NJIT New Jersey Institute of Technology

Center for Building Knowledge

FINAL REPORT

Architects and GEBs: The Role of the Profession in the Emerging Field of Grid-Interactive Efficient Buildings

Prepared for:
American Institute of Architects Upjohn Research Initiative

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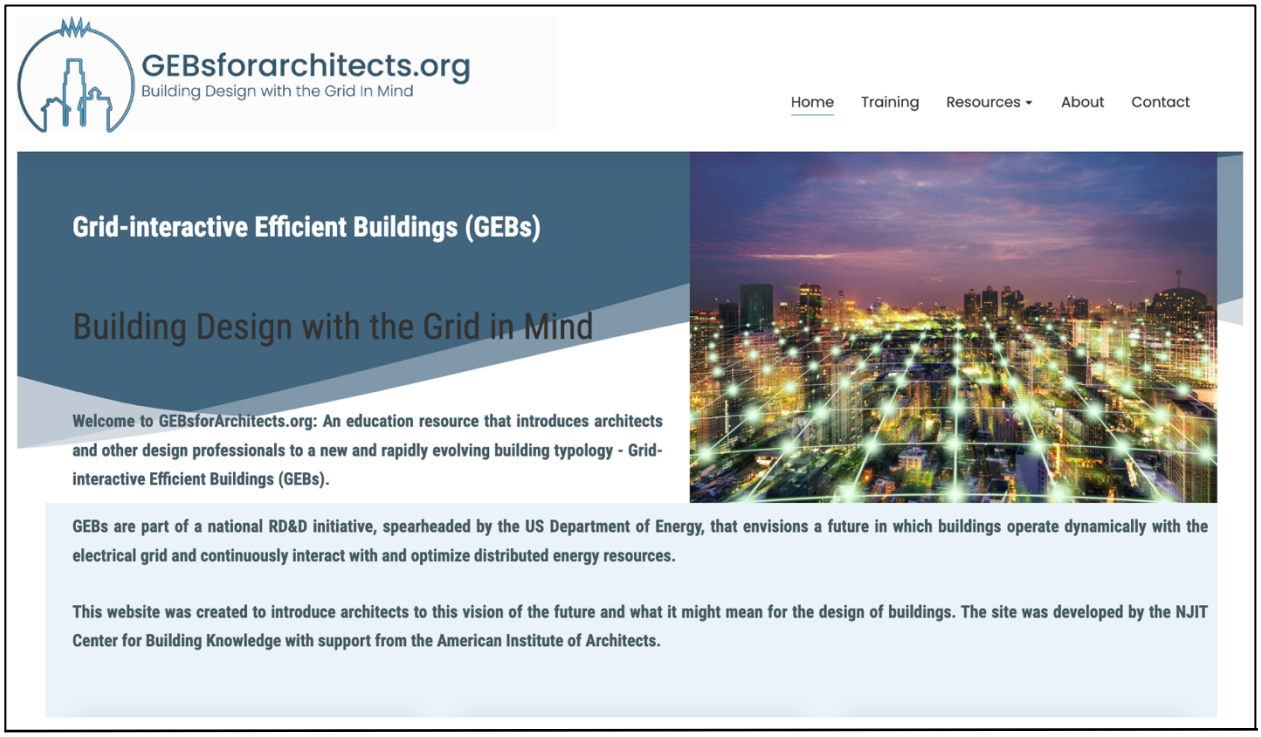
This report is organized into the following sections:

Executive Summary

This report summarizes work undertaken by the NJIT Center for Building Knowledge pursuant to an Upjohn Research Initiative grant from the American Institute of Architects. The purpose of the grant – titled "Architects and GEBs: The Role of the Profession in the Emerging Field of Grid-Interactive Efficient Buildings" – was to: 1) analyze existing, GEB-related R&D activities and findings; 2) identify specific GEB topics that will most strongly impact architects and the facilities they design; 3) convene a focus group of architects to review and discuss these topics in terms of how they impact day-to-day practice; 4) incorporate the results into an online toolkit designed to help architects understand the practical, real-world implications of GEBs on their practices; and 5) identify pathways through which the architectural profession can effectively engage with GEBs activities going forward.

All these objectives were achieved and the core deliverable for the project – an online toolkit designed to help architects understand the practical, real-world implications of GEBs on their practices (titled *GEBSforarchitects.org*) – was developed and launched in June 2023 as a means to both educate architects about GEBs and to bring them into the national conversation about this rapidly evolving building typology.

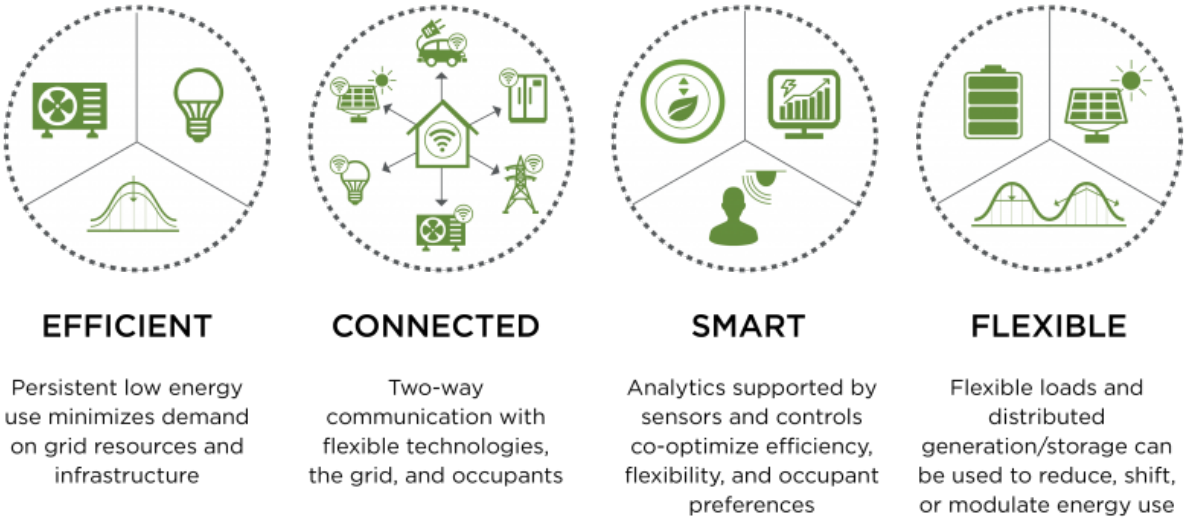


The remainder of this report summarizes the activities undertaken over the course of the project and describes the basic content and format of the GEBSforarchitects.org online toolkit that launched at the conclusion of the project.

Background

Across the US, the electricity system is evolving as it confronts the opportunities and challenges of delivering clean, reliable and affordable power to residential, commercial and institutional buildings. Driving this evolution is the continued growth of variable renewable generation and distributed energy resources (DERs), including energy efficiency, demand response, onsite generation, energy storage, and electric vehicles. As the use of these technologies continues to expand – especially in the buildings sector – the management of electricity within facilities and between facilities and the electric grid continues to become more complex. To help address this complexity, the US Department of Energy has recently launched a new RD&D initiative focused on advancing Grid-Interactive Efficient Buildings ("GEBs") that "…envisions a future in which buildings operate dynamically with the grid to make electricity more affordable and to integrate distributed energy resources while meeting the needs of building occupants."

The key characteristics of GEBs – as defined by the US Department of Energy – are outlined in the graphic below.



Work on this initiative has only recently begun, led primarily by the Department of Energy's national laboratories and organizations such as the National Association of State Energy Officials, with virtually no representation – at least to date – from the architectural community. As a means to both educate architects about GEBs and to bring them into this national conversation, the American Institute of Architects – through its Upjohn Research Initiative – awarded a $15,000 grant to the New Jersey Institute of Technology's Center for Building Knowledge commencing December 1, 2021.

Project Scope

The purpose of the Upjohn grant – which included $15,000 in matching funds – was to fund a research project that would:

1. Analyze existing, GEB-related R&D activities and findings;
2. Identify specific GEB topics that will most strongly impact architects and the facilities they design;
3. Convene a focus group of architects to review and discuss these topics in terms of how they impact day-to-day practice;
4. Incorporate the results into an online toolkit designed to help architects understand the practical, real-world implications of GEBs on their practices; and
5. Identify pathways through which the architectural profession can effectively engage with GEBs activities going forward.

This scope was successfully completed before the May 31, 2023 deadline for the grant. In addition, during June 2023, while this report was being finalized, the results of the project were presented to two groups of architects, who provided commentary that was incorporated into the GEBSforarchitects.org website – the main deliverable for the project.

The activities and outcomes of the project are summarized below.

Project Activities

Research and Analysis

The project began with an extensive research phase that reviewed and analyzed a range of existing GEB-related R&D activities and findings. A wide range of sources were accessed, the most prominent of which were:

- ASHRAE
- General Services Administration
- Lawrence Berkeley National Laboratory
- National Association of State Energy Officials
- National Renewable Energy Laboratory
- New Buildings Institute
- Rocky Mountain Institute
- US Department of Energy

Comprehensive lists of publications, webinars, and organizations resources accessed for this phase of the project – including short descriptions of their content – are included as Appendices B, C, and D to this report. The list is also incorporated into the GEBSforarchitects.org educational toolkit, the primary deliverable for the project.

As anticipated, this due diligence research revealed that the bulk of the R&D on GEBs to date has focused on the "grid" side of GEBS; with some, but much less, concentration on the "buildings" side. This is beginning to change, however, as new, buildings-focused guidance is emerging from a number of sources:

- The General Services Administration through its *Blueprint for Integrating Grid-Interactive Efficient Building Technologies into US General Services Administration Performance Contracts* study;
- ASHRAE through its forthcoming *Design and Operation of Grid-Interactive Buildings for Decarbonization Guide;*
- The New Buildings Institute through its *GridOptimal Buildings Initiative* which includes:
    - Ongoing research on case study buildings.
    - Development of a series of *GridOptimal Design Guidance Factsheets* for architects.
    - Cooperation with the US Green Building Council on a pilot "GridOptimal Building LEED Credit."

The net result is that the GEBS landscape is evolving: from an environment where grid-interactive buildings were something architects should keep their eyes on, but couldn't do much about; to one where more specific guidance – at the building level – is beginning to emerge. Admittedly, much of this emerging guidance is either at a pretty general level (e.g., the *GridOptimal Design Guidance Factsheets*) or, when more specific, primarily MEP-focused (e.g., GSA recommended strategies and/or the ASHRAE *Design Guide*). Likewise, the technologies needed to fulfill the broader goals of true grid-interactivity are still in the development stages. Nonetheless GEBS-focused information of direct use to architects is starting to emerge and should help increase the profession's capacity to engage more directly with the design of GEBS going forward.

Core Topic Identification

At the conclusion of the Research phase, – and based on the findings summarized above – a preliminary series of key GEBS topics of particular interest to architects were identified. Over the course of the project, these topics were refined and consolidated into the following list of topic areas that are addressed in the GEBS 101 training included in the GEBSforarchitects.org educational toolkit (see below).

- What is a Grid-Interactive Efficient Building?
- Why GEBS? Why Now?
- How GEBS Can Help the Grid
- How GEBS Can Help Buildings
- Key Organizations and Early Adopters (GSA, ASHRAE, New Buildings Institute)
- Case Study Examples

Focus Groups

Over the course of the project, a range of individual architects, GEBs researchers, and other stakeholders were contacted for input and comments; including representatives of AIA New Jersey and the New Jersey Clean Energy Program – core collaborators for the project.

In addition to outreach to individuals, the Project Team also convened two focus groups to provide input. The first, organized by AIA New Jersey, was conducted virtually on May 15, 2023. A representative group of 11 architects participated and reviewed the key topics identified during the Research phase. They then provided suggestions for how the topic discussions might be improved and recommended new topic ideas that could be included. A complete list of the professionals contacted over the course of the project, including focus group participants, is included in Appendix A.

The second focus group, convened by the Connecticut Green Bank, was conducted virtually on June 22, 2023, and followed the same "topic review followed by comments and input" format as the AIA NJ focus group. 13 architects and other professionals with a specific focus on high performance, energy efficient buildings participated. The resulting comments/suggestions were incorporated into the final version of the educational toolkit delivered at the conclusion of the project.

In the interim, results from the project were also presented on June 7, 2023 at the AIA Conference on Architecture 2023 in San Francisco. Roughly 50 people attended the session and there was a lively discussion of the presentation and GEBS that included representatives from the New Buildings Institute and from Tesla. Some of the content generated during these discussions was also incorporated into the final version of the educational toolkit delivered at the conclusion of the project.

Online Toolkit: GEBSforarchitects.org

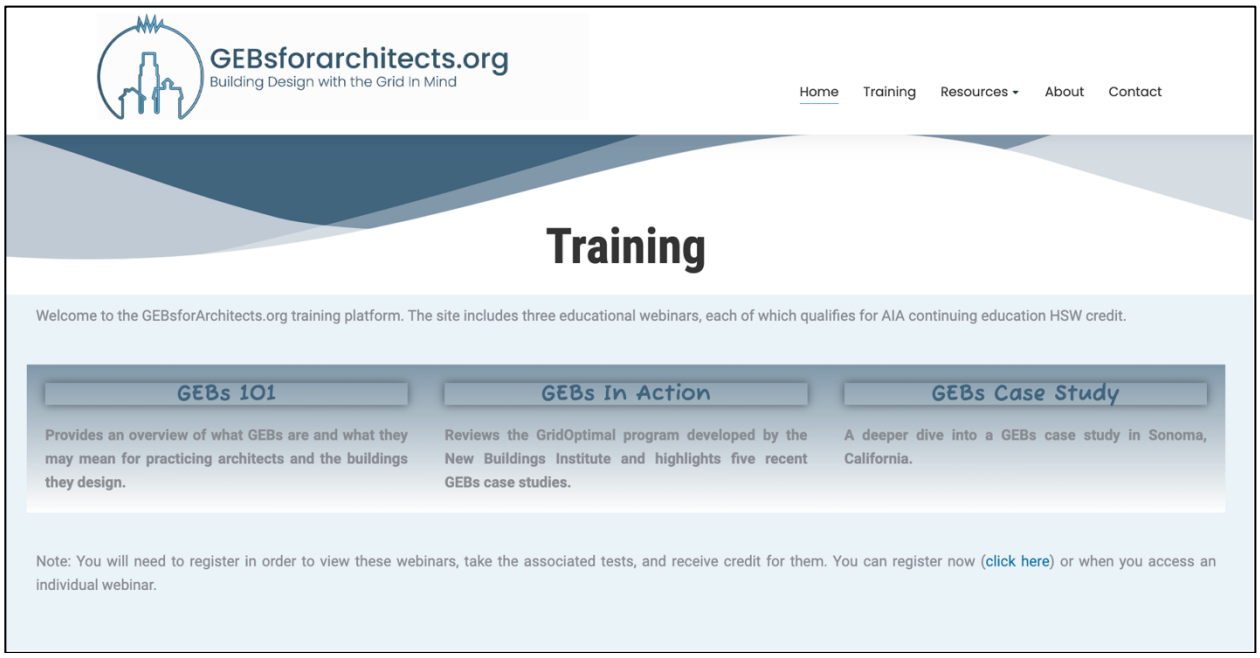
The key deliverable for the project is an online educational toolkit designed to introduce GEBs to architects and to help them understand the practical, real-world implications of GEBs on their practices.

The toolkit – GEBSforarchitects.org – was developed over the course of the project and is complete. The toolkit was launched in late June 2023 and includes two core sections: Training and Resources..

Training

The Training section includes three individual courses, all of which are delivered as online webinars:

- GEBs 101 provides an overview of what GEBs are and what they may mean for practicing architects and the buildings they design.
- GEBs In Action reviews the GridOptimal program developed by the New Buildings Institute and highlights five recent GEBs case studies.
- GEBs Case Study: A deeper dive into a GEBs case study in Sonoma, California.

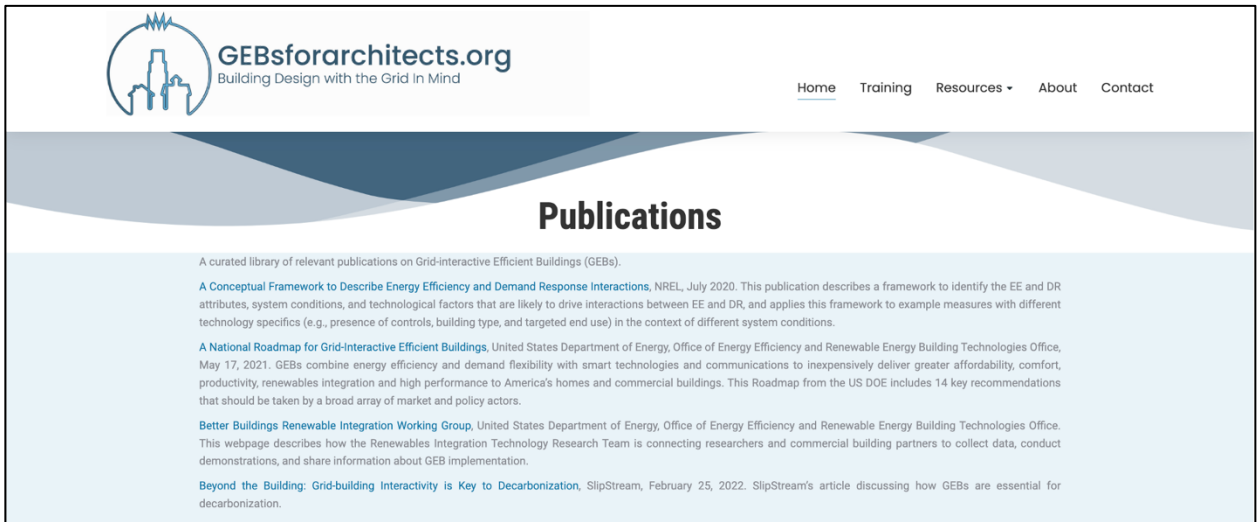


Each training module – like GEBS 101 shown here – includes an online video presentation and an online test, and each module is registered with AIA Continuing Education and is approved for AIA LU/HSW credit.

Resources

The toolkit also includes a comprehensive Resource Library, organized into three categories: Publications, Webinars and Organizations.

The Publications section provides a curated, annotated library of relevant publications on Grid-interactive Efficient Buildings (GEBs).



The Webinars section provides a curated, annotated library of relevant webinars on Grid-interactive Efficient Buildings (GEBs).

The Organizations section provides a list of key, national organizations currently engaged in the evolution of Grid-interactive Efficient Buildings (GEBs).

Pathways for Continued Engagement

As noted elsewhere in this report – and as emphasized in the GEBSforarchitects.org toolkit – the Grid-Interactive Efficient Buildings landscape is rapidly evolving. In order to monitor the impacts that GEBS can and will have on the facilities they design, architects will need to stay engaged with this evolution – at the local and national levels.

Key sources of GEBS-related information at the local level include:

- The local utility where a project is located.
- HVAC, lighting and, especially, controls manufacturers in terms of how their products address grid interactivity…now and in the future.
- Energy integrators who provide comprehensive energy and carbon management services that may impact design decisions at the facility level.
- Energy consultants who will likely be on the cutting edge of what it means to go beyond the load reduction strategies that have dominated building energy performance until now in order to embrace the emerging world of electrification, decarbonization and grid interactivity.

At the national level, the AIA and its components can actively engage with the following organizations – already mentioned in this report and featured prominently in the GEBSforarchitects.org training materials – who are currently driving the Grid-Interactive Efficient Buildings initiative; in terms of both R&D and policy.

- ASHRAE – especially the soon-to-be-released *Design and Operation of Grid-Interactive Buildings for Decarbonization Guide*.
- General Services Administration – continuing experimentation with GEBS and where they make sense in the GSA portfolio.
- Lawrence Berkeley National Laboratory – key national lab spearheading GEBS R&D.
- National Association of State Energy Officials – key organization involved in the development of electrification, decarbonization and grid-interactivity policy.
- National Renewable Energy Laboratory – another key national lab spearheading GEBS R&D.
- New Buildings Institute – continued R&D to develop practical, verifiable strategies and metrics for designing grid-interactive efficient buildings.
- Rocky Mountain Institute – ongoing R&D on operating grid-interactive efficient buildings – specifically with GSA – and work developing GEB-oriented policy recommendations.
- US Department of Energy – national R&D leader in the continuing evolution of GEBS.

Finally, the NJIT Center for Building Knowledge will continue to host and update GEBSforarchitects.org as an ongoing resource and training platform for architects interested in learning about grid-interactive efficient buildings.

APPENDICES

APPENDIX A : PROFESSIONALS CONTACTED
APPENDIX B: PUBLICATION RESOURCES
APPENDIX C: WEBINAR RESOURCES
APPENDIX D: ORGANIZATIONAL RESOURCES

APPENDIX A: PROFESSIONALS CONTACTED OVER THE COURSE OF THE PROJECT

Miscellaneous

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APPENDIX B: PUBLICATION RESOURCES

A Conceptual Framework to Describe Energy Efficiency and Demand Response Interactions, NREL, July 2020. This publication describes a framework to identify the EE and DR attributes, system conditions, and technological factors that are likely to drive interactions between EE and DR, and applies this framework to example measures with different technology specifics (e.g., presence of controls, building type, and targeted end use) in the context of different system conditions.

A National Roadmap for Grid-Interactive Efficient Buildings, United States Department of Energy, Office of Energy Efficiency and Renewable Energy Building Technologies Office, May 17, 2021. GEBs combine energy efficiency and demand flexibility with smart technologies and communications to inexpensively deliver greater affordability, comfort, productivity, renewables integration and high performance to America's homes and commercial buildings. This Roadmap from the US DOE includes 14 key recommendations that should be taken by a broad array of market and policy actors.

Better Buildings Renewable Integration Working Group, United States Department of Energy, Office of Energy Efficiency and Renewable Energy Building Technologies Office. This webpage describes how the Renewables Integration Technology Research Team is connecting researchers and commercial building partners to collect data, conduct demonstrations, and share information about GEB implementation.

Beyond the Building: Grid-building Interactivity is Key to Decarbonization, SlipStream, February 25, 2022. SlipStream's article discussing how GEBs are essential for decarbonization.

Blueprint for Integrating Grid-Interactive Efficient Building (GEB) Technologies into U.S. General Services Administration Performance Contracts, NREL and United States General Services Administration, GSA. Grid-interactive efficient buildings (GEBs) offer an integrated approach to coordinating building energy loads for cost savings, continuous demand management, and to optimize energy use for additional grid services. Advanced controls enable flexibility regarding when and how building electrical and thermal loads are operated. In an optimized manner, GEBs can mitigate peak demand challenges, enhance grid reliability/energy resiliency, and balance the supply of renewable energy generation.

Building-Grid Integration Connecting Buildings and the Power Grid, PNNL Pacific Northwest National Labs. This webpage describes PNNL's partnership with the U.S. Department of Energy's Building Technologies Office that is advancing transactive energy and associated building-grid technology development.

Challenges and Opportunities to Secure Buildings from Cyber Threats, United States Department of Energy, Office of Energy Efficiency and Renewable Energy Building Technologies Office/Pacific Northwest National Laboratory, May 14, 2020. This paper provides an overview of

commercial control systems, potential cybersecurity risks to these systems, and discusses efforts underway in government and industry to protect these systems. It concludes with a discussion of the current challenges in deploying cybersecurity best practices and capabilities and presents existing gaps in capability and resources.

Connected Buildings: The Power of Connected Buildings: Changing the Way We Manage Energy Usage, GridPoint, November 16, 2021. Article on the power of connected buildings and the future of smart buildings.

Connected Communities: A Multi Building Energy Management Approach, United States Department of Energy, Office of Energy Efficiency and Renewable Energy. This webpage discusses connected communities, which are 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 while meeting occupants' comfort and needs.

Considerations for Grid-Interactive Efficient Buildings (GEB) Pilot Projects, NASEO, December 2019. This paper outlines some factors and issues that states, localities, utilities, building owners, energy service providers, and other stakeholders should consider in contemplating grid-interactive efficient building pilot project development.

Coordinating Distributed Energy Resources for Grid Services: A Case Study of Pacific Gas and Electric, NREL, November 2018. This case study explores PG&E's demonstration of a software approach to coordinating diverse DERs—known as a DER management system (DERMS)—in a way that maintains proper grid operation while enabling DERs to provide grid services.

Demand Flexibility and Grid-Interactive Efficient Buildings 101, NASEO, September 2022. This document provides a high-level overview of Demand Flexibility and Grid-Interactive Buildings for decisionmakers and stakeholders, and a glossary of selected terms. It also offers additional resources for deeper exploration of the topics.

Demystifying GEBs: Building Demand Flexibility, Smart Electric Power Alliance, September 29, 2022. This report and associated case studies examine the barriers and potential solutions to this building energy program transition by gathering insights from utilities, program administrators, technology solution providers, and regulators.

Design Optimization and Optimal Control of Grid-Connected and Standalone Nearly/Net Zero Energy Buildings, Applied Energy. This paper presents a comprehensive review on the issues related to the design and control of these buildings, i.e. the effects of climate/site on design, design optimization methods, uncertainty and sensitivity analysis for robust design and system reliability, efficient and optimal control of high efficient generation systems and energy storage systems for alleviating/shifting the peak load, model predictive control for fast responses to smart grid, and adoption of advanced smart technologies.

Determining Utility System Value of Demand Flexibility from Grid-Interactive Efficient Buildings, ACEEE Resources, April 2020. This report focuses on ways current methods and practices that establish the value to electric utility systems of distributed energy resource (DER) investments can be enhanced to determine the value of demand flexibility in grid-interactive efficient buildings that can provide grid services. It introduces key valuation concepts that are applicable to demand flexibility in buildings and links to other documents that describe these concepts and their implementation in more detail.

Emerging Opportunities: Achieving Deeper Energy Savings Through Integrated Building Systems, ACEEE Reports, February 7, 2019. This brief focuses on various types of EMIS, their costs, potential energy savings, and challenges to more widespread use. It also explores energy efficiency program designs that encourage building owners to adopt these technologies.

Emerging Opportunities: Energy Storage, ACEEE Reports, February 7, 2019. This brief outlines the features and benefits of energy storage, defines some current challenges to widespread adoption, and describes several energy efficiency programs that incentivize these technologies. We conclude with recommendations to program administrators and policymakers to encourage the use of storage systems.

Energy-Efficient and Grid-Interactive Buildings, NREL. This webpage describes NREL's buildings-to-grid research at the Energy Systems Integration Facility (ESIF) targeting solutions to minimize energy consumption while improving the interaction between the building and the grid.

GEB Capabilities for Community Equity and Resilience Value, Regulatory Assistance Project (RAP), October 5, 2021. Slide deck for the California Energy Commission (CEC) Integrated Energy Policy Report (IEPR) Workshop on Grid-Integrated Efficient Buildings.

GEB Technical Report Series: An Overview of Research Challenges and Gaps, United States Department of Energy, Office of Energy Efficiency and Renewable Energy Connected Communities, December 2019. This report evaluates state-of-the-art and emerging building technologies that have significant potential to provide grid services. It also identifies major research challenges and gaps facing the technologies as well as opportunities for technology-specific R&D.

Grid-interactive Efficient Buildings, Rutgers: NJ Green Building Manual. Article on Grid-interactive Efficient Homes - energy efficient homes with smart technologies designed to utilize multiple distributed energy resources in an integrated way to optimize energy use for grid services and occupants.

Grid-Interactive Efficient Buildings, United States Department of Energy, Office of Energy Efficiency and Renewable Energy Building Technologies Office. This webpage describes how the Building Technologies Office research is helping make buildings become smarter about the amount and timing of energy use and emit less carbon through the Grid-interactive Efficient Buildings (GEB) Initiative.

Grid-Integrated Buildings: A Profitable Linchpin to Decarbonization, RMI Rocky Mountain Institute, November 15, 2018. This article describes the importance of grid-interactive buildings in the effort to meet climate goals.

Grid-Interactive Efficient Buildings Are Active Efficiency, Michaels Energy, November 29, 2021. This webpage discusses Grid interactive efficient buildings (GEBs) and how they will help accommodate intermittent renewable solar and wind power generation while minimizing grid and supply-side energy costs.

Grid-Interactive Efficient Buildings Fact Sheet, United States Department of Energy, Office of Energy Efficiency and Renewable Energy, April 2019. Fact sheet from the DOE Energy Efficiency & Renewable Energy Office describing grid-interactive buildings and their importance.

Grid-Interactive Efficient Buildings (GEB) in the Midwest, Midwest Energy Efficiency Alliance. This webpage discusses GEBs, energy efficiency programs, and the status of GEBs in the Midwest.

Grid-Interactive Efficient Buildings (GEBs), ACEEE. This webpage discusses the American Council for an Energy-Efficient Economy (ACEEE)'s project to understand the opportunities and barriers to developing programs that support grid-interactive efficient buildings (GEBs).

Grid-Interactive Efficient Buildings (GEBs), Prescriptive Data Nantum Grid Services. Description of grid-interactive, efficient buildings (GEBs) from Nantum OS on their website.

Grid-Interactive Energy Efficient Buildings (GEBs), RMI Rocky Mountain Institute. This webpage describes RMI's efforts in the movement toward a smart, two-way grid interacting with intelligent, responsive buildings that can deliver new opportunities to save costs for building owners, operators, utilities and operators.

Grid-Interactive Efficient Buildings (GEBs), United States General Services Administration. GSA, in partnership with the U.S. Department of Energy (DOE) Commercial Buildings Integration program, released a Request for Information in 2019 seeking technology providers to partner on GEB demonstration projects. In 2020, these two programs selected four Grid-interactive Efficient Building (GEB) technology solutions to be validated in both private sector and GSA facilities.

Grid-Interactive Efficient Buildings (GEBs) Flexibility is the Future, SlipStream. This webpage describes SlipStream's work on Grid-Interactive Buildings.

Grid-Interactive Efficient Buildings: How to Start Saving from Day One, energypost.eu. This webpage discusses the benefits and savings grid-interactive buildings can provide.

Grid-Interactive Efficient Buildings Made Easy: A GSA Building Manager's Guide to Low-and No-Cost GEB Measures, RMI Rocky Mountain Institute, June 10, 2021. This document provides an overview of grid-interactive efficient buildings (GEBs) and actionable steps for GSA building managers to implement low- and no-cost measures that result in utility cost savings and greenhouse gas (GHG) emissions reductions.

Grid-Interactive Efficient Buildings – Projects Summary, United States Department of Energy, Office of Energy Efficiency and Renewable Energy Building Technologies Office, July, 2020. This report on the DOE's Building Technologies Office's grid-interactive efficient building (GEB) research describes its efforts to build on existing energy efficiency efforts to optimize the interplay among energy efficiency, demand response, behind-the-meter generation and energy storage to increase the flexibility of demand-side management.

Grid-Interactive Efficient Buildings State Briefing Paper, NASEO, October 2019. This document provides a brief overview of the core aspects of a grid-interactive efficient building (GEB) and related flexible load management topics to help states and other stakeholders discern benefits of and challenges to demand flexibility.

Incentive Mechanisms for Leveraging Demand-Flexibility as a Grid Asset, Guidehouse, May 11, 2021. An implementation guide for utilities, policymakers, and customers.

Integrated Energy Efficiency and Demand Response Programs, ACEEE Reports, September 10, 2019. This report reviews filings from 44 of the largest utilities in the country to identify and describe existing EE/DR programs. The report concludes by examining barriers to more prevalent EE/DR and make recommendations for overcoming them.

Intelligent Efficiency Technology and Market Assessment, ACEEE Reports, April 25, 2017. This report analyzes over two dozen of intelligent efficiency applications in the buildings, manufacturing, transportation, and government sectors, describing the technologies involved, characterizing their use, and quantifying their deployment. It also looks at several enabling and cross-cutting technologies and the use of intelligent efficiency in utility-sector energy efficiency programs.

Lighting, HVAC, and Plug Load Integration, SlipStream, September 1, 2021. Article discussing SlipStream's Integrated Controls study team's pilot study for the U.S. Department of Energy's Integrated Lighting Campaign to integrate building systems more efficiently to produce greater cost savings and climate solutions.

NASEO GEB Resources, NASEO. NASEO's webpage devoted to GEBs resources.

NASEO NARUC Grid-Interactive Buildings Working Group, NARUC Centers for Partnership & Innovation. This webpage introduces the GEB Working Group, through which State Energy Officials and state utility regulators can explore GEB/DF technologies and applications; identify opportunities and impediments (technical and non-technical); identify and express state

priorities and interests; inform policy, planning, programs and regulation; consider unregulated electric sector investments and implications; and advance GEB/DF road map and pilot options.

Pilot Considerations for Grid-Interactive Efficient Buildings in Hawaii, United States Department of Energy Grid-Modernization Consortium, March 2022. This brief provides information laying out the goals and data needed for a successful GEB pilot and addressing key utility priorities that GEB can help contribute to. It presents illustrative examples that consider the metrics for gauging pilot success and considerations for public utility commissions and pilot designers.

Pilot Considerations for Grid-Interactive Efficient Buildings in Washington, United States Department of Energy Grid-Modernization Consortium, November 2021. This brief provides information laying out the goals and data needed for a successful GEB pilot and addressing key utility priorities that GEB can help contribute to. The report presents illustrative examples that consider the metrics for gauging success and considerations for public utility commissions.

Residential Grid-Interactive Efficient Building Technology and Policy: Harnessing the Power of Homes for a Clean, Affordable, Resilient Grid of the Future, NASEO and AnnDyl Policy Group, LLC, October 2019. Article on Grid-interactive Efficient building technology and policy for homes.

Roadmapping: A Tool for States to Advance Load Flexibility and Grid-Interactive Efficient Buildings, NASEO, This report provides a roadmap guideline to enable states and localities to make informed decisions when considering actions to support GEBs and use of load flexibility for energy management.

Securing Grid-interactive Efficient Buildings (GEB) through Cyber Defense and Resilient System (CYDRES), Arizona State University. This webpage discusses the growing need for cyber security to be considered in Building Automation Systems (BASs) and Grid-interactive Efficient Buildings (GEBs), as they remain vulnerable to cyber-attacks.

Smart Buildings: A Deeper Dive into Market Segments, ACEEE Reports, December 20 2017. Beginning where the previous Smart Buildings study left off, this report takes a deeper dive into four commercial building types: offices, retail, hotels, and hospitals, detailing costs and energy savings for these subsectors, describing the nonenergy benefits of smart technologies, and discussing the challenges to their widespread adoption.

Smart Buildings: Using Smart Technology to Save Energy in Existing Buildings, ACEEE Reports, February 17, 2017. This report provides an in-depth look at various smart technologies for commercial building end uses including HVAC, lighting, and plug loads.

Smart Grid: How to Integrate Buildings for Maximum Benefit, facilitiesnet. This webpage provides tips and advice on how best to integrate buildings with the ever-evolving smart grid.

State and Local Building Policies and Programs for Energy Efficiency and Demand Flexibility, NASEO, February 2021. This report discusses a selection of building energy policies and program types that have focused on energy efficiency but that states and localities can modify and evolve to include Demand Flexibility and grid impact parameters.

State of the Market: Grid-Interactive Efficient Building Utility Programs, ACEEE Reports, October 30, 2019. This paper proposes that holistic GEB programs that accurately value efficiency and grid benefits might have even greater potential. It outlines some ways utilities and program administrators can create programs now to start preparing for a future of grid-interactive efficient buildings.

Sustainable Facilities Tool Grid-Interactive Efficient Buildings, United States General Services Administration. This webpage describes how the U.S. Department of Energy's Building Technologies Office is uniting the goals of building energy efficiency and building and grid integration into one suite of strategies.

The Future of Buildings: Everything is Connected, Northeast Energy Efficiency Partners, This webpage discusses grid-interactive and connected buildings that have the ability to shed, shift, or modulate energy use in response to grid communication signals.

The GridOptimal Buildings Initiative: How Buildings Can Support Grid Operations and Decarbonization, nbi New Buildings Institute, May 2019. This paper describes the New Buildings Institute's GridOptimal™ Buildings Initiative project, in partnership with the U.S. Green Building Council (USGBC), that will develop metrics by which building features and operating characteristics that support more effective grid operation and decarbonization can be measured and quantified.

The Three Pillars of GEB Controls, SlipStream, February 25, 2022. This article discusses GEBs and its three pillars: Integration, Communication, and Organization and Control.

Turning Buildings into a Source of Energy: The Grid Interactive Building, Siemens. Siemens' white paper describing the future vision of grid interactive buildings and how commercial buildings, education, industry and healthcare can play an active role in a more decarbonized energy system.

Why Grid-Interactive Efficient Buildings Feature Prominently in Joe Biden’s Plans, Clean Technica, June 4, 2021. Article discussing the role and importance of grid-interactive buildings in President Biden's plans and programs.

Wringing More Value from Building Energy Operations and Upgrades: Monetizing Demand Flexibility in Public and Institutional Buildings, NASEO, February 2021. This report discusses demand flexibility (DF) as a way to tap value from peak demand management, time-differentiated electricity rates, demand response (DR) programs, and nascent grid-service markets.

APPENDIX C: WEBINAR RESOURCES

A National Roadmap for Grid-Interactive Efficient Buildings, EETDEMP, May 27, 2021. This video webinar, based on the Roadmap developed by Lawrence Berkeley National Laboratory, the Brattle Group, and US DOE's Building Technologies Office, identifies the most important barriers and outlines the key opportunities for full implementation of GEBs and associated demand flexibility.

Connecting Communities with Grid Integrated Buildings and Integrated Distributed Energy Resources, BEST Building Efficiency for a Sustainable Tomorrow, June 2, 2022. This webinar discusses connecting communities with grid-interactive buildings and integrated distributed energy resources.

GEB Capabilities for Community Equity and Resilience Value, Regulatory Assistance Project (RAP), October 5, 2021. Slide deck for the California Energy Commission (CEC) Integrated Energy Policy Report (IEPR) Workshop on Grid-Integrated Efficient Buildings.

Grid Interactive Efficient Buildings, Smart Buildings Center, August 2022. This session features two "case study" presentations on Grid-Interactive Efficient Buildings (GEBs). Additional subject matter experts join in a moderated discussion of GEB potential.

Grid-Interactive Efficient Buildings IEA Modernising Energy Efficiency through Digitalisation Initiative, United States Department of Energy, Office of Energy Efficiency and Renewable Energy Building Technologies Office, January 31, 2019. Slide deck from the United States DOE Office of Energy Efficiency and Renewable Energy Building Technologies Office's webinar on grid-interactive buildings.

Inspecting the Building of the Future, Sustainable Energy Action Committee, Building inspectors can watch this 5-minute video for an introduction to the grid-interactive efficient building (GEB).

Let's Talk about GEB: Modeling and Control, Berkley Lab ETA, May 31, 2019, This webinar by Amir Roth from EERE's Building Technologies Office discusses the GEB initiative, integrating energy efficiency and demand response, what EERE thinks about this, and how it expects to move forward.

NASEO NARUC GEB WG: Considerations for Grid-Interactive Efficient Buildings (GEB) Pilot Projects, NASEO NARUC, Pacific Northwest Laboratory, August 10, 2021. This webinar summarizes key points from a technical brief developed for Washington on GEB pilots and the approach being taken to develop a tailored technical brief for Hawaii. It also includes brief presentations from staff of the Washington Department of Commerce and Hawaii Public Utilities Commission on their motivation and interest in GEB pilots.

NASEO-NARUC Grid-Interactive Efficient Buildings Working Group: GEB and Automated Demand Response Overview Webinar, NASEO, April 10, 2019, This webinar hosted by NASEO discusses challenges and opportunities for the grid and the capability of buildings to provide grid services. The webinar also reviews recent studies and field data, offers a grid needs framework, discusses the complementarity of energy efficiency with demand response, and covers the status of demand response automation technology, metrics, and related efforts.

The Grid-Interactive Efficient Buildings (GEB) Challenge, Oak Ridge National Laboratory, July 29, 2020, This webinar introduces the Grid-Interactive Efficient Buildings Challenge for the 2020 JUMP into STEM competition.

APPENDIX D: ORGANIZATIONAL RESOURCES

ACEEE - The American Council for an Energy-Efficient Economy is a nonprofit, 501 organization. Founded in 1980, ACEEE's mission is to act as a catalyst to advance energy efficiency policies, programs, technologies, investments, and behaviors to help achieve greater economic prosperity, and environmental protection.

ASHRAE - ASHRAE is a global society advancing human well-being through sustainable technology for the built environment. The Society and its members focus on building systems, energy efficiency, indoor air quality, refrigeration and sustainability within the industry. Through research, standards writing, publishing and continuing education, ASHRAE shapes tomorrow's built environment today.

Lawrence Berkley National Laboratory - Lawrence Berkeley National Laboratory is a U.S. DOE Office of Science national laboratory managed by the University of California.

Pacific Northwest National Laboratory - Pacific Northwest National Laboratory is a leading center for scientific discovery in chemistry, data analytics, and Earth science, and for technological innovation in sustainable energy and national security.

NARUC National Association of Regulatory Utility Commissioners - The National Association of Regulatory Utility Commissioners (NARUC) is a non-profit organization dedicated to representing the state public service commissions who regulate the utilities that provide essential services such as energy, telecommunications, power, water, and transportation.

NASEO National Association of State Energy Officials - NASEO is the only national non-profit association for the governor-designated energy officials from each of the 56 states and territories. NASEO facilitates peer learning among state energy officials, serves as a resource for and about State Energy Offices, and advocates the interests of the State Energy Offices to Congress and federal agencies.

nbi New Buildings Institute - New Buildings Institute (nbi) works collaboratively with industry market players—governments, utilities, energy efficiency advocates and building professionals—to promote advanced design practices, innovative technologies, public policies and programs that improve energy efficiency at the highest levels and decarbonize the built environment.

NREL National Renewable Energy Laboratory - NREL is a national laboratory of the U.S. Department of Energy. NREL advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and provides the knowledge to integrate and optimize energy systems.

Oak Ridge National Laboratory - Oak Ridge National Laboratory is the world's premier research institution, empowering leaders and teams to pursue breakthroughs in an environment marked by operational excellence and engagement with the communities where we live and work.

RMI Rocky Mountain Institute - RMI is an independent, non-partisan, nonprofit organization of experts across disciplines working to accelerate the clean energy transition and improve lives. Our Mission: Transforming the global energy system to secure a clean, prosperous, zero-carbon future for all.

United States Department of Energy - The United States Department of Energy is an executive department of the U.S. federal government that oversees U.S. national energy policy and manages the research and development of nuclear power and nuclear weapons in the United States. The mission of the Energy Department is to ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions.

United States General Services Administration (GSA) - The General Services Administration is an independent agency of the United States government established in 1949 to help manage and support the basic functioning of federal agencies.