A National Roadmap for Grid-Interactive Efficient Buildings

Available at: gebroadmap.lbl.gov

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

BUILDING TECHNOLOGIES OFFICE

ESIG SPRING WORKSHOP: BUILDINGS AS A SOURCE OF GRID FLEXIBILITY
MARCH 23, 2022

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Why GEBs?

Integrate the growing share of variable renewable energy

Reduce costs to replacing aging electricity system infrastructure and improve system reliability

Assist in achieving decarbonization goals through reduced fossil fuel generation and increased heating electrification

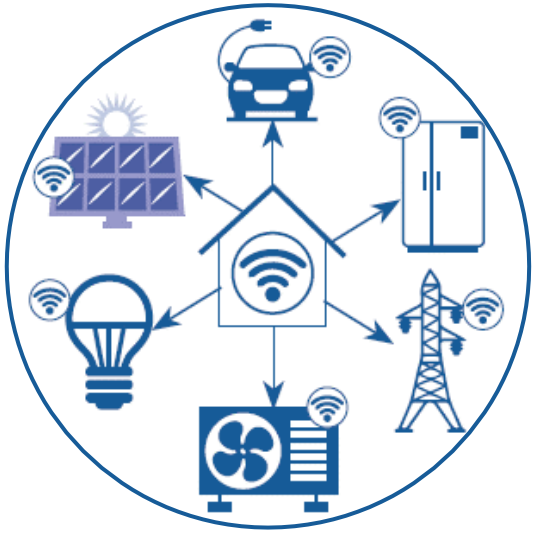
Optimize energy use based on customer preferences

FLEXIBLE BUILDING LOADS CAN BENEFIT OWNERS, OCCUPANTS, AND THE ELECTRIC GRID

GEBs are characterized by active, continuous, and integrated energy use

EFFICIENT

Persistent low energy use minimizes demand on grid resources and infrastructure



CONNECTED

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

SMART

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

FLEXIBLE

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

Figure source: Neukomm et al. (2019). Grid-interactive Efficient Buildings: Overview. US DOE Report.

The *Roadmap* presents key actions that could be taken immediately by a wide range of industry stakeholders

Roadmap objectives

- Estimate the value of the untapped GEB opportunity to the power system
- Define GEB technology features and integration considerations
- Identify and prioritize barriers to GEB deployment and to achieving the untapped potential
- Define options for overcoming the barriers, and recommend key actions for all industry stakeholders

More than 100 practitioners, researchers, regulators, policymakers, and other experts contributed to developing this *Roadmap*

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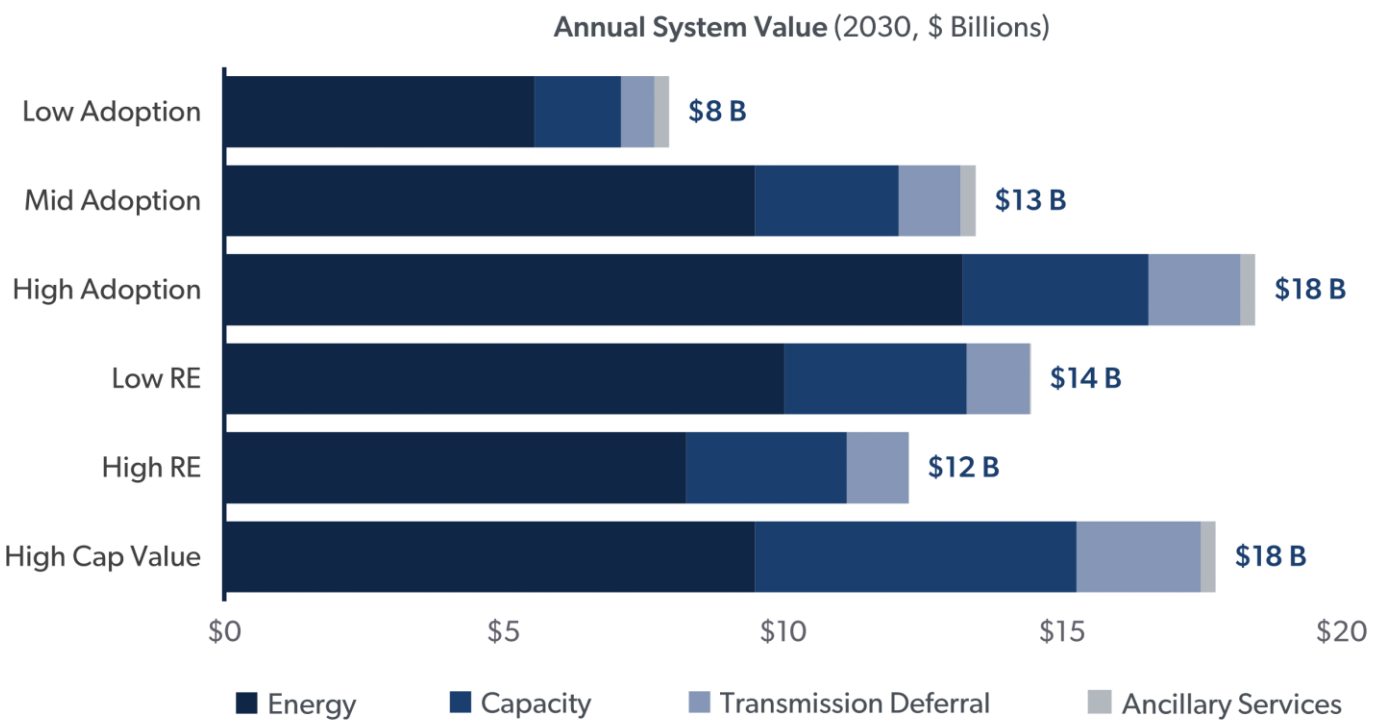
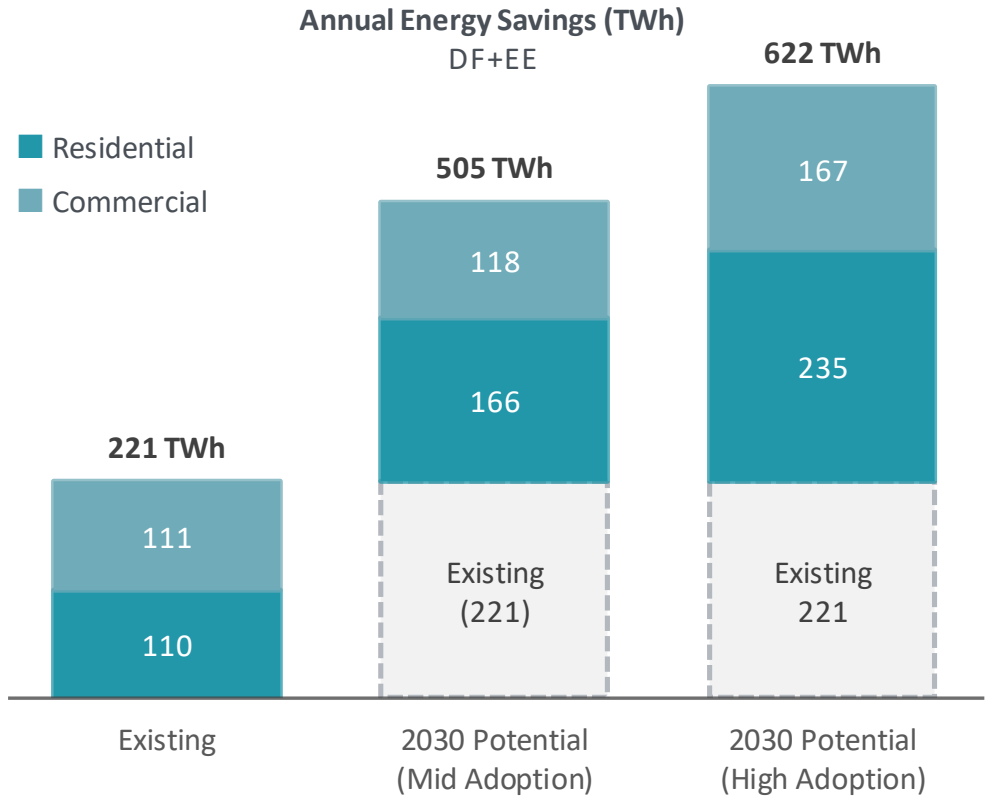
GEBs could save up to $18 billion per year in power system costs by 2030, or roughly **$100 to $200 billion** between 2020 and 2040 and significantly increase existing U.S. DR and EE capability



Notes: All in 2019 dollars. Peak demand savings are computed as the sum of impacts during each region's coincident peak hour. $100 - $200 billion reflects the NPV at a social discount rate of 4% nominal (2% real).

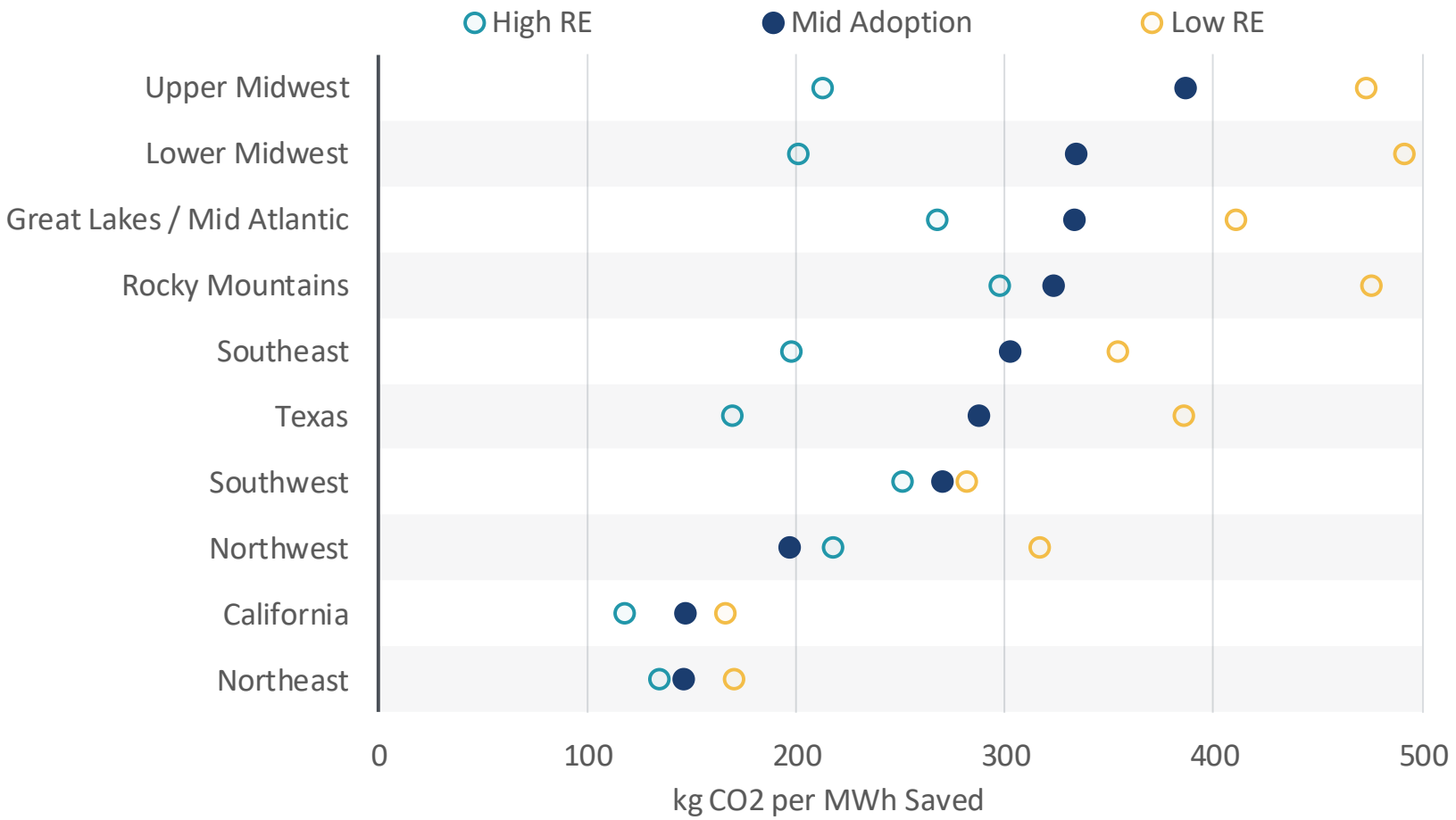


Notes: "Existing" EE covers capability developed between 2010 and 2019. "2030 Potential" EE covers modeled savings capability that could be developed between 2021 and 2030 and is incremental to existing EE.

Nationally, GEBs could save 80 million tons of CO_2 annually by 2030, or 6% of all power sector CO_2 emissions

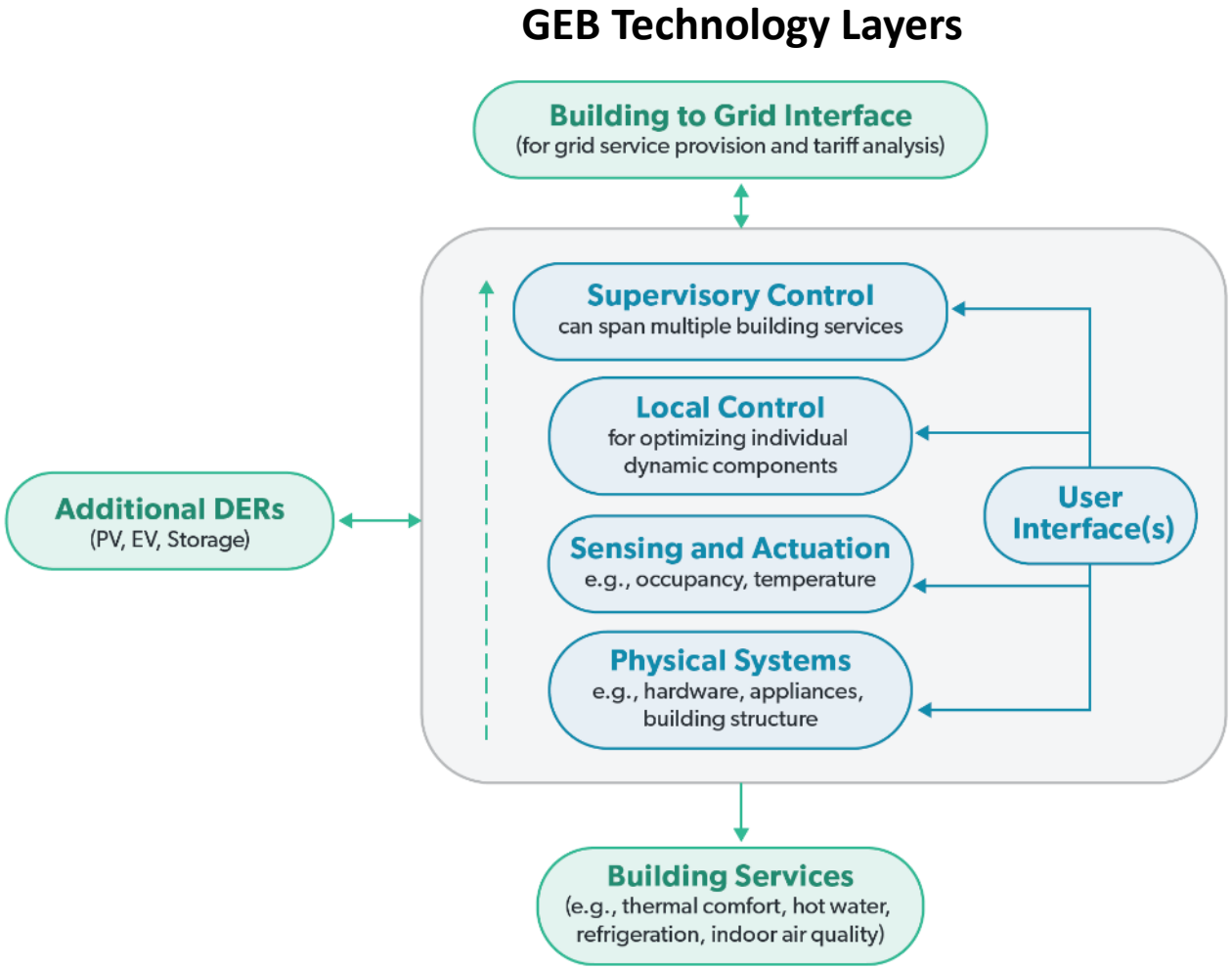
- Equivalent to more than 50 medium-sized coal plants, or 17 million cars
- CO_2 savings opportunities vary by region

Regional Emissions Reduction per MWh of Energy Savings from GEBs (2030)



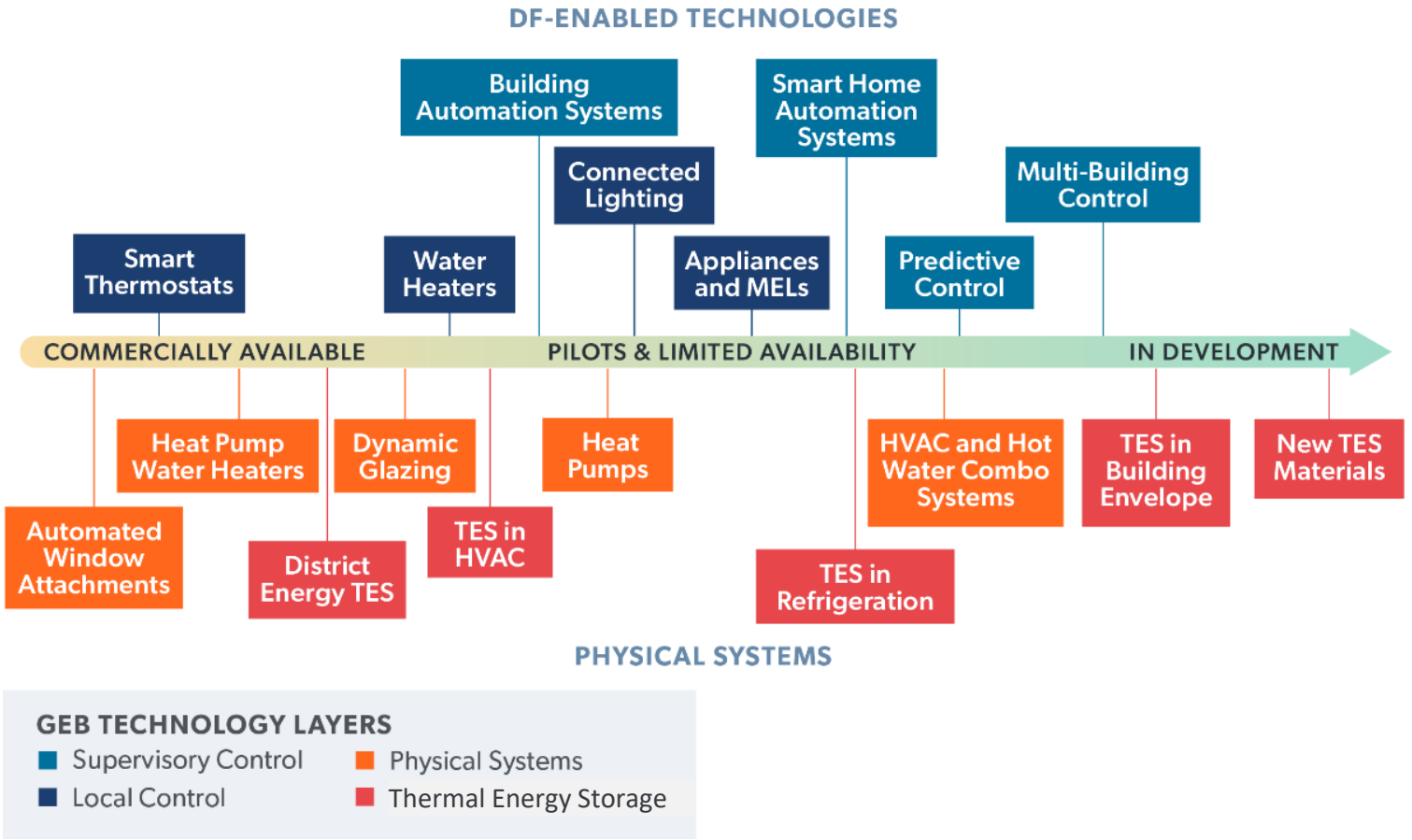
For GEB performance to advance, various systems, technologies, and user interfaces will need to be integrated

- There are several layers of systems between the building and the grid
- Two types of technology integration will be important:
  1. **Integration between layers**, which maximizes performance and avoids conflicts between competing objectives
  2. **Integration across multiple end-uses**, which takes advantage of synergies between end-use systems



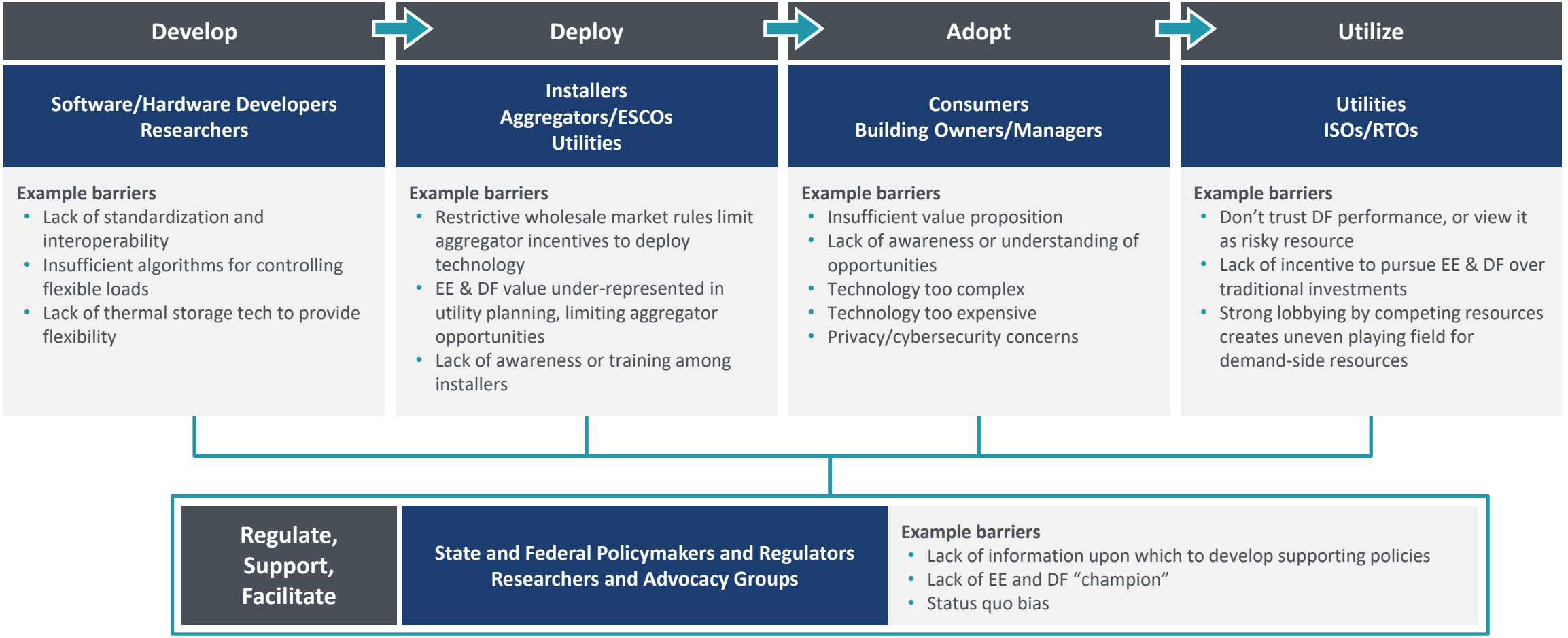
Developing the GEB technology pipeline will unlock new opportunities to improve building efficiency and grid-interactivity

GEB Technology Pipeline, with Examples for Each Technology Layer



Barriers at all points in the value chain need to be overcome in order to maximize the value of GEBs

The GEB Value Chain and Key Barriers



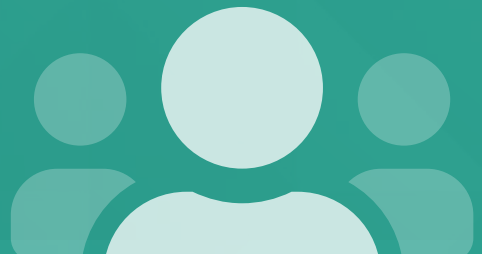
Pillar 1: Advancing GEBs through research and development

Recommendation	Example Action
Research, Develop and Accelerate Deployment of GEB Technologies	Support development and field testing of user-friendly, affordable integrated whole-building control and grid service delivery
Accelerate Technology Interoperability to Optimize Efficiency and Demand Flexibility Performance	Accelerate adoption of existing open standards, particularly at the application layer
Collect and Provide Data and Develop Methods for Benchmarking and Evaluating Demand Flexibility Technology & Whole Building Performance	Expand EE benchmark dataset and benchmarking tools to incorporate demand flexibility

Pillar 2: Enhancing the Value of GEBs to Consumers and Utilities

Recommendation	Example Action
Improve and Expand Innovative Customer Demand Flexibility Program Offerings	Design and market demand flexibility programs with a focus on consumer preferences
Expand Consumer Knowledge and Consideration of Price-based Programs	Plan for full scale deployment
Introduce Incentives for Utilities to Deploy Demand Flexibility Resources	Identify and evaluate the appropriate incentive mechanisms to encourage investment in demand-side programs
Comprehensively Incorporate Demand Flexibility into Utility Resource Planning	Ensure that a comprehensive list of demand-side measures are considered in the analysis, and account for all applicable value streams

Pillar 3: Empowering GEB Users and Operations



Recommendation	Example Action
Understand How Users Interact with GEBs and the Role of Technology	Evaluate the relationship between prices, incentives, technology and load flexibility
Develop Tools to Support Decision Making on Design and Operation of GEBs	Enhance capabilities of existing building performance tools to include demand flexibility and GHG emissions information
Leverage Existing Building-Related Workforce Programs to Integrate Advanced Building Technology and Operations Education and Training	Establish building training and assessment centers

Pillar 4: Supporting GEB Deployment through State and Federal Enabling Programs and Policies

Recommendation	Example Action
Lead by Example	Government building participation in demand response and energy efficiency programs and markets
Expand Funding and Financing Options for GEB Technologies	Identify how requirements of existing financing and funding mechanisms for EE can be modified to include demand flexibility
Expand Codes and Standards to Incorporate Demand Flexibility	Combine grid-interactive requirements and open standards for automated communication with energy efficiency requirements
Consider Implementing Demand Flexibility in State Targets or Mandates	Consider establishing statewide or utility-specific demand flexibility procurement requirements

Appendix

Additional GEB benefits not captured in this study could significantly increase the value estimate

Avoided or deferred need for distribution capacity: Geographically targeted EE and DF deployments can help to alleviate the need for demand-related distribution system upgrades

Reduced need for RPS-related builds: By reducing system load, EE reduces the amount of investment in renewable generation that is otherwise required to satisfy RPS requirements

"Option value": The benefits in this study are based on normal weather and load conditions. System costs can be disproportionately higher when load increases due to extreme conditions

Other consumer benefits: In addition to reduced costs and improved reliability, GEBs can improve the satisfaction of building owners and occupants, increasing choice and flexibility in how electricity is consumed, and in some cases, improve the overall comfort of building occupants.

Electrification: GEB benefits in this study would be considerably higher in a future scenario that involves significant electrification of heating and transportation. Higher electricity demand will increase the need for supporting grid infrastructure, which can be displaced through EE and demand flexibility.

Pillar 1: Advancing GEBs through research and development

RECOMMENDATION 1

Research, Develop and Accelerate Deployment of GEB Technologies

- Set R&D targets to make grid-interactive equipment cost-effective and easier to install and operate, prioritizing thermal energy systems
- Explore opportunities to integrate and control affordable thermal energy storage
- Support development and field testing of user-friendly, affordable integrated whole-building control and grid service delivery
- Develop and demonstrate integrated low-carbon building retrofit packages that leverage GEBs

RECOMMENDATION 2

Accelerate Technology Interoperability to Optimize Efficiency and Demand Flexibility Performance

- Accelerate adoption of existing open standards, particularly at the application layer
- Identify additional open standards needed at the application layer across grid services
- Streamline delivery of GEB applications and capabilities by providing standard solutions for data interpretability
- Provide system and device level reporting capabilities
- Enable users to provide control permissions to trusted third-party applications and services
- Field validate the benefits of enhanced interoperability
- Explore methods to rate or score interoperability of devices and buildings

RECOMMENDATION 3

Collect and Provide Data and Develop Methods for Benchmarking and Evaluating Demand Flexibility Technology & Whole Building Performance

- Develop standard methods for data collection and analysis, and measurement and verification of demand flexibility technologies and strategies.
- Expand energy efficiency benchmark datasets and benchmarking tools to incorporate demand flexibility

Pillar 2: Enhancing the Value of GEBs to Consumers and Utilities

RECOMMENDATION 1

Improve and Expand Innovative Customer Demand Flexibility Program Offerings

- Design and market demand flexibility programs with a focus on consumer preferences
- Package demand flexibility with other consumer offerings
- Consider additional value streams in incentive-based demand flexibility program compensation
- Review existing programs for opportunities to modernize design
- Develop partnerships between utilities and aggregators to help implement incentive-based demand flexibility programs
- Research and socialize data on innovative demand flexibility programs
- Encourage innovative demand flexibility programs and pilots

RECOMMENDATION 2

Expand Consumer Knowledge and Consideration of Price-based Programs

- Consider customer adoption of EE and demand flexibility measures as part of broader rate design objectives
- Understand customer enrollment and bill impacts
- Take an inclusive approach to marketing the new options to consumers
- Plan for full scale deployment

RECOMMENDATION 3

Introduce Incentives for Utilities to Deploy Demand Flexibility Resources

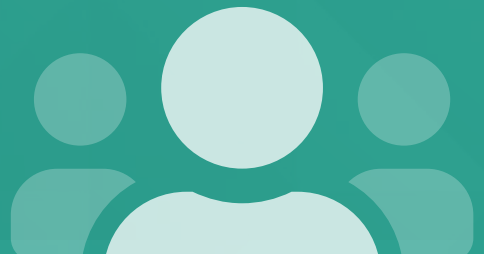
- Identify and evaluate the appropriate incentive mechanisms to encourage investment in demand side programs
- Assess whether and how the incentive mechanisms of interest may comport with existing laws and regulations
- Develop key design parameters and metrics for the adopted incentive mechanisms, as well as the process for setting specific program targets
- Evaluate customer impacts when estimating the cost-effectiveness of the new incentive mechanism
- Perform research studies and provide technical assistance
- Consider underserved communities when establishing performance metrics
- Identify opportunities for improving demand flexibility access to wholesale markets

RECOMMENDATION 4

Comprehensively Incorporate Demand Flexibility into Utility Resource Planning

- Ensure that a comprehensive list of demand side measures are considered in the analysis
- Account for all applicable value streams
- Develop robust representation of demand flexibility measure performance characteristics
- Account for interactions between demand side resources
- Increase consideration of Non-Wires Solutions (NWS)
- Research and socialize best practices for incorporating demand side resources into resource planning

Pillar 3: Empowering GEB Users and Operations



RECOMMENDATION 1

Understand How Users Interact with GEBs and the Role of Technology

- Understand user perceptions of the value of providing demand flexibility
- Openly document technology installation, configuration, and operation experiences
- Quantify user preferences for building service levels and availability
- Evaluate the relationship between prices, incentives, technology and load flexibility

RECOMMENDATION 2

Develop Tools to Support Decision Making on Design and Operation of GEBs

- Enhance capabilities of existing building performance tools to include demand flexibility and GHG emissions information
- Validate GEB decision support tools by comparing field data with simulation data
- Collect and publish data on the hard and soft costs of installing and configuring advanced sensing and control technologies needed for a fully optimized GEB and related DERs
- Develop advanced data-driven analysis methods to support GEB technology decision support, design and selection tools

RECOMMENDATION 3

Leverage Existing Building-Related Workforce Programs to Integrate Advanced Building Technology and Operations Education and Training

- Establish skill and credential standards relevant to advanced building technologies and operations
- Expand relevant curricula, training programs, and certifications
- Broaden relevant workforce development programs
- Develop resources and provide funding to facilitate outreach to students in K-12 schools, community colleges, and universities
- Establish building training and assessment centers

Pillar 4: Supporting GEB Deployment through State and Federal Enabling Programs and Policies

RECOMMENDATION 1

Lead by Example

- Integrate demand flexibility in initiatives for corporate partnerships
- Promote demand flexibility for ESPC
- Participate in demand response and energy efficiency programs and markets
- Broaden building energy tracking requirements in public buildings

RECOMMENDATION 2

Expand Funding and Financing Options for GEB Technologies

- Evaluate financing and funding mechanisms and determine if new financial assistance mechanisms are needed
- Identify how requirements of existing financing and funding mechanisms for EE can be modified to include demand flexibility
- Promote partnerships between utilities and entities that receive public funding

RECOMMENDATION 3

Expand Codes and Standards to Incorporate Demand Flexibility

- Determine aspects of demand flexibility that may be considered for codification
- Combine grid-interactive requirements and open standards for automated communication with energy efficiency requirements
- Provide technical assistance to government entities and professional organizations responsible for codes and standards development

RECOMMENDATION 4

Consider Implementing Demand Flexibility in State Targets or Mandates

- Conduct research to assess cost-effective and achievable demand flexibility potential for a given jurisdiction or service territory
- Consider implementing peak reduction standards
- Consider establishing statewide or utility-specific demand flexibility procurement requirements

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