U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Grid-interactive Efficient Buildings Overview Session

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www.energy.gov/eere/buildings/geb

Objectives of GEB "Virtual" Track

- **Provide an update on GEB strategy and project status**
- **Discuss and solicit feedback on existing research & analysis contributing to GEB strategy formulation**
  - Receive feedback on new definitions and frameworks
  - Share a summary of GEB RFI results and discuss key issues
  - Review draft GEB Technical Reports outlining research opportunities
- **Receive critical feedback on overall progress to identify gaps and new opportunities**

BTO's grid-interactive efficient buildings portfolio

VALUATION

How do *time & the interaction of flexibility options* impact value?

Identify values to stakeholders, quantification of national value.

TECHNOLOGY OPTIONS

Which end use technologies provide solutions to specific grid needs?

Prioritize technologies / solutions based on grid services.

OPTIMIZATION

How to while maintaining or improving optimize for flexibility building operation?

Solutions that meet grid operator & building occupant needs.

VALIDATION

Do technologies perform as predicted and meet grid & occupant needs?

Verification of technologies / strategies, increasing confidence in the value of energy flexibility.

GEB "Virtual" Track at Peer Review

Session Name	Session Time	Location	Notes
GEB Overview	4/15 11:00	Washington	Summary of BTO's GEB efforts
End-Use Load Shape Project	4/15 11:30	Washington	GEB analysis project
GEB Strategy Discussion	4/15 13:30	Washington	Discussion on GEB strategy based on recent RFI feedback and priority issues
GEB Valuation	4/15 15:00	Washington	Discussion on BTO's framework for GEB valuation
Lighting-GEB Technical Report	4/15 16:00	Jackson	Review and discuss GEB Lighting Technical report
Envelope- GEB Technical Report	4/16 13:30	Van Buren	Review and discuss GEB Envelope Technical report
HVAC -GEB Technical Report	4/16 16:00	Commonwealth	Review and discuss GEB HVAC Technical report
Grid-compatible Controls	4/17 10:00	Washington	Portfolio update and discussion on grid-compatible controls
S&C, BEM, and Data Analytics – GEB Technical Report	4/17 14:30	Washington	Review and discuss GEB S&C, Modeling and Data Analytics Technical report

GEB "Virtual" Projects

Session Name	Session Time	Location	Notes
GEB in Codes	4/15 17:00	Washington	Discussion of current codes/potential future requirements
Lighting & Grid Integration Research	4/15 17:00	Jackson	Discussion of grid service opportunities provided by lighting
Active Insulation	4/16 11:30	Van Buren	Envelope project focused on active insulation systems that save energy and provide grid services
Solid State Tunable Thermal Energy Storage and Switches for Smart Building Envelopes	4/16 14:25	Van Buren	Envelope project focused on shaving peak demand
Technology Integration: Heat Pump Water Heaters	4/17 11:30	Commonwealth	Validation of HPWH to provide grid services

Research & Analysis: Determine Research Opportunities

The GEB Technical Report Series will help inform and guide BTO's R&D portfolio and serve as a foundational resource for the larger building research community

Reports will be published in Summer 2019 in partnership with

Navigant, NREL, PNNL

GEB Technical Report Series:

- Overview
- Heating, Ventilation, & Air Conditioning (HVAC); Water Heating; and Appliances
- Lighting
- Building Envelope & Windows
- Sensors & Controls, Data Analytics, and Modeling

1 Establish Frameworks

- Defines grid-interactive efficient buildings and demand flexibility
- Establishes potential grid services and some basic requirements for buildings to provide needed flexibility

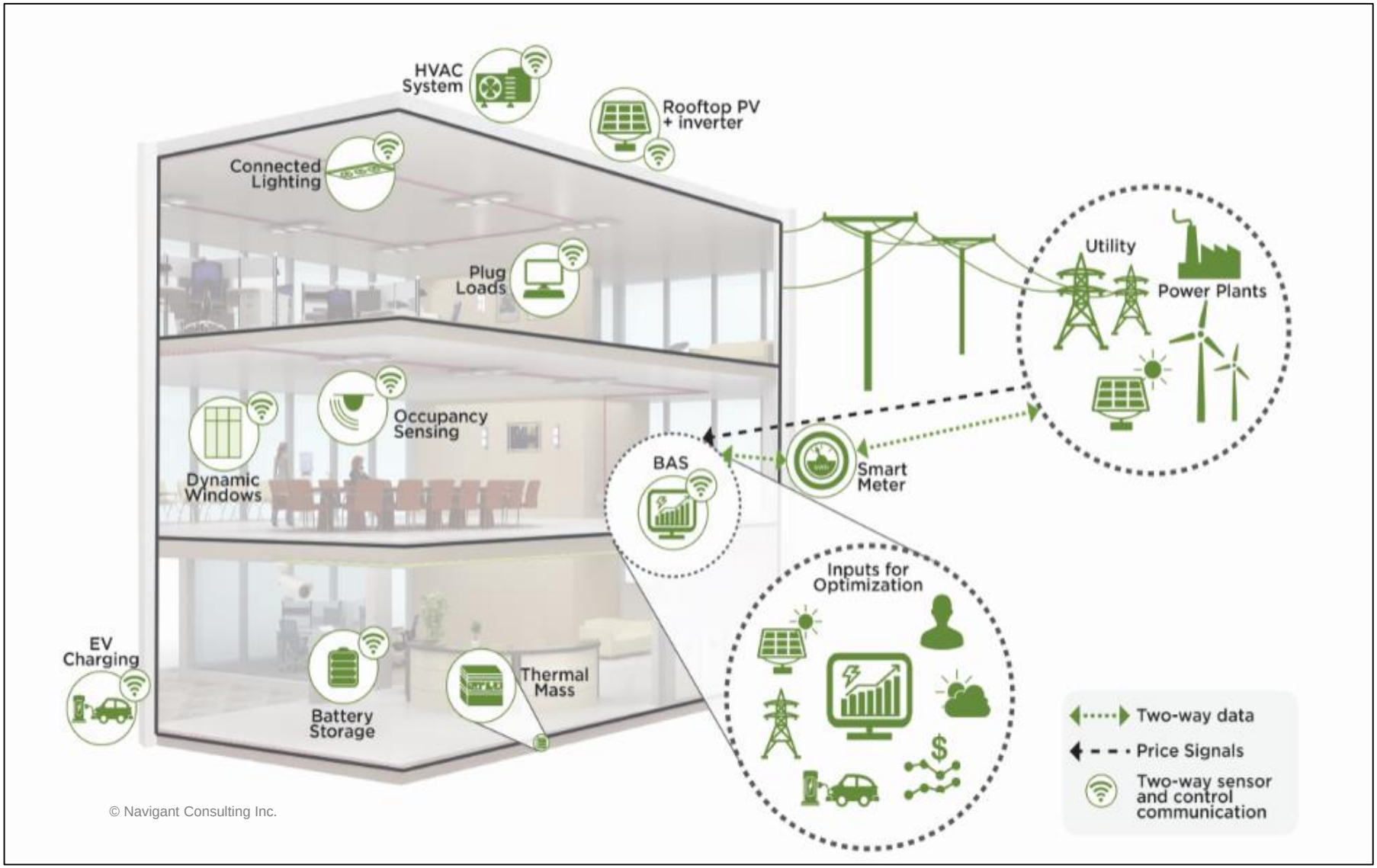
2 Assess Flexibility Potential

- Evaluate state-of-the-art and emerging building technologies that have the potential to provide grid services
- Considers implementation attributes

3 Discuss Research Opportunities

- Identify major research challenges of technologies with significant potential for grid benefits and opportunities for additional technology-specific research and development.

Grid-interactive Efficient Building (GEB)



Key Characteristics of GEB

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

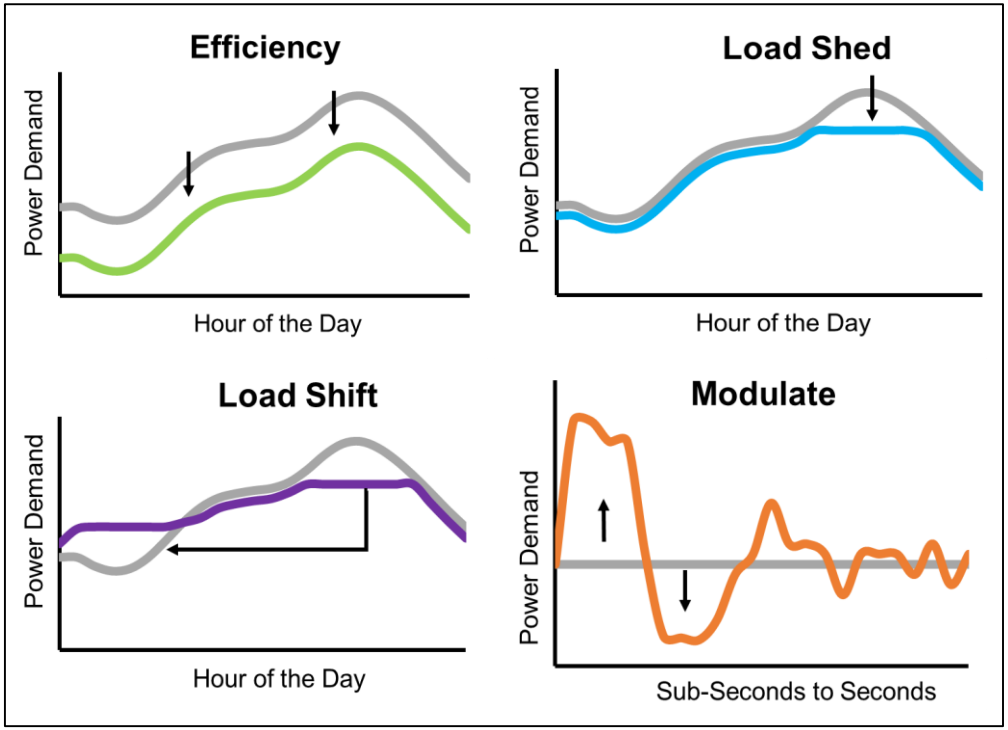
FLEXIBLE

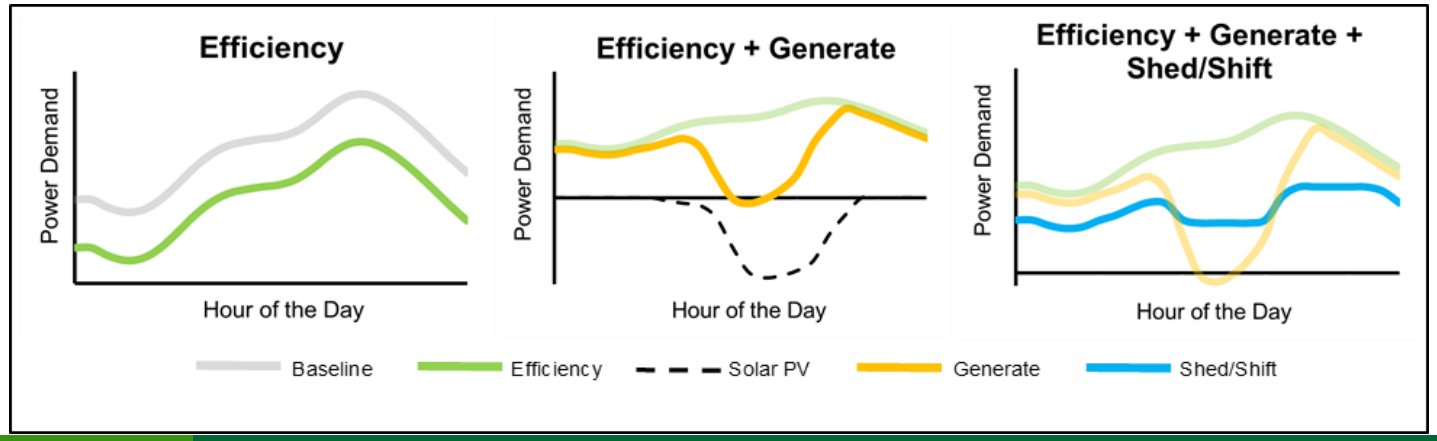
Flexible loads and distributed generation/storage can be used to reduce, shift, or modulate energy use

Definitions

Grid-interactive Efficient Building (GEB)	An energy efficient building with smart technologies characterized by the active use of DERs to optimize energy use for grid services, occupant needs and preferences, and cost reductions in a continuous and integrated way
Demand Flexibility	Capability provided by DERs to reduce, shed, shift, modulate or generate electricity; energy flexibility and load flexibility are often used interchangeably with demand flexibility
Smart Technologies for Energy Management	Advanced controls, sensors, models and analytics used to manage a range of energy assets, while responding to changing ambient and grid conditions, saving energy and meeting occupants requirements

Demand Flexibility Provided by GEB





Demand Flexibility Benefits

Benefit	Utility System	Building Owners/Occupants	Externalities
Reduced operation & maintenance costs	✓	-	-
Reduced generation capacity costs	✓	-	-
Reduced energy costs	✓	-	-
Reduced T&D costs	✓	-	-
Reduced T&D losses	✓	-	-
Reduced ancillary services costs	✓	-	-
Increased resilience	✓	✓	✓
Increased DER integration	✓	✓	-
Improved power quality	-	✓	-
Reduced owner/occupant utility bills	-	✓	-
Increased owner/occupant satisfaction	-	✓	-
Increased owner/occupant flexibility and choice	-	✓	-
Environmental benefits	-	-	✓

Adapted from the **Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments Report, forthcoming** .

Potential Grid Services Provided by Demand Flexibility in Buildings

Grid Services	Potential Avoided Cost	Potential Market Size Addressable by Demand Flexibility in Buildings
Generation Services		
Generation: Energy	Power plant fuel, operation, maintenance, and startup and shutdown costs	Large
Generation: Capacity	Capital costs for new generating facilities and associated fixed operation and maintenance costs	Large
Ancillary Services		
Contingency Reserves	Power plant fuel, operation, maintenance, and associated opportunity costs	Moderate
Frequency Regulation	Power plant fuel, operation, maintenance, and opportunity costs associated with providing frequency regulation	Small
Ramping	Power plant fuel, operation, maintenance, and startup and shutdown costs	Small
Delivery Services		
Non-Wires Solutions	Capital costs for transmission & distribution equipment upgrades	Moderate
Voltage Support	Capital costs for voltage control equipment (e.g., capacitor banks, transformers, smart inverters)	Small

Mapping Flexibility Modes to Grid Services

Flexibility Mode	Grid Services	Description of Building Change	Key Characteristics	
Efficiency	Generation: Energy Generation: Capacity T&D: Non-Wires Solutions	Persistent reduction in load. Interval data may be needed for M&V purposes. This is not a dispatchable service.	Duration	Continuous
			Load Change	Long term decrease
			Response Time	N/A
			Event Frequency	Lifetime of equipment
Shed Load	Contingency Reserves	Load reduction for a short time to make up for a shortfall in generation.	Duration	Up to 1 hr
			Load Change	Short term decrease
			Response Time	<15 min
			Event Frequency	20 times per year
	Generation: Energy Generation: Capacity T&D: Non-Wires Solutions	Load reduction during peak periods in response to grid constraints or based on time-of-use (TOU) pricing structures.	Duration	2 to 4 hrs
			Load Change	Short term decrease
			Response Time	30 min to 2 hrs
			Event Frequency	<100 hrs per year/seasonal

Research Opportunities

Technology

- Quantify how different modes of demand flexibility impact building envelope durability (e.g. missing latent cooling with "shut down" sensible cooling)
- Determining which technologies (both emerging and on the market) have the greatest potential to provide demand flexibility of different modes

Optimization

- Quantifying the impacts of different modes of demand flexibility on energy efficiency
- Identifying the trade-offs between functionality and security

Value & Market

- Determining the role of demand flexibility in different energy market contexts
- Identifying business models that allow for aggregation to exercise inter-building demand flexibility and energy exchange