U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Grid-Interactive Efficient Buildings

IEA *Modernising Energy Efficiency through Digitalisation* Initiative

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Director, U.S. Building Technologies Office
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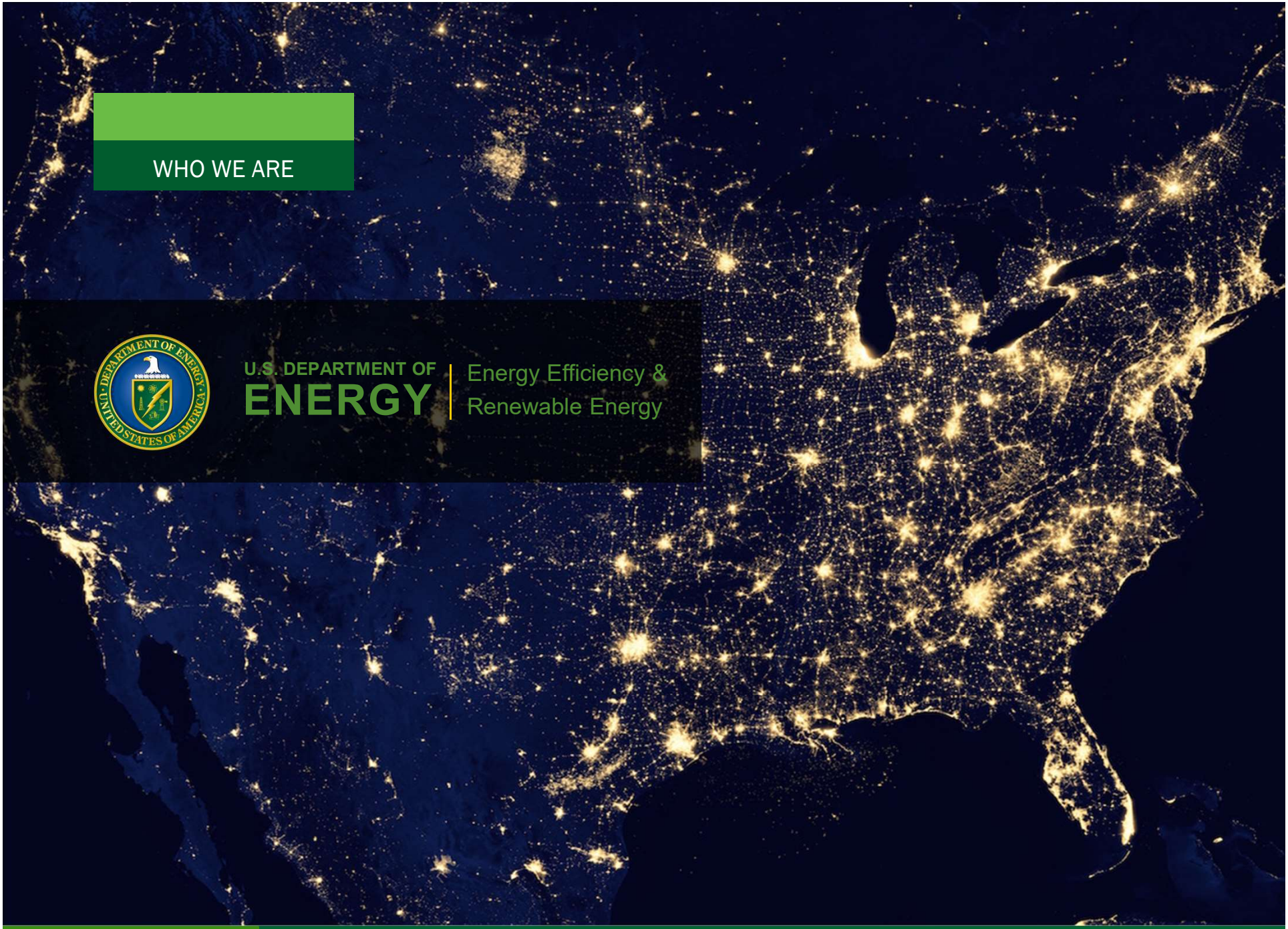
WHO WE ARE



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

US Homes and Buildings

The U.S. building stock is comprised of more than 123 million commercial buildings and housing units totaling 324 billion square feet

More than 80% of structures are at least 20 years old

5.5 million commercial buildings totaling 87 billion square feet

118.2 million housing units totaling 237.4 billion square feet

37% of homes & buildings produce rental income for their owners

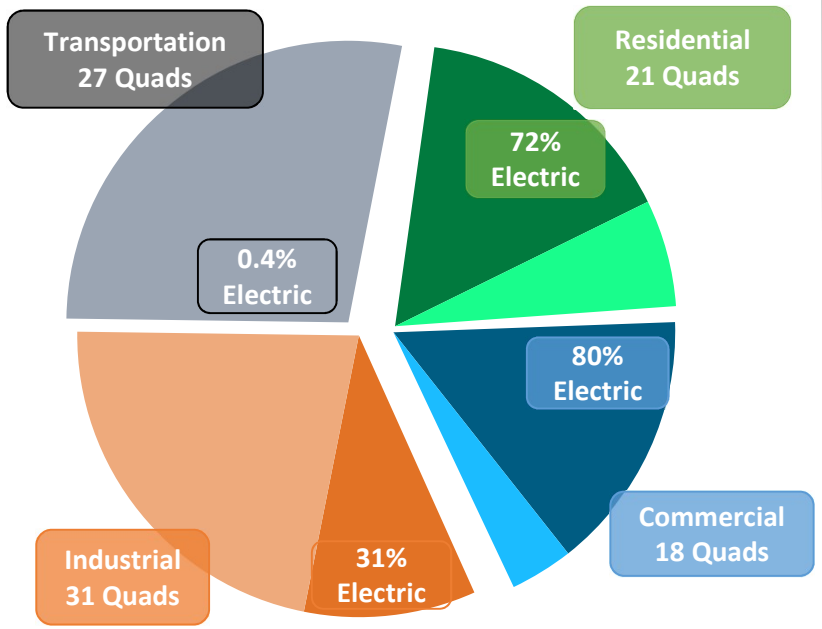
80 million Americans are invested in real estate through retirement and investment funds

Buildings energy bill is ~US$380 billion annually, much of which is wasted

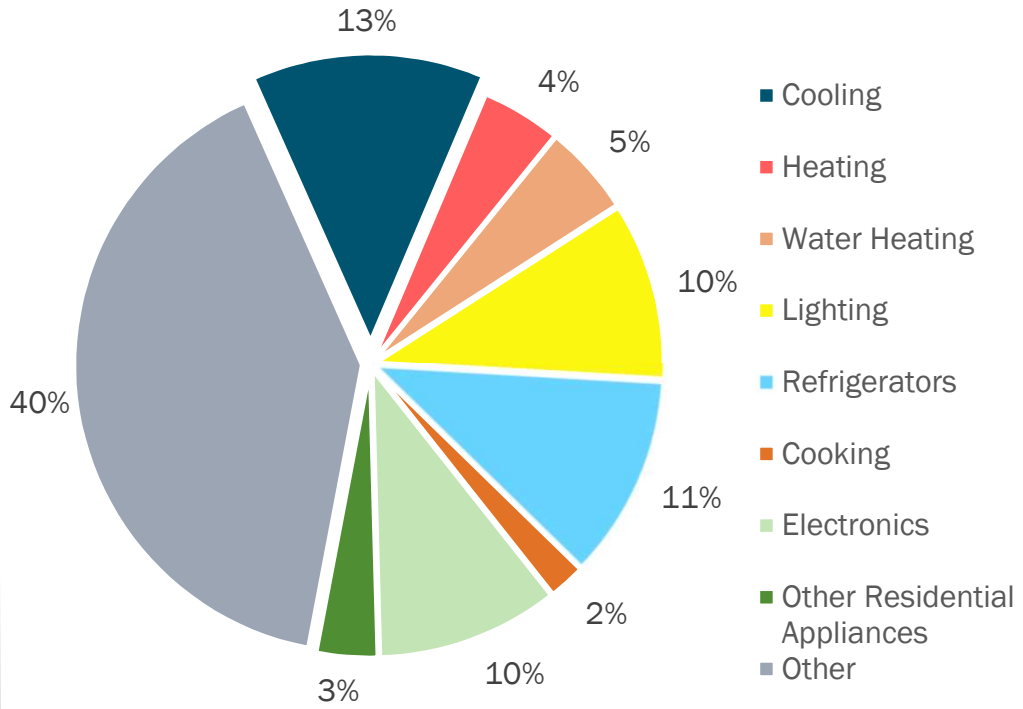
Source: U.S. Energy Information Administration (CBECS 2012/RECS 2015); NAREIT Reits by the Numbers; Census Bureau Quarterly Retail E-Commerce Sales 4th Quarter 2016

Energy use in the U.S. building sector

Energy Use



Building Electricity Use



Buildings Energy Use: 40% of U.S. total

Buildings Electricity Consumption: 75% of U.S. total

Buildings Peak Electricity Demand: ~80% of regional total

U.S. Building Energy Bill: US$380 billion per year

Source: EIA 2017 Annual Energy Outlook

Building Technologies Office

11 technology offices within the Office of Energy Efficiency and Renewable Energy (EERE)

Our 2019 budget is $226 million, ~10% of EERE $2.4 billion budget. DOE total is ~$35.7 billion

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Energy Efficiency & Renewable Energy

ENERGY EFFICIENCY	RENEWABLE POWER	SUSTAINABLE TRANSPORTATION
Advanced Manufacturing	Geothermal Technologies	Bioenergy Technologies
Building Technologies	Solar Energy Technologies	Fuel Cell Technologies
Federal Energy Management	Wind Energy Technologies	Vehicle Technologies
Weatherization & Intergovernmental	Water Power Technologies	

US BTO approach

BTO invests in energy efficiency & related technologies that make homes and buildings more affordable and comfortable, and make the US (and beyond) more sustainable, secure and prosperous. Budget ~US$226M/year; activities include:

R&D

Pre-competitive, early-stage investment in next-generation technologies

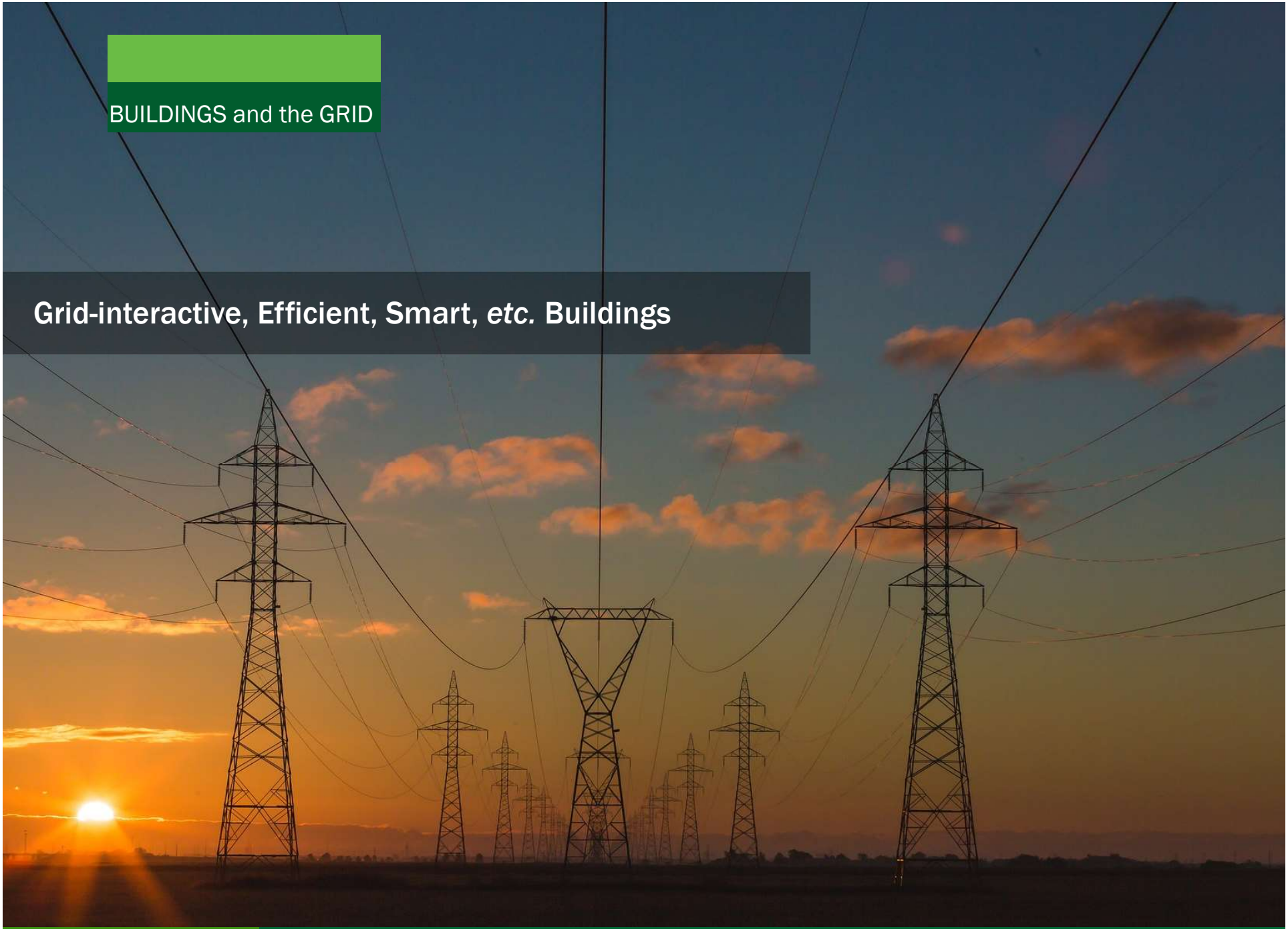
Integration

Technology validation, field & lab testing, metrics, market integration

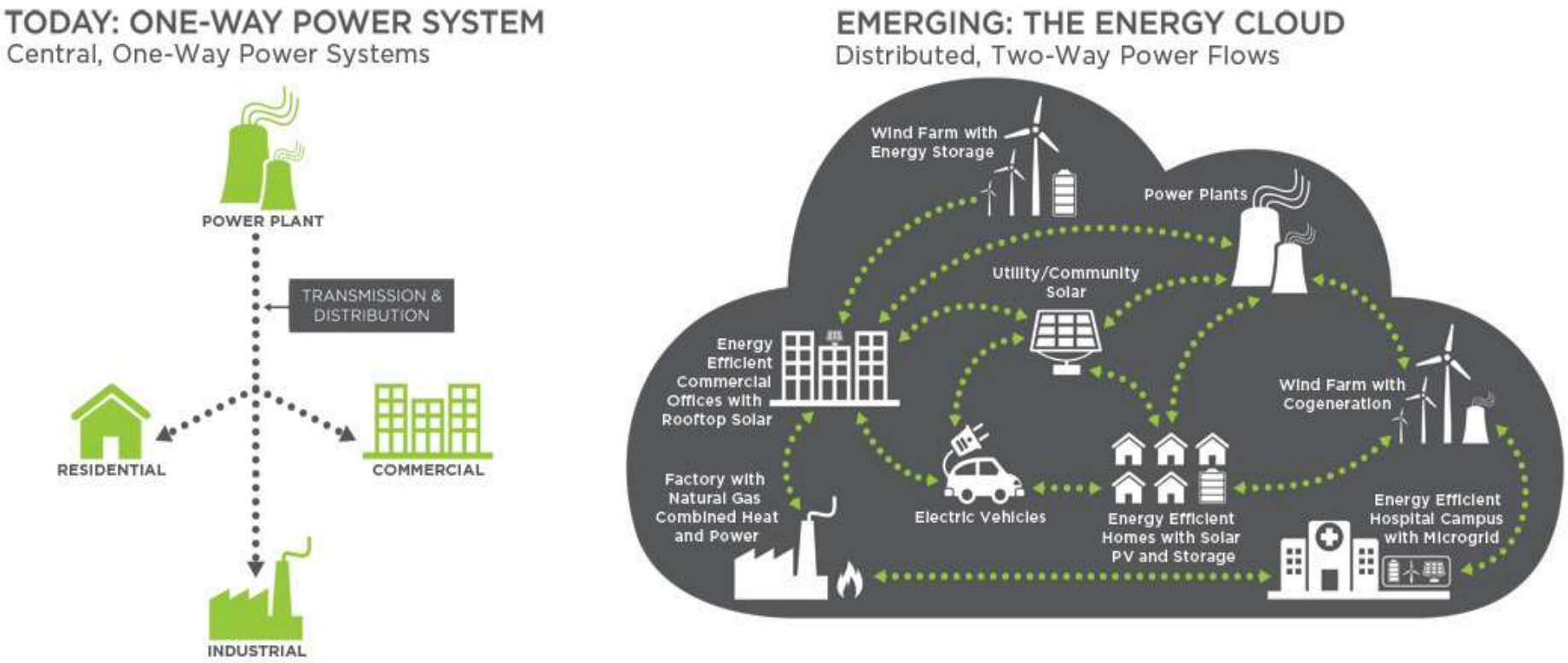
Codes & Standards

Whole building & equipment standards technical analysis, test procedures, regulations

Grid-interactive, Efficient, Smart, *etc.* Buildings



Moving toward the Grid of the Future



(Source: Navigant.)

Flexible building loads

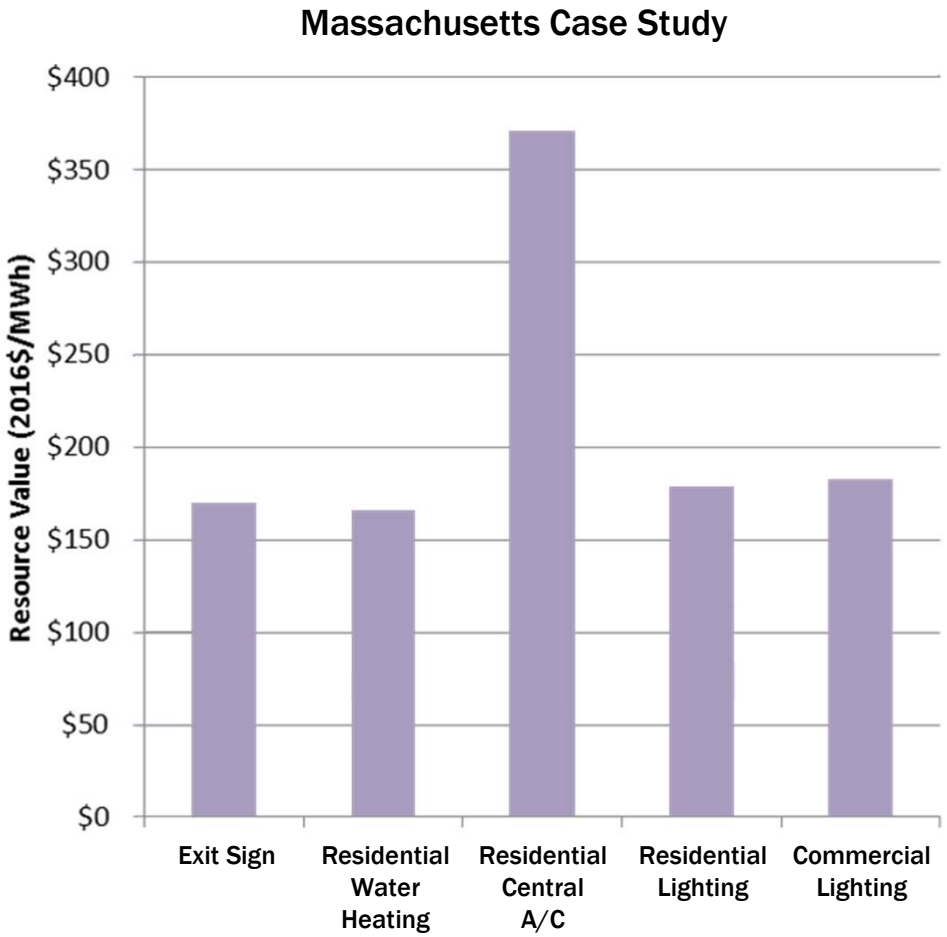
Provide options to increase electricity system reliability & energy affordability

Support renewables & all generation options resulting from grid modernization

Optimize energy use based on customer preferences

Respond to innovations in the energy economy

Not All Energy Efficiency is Equally Valuable

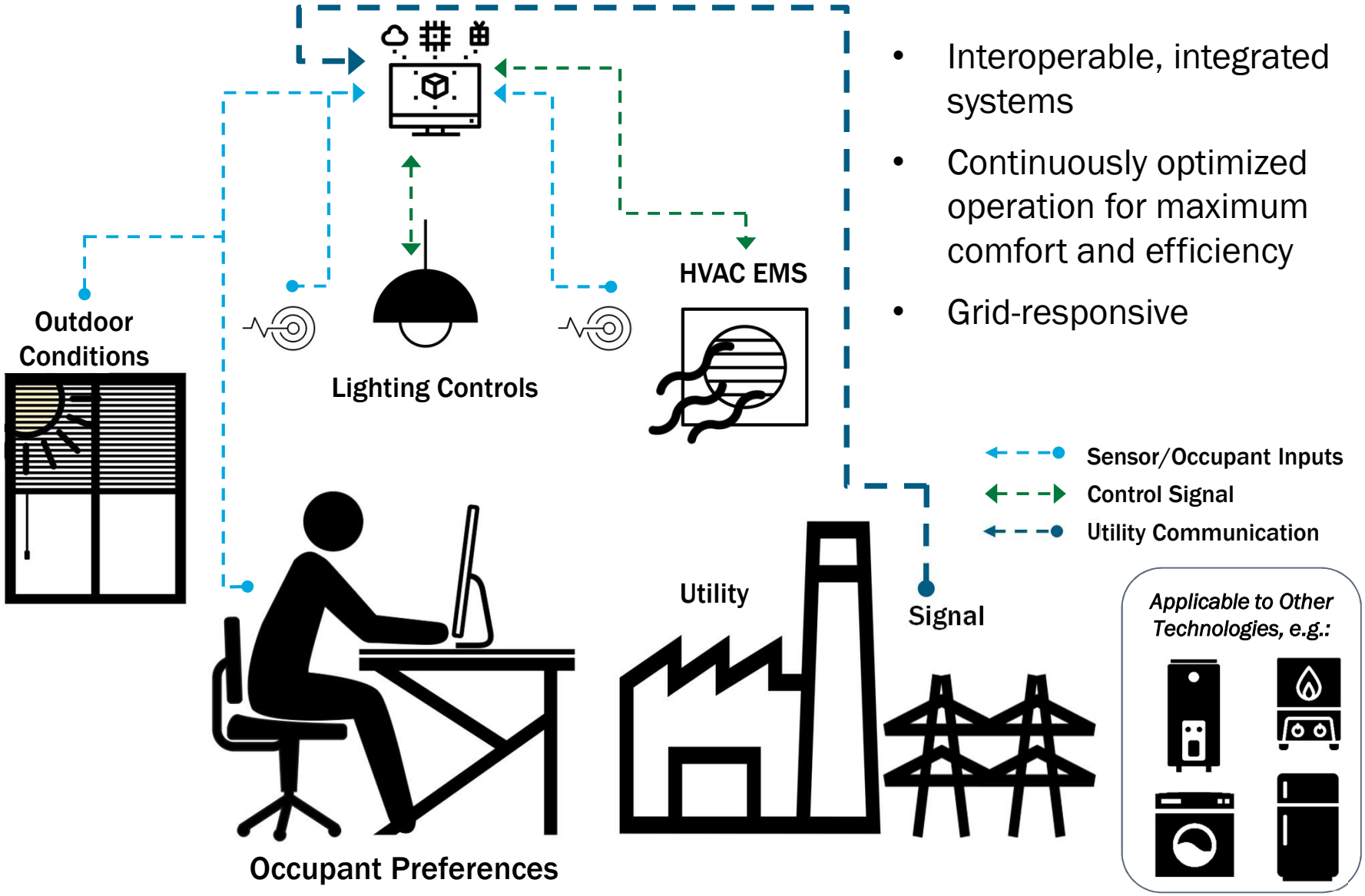


Time-varying value of energy efficiency savings by load shape

(reflects publicly available data only)

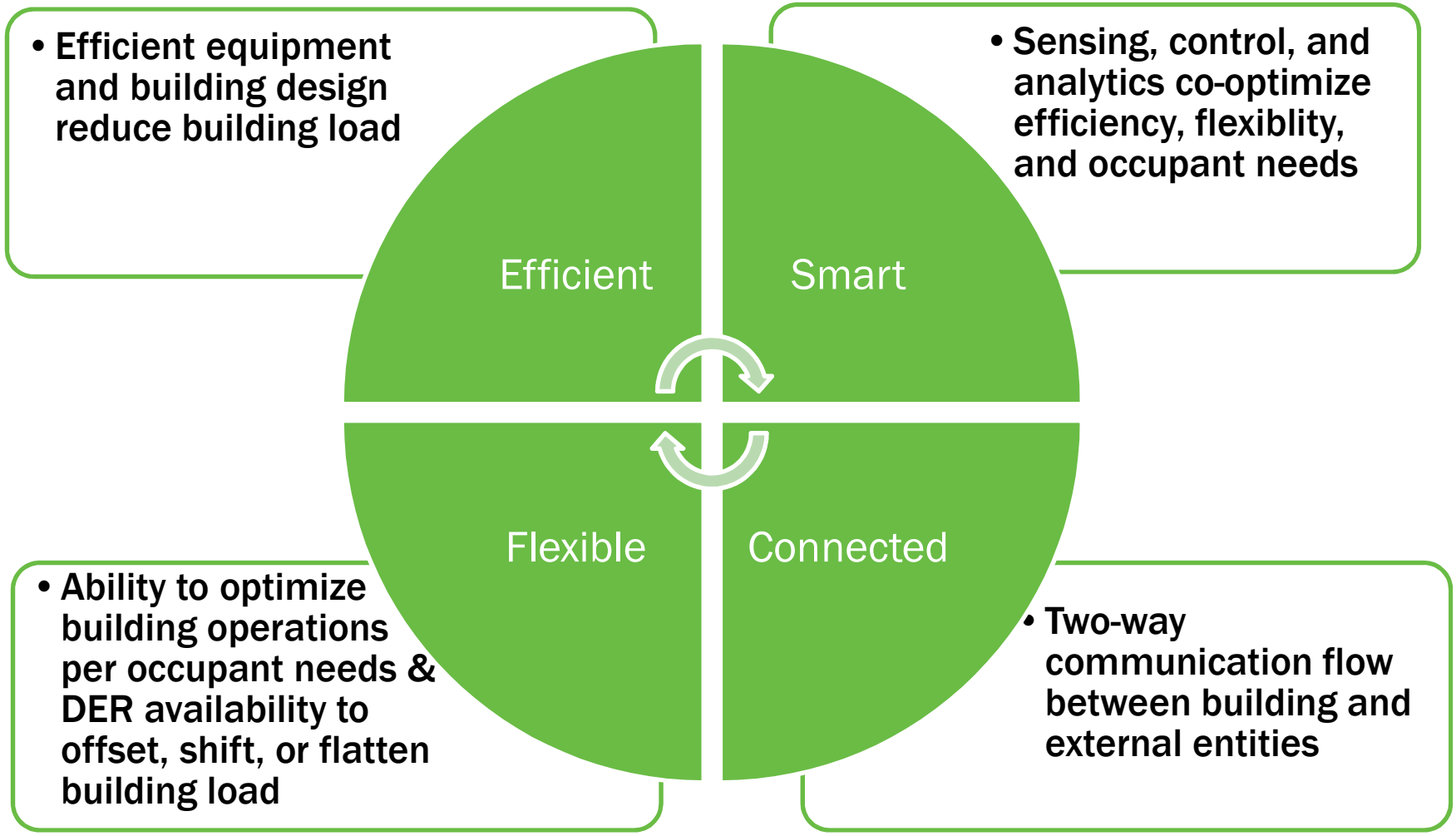
Source: ***Time-Varying Value of Electric Energy Efficiency*** *June 2017* N.Mims, T.Eckman & C.Goldman, LBNL, for BTO

Interactions with Building Occupants



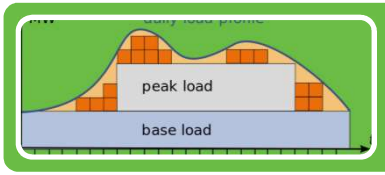
- Interoperable, integrated systems
- Continuously optimized operation for maximum comfort and efficiency
- Grid-responsive

Grid-interactive Efficient Buildings



Potential Benefits of Flexible Building Loads

✓ Energy Affordability



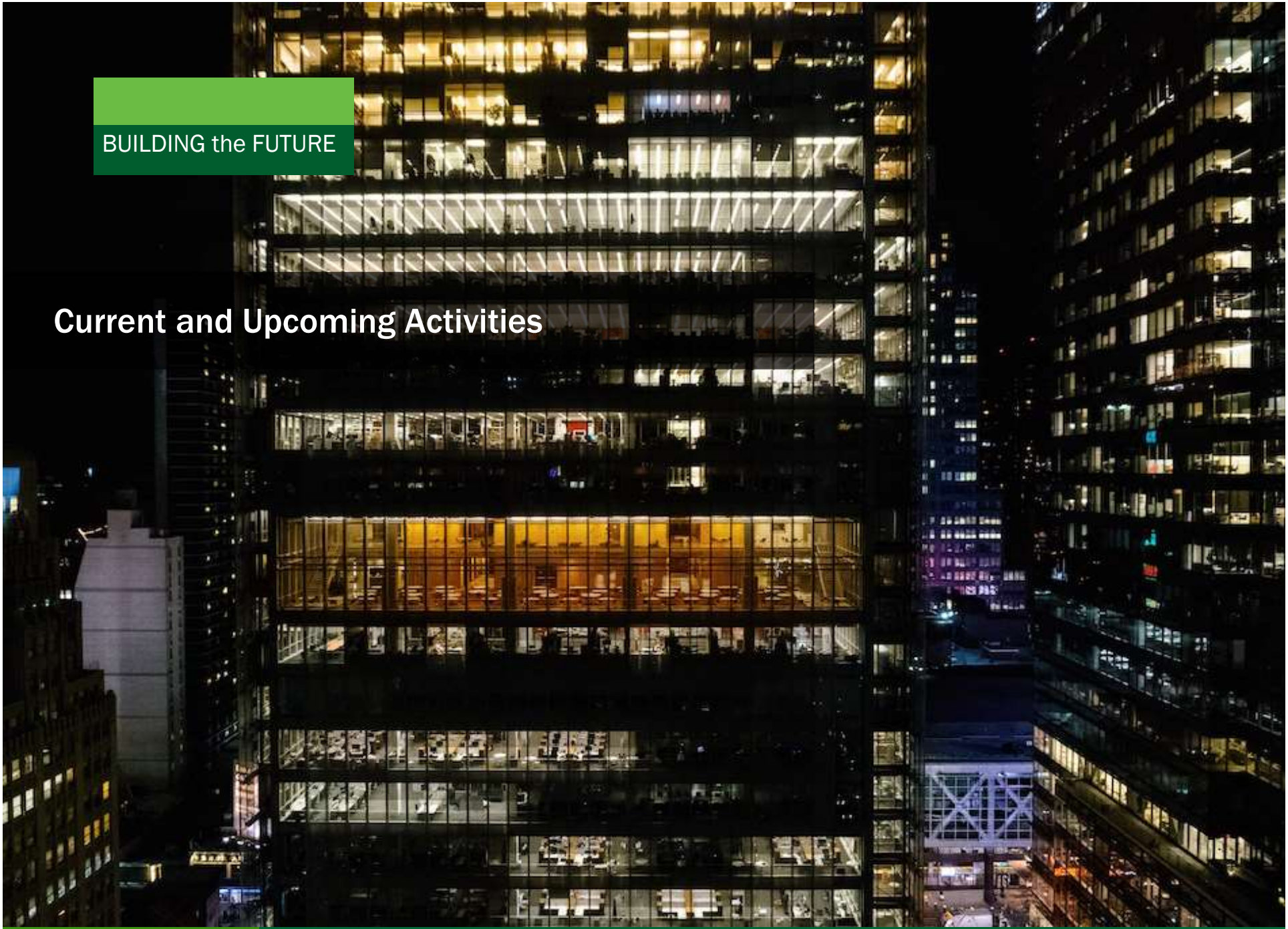
✓ Improved reliability

✓ Reduced grid congestion

✓ Enhanced services

✓ Environmental benefits

✓ Customer choice



BUILDING the FUTURE

Current and Upcoming Activities

Questions & Challenges

- How do grid-interactive efficient buildings fit into broader renewables integration and grid modernization?
- What are the top priority benefits that buildings provide the grid?
- How critical are better
  - Technologies? Analytics? Policies & programs?
- What are key barriers to adoption of advanced controls, technologies, practices?
  - Making the case? Complexity? Cybersecurity concerns?
- Will efficiency get its 'fair share'?
- Is this a 'bridge too far' (at least today) for buildings, utilities, utility regulators, governments?
- How to best work with other national, state governments

BTO grid-interactive efficient buildings portfolio

VALUATION ANALYSIS

Key Question: *How do time & the interaction of flexibility options impact value / improve affordability?*

Outcome: *Identify values to stakeholders, quantification of national value.*

TECHNOLOGY OPTIONS

Key Question: *Which end use technologies provide solutions to specific grid needs?*

Outcome: *Prioritize technologies / solutions based on grid services.*

OPTIMIZATION

Key Question: *How to optimize for flexibility while maintaining or improving building operation /occupant comfort / productivity?*

Outcome: *Solutions that meet grid operator & building occupant needs.*

VALIDATION

Key Question: *Do technologies perform as predicted / meet grid operator & building occupant needs?*

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

GEB – select research & analysis activities (1)

BTO and US National Laboratories are conducting R&D and field testing to advance key concepts that will shape grid-interactive buildings, including:

- ✓ Developing analytical frameworks that fully ***value*** buildings as flexible grid resources, including valuing efficiency on a time-sensitive basis
- ✓ Quantifying flexible building ***load potential*** to provide grid services and maximize demand response capacity
- ✓ Developing open source, scalable, cybersecure transactive ***control systems*** that enable buildings to provide grid services without decreasing performance
- ✓ Conducting end-use ***load profile modeling*** across the US building stock to inform energy efficiency and demand response savings profiles for buildings & technologies

Select activities (2) www.energy.gov/eere/buildings/geb

- ***End Use Load Shapes*** (FY19-21; NREL/LBNL): This project will result in: 1) end-use load profiles for U.S. building stock at both aggregate and individual building scales; 2) calibrated building stock end use models with ability to estimate EE/DR savings profiles for existing and emerging technologies. These datasets will be made publicly available via the EPRI load shape database and the methods used to develop these end use load shapes will be documented in a research paper.
- ***Regulators and State Energy Office Working Group*** (FY19; NASEO/NARUC): A working group to learn about the needs and questions of State leaders related to the value proposition of flexibility. This project will result in a set of documents that will support the development of state flexibility roadmaps and the initiation of state-led pilot projects; TA will be provided to states.
- ***Characterization of Connected Lighting Systems (CLS) Potential to Provide Grid Services*** (FY19-21; PNNL): The ability of CLS to deliver potential grid services while simultaneously delivering sufficient lighting service and occupant satisfaction has not yet been proven or quantified. This project will evaluate and advance the ability of CLS to provide grid services through modeling and simulation, laboratory testing, and field testing.
- ***Adaptive and autonomous controls:*** ***S***uite of projects (FY16-19: $6.5 million) at both universities and national laboratories aim to develop adaptive and predictive control algorithms through a combination of physics-based and data-driven modeling techniques along with machine learning by accounting for the trade-offs between model and computational complexity versus enabled energy savings. Occupant inputs (presence, movement, etc.) through advanced monitoring approaches are being incorporated to better match building operations with occupant comfort requirements.

2019 Planned activities and projects

- ✓ **Continued Feedback on Concept**
  - Flexible Building Loads RFI
    - https://eere-exchange.energy.gov/Default.aspx#Foaldd5fd318d-0a38-44fc-b1ab-aa54579c6177
  - IEA *Modernising Energy Efficiency through Digitalisation*
  - U.S. State/regulatory working group with states and utilities (February start)
  - Time-sensitive Valuation working group and webinars (Ongoing)
  - BTO Peer Review (April, Washington, DC)
    - www.energy.gov/eere/buildings/building-technologies-office-2019-peer-review
  - Multiple Technical Advisory Groups on GEB projects (Ongoing)
    - If interested in joining any project TAG, contact: monica.neukomm@ee.doe.gov
- ✓ **Refined Determination of Opportunity**
  - GEB Technical Report Series (Drafts complete for BTO Peer Review in April)
    - If interested in reviewing drafts, contact: monica.neukomm@ee.doe.gov
  - GEB Resource Potential (Fall)
- ✓ **Upcoming Competitive Funding**
  - Grid Modernization Lab Consortium – 2nd round of focus areas and projects (January)
  - Inclusion in non-governmental and national lab competitive funding RFPs (spring/summer)
- ✓ **More to come!**
  - Greater coordination with IEA including IEA's Energy in Buildings & Communities Programme www.iea-ebc.org

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