The Economics of Grid-interactive Efficient Buildings (GEBs)

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Getting to Zero Forum
October 10th, 2019

Evolution of green buildings

Energy Efficiency

Isolated measures

<15% energy savings

Deep Energy Retrofits

Integrated measures

>40% energy savings

Net Zero Energy

Holistic solution across efficiency and renewables

Generation = use

Grid Interactive Buildings

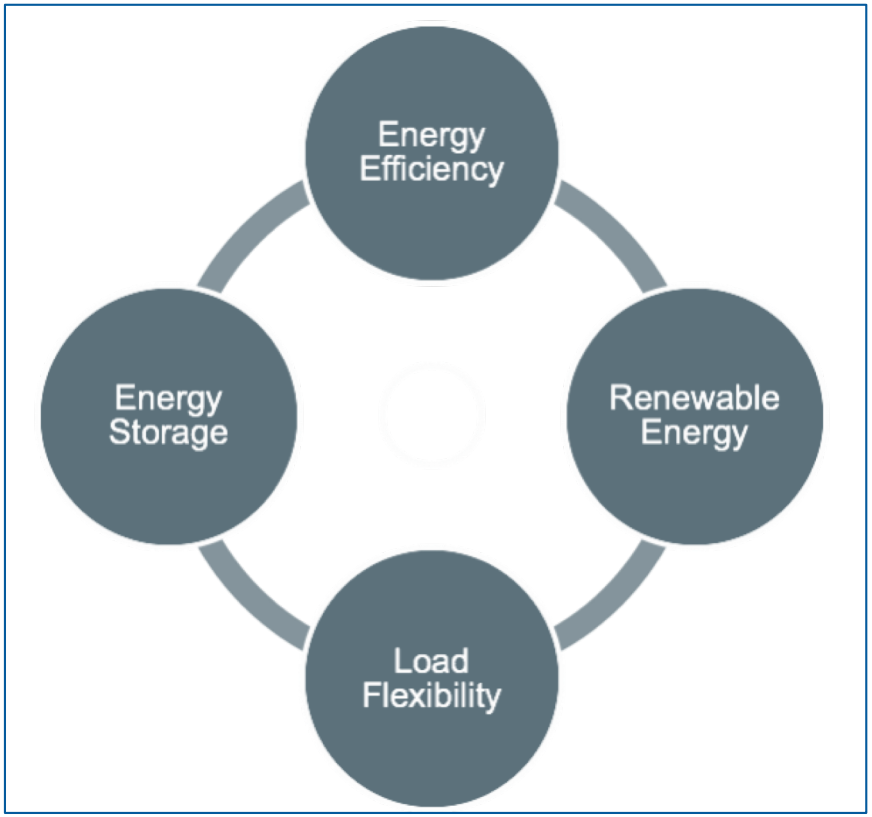
System level solution

Benefit both building owners and the grid

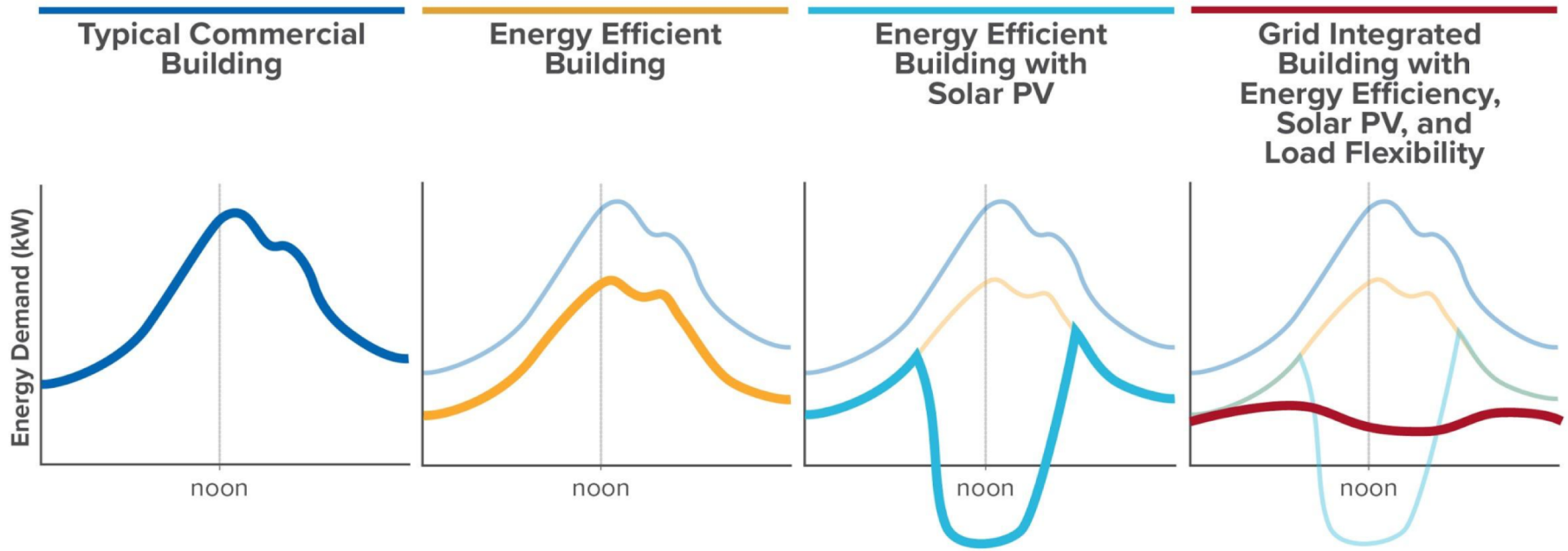
Optimizes demand and consumption

What are Grid-interactive Efficient Buildings (GEBs)?

- Grid interactive buildings leverage energy efficiency, renewable energy, energy storage and load flexibility to benefit building owners, occupants, and the electric grid.
- A GEBs strategy goes beyond traditional demand response, to re-shape a building's energy demand profile and enable load flexibility
- By reacting to utility price signals, the building can reduce costs to the building owner and the utility



GEBs illustrative load profiles



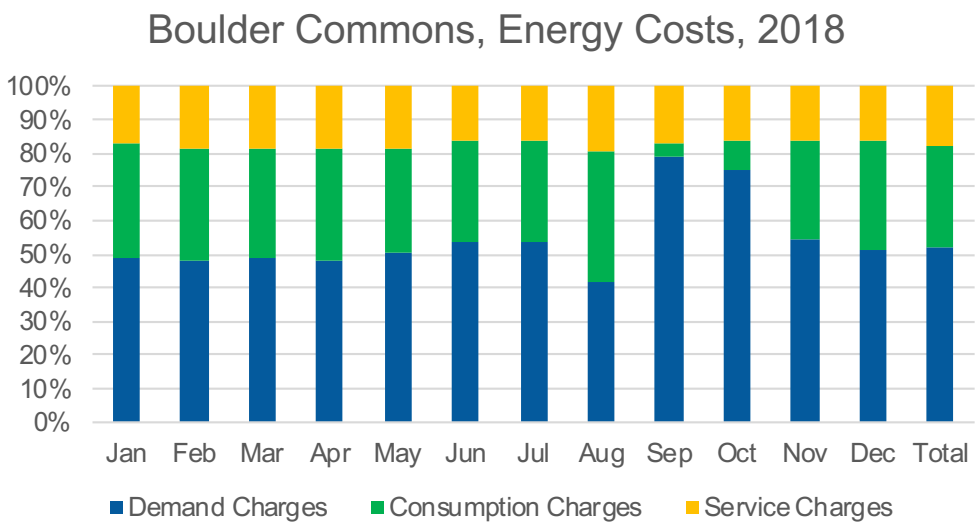
Efficiency reduces demand and energy costs

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 increases resilience by providing a lower, flatter, more flexible load shape.

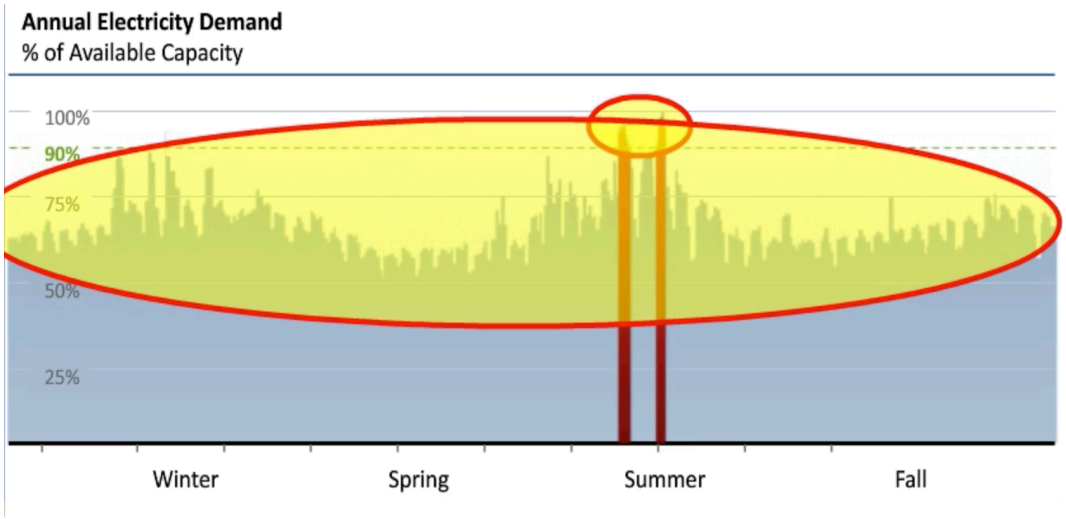
GEBs are important to building owners/operators: Significant cost savings by managing both consumption and demand

- Demand charges can be up to 60% of annual energy costs
- Most buildings track energy consumption, not necessarily demand
- Shelters buildings against future rate structures changes
- Supports with deep energy retrofits, zero carbon goals



GEBs are important to the grid: Building peaks drive grid peaks

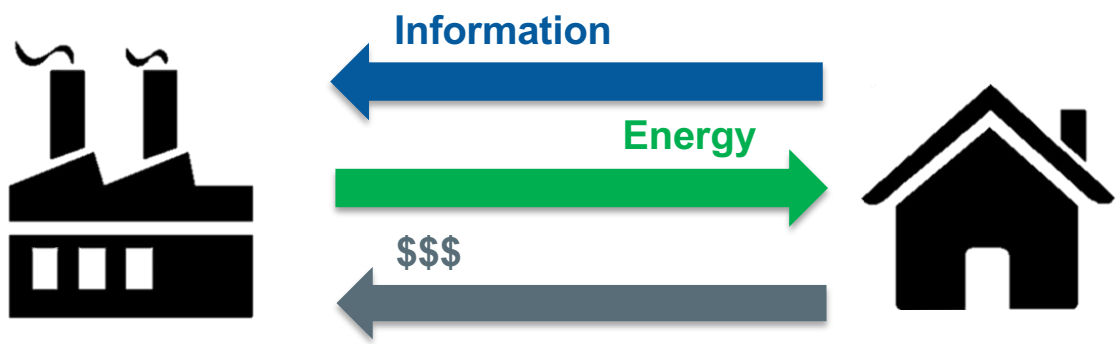
- 80% of grid peak demand is driven by buildings
- >10% of grid infrastructure costs are spent to meet the peak demand that occurs <1% of the time – making those peak times the most expensive, and likely carbon intensive power.
- Building level RE exports are largely coincident with peak grid/utility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



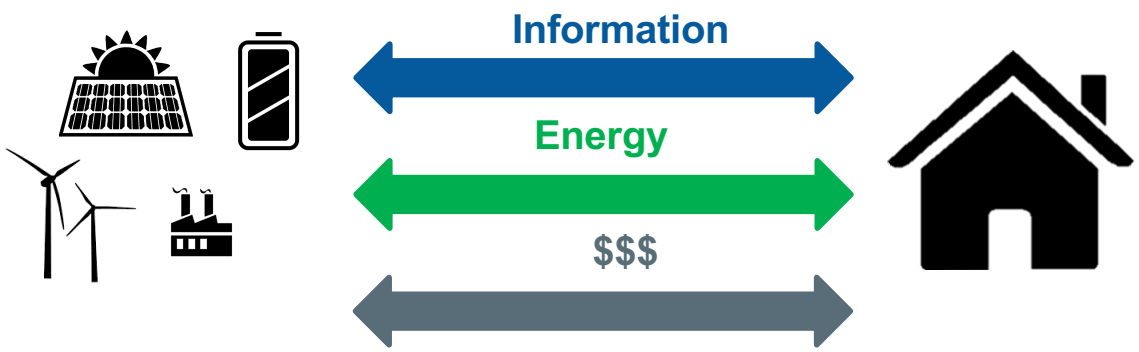
Source: DOE, SEPA

Grid-interactive efficient buildings

Business as Usual



Grid-interactive Efficient Buildings



Key differentiators of grid interactive buildings

Attribute	Today	Future
1. Interoperability and intelligence from building to grid	• DR programs, often manual, fairly static	• Ability to receive and respond to utility price signals • Ability to send load flex potential
2. Interoperability and intelligence across building systems	• BMS system for major loads (HVAC) • Individual system controls (Lighting, storage)	• Single, overarching integrator to monitor and control all loads, inc. plug loads and storage • Ability to optimize for cost, carbon, reliability, etc.
3. Load flexibility and demand-focused optimization	• Thermal energy storage • Battery storage	• Intelligence to track and map demand, shift or shed rapidly based on inputs such as price, weather, carbon, events, etc.

Key Findings

The Economics of Grid-interactive Efficient Buildings (GEBs) in GSA's Building Portfolio

Context and Purpose

Purpose of Study	• To explore the strategies and value provided by grid interactive buildings and how that could impact the GSA portfolio. • To inform GSA's GEB strategy
Intended Use	• This study provides a fact base to demonstrate the value of a GEBs strategy for the GSA (and others) • Recommends specific strategies for the GSA to save operating costs • This effort complements work by the GSA GBAC, DOE BTO, NASEO-NARUC, and others • To inform next steps

Approach

6 locations

- CA, NY, GA, MD, AZ and CO
- Variety of climate zones and rate structures, representative of portfolio

29 measures

- Focused on demand reduction

Localized labor and materials costs

- Using vendor-supplied equipment costs and location-based labor and material factors

2 Fuel Scenarios

- Assuming 87% of GSA's buildings are dual fuel, 13% are electric only

1-2 utility rate structures per location

- Variation in consumption charges, demand charges, and time value. Represents current and potential rate structures

Demand Response Value and Program Terms

- Based on quotes and program terms from aggregators

Modified DOE Reference Model

Adjusted to represent a large GSA office

NPV of measures and bundles

Energy and demand reduction metrics

Portfolio-wide patterns and guidance

Sensitivity analysis

Key Findings: Three Core Values of GEBs

Direct Value to GSA

- Portfolio: $50 MM annual cost savings, $206 MM in NPV
- Project: 30% average annual cost savings per project, sub 4 year payback
- Flexibility to accommodate future rate structure changes

Indirect Value to GSA

- Demonstrates federal and real estate industry leadership
- Enables deeper savings in ESPCs and UESCs
- Better building control can improve comfort, health, and productivity
- CO2 savings

Societal Value

- Reduce grid-level T&D and generation costs up to $70MM/yr
- These savings ultimately benefit taxpayers, increase resilience and reliability
- 2x as effective as DR

Assumes GEBs are applied across the GSA portfolio of owned office buildings; Based on bundle of measures modeled by RMI. NPV is based on an 8 year time horizon and a 3% discount rate.

Key Findings: Critical ECM's and Strategies

1. **Adoptable measures.** HVAC, lighting, plug load, renewable energy, and storage measures define the cost-optimal strategy
2. **Investment in fully controllable systems.** For example, many GSA buildings have LEDs, but fully controllable fixtures provide much more value.
3. **Stage large building loads** like electric heating, AHU fans and motors, and plug loads. Staged loads are an untapped source of demand savings and require little-to-no new equipment.
4. **Consistent demand management**. Year-round demand management delivers greater value than demand response in most scenarios.
5. **Battery storage and solar PV.** These technologies make economic sense in most locations, but to varying degrees. Falling first costs make these technologies more important for future projects.

Key Findings: Recommended Next Steps

1. **Fold GEBs measures into current projects and pipeline:**
   a. Short payback and a high NPV can help 'buy down' longer-payback measures in ESPC and UESC projects
2. **Develop GEBs pilots as proof points in advantageous locations:**
   a. Prioritize locations with high demand rates or time of use rates, including include NYC ($3.1MM NPV, 2.3 yr payback) and Fresno ($4.0MM NPV, 3.7 yr payback)
   b. All-electric buildings are top-priority – 2x NPV vs dual fuel buildings
   c. Locations with high concentrations of same agency buildings, regional leadership and motivated building managers
3. **Develop and/or adopt a building performance metric that considers electric demand (e.g., demand load factor)**

* Maximum figure, which assumes that load flexibility and peak reduction align with grid coincident peaks. This is not an absolute figure.

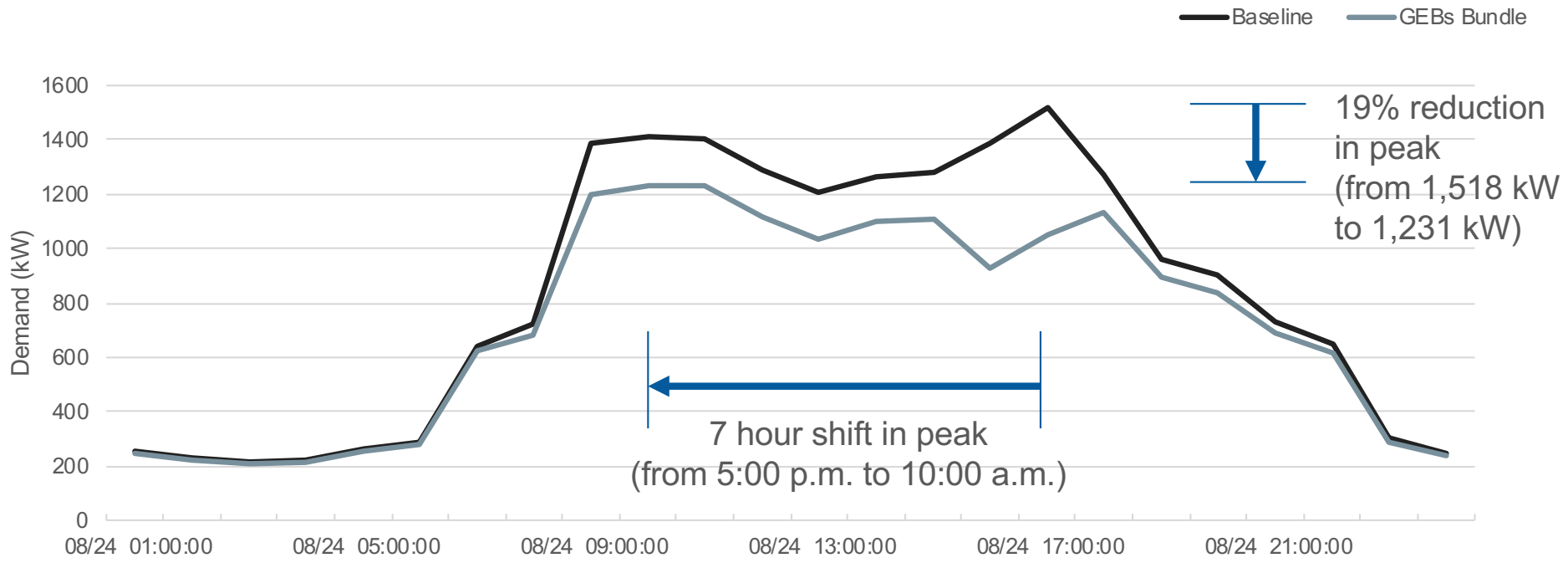
There is a large, untapped, and cost effective opportunity to invest in GEBs measures today

	First Cost of GEBs Measures	Annual cost savings	Payback* (yrs)	NPV*
Fresno, CA	$2,458,955	$612,178	3.66	$4,006,943
New York, NY	$2,013,386	$429,315	2.30	$3,084,392
Denver, CO	$282,357	$122,803	0.90	$894,312
Phoenix, AZ	$664,291	$207,468	3.15	$1,021,321
College Park, MD	$107,138	$48,251	2.22	$227,549
Atlanta, GA	$190,687	$59,072	2.89	$238,934
Average (unweighted)	**$952,802**	**$246,514**	**2.52**	**$1,578,894**

- GEBs measures have **high net present value** and **short paybacks** across all locations, largely due to low first cost measures such as controllability and staging existing equipment.
- Investing now will **secure financial returns,** enable savings to persist as rate structures change.
- The **best returns** are in locations with **high demand charges, time of use rates, and seasonal variation** – and utility rate structures overall are trending in this direction.

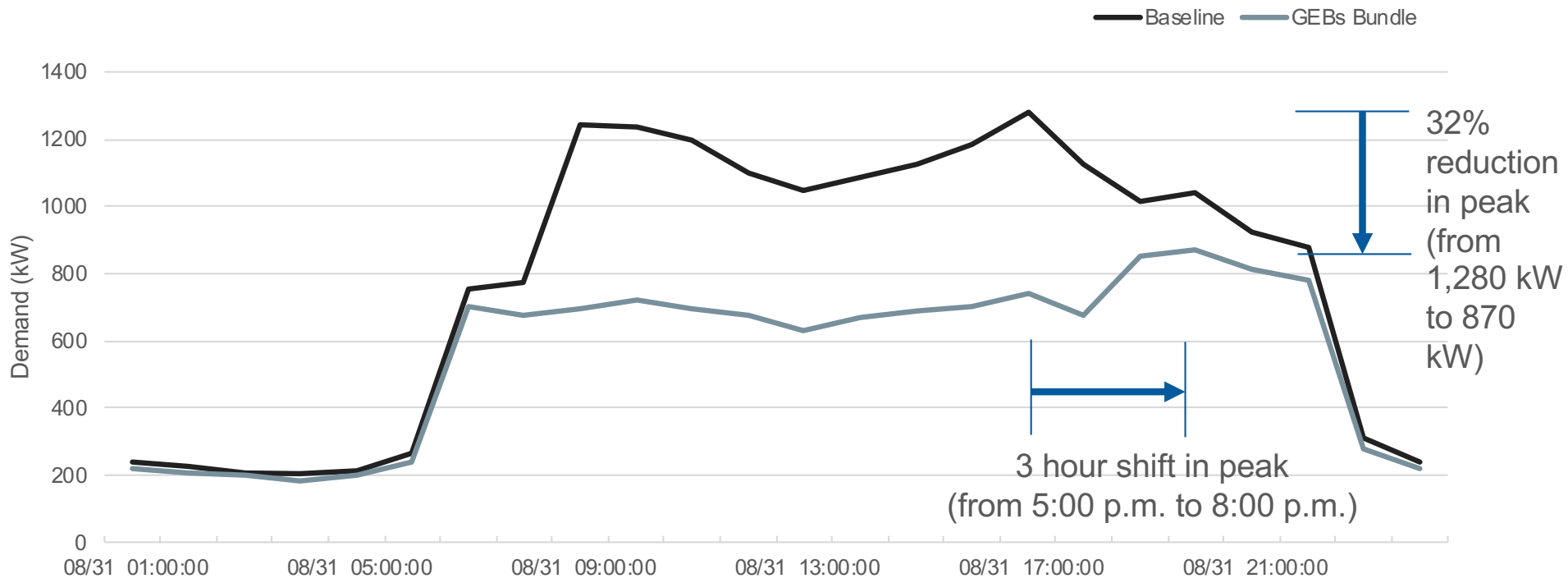
*Includes local rebates and incentives available to the federal government. This does not include demand response revenue.

5 Phoenix: 19% reduction, 7 hr shift in peak demand



Assuming coincident utility and building peaks at 5:00 p.m., load reduction and shifting provides significant value to the utility.

5 NY: 32% reduction, 3 hr shift in peak demand



Assuming coincident utility and building peaks at 5:00 p.m., load reduction and shifting provides significant value to the utility.

On the horizon…

1. RMI's full report (released August 1st) – www.rmi.org/gebs
2. GSA Proving Ground Pilot – Request for Information released October 9th 2019.
   - Partnership between DOE BTO and GSA
   - Both GSA buildings and BBA portfolio buildings
   - Nov 7th, 2019 informational webinar
   - Check www.rmi.org/gebs for a link to the RFI website and webinar
3. GSA Green Building Advisory Committee is releasing ESPC/UESC guidance for grid interactive buildings - this fall
4. DOD ESTCP Symposium in December

RMI seeks to partner on leading edge projects and programs around grid interactive buildings:

- Technical optimization and economic analysis
- Agency and organization program development
- Sharing successes

Additional Resources

- Rocky Mountain Institute - Grid interactive buildings and GSA Value analysis: (https://rmi.org/gebs)
- U.S. General Services Administration – Green Building Advisory Committee - GEBs Task Groups
  - 1. Policy recommendations and 2. GEB in ESPC/UESC guidance)
- DOE BTO – GEBs Homepage
- Laurence Berkeley National Lab – FlexLab
- New Buildings Institute – GridOptimal Initiative
- NASEO – NARUC GEB Working group
- More from ASHRAE, NREL, ACEEE…