U.S. DEPARTMENT OF ENERGY

Decarbonization Considerations: Grid-Interactive Efficient Buildings

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FEMP
Federal Energy Management Program

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- Don't hesitate to ask questions!
  - Send questions to all panelists in the Q&A window
  - Feel free to contact us through the FEMP Assistance Request Portal (https://www7.eere.energy.gov/femp/assistance/node/add/application-combined)

Webinar Overview

Agenda

- Grid-Interactive Efficient Buildings (GEBs)
  - GEB concept introduced
  - Drivers
- GEB Technologies
  - Metrics
  - Utility offerings
- Deployment
  - Deployment considerations
  - Cyber considerations
  - Financing/procurement
- Resources

Learning Objectives

- Identify opportunities and pathways to increase GEB deployment
- Identify how GEBs interact with distributed energy resources (DERs)
- Recognize how to leverage available FEMP and other resources to help agencies meet decarbonization goals.

Speakers

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Grid-Interactive Efficient Buildings Background

What are GEBs?

GEBs incorporate energy efficiency, renewables, energy storage, and load flexibility

GEBs employ these capabilities to flexibly **reduce, shed, shift, modulate, or generate** electric load as needed

Illustration from GSA

Key Characteristics of GEBs

A GEB is an energy-efficient building that uses smart technologies and on-site DERs to provide demand flexibility while co-optimizing for energy cost, grid services, and occupant needs and preferences, in a continuous and integrated way.

EFFICIENT

Persistent low energy use minimizes demand on grid resources and infrastructure

CONNECTED

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

SMART

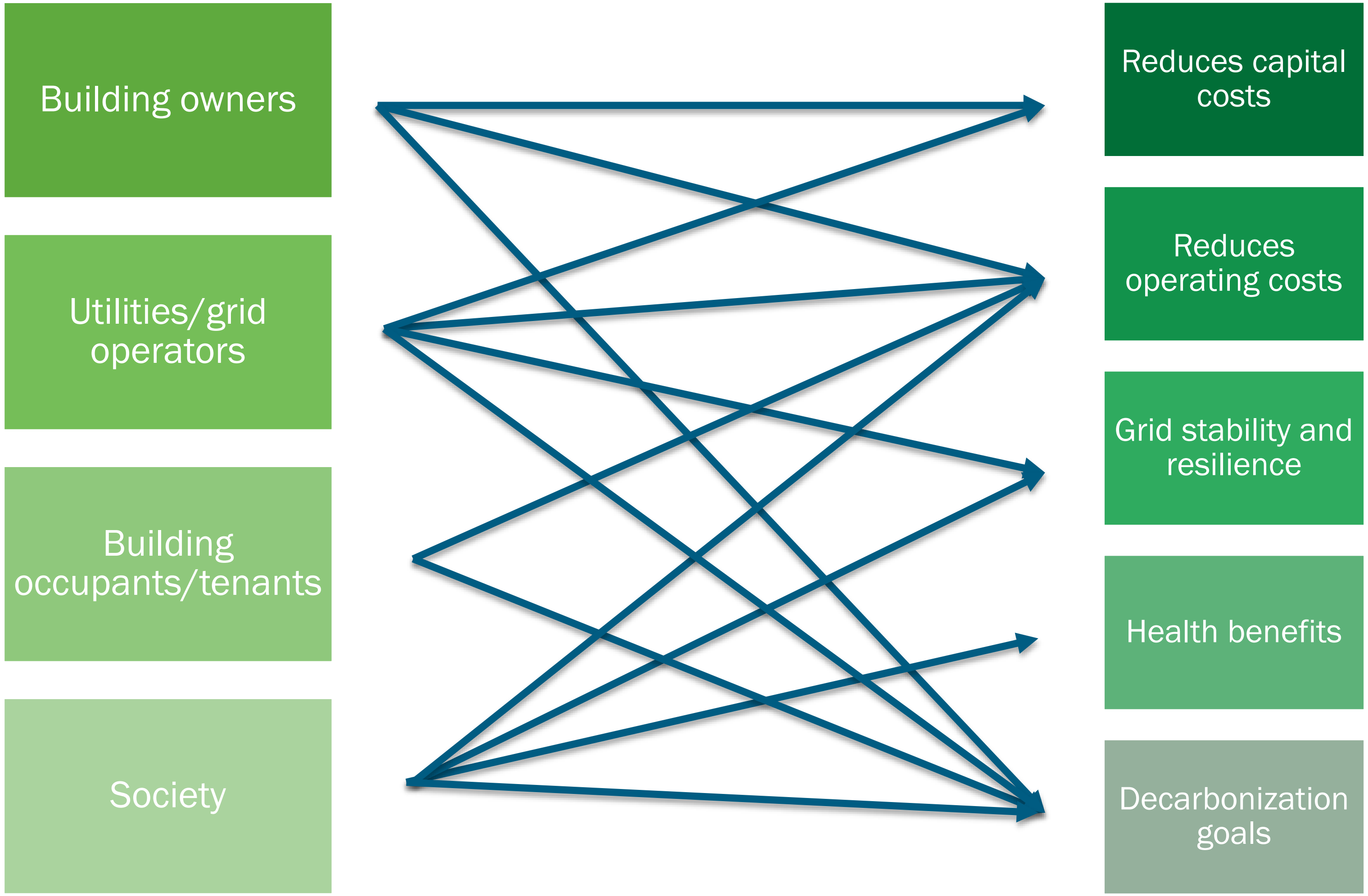
Analytics supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences

FLEXIBLE

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

https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/bto-geb-factsheet-41119.pdf

Multiple Stakeholders, Multiple Sources of Value



https://newbuildings.org/wp-content/uploads/2021/04/GTZ-GridIntegratedBuildings_4-29-21presentations.pdf

Drivers

Drivers: Legislative

Legislative Drivers

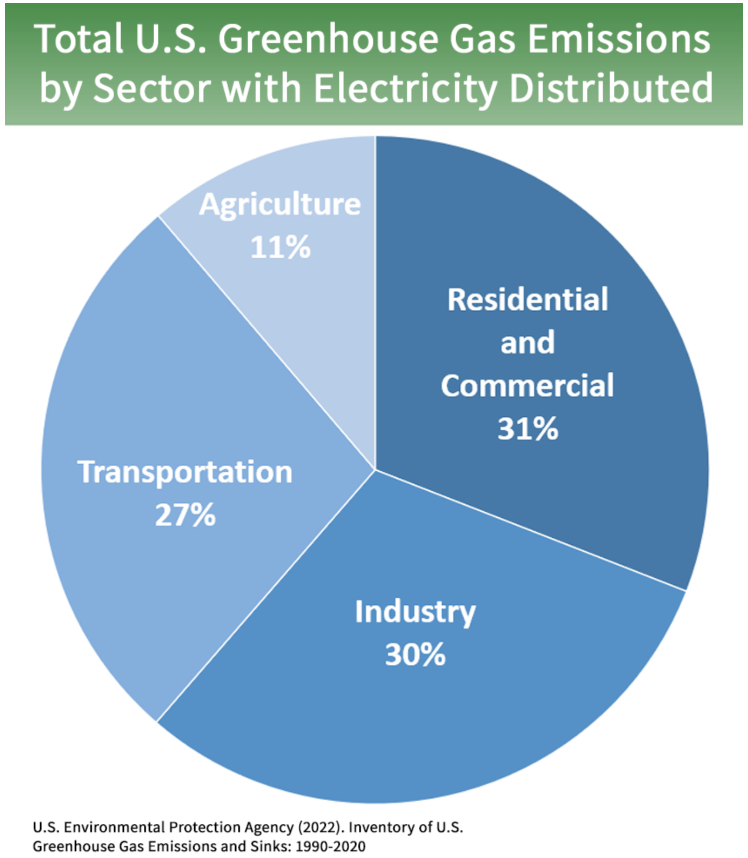
- **EISA 2007**
  - Numerous mentions (114 to be exact!) of “smart” (e.g., smart grid technologies, smart consumer devices and appliances, smart services and practices)
- **EA 2020**
  - Smart building acceleration
    - The section requires the Secretary of Energy, as a part of the Better Building Challenge, to develop smart building accelerators to demonstrate innovative policies and approaches to accelerate the transition to smart buildings.
    - The section also establishes an R&D program focused on building-to-grid integration.
- **EO 14057 (Catalyzing America’s Clean Energy Industries and Jobs through Federal Sustainability)**
  - Guidance for both existing facilities (energy efficiency and deep energy retrofits) and new construction and modernization to implement GEB

Drivers: Decarbonization Potential

Greenhouse Gases (GHGs) and Buildings

- **31% of GHG emissions by electricity end-use due to residential and commercial buildings**

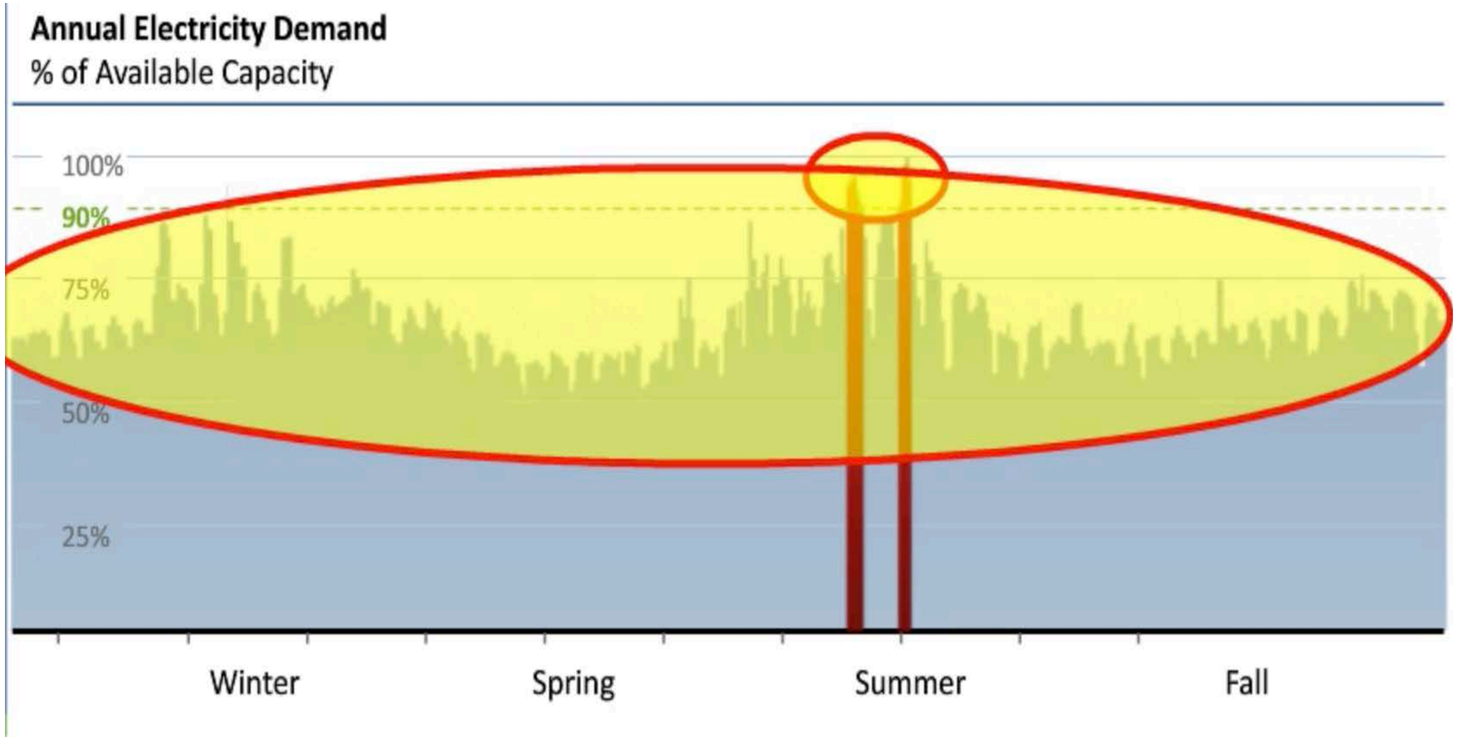
- **Commercial and Residential Sector Emissions:**
  - **Direct emissions:** include fossil fuel combustion for heating and cooking needs, management of waste and wastewater, and leaks from refrigerants
  - **Indirect emissions:** occur offsite but are associated with use of electricity consumed by homes and businesses



https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Building Peaks Drive Grid Peaks

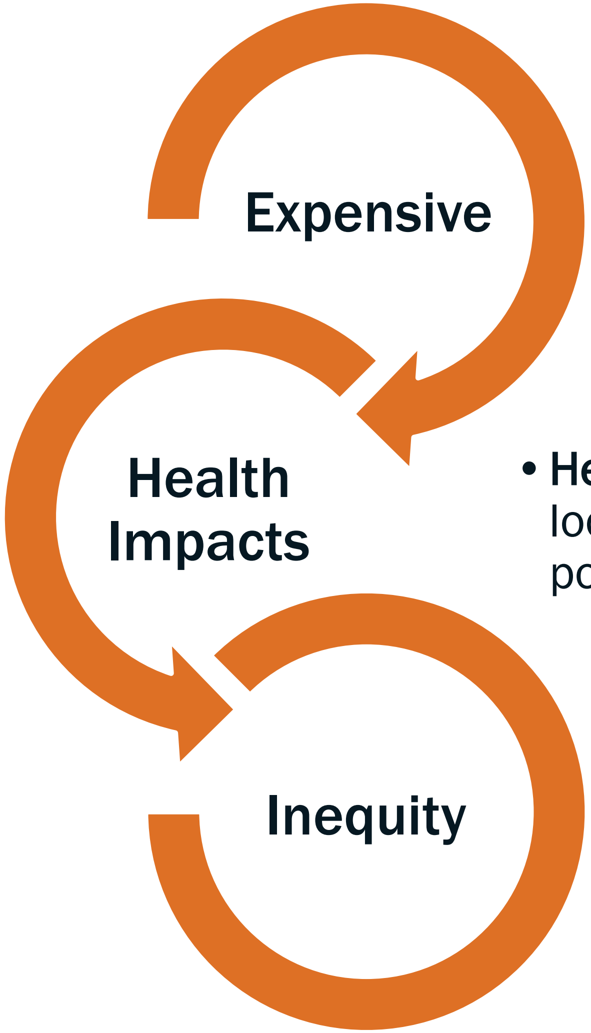
- 80% of grid peak demand is driven by buildings
- >10% of grid infrastructure costs are spent to meet the peak demand that occurs <1% of the time — making those peak times the most expensive, and likely carbon-intensive power
- Building-level renewable energy (RE) exports are coincident with peak grid/utility RE generation



GEBs enable buildings to work with the power grid, not against it — unlocking value and enabling grid decarbonization

https://www.youtube.com/watch?v=upWdrys8SSU

Cost and Health Benefits by Avoiding Peaking Power Plants



- **Low efficacy:** Avoid $268 Million annually[1] in capacity payments that support the peaking power plants which run < 10% of the time
- **Disproportionately expensive:** Peaking power plants can cost up to 1300% more than other typical sources[2]

- **Heavy Polluters:** Despite limited run-times, peaking power plants contribute significantly to local air pollution with localized pollutants (i.e., Nox , SO2, PM2.5). While running, peaking power can account for more than 1/3 of daily power plant NOx emissions[3]

- **Low-income and communities of color:** disproportionately bear the brunt of peaking power plant health concerns. In these high impacted areas, rates are 4x higher for ozone-attributable asthma admissions[3]

Sources:
1. [Strategen for NY-BEST] NYC's Aging Power Plants: Risks, Replacement Options, and the Role of Energy Storage, 2017
2. [NYSERDA] Monthly Average Price of Residential Electricity, 2020
3. [Governor's Office of NY] Adoption of Regulations to Improve Air Quality, 2019

https://newbuildings.org/wp-content/uploads/2021/04/GTZ-GridIntegratedBuildings_4-29-21presentations.pdf

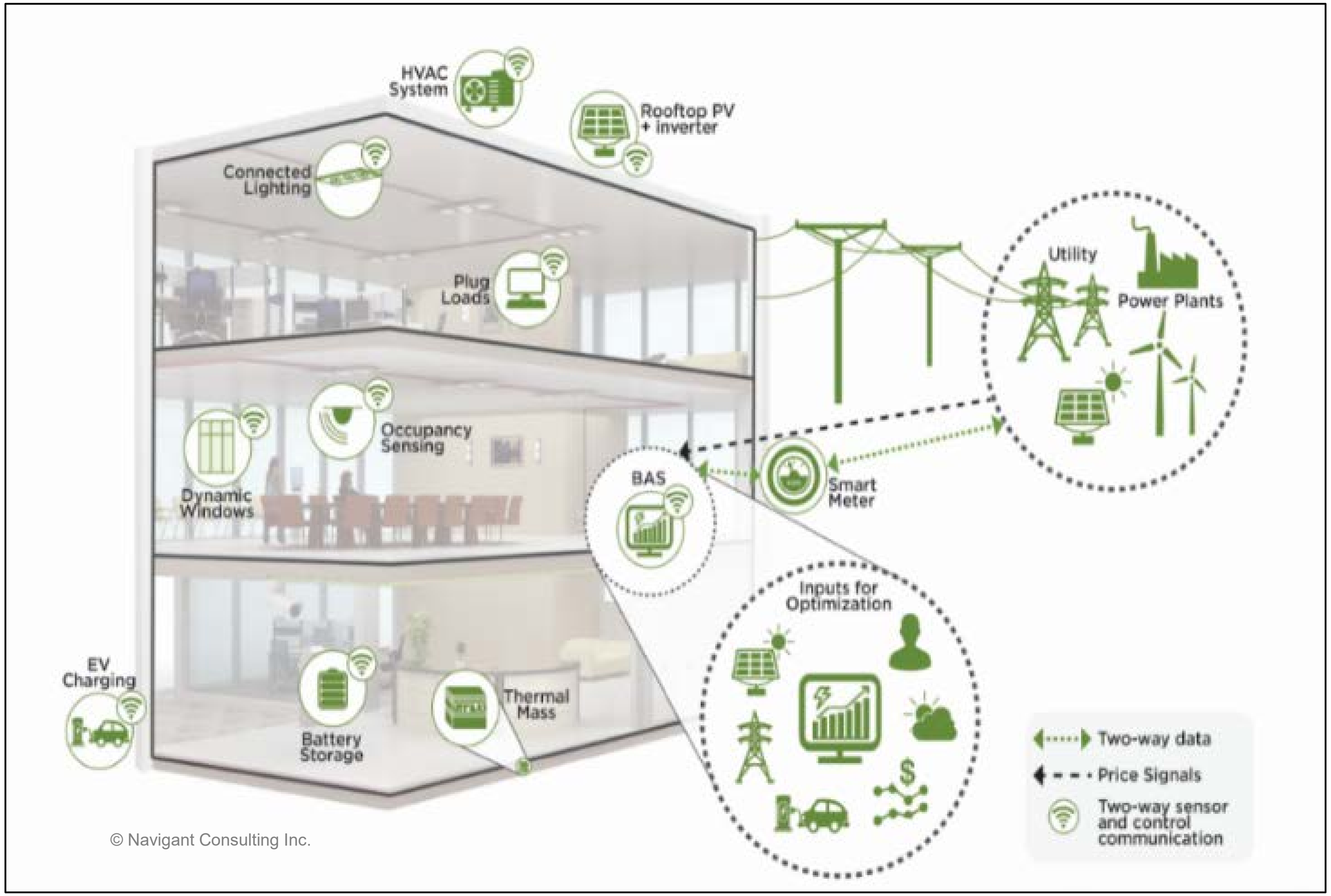
GEBs and Decarbonization

GEBs decarbonize the building stock by utilizing:

1. Energy efficient equipment to ***reduce*** energy usage
2. Tight building envelopes to ***reduce*** heating/cooling energy use
3. Renewable energy generation (e.g., PV panels, etc.) and energy storage to ***replace*** carbon heavy energy sources and ***enable*** fleet decarbonization
4. Grid connected smart technology and energy storage help integrate variable renewable energy sources on the grid to further ***replace*** carbon heavy sources

Drivers:
Grid Resilience

How Can Buildings Provide Flexibility?

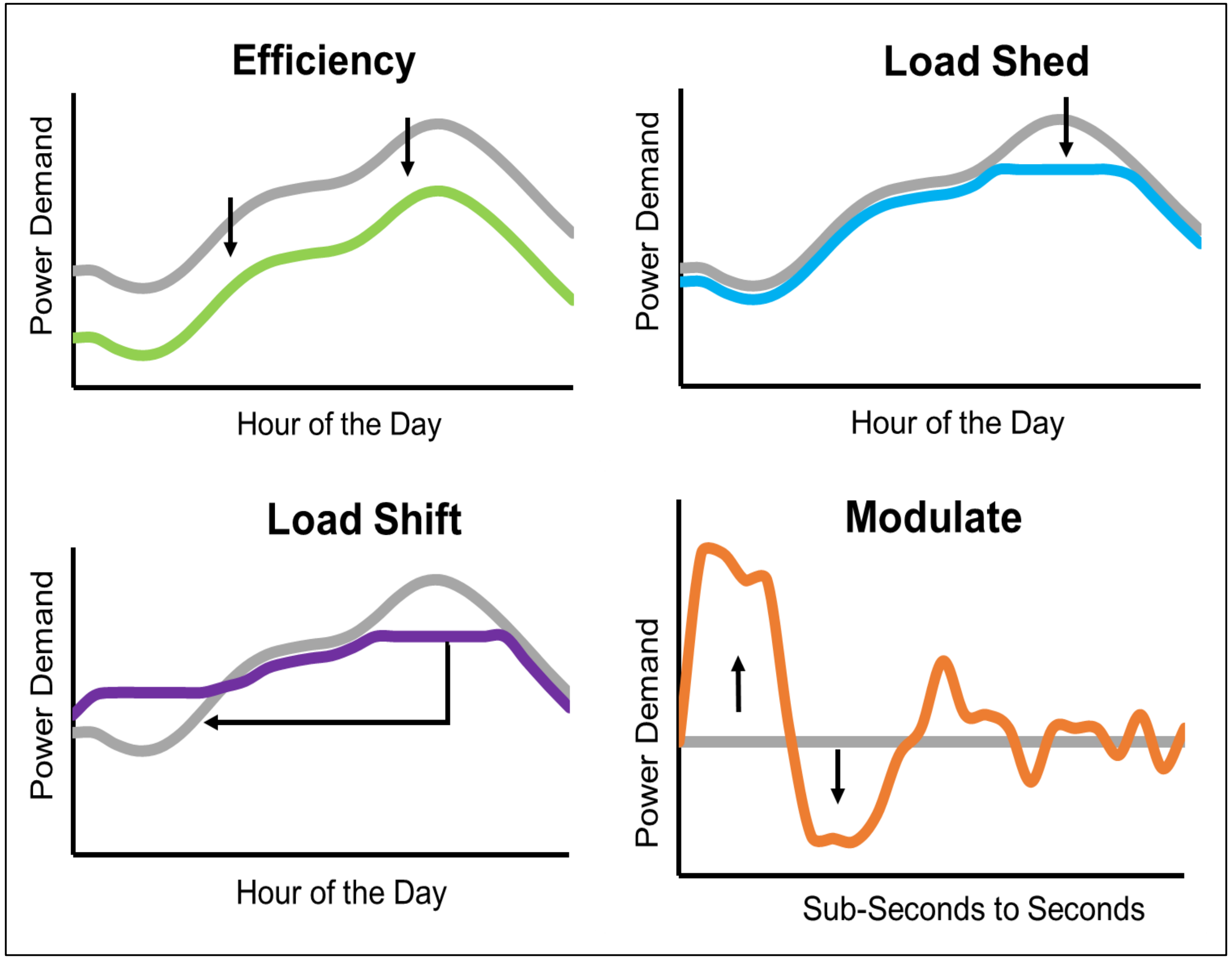


Why are GEBs important?

- Buildings can provide flexibility by reducing wasted energy, helping balance energy use during times of peak demand and/or plentiful renewable generation, and reducing the risk of frequency deviations.
- As the grid becomes increasingly complex, demand flexibility can play an important role in helping maintain grid reliability, improving energy affordability, and integrating a variety of generation sources.

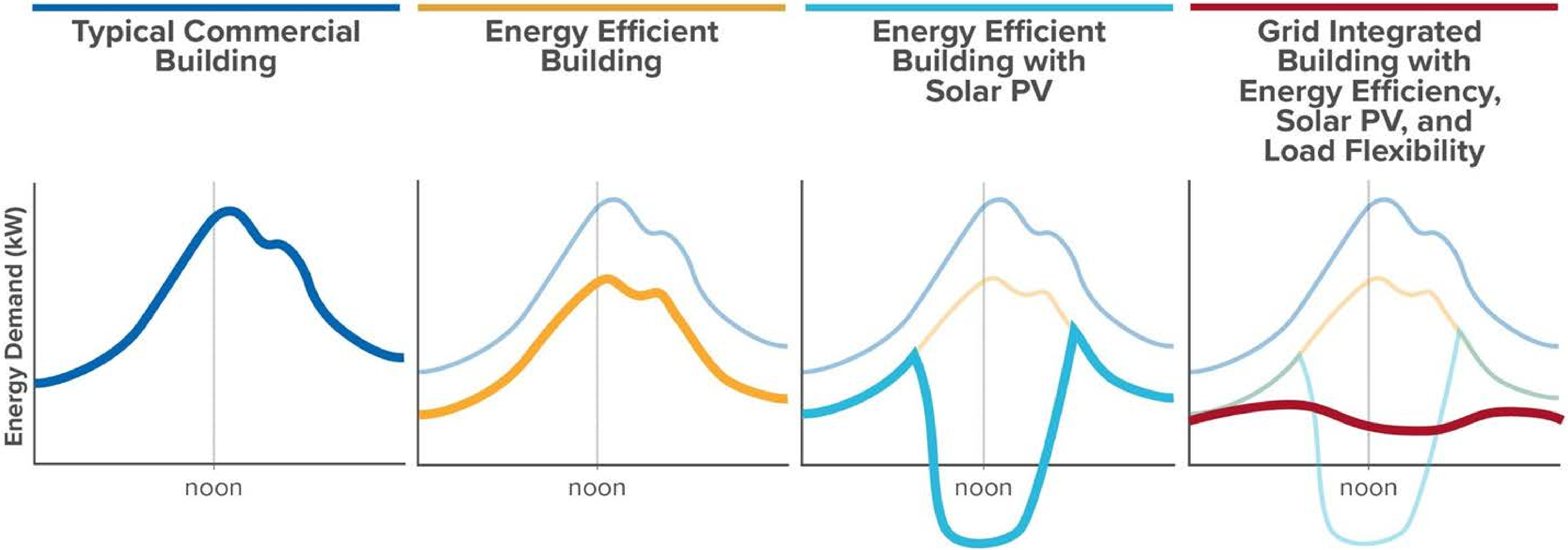
https://connectedcommunities.lbl.gov/sites/default/files/2021-08/GEB%20Technical%20Report%20Series%20-%20An%20Overview%20of%20Research%20Challenges%20and%20Gaps%2075470_2.pdf

Demand Flexibility Provided by GEB



https://connectedcommunities.lbl.gov/sites/default/files/2021-08/GEB%20Technical%20Report%20Series%20-%20An%20Overview%20of%20Research%20Challenges%20and%20Gaps%2075470_2.pdf

GEB Load Profile Potential



Efficiency reduces demand and energy costs

Solar reduces demand and energy charges but causes steep ramping of loads and utility challenges

Grid-interactive efficient buildings optimize energy use and demand costs and increase resilience by providing a lower, flatter, more flexible load shape

https://rmi.org/insight/value-potential-for-grid-interactive-efficient-buildings-in-the-gsa-portfolio-a-cost-benefit-analysis/

GEB Technologies

GEB Technologies and Solutions

- Can leverage existing equipment
- Technologies may or may not be “smart”
- Building managers can control individual equipment or leverage software solutions to optimize multiple end-use systems
- Flexibility can be provided through:
  - Continuous demand management
  - Response to specific demand response (DR) events
- Dynamic utility signals can and should be leveraged where possible

Sampling of GEB Enabling Technologies

- Building Automation
  - Grid-Connected BAS/EMIS
  - Chiller Temperature Setpoint Reset
  - Air Handling Unit (AHU) Pressure and Temperature Reset
  - Supervisory Control and Automation

- Connected Technologies and Controls
  - Automated Window Attachments
  - Modulating/Advanced Clothes Dryers
  - Advanced BAS/Energy Management Information Systems (EMIS)
  - Advanced Controls for Commercial Refrigeration
  - Advanced Lighting Sensors and Controls
  - Advanced Plug Load Controllers (including Smart Power Strips)
  - Advanced/Smart Water Heater
  - Basic Building Automation Systems (BAS)
  - Electronic/Computing Energy Management
  - Rooftop Unit Advanced Control
  - Smart Thermostats

Distributed Energy Resources and Storage

- Battery Energy Storage System (BESS)
- Electric Vehicles and Chargers
- Thermal Energy Storage
- Small Wind Turbines
- Solar Photovoltaic (PV) Panels
- Building Scale Combined Heat and Power (CHP)

Sample Alignment of GEB Measures With Grid Services

GEB Measure	GEB Control Capability	Load Shed	Load Shift	Demand Response	Demand Reduction (Efficiency)
LED fixture with full control	Dim lights for load shed capability	X		X	X
Automatic window shade devices	Control for west, south, and east-facing facades to shed solar heat gain during the day	X		X	X
Staging of electric resistance heating	Stage operation for load shed capability	X		X	
Zone space temperature setback	Program setbacks during defined peak demand periods for load shed capability	X		X	X
Thermal energy storage	Leverage building thermal mass or water storage to shift heating and cooling loads		X	X	X
Staging of AHU fans	Stage operation for load shed capability	X		X	
Static pressure reset for demand response	Static reset for load shed capability	X		X	X
Laptop battery charger staging	Stage battery-based plug-in equipment for load shed capability	X	X	X	
Solar PV	Utilize on-site generation to offset peak load	X			X
Battery storage	Utilize battery storage to shed and shift load	X	X	X	X

GEB Software Solutions

- Connect to building automation systems (BAS) or home energy management systems (HEMS)
- Can control multiple building end-use systems
- May offer 1- or 2-way communication with the grid
- Provide analytics for flexible control
- Trend load data
- Should capture dynamic signals:
  - Weather
  - Time-Of-Use (TOU) utility rates
  - Carbon emissions
  - Utility demand response

Photo by Werner Slocum, NREL 65538

Utility Offerings

Utility Rates Considerations

- Demand response programs
- Coincident peak demand charges
- Virtual power plant/aggregator laws
- Minimum billing demand clauses
- Time Variable Pricing
  - Real-time pricing (RTP)
  - Day-ahead hourly pricing
  - Block-and-index pricing (sometimes called block-and swing pricing)

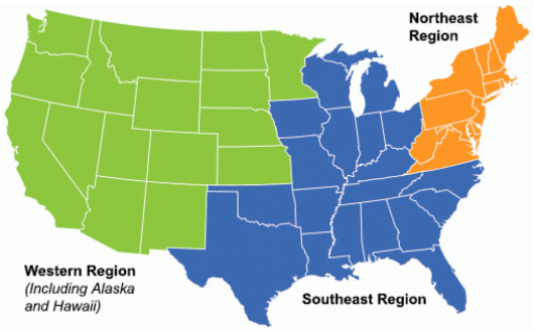
Demand Response and Time-Variable Pricing Programs

Federal Energy Management Program

Federal Energy Management Program » Demand Response and Time-Variable Pricing Programs

The Federal Energy Management Program developed profiles of demand response and time-variable pricing programs throughout the United States. These profiles are grouped regionally by state.

- Western States
- Northeastern States
- Southeastern and Midwestern States



Demand response (DR) is a short-term, voluntary decrease in electrical consumption by end-use customers that is generally triggered by compromised grid reliability or high wholesale market prices. In exchange for conducting (and sometimes just committing) to curtail their load, customers are remunerated.

https://www.energy.gov/eere/femp/demand-response-and-time-variable-pricing-programs

Utility Offerings and Incentives

Favorable utility rates

- High peak demand rates;
- Large differences between peak and non-peak energy and demand charges; or
- TOU rates available with high on-peak charges

Incentives: prescriptive and customized offerings for efficient building equipment and distributed energy technologies (e.g., lighting, refrigeration equipment, HVAC equipment, smart thermostats, PV, batteries).

Table 6. Illustrative Utility Rate Favorability for GEB

Rate Type	GEB Favorability	Total Energy Charges	Total Demand Charges
Low energy and demand rates	Less	$0.05–0.10/kWh	$5–$10/kW
High demand rate (low energy rate)	More	$0.05–0.10/kWh	$10–$20/kW
High demand rate (high energy rate)	Most	$0.10–$0.20/kWh	$10–$20/kW

https://www.nrel.gov/docs/fy21osti/78190.pdf

Deployment Considerations

Deployment Considerations

- **How do you currently approach energy efficiency (EE)/Demand Response (DR)/load management and interconnectivity efforts?**
  - Do you have an integrated approach to control and ongoing management of plug loads, lighting, and HVAC?
  - Would better analytics support decisions for optimal balance of grid resources, EE/DR, renewables, and energy storage?
  - Do you wait for the utility signal to reduce demand, or do you continually manage demand?
- **What are key barriers to adoption of advanced controls that enable the ability to provide grid services?**
  - Concerns about impact on productivity
  - Making the business/investment case
  - Complexity of advanced controls and potential of obsolescence
  - Cybersecurity concerns
- **What utility offerings can help support technology adoption?**

Selection/Screening Process

	Screening Phase	Description	Data Needs/Considerations
1	**Market Screening**	Market-based screening utilizing existing datasets	• Site locations • Site consumption • Blended electricity rate • Presence of utility incentive programs
2	**High-Level DER Screening**	High-level DER screening incorporating site-specific utility rate	• Type of existing electric rate • Annual electricity consumption (hourly consumptions will be simulated and scaled)
3	**Detailed GEB Analysis**	In-depth energy modeling analysis at top sites; will require additional data from sites.	• 15-minute electrical meter interval data from site • Custom modeled utility rate • Additional building data and existing BAS and control system data, LED lighting, and plug load data

https://www.nrel.gov/docs/fy21osti/78190.pdf

Cost Effective GEB Measures and Strategies

Measures

Cost-effective in almost every location	Cost-effective in some locations

• **LED lighting upgrades,** including tube retrofits, fixture retrofits
• **Staging to reduce peak demand:**
  • Laptop battery charging
  • AHU fans
  • Electric resistance heaters (all-electric only)
• **Temperature setback to reduce peak demand**
	• **Advanced lighting controls,** which enable peak shaving and DR
	• **Battery energy storage system**
	• **Solar PV** energy generation
	• **A solar + storage "bundle" —** bundling enhances the value beyond investing in solar and storage individually

Cost-effective GEBs measures have high net present value and short paybacks.

Strategies

- The best returns are in locations with high demand charges, time of use rates, and seasonal variation.
- Consistent demand management and peak shaving delivers greater value than demand response in most scenarios.

Metrics

Quantitative Objectives for Demand Flexibility	Metrics
Energy Efficiency Savings (from GEB solution)	Energy savings: kWh/year and % savings Energy intensity savings: kWh/ft^2/year
Continuous Demand Management	Monthly peak demand reduction: kW and % Summer and winter average peak kW reduction
Peak Load Shed	Demonstrated load shed based on a utility signal: • Demand shed per event: Average kW reduction (for shed) over a specified time window • Average % demand reduction • Demand shed intensity: W/ft^2
Load Shift	Average demand increase or decrease over shift days during the summer and winter: kW, W/ft^2, % Net building consumption change in 24 hours over shift days during the summer and winter: %
Carbon Reduction	CO_2/ft^2/year

The End Goal

- Support decarbonization
- More flexible and optimized building performance
- Reduced peak demand and lower demand charges
- Responsive to building and grid needs

Cybersecurity Considerations

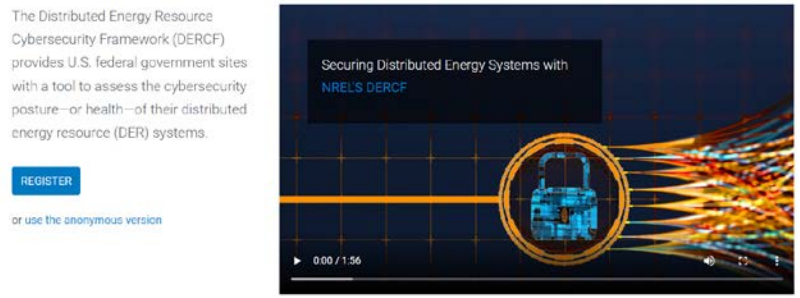
Cybersecurity Considerations

Figure 2. Managing cybersecurity risks using NIST's RMF. *Image by Anuj Sanghvi and Fred Zietz, NREL*

https://csrc.nist.gov/projects/risk-management/about-rmf

FEMP Cybersecurity Resources

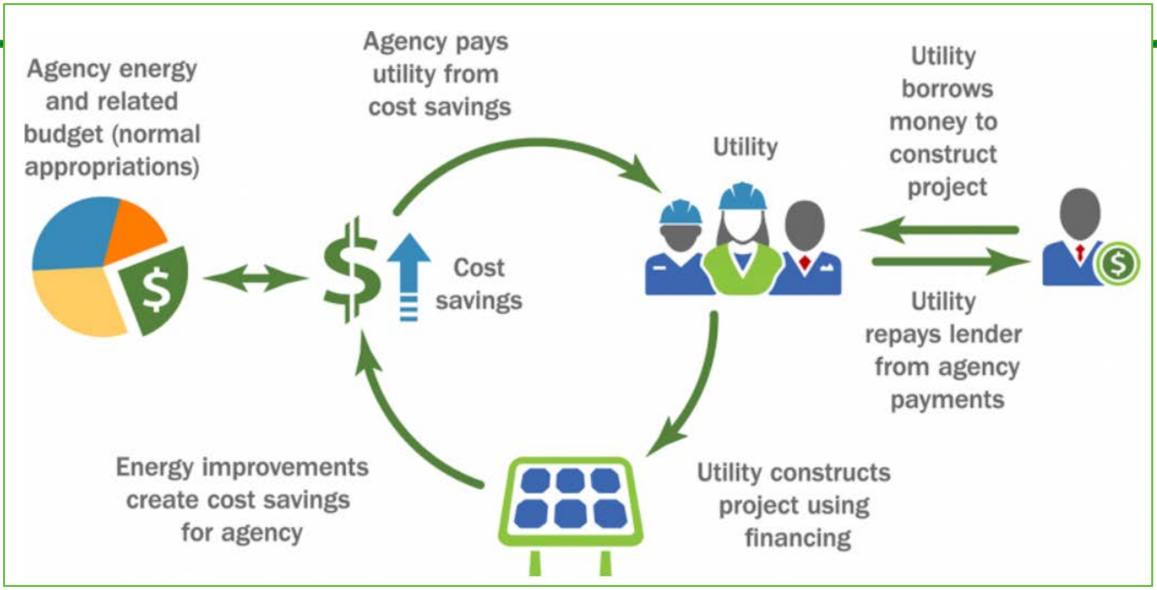
- Distributed Energy Resources Cybersecurity Framework
  - https://dercf.nrel.gov/
- Distributed Energy Resources Risk Manager
  - https://www.nrel.gov/docs/fy22osti/83237.pdf
- EMIS Cybersecurity Best Practices
  - https://www.energy.gov/sites/default/files/2022-07/emis-cybersecurity-best-practices.pdf
- Facility Cybersecurity Framework
  - https://facilitycyber.labworks.org/



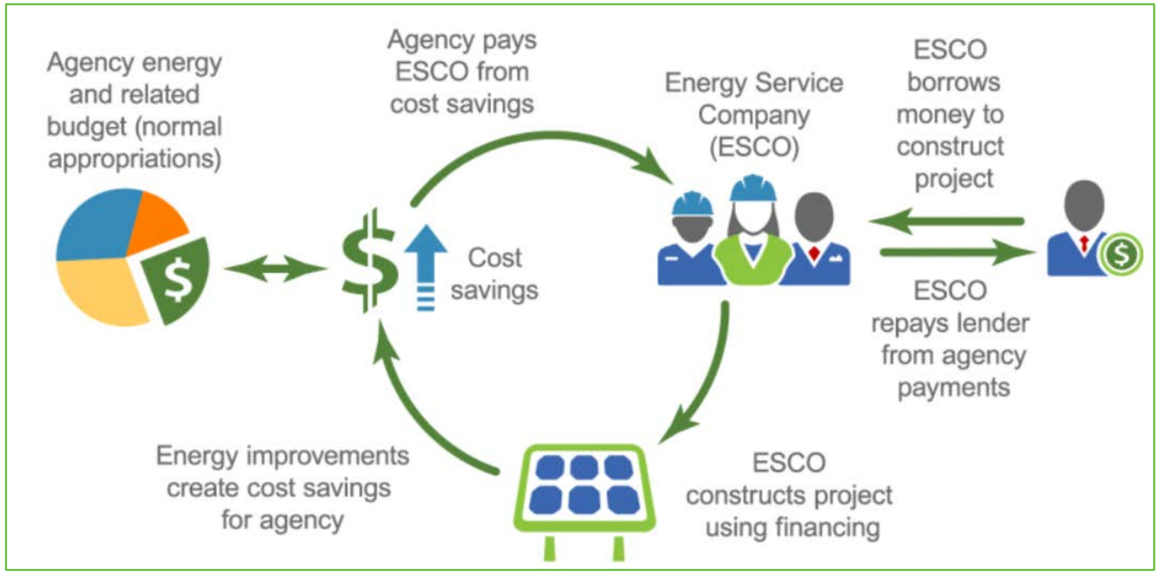
Financing and Procurement of GEB Solutions

ESPC and UESC Integration

- Utility Energy Services Contracts (UESCs) and Energy Savings Performance Contracts (ESPCs) can be used to finance and implement energy and water efficiency improvements and energy demand reduction.
  - FEMP UESC Website: https://www.energy.gov/eere/femp/utility-program-and-utility-energy-service-contracts-federal-agencies
  - FEMP ESPC Website:
  - https://www.energy.gov/eere/femp/energy-savings-performance-contracts-federal-agencies



Cycle of Cost Savings and Payments (UESC top, ESPC bottom)



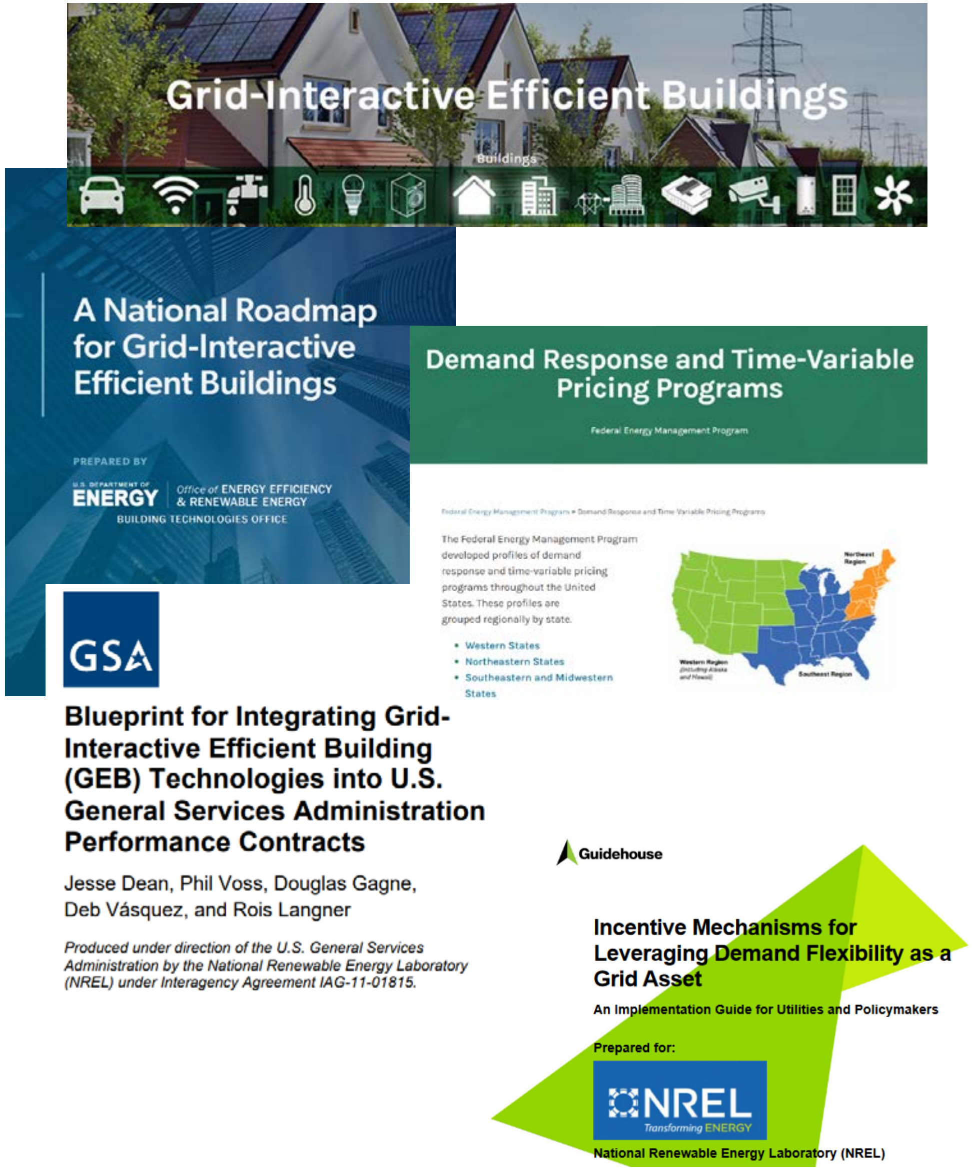
AFFECT 2022 Appropriations Federal Agency Call (FAC)

- The Federal Energy Management Program (FEMP) just recently issued a $13 million solicitation for new energy projects that will help federal facilities improve the efficiency of their operations and reduce their carbon footprint.
- "Assisting Federal Facilities with Energy Conservation Technologies (AFFECT)" will help ensure that the federal government is leading by example in the effort to achieve the Biden Administration's goal of a 100% clean-energy economy and net-zero emissions by 2050.
- The AFFECT 2022 Appropriations FAC will fund projects addressing:
  - clean energy supply;
  - load management;
  - storage and resilience;
  - energy efficiency; and
  - mitigation and/or adaptation to effects of climate change.
- For more information: https://eere-exchange.energy.gov/Default.aspx#FoaIdf565c25e-de3e-4ff4-bda5-6f6b4c3dad08

Resources

Resources – Websites and Reports

- DOE's "GEB-site": https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings
- A National Roadmap for Grid-Interactive Efficient Buildings: https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs%20-%20Final.pdf
- Blueprint for Integrating Grid-Interactive Efficient Building (GEB) Technologies into U.S. General Services Administration Performance Contracts: https://www.nrel.gov/docs/fy21osti/78190.pdf
- Demand Response and Time-Variable Pricing Programs: https://www.energy.gov/eere/femp/demand-response-and-time-variable-pricing-programs
- Incentive Mechanisms for Leveraging Demand Flexibility as a Grid Asset: https://www.energy.gov/sites/default/files/2021-06/GEB_Implementation_Guide_May_2021.pdf



Resources - Webinars

- Managing Your Load for Money and Energy Security: Demand Response and Time-Variable Pricing:

  https://www.wbdg.org/continuing-education/femp-courses/fempws10242022c

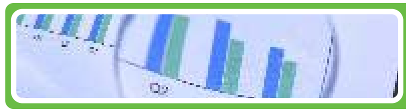
- Taking Advantage of Demand Response and Time-Variable Pricing Offerings:

  https://www.wbdg.org/continuing-education/femp-courses/fempodw060

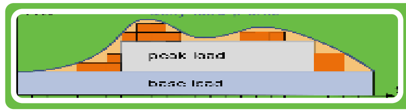
In Closing

GEBs are an efficient, connected, smart, and flexible solution to decarbonizing our building stock, with numerous additional benefits.

✓ Energy affordability



✓ Operational cost reduction



✓ Improved reliability and resiliency

✓ Reduced grid congestion

✓ Enhanced services

✓ Environmental benefits

✓ Customer choice

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Thank you!
Q&A

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IACET Credit for Webinar

The National Institute of Building Sciences' (NIBS) Whole Building Design Guide (WBDG) hosts the FEMP training program's learning management system (LMS).

The WBDG LMS:

- Allows for taking multiple trainings from multiple organizations through one platform.
- Houses the assessments and evaluations for all accredited courses.
- Allows you to:
  - Track all of your trainings in one place.
  - Download your training certificates of completion.
- Eases the CEU-achievement process.

Visit the WBDG at www.wbdg.org to view courses and create an account

IACET Credit for Webinar

To receive IACET-Certified CEUs, attendees must:

- Attend the training in full (no exceptions).
  - If you are sharing a web connection during the training, you must send an e-mail to Elena Meehan (elena.meehan@ee.doe.gov) and indicate who was on the connection and who showed as connected (will reflect in the WebEx roster).
- Complete an assessment demonstrating knowledge of course learning objectives and an evaluation **within six weeks of the training**. A minimum of 80% correct answers are required for the assessment.

To access the webinar assessment and evaluation, visit:

https://www.wbdg.org/continuing-education/femp-courses/femplw03312022

If you have a WBDG account and enrolled previously, simply log in and click the *Continuing Education* tab on the user account page. Click *Proceed to Course* next to the course title.

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