy solutions such as GEBs can benefit the broader community.

SOLUTION OPTION

Updated Building Codes or New Stretch Codes

State/Government decision that propels GEBs.

EXAMPLES

- Washington and Oregon require a standard demand response (DR) interface in electric water heaters. *See "**Additional Resources**" for more information.*

STAKEHOLDERS

- Local power companies
- State and local government agencies
- Impacted technology providers, engineers, architects
- Building owners

SOLUTION OPTION

Educational Campaign

Run programs to educate about energy management.

EXAMPLES

- **EnergyWise Schools** *South Carolina*
- **National Energy Education Development**

STAKEHOLDERS

- Program owners *i.e., Nonprofit, government*
- School systems or colleges
- Local power companies
- Building owners

Explore Solutions

Identify Ownership

The way a community promotes and leads adoption of GEBs is dependent on the roles of your stakeholders.

Pursuing a GEB is a building owner's decision that requires a compelling business case and depends on their education on the topic, any financial/technical support provided and requirements such as building codes/standards.

SOLUTION OWNER

Local Power Company

If promoted through incentives, installation support or an educational campaign, like traditional energy efficiency (EE) programs, the solution could be led by the local power company with a technology partner as the solution provider.

PROS

- Full ownership allows flexibility with deployment

CONS

- Requires regulator-approved funding, likely requires business case

SOLUTION OWNER

University or Research Institution

Pilots may have a university or research institution partner and grant funding, though full-scale programs may need to be supported by a business case without one-time funding.

PROS

- Cost-sharing

CONS

- Locked into a specific technology provider

SOLUTION OWNER

Local Government

Incentives, installation support or educational campaigns could be led by the local government, with a technology partner as the solution provider.

PROS

- Can implement building codes to support adoption, though process is typically slow

CONS

- Limited budget

SOLUTION OWNER

Building Owner or Developer

GEB adoption could also be spurred by a local building owner/developer that pursues GEBs, providing a case study for others to learn from and model.

PROS

- Provides a case study of an independently successful project
- Drives awareness of GEBs

CONS

- Requires proactive early mover

CASE STUDY

A Community Effort

Colorado's Basalt Neighborhood[4] was struggling to acquire and retain their teachers because wages were low and housing costs for the area were high. In order to make housing more affordable, they developed a plan to develop Basalt Vista as an electric, net-zero, affordable housing community and make it a template for others to follow.

Roaring Fork Valley, Habitat for Humanity, and the Community Office for Resource Efficiency worked with the community to fill funding gaps. The school district donated land ($3.3M), Pitkin County donated the road and utilities ($3M), Holy Cross Energy, the utility, provided the technology for the first four homes, and Community Office for Resource Efficiency contributed $107,500 among other contributions.

Read more >

Explore Solutions

Secure Funding

Consider your funding approach to determine the size and scale of your GEBs strategy.

State or Federal Funding

State or federal funding support for GEBs is limited, though in the future funding for energy efficiency or demand flexibility may be able to support GEB adoption.

Research, Technology or Commercial Partnership

Currently, communities are more likely to obtain funding through a partnership model with research institutes, technology providers and/or commercial spaces looking to explore building solutions for a pilot model.

Third-Party Options

Third-party financing (e.g., Pathway Lending Energy Efficiency Loan Program, TN's Energy Efficient Schools Initiative, Commercial Property Assessed Clean Energy and Resilience financing, guaranteed energy savings performance contracting) may also be available.

Create a Business Case

Broader adoption likely requires a building code requirement and/or a business case that is attractive to the building owners, developers or facility managers who make the upfront investment in technology. This business case could be bolstered by incentives and/or technical support from a local power company or local government, through regulator-approved funding or the government's funds, respectively.

For more information, see additional resources.

Building the Case for an Individual GEB

In a review for the General Services Administration, Rocky Mountain Institute found that a GEB strategy should prioritize:

- Investment in fully controllable systems such as fully controllable lighting fixtures
- Staging of large building loads such as electric heating, air handling unit (AHU) fan motors and plug loads
- Year-round demand management, including smoothing out peak electricity loads (though a process known as "peak shaving") instead of demand response
- Battery storage and solar photovoltaic (PV) panels
- Occupant comfort and building operations
- Interoperable, intelligent building controls

4 years or less for payback

30% annual energy cost savings[5]

KEY BENEFITS

- Increased operational efficiency
- Better returns from energy efficiency investments than without centralized optimization
- Reduced electricity bills
- Increased choice and flexibility of how electricity is consumed
- Increased comfort for occupants
- Greater resilience

KEY COSTS

- Heating and cooling systems
- Smart control technologies
- Smart appliances
- Grid-interactive electric water heaters
- Smart thermostats
- Smart LED lighting
- Rooftop solar panels
- Battery storage
- Electric vehicle chargers

Mitigate Risks

Communities should understand and plan for risks or constraints in deploying building technology solutions.

Adoption Risks

Upfront investment

Consumers may be wary of the upfront cost of technologies to enable demand flexibility.

Data privacy and cybersecurity concerns

Coordination of multiple devices to share data requires careful consideration of user data privacy and potential risk of malicious attacks on the devices. An IT management system can protect a GEB against cybersecurity attacks and vulnerabilities and provide data security.

End user adoption

Residential and commercial building owners may be hesitant to explore building technology solutions that seem complicated, or they may not use solutions to their full potential without proper training. Clear incentives and education about their benefits can help to attract interest and involvement.

CONSIDER:

- What is the likelihood of this risk impacting the project?
- If realized, what is the impact of this risk?
- What steps can you take to mitigate this risk?
- Can the project move forward if this risk is not mitigated?

Deployment Risks

Address existing building inefficiencies

GEBs can reduce the energy required by a building, but this is also dependent on the efficiency of the buildings appliances *(e.g., HVAC system, water heater)* and properties of the building *(e.g., building envelope).*

Technology interoperability and advancement

Smart energy management devices often do not easily integrate between one another and a control platform, particularly in the residential space. One solution may be a connectivity and control device at the building's electrical panel that can act as a gateway for the building's devices. Technology is also evolving quickly; a system should be flexible to integrate new technologies later.

Sufficient installers and managers for large-scale deployment

Deploying advanced devices and controls for buildings at a large-scale within a community requires enough installers in the area to meet demand. It also requires trained facilities staff to manage the building technology following deployment.

Deploy and Operate

Deploy a Solution

DEPLOYMENT LEADING PRACTICES:

Pilot Program

Inform community stakeholders

To encourage awareness of the pilot benefits, prioritize stakeholder communications and engagement from the beginning of the implementation process.

Ensuring the highest standards are maintained through construction

When piloting a new solution in the construction environment, it is critical that high standards are maintained across the entire project. An error or disruption at any point may discourage stakeholders from supporting the entire GEB solution.

Incentives and Technical Support

Inform community stakeholders

Ensure that stakeholders are aware of and have access to incentive opportunities.

Build relationships

Build relationships in the community to ensure the full incentive opportunity is utilized and success stories are shared. Word of mouth marketing, community news sources and trusted leaders can be effective ways to build awareness and support the effort.

Adopt a process for continual improvement

To drive program success, develop a process to determine how program incentives are utilized or could be better utilized by appropriate stakeholders.

Develop IT management

Provide building owners with information technology education and resources to prevent malfunctions and security breaches.

Once a specific solution is identified, you can begin to focus on the specific stakeholders, funding resources and deployment needs for the project.

Update Building Codes or Introduce Stretch Codes

Inform community stakeholders

Ensure that members of the building community are aware of the updates and set up for success.

Leverage best practices from other jurisdictions

Across the country, jurisdictions are developing building codes to promote GEB development. Leverage and learn from great work that has already been implemented. See “Additional Resources” for more examples.

Proactively work to reduce barriers

Adopting or amending a building code is a public process. There will be stakeholders in your community that may not want to see these changes. Proactively talk to these stakeholders to understand perspectives and help eliminate barriers.

Educational Campaign

Inform community stakeholders

Ensure that stakeholders are aware of educational opportunities and can take advantage of resources.

Identify the list of primary stakeholders to participate. Identify the population of stakeholders that you want to reach through this effort.

Assess effectiveness

Continually assess effectiveness of your outreach plan to reach the intended stakeholders.

Work with organizations and institutions

Work within the community to leverage existing communication channels. Work with trade organizations and institutions that train the future workforce.

Deploy and Operate

Launch Operations

After deployment, communities must continue to monitor whether the GEBs address the needs that they are intended to through these ongoing key activities.

ONGOING KEY ACTIVITIES:

Track and Monitor Key Performance Indicators (KPIs)

How the solution is delivering on the proposed goals. Potential KPIs include:

- Number of GEBs built
- Cumulative peak reduction on the grid
- Cumulative energy savings
- Cumulative demand flexibility[6]
  See GridOptimal Metrics for more details on evaluating building-grid interactions.

Monitor and Maintain Materials and Incentives

Continue to drive interest from the building community, businesses and residents. The materials should continue to be updated as successes / case studies are identified.

Manage Local, Regional, and National Partnerships

GEBs are being piloted across the country; local communities should maintain relationships to leverage the successes of others and continue to incorporate this knowledge into the activities of the local community by sharing best practices.

Share Successes

Share the impact and value of the delivered solution so that the successes and lessons learned can be replicated.

Continue to Engage with Stakeholders

The building and design community, particularly, can continue to build interest in developing GEB solutions.

CASE STUDY

Measuring Success

New technology and more renewable energy resources have changed the utility industry from centralized energy flows to distributed sources of renewable energy. This shift created a gap in the way that buildings capture usage metrics and interact with the grid.

The GridOptimal Buildings Initiative[7]

The GridOptimal Buildings Initiative developed metrics to address integration of DERs into buildings, such as solar and wind energy, for buildings to have more grid effective operations.

GridOptimal Buildings provides tools, utility program criteria, metric deployment, market design guidance and materials such as standards and policies.

For more information, see additional resources.

Introduction

Grid-interactive Efficient Buildings (GEBs)

- Lucid. (n.d.). Connected buildings: A disruptive new approach to building management. http://info.greenbiz.com/rs/greenbizgroup/images/ConnectedBuildings-Disruption-Final.pdf?mkt_tok=3RkMMJWWfF9wsRohu6zOZ-KXonjHpfsX66%2BQoW6G3IMI%2F0ER3fOvrPUfGjI4HRMFqI%2BSLDwEYG-Jlv6SgFSLHEMa5qw7gMXRQ%3D

- Satchwell, A., Piette, M. A., Khandekar, A., Granderson, J., Frick, N. M., Hledik, R., Faruqui, A., Lam, L., Ross, S., Cohen, J., Wang, K., Urigwe, D., Delurey, D., Neukomm, M., & Nemtzow, D. (2021, May). A national roadmap for grid-interactive efficient buildings. https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs%20-%20Final.pdf

- The State and Local Energy Efficiency Action Network. (2020, April). Grid-interactive efficient buildings: An introduction for state and local governments. https://www.energy.gov/sites/default/files/2020/04/f74/bto-see-action-GEBs-intro-20200415.pdf

- United States Department of Energy. (2019, April). Grid-interactive efficient buildings. https://www.energy.gov/sites/default/files/2019/04/f62/bto-geb-factsheet-41119.pdf

Potential Impacts

[1] United States Department of Energy. (2019, April). Grid-interactive efficient buildings. https://www.energy.gov/sites/default/files/2019/04/f62/bto-geb-factsheet-41119.pdf

[2] Satchwell, A., Piette, M. A., Khandekar, A., Granderson, J., Frick, N. M., Hledik, R., Faruqui, A., Lam, L., Ross, S., Cohen, J., Wang, K., Urigwe, D., Delurey, D., Neukomm, M., & Nemtzow, D. (2021, May). A national roadmap for grid-interactive efficient buildings. https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs%20-%20Final.pdf

[3] Olgyay, V., Coan, S., Webster, B., & Livingwood, W. (2020, May). Connected communities: A multi-building energy management approach. National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy20osti/75528.pdf

Engage Stakeholders

Confirm the Community Need

Community surveys example:

- McCullough, J., (2021, January). The results are in: Demand for smart buildings is up. Schneider Electric. https://blog.se.com/sustainability/2021/01/07/the-results-are-in-demand-for-smart-buildings-is-up/

Demand forecasting example:

- Hale, E., Fontanini, A., Wilson, E., Horsey, H., Parker, A., Muratori, M., McMillan, C., Sanders, K., Mooney, M., Roberts, D., Reyna, J., Adhikari, R., Harris, C., Horowitz, S., Jones, D., Merket, N., Pathak, M., Robertson, J., Speake, A… & Lockshin, J. (2021, March). Electricity demand projections. In J. Cochran & P. Denholm (Eds.), The Los Angeles 100% renewable energy study. National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy21osti/79444-3.pdf

Development planning and building stock assessment examples:

- FirstView. (2017, November). Take a FirstView® of your building's energy performance. New Buildings Institute. https://newbuildings.org/wp-content/uploads/2017/01/nbi_fv_overview.pdf

- Bryan, W. (2020, August). Energy insecurity in Memphis. Southeast Energy Efficiency Alliance. https://storymaps.arcgis.com/stories/b46e354dbd2d4ffe81151b4880be607a

- Mardookhy, M., (2013). Energy efficiency in residential buildings in Knoxville, TN, U.S. [Unpublished master's thesis]. University of Tennessee, Knoxville. https://trace.tennessee.edu/cgi/viewcontent.cgi?article=2652&=&context=utk_gradthes&=&sei-redir=1&referer=https%253A%252F%252Fscholar.google.com%252Fscholar%253Fhl%253Den%2526as_sdt%253D0%25252C24%2526q%253Denergy%252Befficiency%252Bin%252Bresidential%252Bbuildings%252Bin%252BKnoxville%25252C%252Btn%2526btnG%253D#search=%22energy%20efficiency%20residential%20buildings%20Knoxville%2C%20tn%22

Hosting capacity analysis example:

- National Renewable Energy Laboratory. (n.d.). Advanced hosting capacity analysis. https://www.nrel.gov/solar/advanced-hosting-capacity-analysis.html

Explore Solutions

Select Solutions

Pilot program examples:

- Starke, M. (n.d.). Transactive whole homes as integrated assets (connected neighborhoods) [PowerPoint slides]. United States Department of Energy. https://www.energy.gov/sites/default/files/2018/06/f52/32740b_Starke_050118-1210.pdf

- United States Department of Energy. (2017, August). Zero energy schools. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/ZeroDiscovery.pdf

Resources

Incentives/technical support examples

- Carlson, K., (2018, March). Green Mountain Power offers new "bring your own device" program to cut energy peaks. Green Mountain Power. https://greenmountainpower.com/gmp-offers-new-bring-device-program-cut-energy-peaks/

- Duke Energy. (2020, September). Duke Energy reaches deal with Volte Solar, Sunrun, renewable energy advocates to modernize, expand rooftop solar in South Carolina. https://news.duke-energy.com/releases/duke-energy-reaches-deal-with-vote-solar-sunrun-renewable-energy-advocates-to-modernize-expand-rooftop-solar-in-south-carolina

Update building codes/introduce stretch codes to encourage development of GEBs example

- Northeast Energy Efficiency Partnerships, Inc. (2021, January). Emerging codes and standards for grid-interactive buildings. https://neep.org/sites/default/files/media-files/grid_final_formatted.pdf

Educational campaign examples

- Staff. (2019). EnergyWise club students to serve as ambassadors of new Jones County PK-12 school at opening. EducationNC. https://www.ednc.org/energywise-club-students-to-serve-as-ambassadors-of-new-jones-county-pk-12-school-at-opening/

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Identify Ownership

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Secure Funding

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Deploy and Operate

Launch Operations

[6] Miller, A. & Carbonnier, K. (2020). New metrics for evaluating building-grid integration. New Buildings Institute. https://newbuildings.org/wp-content/uploads/2020/11/NewMetricsForEvaluatingBuildingGridIntegration.pdf

[7] Miller, A. (2020, May). Gridoptimal metrics offer guidance on optimizing building-grid interaction. New Buildings Institute. https://newbuildings.org/gridoptimal-metrics-offer-guidance-on-optimizing-building-grid-interaction

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Grid-interactive Efficient Building Solutions

tva.com/energy/technology-innovation/connected-communities