Year Three Progress and Outcomes

A Summary of Achievements from the GridOptimal Buildings Initiative

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Acknowledgements

The GridOptimal Buildings Initiative made substantial progress in advancing building-grid integration from its formal launch in July 2018 to the official conclusion of its first initiative in December 2021. NBI has provided this overview of work areas and outcomes to the supporting members and other Technical Advisory Committee (TAC) members of the GridOptimal Buildings Initiative. The Year 1 outcomes summary document was delivered to the TAC in June 2019 and the Year 2 outcomes summary document was delivered in July 2020. Both are available upon request.

GridOptimal is a joint initiative led by New Buildings Institute (NBI) and the US Green Building Council (USGBC), with NBI conducting most work and preparing all deliverables. Both NBI and USGBC would like to acknowledge the support of the sponsors (shown below) of the GridOptimal Buildings Initiative whose support has have made this work possible.

GRIDOPTIMAL™
BUILDINGS INITIATIVE

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1. Executive Summary

The GridOptimal Buildings Initiative, a collaborative initiative led by New Buildings Institute (NBI), in partnership with the U.S. Green Building Council (USGBC), focuses in large part on developing metrics by which building features and operating characteristics that support more effective grid operation can be measured and quantified. This will support the least-cost decarbonization of the grid through better integration of both distributed energy resources (DER) and utility-scale wind and solar energy. This document describes key GridOptimal project outcomes, with a focus on final deliverables, most of which have been published during 2021. For detailed summaries of prior work, refer to the Phase 1 and 2 Outcomes Summary reports. Key GridOptimal outcomes include:

- **GridOptimal Metrics and Data Library:** NBI led the development and documentation of GridOptimal metrics, including the creation of a spreadsheet calculation tool, internal TAC documentation memos (shared with the TAC in December and updated in April 2020), a blog, and a peer-reviewed conference paper. NBI convened the Metrics and Mechanics Working Group and achieved consensus on GridOptimal metrics among this group and the TAC. NBI gathered data from multiple sources to build a data library enabling calculation of all metrics.
- **LEED Pilot Credit:** The LEED GridOptimal Building Alternative Compliance Path (ACP) Pilot Credit offers up to three points for LEED v4.0 and v4.1 BD&C (new construction). The goal of this credit is to use selected GridOptimal metrics to score specific building-grid integration characteristics, helping project teams deliver buildings that are lower-carbon, less impactful to grid infrastructure, and more resilient. The Pilot Credit and accompanying guidance and calculator were initially published February 9, 2021 and have since been updated to make the tool easier to use for project teams and to improve methodology.
- **Design and Operations Guidance:** In October 2021, NBI published 13 design guidance factsheets that recommend selected high-impact building design and operational strategies for six building types (commercial and residential) and seven US regions. The recommended strategies build upon GridOptimal research, including building-scale and grid-scale modeling and pilot project experience.
- **Utility Program Guidance and Measure Impact Analysis:** NBI considered utility program implications of various energy efficiency and demand flexibility measures and performed a comprehensive impact analysis to help compare these measures using GridOptimal and other metrics to inform utility program design and deployment. To summarize the most effective strategies that utilities can prioritize based on their individual goals, NBI developed an interactive, online dashboard powered by Tableau, accompanying Excel-based data to enable customized analysis, and a memo summarizing the key analysis results and recommendations.

Key focus areas for topically related NBI/ GridOptimal work over the next 1-3 years include:

- LEED credit support and advancement
- Technology field validations and pilot projects
- Industry support, including additional design and operational guidance and energy modeling software/process improvements
- National (model), state, and local code proposals
- Policy roadmaps & frameworks

2. GridOptimal Metrics and Data Library

GridOptimal metrics are a standardized set of metrics that evaluate building performance and define a building's contribution to the relevant utility grid scale. The relative importance, or weight, of each metric is not universally defined, precluding the combination of all output scores into a single overall score; each metric stands alone.

Metrics are scored on a percentage basis, from 0% to 100% (higher is better); scores of greater than 100% are possible in some categories. Comparisons are not necessarily comparable across categories. That is, a score in one category may not indicate the same degree of achievement or performance as the same score in a different category.

The first four metrics in the table below apply load shape evaluation calculations for each of the 8,760 hours in a year, resulting in a single score. The other four metrics are intended to directly measure the building's potential to serve as a grid resource.

GridOptimal Metric	What it Measures
Grid Peak Contribution	Degree to which building demand contributes to load on the grid during system peak hours
Onsite Renewable Utilization Efficiency	Building's consumption of renewable energy generated onsite (not exporting to grid) over a year
Grid Carbon Alignment	Degree to which the building demand contributes to upstream (grid) carbon emissions over a year
Energy Efficiency vs. Baseline	Percent better than code (annual total energy use)
Short-Term Demand Flexibility	Building's ability to reduce demand (shed) for 1 hour
Long-Term Demand Flexibility	Building's ability to reduce demand (shed) for 4 hours
Dispatchable Flexibility	Building's ability to automatically reduce demand (shed) for 15 minutes, controlled by utility/ third party
Resiliency	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

Programs may consider incorporating simple, straightforward metrics that provide a basis and framework for incentivizing customers to deploy high-priority strategies and technologies. Two recommended market-oriented metrics are:

- **Grid Peak Contribution Index:** a measure of a building's average normalized net power demand (W/ft^2) during high-priority grid peak hours.
- **Demand Flexibility Index:** a measure of how much peak-day load a building can shed (W/ft^2) based on a utility signal over a four-hour period, much like a demand response call.

These metrics are useful not only in a customer-facing application but also potentially useful as a way to compare program components to each other and to compare programs to other programs for evaluation and assessment.

2.2 Research Approach

The analysis relies on multiple sources for both building-side and grid-side data. Data sources are both internal to GridOptimal and external, in large part from national labs working to explore grid-integrated efficient building (GEB) opportunities.

Key building-side data sources are summarized below. More details about these sources can be found in the Utility Program Guidance memo:

- Comprehensive GEB energy simulation model demand profiles by LBNL (used as basis information for the 2021 DOE GEB Roadmap[1])
- GridOptimal energy simulation model demand profiles by Red Car Analytics
- Operational GEB energy simulation modeling by LBNL
- GridOptimal Pilot Projects: actual building-specific data from design team scale engagement with buildings in Sonoma, CA; Seattle, WA; northern Vermont; Manhattan, NY; and Brooklyn, NY
- PVWatts modeling: online tool by National Renewable Energy Lab

To evaluate the measures contained in the data sources described above, a multi-step process was required. First, raw data was formatted into an hour-by-hour dataset containing electricity consumption information for all 8,760 hours of the year (8760 data), for both the baseline building and proposed building with measures applied. This data was placed into a calculator template based on the GridOptimal LEED ACP Pilot Credit calculator. The calculator was populated with state-level decadal averages of hourly grid demand and marginal carbon data from NREL's Cambium dataset. The calculator used these inputs to evaluate the performance of the baseline building vs. proposed building (with energy efficiency and/or demand flexibility measures applied). The analysis included the GridOptimal metrics defined in Phase 1 (see details here), as well as additional metrics that help to inform the Utility Program Guidance. The calculator output was then formatted for input to Tableau, which was used for data visualization to identify trends and most impactful measures.

The analysis described above was completed by comparing the results of over 20 energy efficiency (EE), demand flexibility (DF), and combination measures across seven building types and 16 climate zones.

3.1 Data Sources

To calculate the GridOptimal metrics across a wide range of buildings in a comprehensive manner, a range of data sources are necessary. NBI and other GridOptimal members have worked together to assemble a data library for GridOptimal. Key data sources include:

Data Type	Source	Status
Grid System Load Data	Energy Information Administration Hourly Grid Data Monitor[2]	Available
Building Demand Profiles	DOE Commercial Building Prototype Models[3]	Available as energy model files; NBI generated 8760 profiles

[1] *U.S. DOE. "A National Roadmap for Grid-Interactive Efficient Buildings." Prepared by Building Technologies Office, May 2021.* https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs-20210712.pdf

[2] http://www.eia.gov/beta/electricity/gridmonitor
[3] https://www.energycodes.gov/development/commercial/prototype_models

Data Type	Source	Status
Building Onsite Generation Profiles	PVWatts[4]	NBI generated 8760 profiles
Current Marginal Grid Carbon Emissions Factors	WattTime[5]	Available from WattTime; has been used only for limited testing/evaluation of metrics
Current Average Grid Carbon Emissions Factors	NREL Standard Scenarios 2021 Report[6]	Available, loaded in GridOptimal LEED calculator and dashboard
Long-run Marginal Grid Carbon Emissions Factors	NREL Standard Scenarios 2021 Report[4]	Available, loaded in GridOptimal LEED calculator and dashboard
Building Demand Flexibility Potential	"Commercial Building Load Modification and Flexibility Potential" (by Red Car Analytics)	Commissioned by NBI to support GridOptimal during Phase 1; completed and available

2.3 Key Findings

Across building types and climate zones, several measures emerged above the rest. The following table shows selected high-impact EE and DF measures that were found to deliver the greatest benefit.

Sector	System peak demand reduction	Demand flexibility
Commercial	HVAC efficiency	Battery storage
	Envelope upgrades	HVAC temperature reset (2-3°F)
	Window performance and treatments	Thermal energy storage
	Solar PV	Lighting controls
Residential	Insulation upgrades	Smart thermostats
	HVAC efficiency	Water heater controls
	Air sealing	Appliance controls
	Plug load efficiency	Pool pump controls

Additional high-impact measures targeting specific building types and US climate regions were identified through the development of the Design and Operations Guidance fact sheets; see below.

In many cases, the time-oriented energy efficiency measures listed above can passively reduce building demand during grid priority hours by up to 15% in commercial buildings and over 50% in single-family homes; impacts vary widely depending on baseline system type, operations, and climate. The demand flexibility measures deployed during the same high-priority hours can provide 15% savings with modest HVAC controls or much greater savings with the addition of thermal or battery storage. In the residential sector, demand flexibility measures offer modest savings with large exceptions for electric water heaters and pool pumps, depending on system size, type, and climate. These active flexibility measures require operator intervention in most cases, though automated, dispatchable flexibility is available for batteries and increasingly common for building system controls (i.e., temperature setpoints).

[4] https://pvwatts.nrel.gov/pvwatts.php
[5] https://www.watttime.org/
[6] https://www.nrel.gov/analysis/standard-scenarios.html

3. Outcomes: LEED Pilot Credit

NBI and USGBC have collaborated on improvements to USGBC's LEED rating system for several years. In February 2021, USGBC formally approved and published the GridOptimal Alternative Compliance Path (ACP – pilot credit) for the LEED-NC v4 and v4.1 rating systems.

LEED-NC project teams can elect to pursue the GridOptimal (ACP) in lieu of the EA Demand Response (v4) or Grid Harmonization (v4.1) credit. Using the same building energy simulation used to document compliance with a LEED Energy Performance prerequisite, teams calculate GridOptimal metric scores for the baseline and proposed building cases. The metrics included in the calculator are:

1. Grid Peak Contribution
2. Grid Carbon Alignment
3. Site Renewable Utilization Efficiency
4. Short-Term Demand Flexibility
5. Long-Term Demand Flexibility
6. Dispatchable Demand Flexibility

Teams can earn one point by simply calculating baseline and proposed scores and reporting on the GridOptimal performance. For each GridOptimal metric for which the Design Score is lower than the Baseline Score, teams must produce a narrative that describes technologies or strategies that would have improved the Design Score but were deemed unacceptable to implement by the project team.

Teams may earn up to an additional two points by meeting across-the-board or focused area improvement requirements. A full summary of the requirements can be found here.

A copy of the LEED GridOptimal calculator (available here) is required for each project submission. Project teams must input the building's net demand profile for the baseline and proposed building. To calculate demand flexibility, a distinct net demand profile for the proposed building that includes the demand flexibility strategy or strategies must be provided. The calculator uses these inputs to generate GridOptimal metric scores for the baseline and proposed building. The score improvement is used to determine the number of LEED points achieved.

4. Outcomes: Design and Operations Guidance

These easy-to-understand fact sheets were developed to provide key context and recommend selected high-impact building design and operations strategies. The strategies and recommendations included in these factsheets build upon GridOptimal's body of research and analysis, which includes building-scale and grid-scale modeling and pilot project experience.

Factsheets are available for six commercial and residential building types and seven regions across the United States. The table below lists all the available factsheets and a download link.

Optimizing Building Grid Integration in Building Types	Optimizing Building Grid Integration in U.S. Regions
Office Buildings	Southwest United States
Education Buildings	Northwest United States
Multifamily Buildings	Texas and the Southern Great Plains
Single Family Homes	Northern Great Plains
Retail Buildings	Midwest and Mid-Atlantic
Warehouses	Northeast United States
	Southeast United States

5. Outcomes: Utility Program Guidance

NBI developed Utility Program Guidance resources to summarize the results of NBI's research into the utility program implications of various energy efficiency (EE) and demand flexibility (DF) measures across multiple building types, grid regions, and climate zones. The goal of this research was to inform utility program design and deployment, including both the adjustment of existing incentives and other strategies as well as to suggest potential alternate program frameworks. This work highlights effective strategies that utilities can prioritize to limit peak system loads, grow the collective demand response potential of its served loads, or address other priorities (e.g., emissions).

Utility Program Guidance deliverables can be accessed here and include:

1. A memo summarizing key results, program alignment and best practices recommendations, and analysis results for programmatic improvements
2. A publicly accessible interactive web-based measure impact analysis dashboard
3. Excel-based summary data to enable customized analysis (contact NBI to access this data)

Key recommendations for utility programs include:

- Focus retrofit incentives on envelope upgrades and high-efficiency HVAC equipment replacements and replacing or upgrading equipment to reduce overall load.
- Controls updates and upgrades to comply with the latest standards and adding controllable devices like smart thermostats provide low-to-no-cost energy savings. Incentivizing grid-connected appliances can provide greater capacity for real-time signals from the grid or utility.

- Energy storage installation (battery and thermal) increases demand flexibility capacity. With proper controls and agreements in place, the utility may dispatch the energy storage to ensure firm demand response availability.
- Process load measures and controls for specific end-uses may provide significant peak savings and demand response potential, including refrigeration, air compression, electric vehicle fleet charging, and other processes with inherent time-of-use flexibility.
- Onsite solar PV installation helps to reduce net building demand during grid peak hours, particularly during summer afternoons and evenings.

1	2	3
Run incentive programs to achieve key outcomes outlined in this memo	Ensure incentives include grid-connectivity to capture potential flexible loads	Offer automated demand response program to drive customer participation

Small updates to existing programs requiring connected devices will enhance the benefits of the incentives by expanding behind-the-meter load flexibility potential. Paired with automated demand response incentive programs, customers can cost-effectively enroll additional load that the utility can then control to mitigate peak demand and costs. Developed standards are available for smart grid communications and interconnectivity, and provide criteria for inclusion in incentive program qualified products lists without requiring customer buy-in.

The table below outlines specific standards (aligned with current and upcoming codes and policy) to specify by equipment type for utility incentives, including existing incentive programs that pair equipment incentives with connectivity requirements. Often, these requirements are part of the behind-the-scenes criteria for inclusion in incentive program qualified products lists: the customer need not be aware of the connectivity standards or even capabilities of their equipment.

Equipment	Common Standard(s)
Electric Vehicle Charger	OCPP 2.0, OpenADR 2.0b
Smart Thermostat	OpenADR 2.0b
Heat Pump Water Heater	ANSI/CTA-2045-B
PV (or other DER) Inverter	IEEE 2030.5-2018, IEEE 1547-2018a

6. Conclusions and Next Steps

Over the last 3.5 years, NBI, USGBC, supporting utility partners, and the rest of the GridOptimal team have laid critical groundwork enabling measurable and scalable building-grid integration improvement. Work completed through GridOptimal has supported leading building designers and operators, improved utility programs, advanced codes and policies, and moved the market forward. Moving forward, NBI expects to continue this important work in a variety of ways including technology field validations, code and policy advancement, industry guidance, and market transformation. We are grateful to our supporters and collaborators for enabling this progress to date and in the future.

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New Buildings Institute (NBI) is a nonprofit organization driving better energy performance in buildings. We work collaboratively with industry market players—governments, utilities, energy efficiency advocates, and building professionals—to promote advanced design practices, innovative technologies, public policies, and programs that improve energy efficiency. We also develop and offer guidance and tools to support the design and construction of energy efficient buildings.

Throughout its 20-year history, NBI has become a trusted and independent resource helping to drive buildings that are better for people and the environment.