Better Buildings Alliance
Renewables Integration
Technical Research Team

Identifying Cost-Effective Energy Efficiency and Load Flexibility Measures Supporting Grid-Interactive Efficient Building (GEB) Strategies

July 12, 2023
1:00 – 2:00 PM EST
Welcome!

RENEWABLES INTEGRATION

https://betterbuildingsinitiative.energy.gov/alliance/technology-solution/renewables-integration

Grid-interactive efficient buildings (GEBs) combine energy efficiency, strategic integration of renewables, and demand flexibility technologies and techniques to dynamically reduce and shift building energy use. GEB measures can lower energy costs and increase building performance while providing grid services that increase the reliability, flexibility, and resiliency of our electricity system. The Renewables Integration Technology Research Team is connecting researchers and commercial building partners to collect data, conduct demonstrations, and share information about GEB implementation.

Team Goals:
- Strategic use of renewables
- Building load flexibility
- Electrification
- Carbon reduction
- Grid coordination
Call Agenda

- Quick Announcements
  - Tim LaClair, NREL

- Technical Presentation:
  - Sheldon Mendonca, RMI
  - Christina McPike, WinnCompanies

- Discussion and Q&A
  - Led by Zahra Fallahi
Announcements
https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings
RENEWABLES INTEGRATION

Strategic use of renewables can help businesses reduce energy costs and their environmental footprint. On-site renewable energy, when paired with energy storage and configured appropriately, can also increase a site's resilience during a grid outage. Explore all previously recorded webinars on this topic by pressing MORE.

- Selecting and Connecting EV Chargers to Commercial Buildings (2023)
- PV Valuation: How Solar PV Adds Value to Your Assets (2022)
- Balancing the Benefits of Community Solar in Multifamily Buildings (2021)
- Renewables and Advanced Controls: Why Now Is the Time (2021)
- Unleashing the Power of Community Solar for Multifamily Buildings (2021)
- Valuing and Incentivizing Demand Flexibility as a Grid Asset (2021)
- Buildings-to-Grid Integration in the Context of COVID (2020)
- Distributed Energy Resources for Cost Savings and Resilience (2020)
- The Value of Distributed Energy Resources to Owners: A Current Market Landscape (2020)
- Utility Rate Structures & Opportunities to Incentivize Load Flexibility (2020)
- Bridging the Gap Between Efficiency and Demand Response (2019)
- Building Load Flexibility and Grid Coordination (2019)
- EVs: Buildings as the New Gas Station (2019)
Selecting and Connecting EV Chargers to Commercial Buildings

This webinar provided an overview of a fact sheet published by the Renewables Integration Team: Connecting Electric Vehicle Charging Infrastructure to Commercial Buildings on how EV chargers can be connected to commercial buildings.

Notable Publications

Cost-Effective Grid-Interactive Efficient Buildings: Potential for the WinnCompanies Portfolio

Notable Publications

Other Portfolio Analyses:
Cost-Effective Grid-Interactive Efficient Buildings: Decarbonization Potential for a US Retail Portfolio

https://rmi.org/insight/cost-effective-grid-interactive-efficient-buildings/
Upcoming Publications

EV Case Studies

• Commercial Real Estate
• K-12 Schools

FERC 2222 Fact Sheet
Technical Presentations
Today’s Presenters:

Sheldon Mendonca  
Manager, Buildings  
RMI

Christina McPike  
Director, Energy & Sustainability  
WinnCompanies
COST EFFECTIVE GRID-INTERACTIVE EFFICIENT BUILDINGS

Potential for the multifamily sector

July 2023
WinnCompanies portfolio is a model for efficient operations

- WinnCompanies is a national owner and operator of mixed income multifamily housing
- Winn has an in-house sustainability department dedicated to energy efficiency, renewable energy development, and environmentally responsible development
- Over the last 15 years, Winn has implemented over $50 million in energy efficiency, including electrification, deep energy retrofits, LED lighting, pumps and controls, and condensing boilers for heating and DHW, in addition to developing 2 MW of solar
- The analyzed portfolio has an average EUI of 59 kBTU/ft², which is 60% better than the regional average for multifamily buildings in the northeast United States
1. Project Overview

2. Key Findings

3. Impact on Demand Profiles
Purpose of study

1. Evaluate energy and cost savings potential for the multi-family portfolio
   - Evaluate optimized portfolio-wide energy projects investment potential for various measures & bundles of measures
   - Provide investment pathways to achieve GEBs buildings

2. Inform the emerging national conversation around demand flexibility
   - Evaluate how load flexibility, energy efficiency, renewables and energy storage measures can work together to reduce peak demand and consumption
   - Identify high potential measures, rate structures and climate zones
   - Explore demand flexibility and DER benefits to the grid

3. Scale success to entire multi-family sector
   - Draw broader conclusions that can inform the US multi-family sector
   - Encourage other multi-family portfolio managers to invest in GEBs strategies
Essential building blocks of decarbonized buildings

Grid-Interactive Efficient Buildings (GEB)

Efficiency + Demand Flexibility + Onsite Renewable Energy & Storage + Electrification

Carbon-Free Electric Grid

This study evaluates each of these key building blocks to decarbonized buildings with a focus on cost effective GEB strategies for the multifamily sector.
Analysis overview

- **29** Properties were evaluated across 6 states and 3 climate zones
- Property size range between 45,000 ft² & 900,000 ft²
- Buildings were built between 1929 and 2019
- **13** buildings are master metered
- **16** buildings are direct metered
- **11** buildings are under Section 8
- **24** buildings are under Section 42/Low-income Housing Tax Credit (LIHTC)

GEB Analysis for the Multi-Family Portfolio

- **29** Properties
- **5.3 Million** Square Feet
- **90+** Measures & variations
- **1500+** Energy Simulations
Diversity of conditions within the portfolio impact performance

• 10+ central and de-centralized HVAC system types

• Buildings with heat pump and energy recover ventilation generally perform better than those with traditional HVAC systems

• Boilers with decentralized cooling systems use less energy than buildings with boiler systems and central cooling plants

Data shown in the graph only includes those with whole building metered data and excludes buildings with extrapolated EUI data
Our approach delivers cost effective recommendations without compromising on process integrity

**Inputs**
- Client provided information
  - Space uses, system types, schedules, drawings, bills, lease terms...
- Publicly available data
  - Geometry, utility rates, emissions, incentives, climate...

**Energy Models**
- Virtual building representation, model QC & calibration
- Automated generation of digital twin (IDFs) through Zetro templates

**Financial Analysis**
- Client investment target and scope (e.g., Return of investment or CO2 reduction goals)
- Automated application of relevant solutions using Zetro’s ECM libraries

**Outputs**
- Building-specific investment plan on timeline
- Individual building results aggregated across portfolio
Agenda

1. Project Overview

2. Key Findings

3. Impact on Demand Profiles
Analyzed 13 measures with 90+ variations (energy and financial combinations)

<table>
<thead>
<tr>
<th>Category</th>
<th>Measures</th>
<th>What the measures will do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable energy</td>
<td>Rooftop solar</td>
<td>Rooftop solar was modeled based on total cost of ownership.</td>
</tr>
<tr>
<td>Demand flexibility</td>
<td>Battery storage</td>
<td>Either maximize kW shifted or Internal Rate of Return (IRR). Battery size was based on a target 10%, 30% or 50% peak load (kW) reduction for a particular building</td>
</tr>
<tr>
<td></td>
<td>Light dimming</td>
<td>Shed measure, not shifting load</td>
</tr>
<tr>
<td></td>
<td>Peak demand curtailment-Temperature Setback</td>
<td>Setback temperatures in appropriate zones to reduce demand during TOU times or peak demand events</td>
</tr>
<tr>
<td>Envelope Efficiency</td>
<td>Improved thermal envelope—roof and wall insulation</td>
<td>Within each measure, there are several different R-value scenarios (e.g., R20, R30, and R40) and types of insulation</td>
</tr>
<tr>
<td></td>
<td>Roof membrane</td>
<td>Dark or light roof membrane</td>
</tr>
<tr>
<td></td>
<td>Improved fenestration</td>
<td>Replacing current windows (curtain walls, load windows and storefront windows) with high performance windows; Adding window films</td>
</tr>
<tr>
<td></td>
<td>Exterior door upgrades</td>
<td>Door air-curtains and fast acting dock doors to reduce infiltration</td>
</tr>
<tr>
<td></td>
<td>Unitized wall panels</td>
<td>Prefabricated insulated panels with pre-installed high-performance windows that will be attached to the exterior of the building</td>
</tr>
<tr>
<td>HVAC and Plug Load Efficiency</td>
<td>Smart Thermostat</td>
<td>Installing smart thermostats in apartments (non-BMS)</td>
</tr>
<tr>
<td></td>
<td>LED lighting upgrades</td>
<td>LED lamp retrofit; LED fixture upgrade with integrated sensors</td>
</tr>
<tr>
<td></td>
<td>High efficiency appliances</td>
<td>Install high efficiency refrigerators, dish washer, in-unit washer/dryer where applicable</td>
</tr>
<tr>
<td>Heat Pumps</td>
<td>Heat Pumps for heating, cooling and domestic water heating</td>
<td>Replace natural gas boilers for heating and Domestic Hot Water with Ground Source Heat Pump, Air Source Heat Pump, Variable Refrigerant Flow or distributed Water Source Heat Pump where applicable</td>
</tr>
</tbody>
</table>
Portfolio wide key findings

1. There is a potential to shave 800 kW of annual electric peak demand across 21 buildings.

2. With a 6% internal rate of return, the portfolio could save $701,958 on annual energy utility costs and cut carbon emissions by 1,600 tons CO2 savings annually.

3. Rooftop solar PV has the largest potential for both NPV potential and carbon emissions reductions and was financially successful on 13 of the 29 buildings.

4. HVAC and plug load efficiency measures had the second highest potential for carbon emissions reductions and NPV.

The pathways don’t recommend removing equipment that has remaining useful life. Measures that replace existing equipment have been priced at an “incremental cost,” or cost differential between a business-as-usual versus a premium efficiency product. The analysis models actual rate structures and pricing from utility bills. The carbon intensities were based on the specific state-level carbon emissions as defined by the EPA’s eGRID program.
Insights for the multifamily sector

If WinnCompanies’ strategies, along with the demand management measures proposed in the study, are implemented on a larger scale across multifamily portfolios in the US, the potential for significant reductions in both absolute electric peak demand and carbon emissions would be greatly amplified.

1. **Rooftop solar arrays** to offset electricity use
2. Replace light fixtures with **LEDs with integrated sensors**
3. Replace older **common area washers and dryers** with high-efficiency models
4. Implement temperature setbacks using **smart thermostats** during high demand periods in buildings with central heating and cooling plants
6 Percent IRR scenario results

Portfolio Economics

$3.9 million
Investment opportunity

$4.5 million (NPV)

5.5 years
Simple payback

Portfolio Energy

$702K
Or a 10% reduction in annual utility costs

800 KW
8% annual peak demand reduction

1,600 tons CO2 savings/yr.
Portfolio wide 7% reduction in CO2 emissions

Key Takeaways

• The most successful measures included rooftop solar PV, increasing wall insulation, replacing light fixtures with LED fixtures, and replacing washers and dryers with high-efficiency models

• The annual energy savings are driven by rooftop solar PV followed by HVAC and Plug Load Efficiency measures
Rooftop solar PV has the largest NPV potential and potential for carbon reductions across the portfolio.

Replacing washers and dryers with high efficiency models in five buildings accounted for most of the impact in the plug load category.

Smart thermostats with temperature setback have a strong potential to reduce utility costs while meeting return requirements.
10-year payback scenario results

**Portfolio Economics**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment opportunity</td>
<td>$2.8 million</td>
</tr>
<tr>
<td>NPV</td>
<td>$2.0 million</td>
</tr>
<tr>
<td>Simple payback</td>
<td>4.3 years</td>
</tr>
</tbody>
</table>

**Portfolio Energy**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual electricity savings</td>
<td>9%</td>
</tr>
<tr>
<td>Annual peak demand reduction</td>
<td>6%</td>
</tr>
<tr>
<td>CO2 savings/yr.</td>
<td>1,500 tons</td>
</tr>
<tr>
<td>CO2 emissions reduction</td>
<td>6%</td>
</tr>
</tbody>
</table>

**Key Takeaways**

- The most successful measures were rooftop solar PV, demand flexibility, replacing common area washers and dryers with high-efficiency models, and replacing light fixtures with LED fixtures.
- This scenario also has two buildings with heat pump measures that contribute substantially to carbon emission saving potential.
- The annual energy savings are driven by HVAC and plug load efficiency measures and rooftop solar.
Building wise measure packages help identify high potential sites for pilot projects

- Rooftop solar PV was most successful for 10-year payback scenario.
- Replacing washers and dryers with high efficiency models in five buildings had the next highest NPV and carbon savings potential.
- LED light fixture replacement proved to be successful in the buildings that have traditional fluorescent lights.
- Smart thermostats with temperature setback have a strong potential to reduce utility costs while meeting return requirements.
Agenda

1. Project Overview
2. Key Findings
3. Impact on Demand Profiles
We can clearly see the impact of GEBs measures when we compare the Baseline vs 6% Scenario and the Heat Pump vs Heat Pump Plus scenarios. The GEBs measure applied in the 6% IRR scenario reduce peak demand throughout the year when compared to the baseline. When loads are electrified, the peak demand rises in winter but GEBs measures work to limit the yearly peak demand at or below the baseline peak. In the summer, the peak demand is driven by cooling loads, which in turn is driven by high humidity in the Northeast climate zone.
Demand Profile Comparison Across Scenarios for Building #1
Mild Day April 6

Key Takeaway
The heat pumps plus peak shows a 24% drop when compared with the heat pumps scenario, and the 6% IRR scenario shows a 26% decrease from the baseline peak load. The two scenarios with solar PV arrays show much lower midday loads because the solar panels offset electricity demand during the day.
Demand Profile Comparison Across Scenarios for Building #1
Winter Day, February 2

The winter day shows a peak in the morning as occupants wake up and get ready for work, and a peak upon their return home in the evening. The heat pumps scenario has the highest electrical demand due to increased electric loads for heating and DHW. The heat pumps plus scenario, which is 31% lower, highlights the peak demand savings that can be achieved by combining electrification measures with GEB measures. Dips in demand during the day for the 6% IRR scenario when compared with the baseline can be attributed to the rooftop solar PV, while the late evening difference can be attributed to light dimming and plug load efficiencies.

Key Takeaway

The winter day shows a peak in the morning as occupants wake up and get ready for work, and a peak upon their return home in the evening. The heat pumps scenario has the highest electrical demand due to increased electric loads for heating and DHW. The heat pumps plus scenario, which is 31% lower, highlights the peak demand savings that can be achieved by combining electrification measures with GEB measures. Dips in demand during the day for the 6% IRR scenario when compared with the baseline can be attributed to the rooftop solar PV, while the late evening difference can be attributed to light dimming and plug load efficiencies.
Demand Profile Comparison Across Scenarios for Building #1
Summer Day August 18

Key Takeaway

In the summer, energy consumption increases and plateaus in the afternoon into the evening as cooling demand increases with rising daytime temperatures. The peak demand is reduced by 3% for the 6% IRR scenario compared with the baseline, while the heat pumps plus sees a negligible drop when compared with the heat pumps scenario.
From GEBs to Connected Communities

- DOE funding to support GEB R&D and deployment, considering technical GEB Solution Packages and financeability to help drive commercial opportunities and market transformation in the multifamily sector
- Develop and implement utility data acquisition strategies along with a light-touch screening tool to help multifamily portfolio owners develop GEB scopes
- Enhance new or existing platforms to integrate control of energy storage, PV, and connected devices, fully automating the load flexibility within existing housing communities
- Design and engineer GEB packages for up to 6 multifamily properties with the potential to deliver at least 500 kW of peak (30-min) load flexibility or 175 kW of 4-hour load flexibility
Thank you!

Email: GEB@nrel.gov to be added to our listserv.

Stay tuned for announcements on upcoming BBA Renewables Integration Team calls!