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Center for Sustainable Landscapes | Pittsburgh, PA. Photo: Paul G. Wiegman

Getting to Zero: Grid Integrated Buildings
April 29, 2021
Efficiency delivered.

NBI is responding to increasing urgency to reduce carbon emissions and increased demand for improved energy performance of new and existing buildings.

NBI's Theory of Market Change:

- Vision
- Thought Leadership
- Research
- Solutions
- Codes & Policy

Our Program Areas

1. Building & Program Innovation
2. Zero Energy Leadership & Market Development
3. Advancing Codes & Policy

Today's panel:

- Alexi Miller
  Associate Technical Director
  New Buildings Institute
- Rushil Desai
  Senior Building Analyst
  Elemental Engineering
- Rois Langer
  Senior Research Engineer
  National Renewable Energy Lab
- Victor Olgyay
  Principal
  RMI
rushil desai

buildings in the context of an evolving grid

Grid-integrated buildings - what and why
NYC LL84 Reported GHG Intensity

18 kgCO₂e/ft²/yr

- 2024 cap: 8.46
- Current energy code: 5.8
- 2030 cap: 4.53
- 2050 cap: 1.40

21% of sample set exceed 2024 cap
Energy, Cost and GHG emissions based on consumption at boundary

PROJECT BOUNDARY

- GAS
- CHW
- HHW
- ELECTRICITY

Energy, Cost and GHG emissions based on consumption at boundary
Partial Fuel Switching
Designing a system to completely switch away from central steam while still served by central chilled water

Onsite Co-Generation
Assessing the GHG impact of onsite Fuel Cell based combined cooling and power in 2024 and 2030
**All-Electric Plant**
Switching away completely from central utilities through an onsite all-electric chilled and hot water plant

**Prioritization Plan**
Estimating the range of magnitude of required offsets based on the rate at which the grid gets cleaner
Future marginal emissions
The true GHGi of a building is affected by the magnitude as well as the hours of grid electricity draw.

Generation is not enough
As the future grid gets cleaner, the significance of renewable energy generation will drop considerably.
Automated dispatch logic
Look ahead at demand, emissions and signal a battery bank to charge and discharge optimally

Shifting the load curve
By charging during low emissions hours and dispatching during high grid emission intensity hours
Avoided Emissions
The same renewable energy offset can avoid anywhere from 6% to 48% GHG as the grid gets cleaner.

Rate structure optimization

Resilience
The Value of GEB

Rois Langner
NREL
GEB is about enabling buildings to provide **flexibility** in energy use and grid operations.

Supply

Demand

~75% of electricity generation is used in buildings

Potential Benefits of Flexible Building Loads

- Energy affordability
- Improved reliability & resiliency
- Reduced grid congestion
- Enhanced services
- Environmental benefits
- Customer choice
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

Multiple Stakeholders, Multiple Sources of Value

- **Building Owners**: Reduces Capital Costs
- **Utilities/grid operators**: Reduces Operating Costs
- **Building Occupants/Tenants**: Grid Stability and Resilience, Health Benefits
- **Society**: Decarbonization Goals

Today’s conversation:
1. Economic value to owners and grid stakeholders
2. Carbon value to society
The Value Potential for GEB in GSA’s Portfolio

Direct Benefits to GSA
- $50 MM in annual cost savings
- $206MM in NPV
- Project-level payback under 4 years
- Futureproof: Accommodates future rate structure changes and helps manage costs

Grid and Societal Value
- Reduce grid-level T&D and generation costs up to $70MM/yr
- These savings ultimately benefit the government and taxpayers
- Future grid economic models will value savings (e.g. NWA’s)

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

Assumes GEBs are applied across the GSA portfolio of owned office buildings; Based on bundle of measures modeled by RMI.

Cost Effective GEB Measures & Strategies

<table>
<thead>
<tr>
<th>Measures</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost-effective in almost every location</strong></td>
<td>1. The best returns are in locations with high demand charges, time of use rates, and seasonal variation.</td>
</tr>
<tr>
<td>• LED lighting upgrades, including tube retrofits, fixture retrofits</td>
<td>2. Consistent demand management and peak shaving delivers greater value than demand response in most scenarios.</td>
</tr>
<tr>
<td>• Staging to reduce peak demand:</td>
<td>- Advanced lighting controls, which enable peak shaving and DR</td>
</tr>
<tr>
<td>- Laptop battery charging</td>
<td>- Electric Battery storage</td>
</tr>
<tr>
<td>- AHU fans</td>
<td>- Solar PV energy generation</td>
</tr>
<tr>
<td>- Electric resistance heaters (all-electric only)</td>
<td>- A solar + storage “bundle” – bundling enhances the value beyond investing in solar and storage individually</td>
</tr>
<tr>
<td>• Space temperature setback to reduce peak demand</td>
<td></td>
</tr>
</tbody>
</table>

GEBs measures have high net present value and short paybacks.
Carbon Value: Demand flexibility can cut building demand by 30-50%, reducing the need for peaker plants

- 80% of grid peak demand is driven by buildings
- By shifting load strategically at peak hours can reduce or eliminate the need for dirty and expensive peaker plants

Source: 1. SEPA Webinar 2019

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Significant cost and health benefits by avoiding peaker plants.

- **Low efficacy:** Avoid $268 Million annually in capacity payments that support the peaker plants which run < 10% of the time
- **Disproportionately expensive:** Peakers can cost up to 1,300% more than other typical sources
- **Heavy Polluters:** Despite limited run-times, peaker plants contribute significantly to local air pollution with localized pollutants (i.e. Nox, SO2, PM2.5). While running, peakers can account for more than 1/3 of daily power plant NOx emissions
- **Low-income and communities of color:** disproportionately bear the brunt of peaker plant health concerns. In these high impacted areas, rates are 4x higher for ozone-attributable asthma admissions

Sources:
2. NYSEERAI Monthly Average Price of Residential Electricity, 2020
3. Governor’s Office of NYS Adoption of Regulations to Improve Air Quality, 2019
**On the horizon…**

1. RMI, NREL, DOE and GSA are applying a similar GEB Value Analysis methodology on 2 BBA commercial portfolios (big box retail and multifamily) …stay tuned for results
2. GSA GEB RFI – piloting GEB controls solutions in public and private projects.
3. RMI working with NYiserDA to explore the carbon value of demand flexibility, implications on LL97.
5. Forthcoming DOE Connected Communities projects

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**GEB Field Studies**
GSA Proving Ground DOE High Impact Technology Catalyst

2019 Request for Information:
• GEB solutions that cost-effectively provide building load flexibility
• Load flexibility modes (at least 3):
  • Energy efficiency
  • Load shed
  • Load shift
  • Modulation
• Integrate multiple building systems, beyond HVAC & lighting
• Aggregate data and dynamically manage and coordinate loads

5 Selected GEB Solutions

Federal (GSA) & Non-Federal Buildings

4 Laboratories to Lead M&V:
• NREL, LBNL, PNNL, ORNL
### Key Objectives for GEB M&V

- Key objectives for evaluating GEB solutions:
  - Capability to enable energy efficiency & load flexibility – continuously & in response to DR events
  - Costs
  - Building owner and utility benefits
  - Integration and building service impact

- Highly complex solutions
  - Control of multiple building systems
  - Multiple load flexibility modes
  - Climate zone implications
  - Differences in building operational mission

*Important to coordinate language, metrics, and M&V approach to enable as much consistency as possible across projects*

### Metrics for Demand Flexibility

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency</td>
<td>- Energy savings: kWh/yr, % savings</td>
</tr>
<tr>
<td>Load Shed &amp; Shift</td>
<td>- Monthly peak demand reduction: kW and %</td>
</tr>
<tr>
<td></td>
<td>- Monthly demand charge reduction</td>
</tr>
<tr>
<td></td>
<td>- Summer and winter average peak kW and charge reduction</td>
</tr>
<tr>
<td></td>
<td>- Demand shed per event: average kW</td>
</tr>
<tr>
<td></td>
<td>- Average demand increase/decrease over shift days summer/winter: kW, %</td>
</tr>
<tr>
<td>Load Modulation</td>
<td>- Upper and lower demand bounds for kW increase and decrease</td>
</tr>
<tr>
<td>Carbon Reduction</td>
<td>- Annual CO2 equivalent per year</td>
</tr>
<tr>
<td>Costs</td>
<td>- Capital costs</td>
</tr>
<tr>
<td></td>
<td>- Cost savings</td>
</tr>
</tbody>
</table>
Project Outcomes

1. Public facing reports and presentations
2. Calculating key success metrics – quantitative and qualitative
3. Capturing lessons learned and best practices from each field study

Thank You

www.nrel.gov

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Designing a Climate Positive Future with Zero-Energy Districts
Victor Olgyay, AIA
April 29, 2021

Vision... what you see and what you imagine...

Is that a duck?
“Eventually everything connects - people, ideas, objects. The quality of the connections is the key to quality per se.”
— Ray and Charles Eames

But we are still on “Version 1.0” of understanding building connections.
**The “Duck Curve”**: Design generation and demand to fit load profiles

![Duck Sitting in Water](image1)

![Duck in Flight](image2)

**Figure 3**

**Comparison of Pre-Strategies and Post-Strategies Load Profiles**

- Expensive, valuable electricity
- Balance demand to follow supply

---

With grid integration, buildings can deliver significant value across stakeholder groups

**Source of income to building owners**
- Reduced operating cost, increased asset value
- Profit to building owner through selling electricity and associated grid services

**Helps the grid run more smoothly**
- Assist with load shaping by providing storage, demand flexibility
- Add diversity and resilience to grid by providing “spinning reserves” and frequency regulation
- Reduce capacity, transmission and distribution infrastructure costs and upgrades

**Reduces energy costs and pollution for owners, utilities, and the general public**
- Essential for the transition to a renewable powered system and ultimately decarbonization
- Demonstrates industry leadership
- Improves control and occupant comfort in buildings

Buildings: Grid services are one of many value propositions of buildings, try using an integrated design approach
Pollute less by operating buildings strategically

Our buildings can influence the carbon emissions intensity of the electricity grid.

With grid integration we can use operational strategies to optimize both carbon & cost benefits today. 

Our buildings can influence the carbon emissions intensity of the electricity grid.

With grid integration we can use operational strategies to optimize both carbon & cost benefits today.

Connected Communities

- **Are Grid-interactive and efficient**
  - The capability to shed, shift, or modulate energy use in response to grid signals.

- **Connect Buildings and Grid Services**
  - Accessed with multiple technologies: building load flexibility, renewable energy generation, and energy storage.

- **Use Multi-building optimization**
  - Employ diversity and strategies to optimize energy use and dispatch of distributed energy resources to increase the benefits beyond that of a building-by-building approach.

- **Employ Shared systems**
  - Geographically contiguous connected communities can incorporate physically connected shared systems such as district thermal plants, community solar, or energy storage installations across multiple facilities.

- **Coordinate with Central Control systems**
  - Connected communities accomplish this through a controls platform enabling grid-interactivity at the multi-building scale.
Basalt Vista Affordable Housing
A Net zero, all-electric community

- Led by Habitat for Humanity, this development has 27 families with all-electric, energy-efficient homes, no gas
- Simple design,
- High efficiency
- Hybrid electric water heaters
- Heat recovery ventilators
- Cold climate heat pumps
- Sealed conditioned crawlspaces
- Rooftop PV
- Battery storage
- EV chargers

Holy Cross Energy, the local electric utility co-op, is working to reach its goal of 70% carbon-free energy by the year 2030. Basalt Vista a sophisticated communication and control device called a “coordinator” that interfaces between the house and the utility’s dispatch center.

The batteries store power from the solar panels; supply power to the house; store power drawn from the grid; and they supply power to the grid. All those functions are managed by the coordinator, which is also able to control other “distributed energy resources” in the house—the heat pumps, the heat pump water heater, and the electric vehicle charger.

delayed self-consumption
harmonize the requirements of the house with the grid’s need for optimal power flow
Providing meaningful amounts of grid services

A solar microgrid in conjunction with a one megawatt/ two MWh lithium-ion battery system. This 100-building district is connected to the local electric grid and provides services including solar to grid integration, ramp control, grid peak demand reduction, and frequency regulation. These valuable grid support services also strengthen grid resilience through backup power and ensures the community is supplied by abundant clean energy.

In this district Xcel Energy was able to avoid the capital cost of building an electrical substation because of the grid support provided by the energy storage system.

Peña Station—Denver, CO

Microgrid Powered by Clean, Resilient, Renewable Energy

A 1.6 MW solar PV system at the 61st and Peña rail station, and another 259 kW of solar PV on Panasonic’s rooftop, help power Peña Station NEXT with renewable energy. This system and a large on-site battery system owned and operated by Xcel Energy form a microgrid that strengthens energy resilience and ensures the community is supplied by clean energy.
Hazelwood Green
A Brownfield Site with a Forward-Leaning Vision

- Location: Pittsburgh, PA
- 180 acre former steel mill site
- 6M gross ft² of building floor area
- 60% residential, 30% office, 10% other
- Deregulated electricity market

- Problem Statement
  - Site owners have a net-zero energy ambition
  - Must be financially sound for developers, building owners, and tenants
  - First-cost premium may threaten project viability
  - Market advised that net zero energy was unachievable

The pathway to zero for Hazelwood Green includes on-site renewables, district scale GSHP, and efficient building design
The Integrated Energy Services Provider (IESP) aligns incentives while driving a greater investment opportunity

The integrated energy services provider (IESP) aggregates site energy services while ensuring that net-zero energy is financially attractive to vertical developers and tenants while collecting a steady, long-term return.
IESP shifts up front costs from individual building to central entity

IESP revenues are delivered through the occupant energy bills
The next ten years are critical to reach our climate goals!

- Zero emissions by 2050
- 65% chance of staying below 2°C
Resources for designing Net Zero Districts:

Innovation Opportunities in Grid-Interactive Efficient Buildings

https://rmi.org/insight/zero-over-time-for-building-portfolios/

An Integrative Business Model for Net-Zero Districts

Designing a Climate-Positive Future with Zero-Energy Districts
https://rmi.org/designing-a-climate-positive-future-with-zero-energy-districts/

Connected Communities: A Better Way of Building
https://rmi.org/connected-communities-a-better-way-of-building/

“Connected Communities: A Multi-Building Energy Management Approach”
https://www.nrel.gov/docs/fy20osti/75528.pdf

Thank You

Maybe we can help more ducks to fly?

GridOptimal Buildings LEED Pilot Credit
Overview – April 29, 2021

https://newbuildings.org/gridoptimal/
Main Focus: new building-grid interaction metrics

- Metrics published (blog, white paper)
- LEED Credit: GridOptimal Buildings Pilot Alternative Compliance Path published & available

Current Work: deployment

- Utility program criteria
- Design guidance
- Code and policy frameworks

GridOptimal Metrics: at the core of it all

<table>
<thead>
<tr>
<th>GridOptimal Metric</th>
<th>What it Measures</th>
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<tbody>
<tr>
<td>Grid Peak Contribution</td>
<td>Degree to which building demand contributes to load on the grid during system peak hours</td>
</tr>
<tr>
<td>Onsite Renewable Utilization Efficiency</td>
<td>Building’s consumption of renewable energy generated onsite (not exporting to grid) over a year</td>
</tr>
<tr>
<td>Grid Carbon Alignment</td>
<td>Degree to which the building demand contributes to upstream (grid) carbon emissions over a year</td>
</tr>
<tr>
<td>Energy Efficiency vs. Baseline</td>
<td>Percent better than code (annual total energy use)</td>
</tr>
<tr>
<td>Short-Term Demand Flexibility</td>
<td>Building’s ability to reduce demand (shed) for 1 hour</td>
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<td>Building’s ability to reduce demand (shed) for 4 hours</td>
</tr>
<tr>
<td>Dispatchable Flexibility</td>
<td>Building’s ability to automatically reduce demand (shed) for 15 minutes, controlled by utility/third party</td>
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<td>Resiliency</td>
<td>Building ability to island from grid and/or provide energy for critical loads for 4-24 hours; motor soft start capability to help grid restart after outage</td>
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</table>

These metrics evaluate the building’s load shape (demand profile)

- Grid load (MW): bulk system peak shaving
- Grid emissions factors: GHG savings
- Renewable self-consumption: distribution congestion
GridOptimal Metrics: Capability Metrics

These metrics evaluate the **building’s capabilities/assets**

- Demand Flexibility (load shed): how much of building’s peak can it shed
  - Duration & controllability considerations (short/long/dispatchable)
- Resiliency: both sides of the meter
  - Islanding capability
  - Buildings supporting grid black starts w/ motor soft start

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GridOptimal Buildings LEED Credit

- 3 options for project teams
  - 1 point: Calculate and report
    - do no worse baseline -> design (or explain)
  - 2 points (+1 ID avail.): Across-the-board improvements
    - Minimal score improvements in 3 categories (or 6 categories for +1 ID point)
  - 2 points (+1 ID avail.): Focused area improvements
    - Moderate score improvement in 1 category
    - (or higher for +1 ID point)

GridOptimal Utility Program Criteria

- Define Credit Thresholds for each metric
  - Improvement from baseline to proposed
  - Vary by Building Type, New/Retrofit, ...
- Building the dataset needed for utilities to compare measures/strategies
  - GridOptimal metric scores
  - Conventional energy efficiency savings
  - Conventional DR / peak kW savings
Grid Context Varies by Region & Over Time

- **Solar Heavy**, ex. California: PV produces more energy during summer and mid-day.
- **Wind Heavy**, ex. Midwest and Texas: onshore wind often stronger at night; can be variable over short term.
- **Hydro Heavy**, ex. Pacific Northwest: high hydro generation during the spring and early summer months as snow melts; system flexibility over short term.
- **Fossil Fuel Heavy**, ex. Rust Belt, Southeast: Emissions are typically highest during grid system peak demand hours (inefficient gas peakers) but are often also high during off-peak hours (coal base load).

Climate Context Contributes to Grid Conditions

- **Summer Peaking**: Peak system load occurs in summer afternoon
  - Nearly all regions have a significant summer peak – some more than others
  - Focus on cooling system performance, thermal envelope upgrades, afternoon shading, internal load reductions, precooling
- **Winter Peaking**: Peak during cold winter morning, mid-day, or evening hours
  - Reduce energy usage in winter peak hours: thermal envelope upgrades, heating system performance, preheating strategies
- **Dual-peeking**: Peak system load in summer and again in winter
  - Consider both summer and winter strategies – ex., thermal energy storage tanks for precooling on summer afternoons and preheating on winter mornings/days
  - Some regions are summer-peaking today but may become dual-peeking as electrification of building heating systems accelerates
Resiliency on Both Sides of the Meter

Grid Integration Features in Buildings Support Resiliency Goals

- Independent power sources (PV) may allow grid-independent operation (islanding)
- Passive features support building habitability during no-power operation
- Staged start up capabilities can support faster grid recovery after outages
- On-site energy storage can provide emergency support for communities (communication, refrigeration, etc.)

Puerto Rico, 9/22/17 (NBC)

Our Long-Term Vision

- **Transform the built environment for tomorrow’s grid**
- Support development of integrated utility programs
  - Holistic efficiency *and* demand response programs
  - Incentives: new metrics & a fresh framework
- Design guidance and tools for designers
- Program, Rating System, Market, and Policy Deployments

Buildings can be grid decarbonization enablers
Now welcoming pilot buildings + program participants – join us!
https://newbuildings.org/gridoptimal/
Save the Date!

Join building and energy industry leaders at the premier global event dedicated to defining a low-energy, low-carbon future for the built environment.

Access case studies, research, guidance, models and more

The Getting to Zero Resource Hub is an open-source collection of over 300 zero energy and zero carbon resources across six different topic areas:

- Design & Development
- Embodied Carbon
- Codes & Policy
- Local Governments Toolkit
- Residential
- Schools

The Getting to Zero Resource Hub was developed and delivered by New Buildings Institute with ongoing support from our sponsors and partners.

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Thank you!
You will receive an email tomorrow with links to the on-demand recording and a PDF of the slides.