



GRIDOPTIMAL-INDIA: PROMOTING BUILDING-GRID OPTIMIZATION IN SOUTH ASIA

White Paper

New Buildings Institute (NBI)

South Asia Regional Energy Partnership (SAREP)

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INTRODUCTION AND CONTEXT

India's building sector is undergoing remarkable expansion, constituting over 30% of the nation's total electricity usage. India is poised for one of the most substantial booms in commercial and residential building construction over the next two decades. The surge will inevitably lead to heightened electricity demand, emphasizing the critical necessity to optimize electricity consumption in both forthcoming and current building stock.

Due to this central position in our energy systems, buildings can be an important part of grid management, and building-grid integration strategies can provide important value to people and organizations on both sides of the electric meter. However, most people in the buildings sector today (including architects, engineers, construction companies, utilities, policymakers, nonprofits, advocates, and government agencies) do not understand the multiple value streams that improved building-grid integration strategies can deliver. Better building-grid integration can offer utility bill savings, bulk energy procurement savings, reduced greenhouse gas and air pollutant emissions, and improved resiliency, all without negatively impacting building operations.

Under the South Asia Regional Energy Partnership (SAREP) program of the USAID, through SAREP Partnership Fund (SPF), SAREP is working with New Buildings Institute (NBI) to advance building-grid optimization research and bring new metrics, tools, and resources to India.

With support from project partner Environmental Design Solutions (EDS), NBI has developed tools and analyses that identify key behind-the-meter time-oriented energy efficiency and demand flexibility strategies in major building typologies and grid contexts specific to India.

The work undertaken through this project will benefit stakeholders on both sides of the meter. This includes support for Indian utilities in developing energy savings programs, energy efficiency rating systems such as Leadership in Energy and Environmental Design (LEED), policy development, as well as market levers such as building valuation and financial decision making.

APPROACH

The project kicked off in September 2022 and the team worked with key stakeholders including National Smart Grid Mission (NSGM) to identify and formally invite two distribution utilities (DISCOMs) to participate in the project. Dakshin Haryana Bijli Vitran Nigam (DHBVN) in Haryana, and Madhya Pradesh Paschim Kshetra Vidyut Vitaran Co. Ltd. i.e. Madhya Pradesh West Zone, Indore (MPPKVCL) in Madhya Pradesh were shortlisted. The project team held initial meetings with the DISCOMs in June and September 2023. Both utilities subsequently shared load and system data with NBI, which enabled the development of Tableau dashboards: interactive data visualization tools to interpret the data.

Based on a literature review and conversations with key stakeholders, the team identified a lack of publicly-available load profiles for typical buildings in India. To deliver meaningful metrics and analyses in the Indian context, the team determined that developing and running building models for the most common building types would be necessary. The national level representative building models developed under development of the Energy Conservation Building Code 2017 and thermal comfort study for residential buildings have been used for the study. These models were developed in eQUEST v3.65 and EnergyPlus v9.4 building energy simulation software. The team selected the following building types:

1. Assembly
2. Hospital
3. Secondary School
4. University
5. Small office
6. Large office
7. Strip mall
8. Shopping Mall
9. Hotel
10. Residential

The modeling determined load shapes for new and existing buildings with and without a range of efficiency and demand response measures across a set of common building types. The models estimate the energy demand reduction (amount and time) for the interventions for each building type. Input was solicited from the DISCOMs and incorporated into the final models and EE interventions. Table I summarizes the interventions included in the modeling.

TABLE I. SUMMARY OF MODELING INTERVENTIONS.

INTERVENTION NAME	DESCRIPTION	APPLICABLE BUILDING TYPES
LED lighting upgrade	Efficient lighting for different spaces (SuperECBC level of ECBC 2017)	All
HVAC efficiency upgrade	Efficient chillers, unitary ACs, efficient motors for fans and pumps, controls (SuperECBC level of ECBC 2017)	All
Hot water upgrade	Convert conventional space heating and service hot water system to efficient Heat pump systems.	All
High efficiency ceiling fans	Convert conventional induction motor-based ceiling fans to Brushless DC fans or BEE 5 Star fans	Residential
High-efficiency appliances	Specifically for residential buildings. BEE 5 star rated refrigerators, TV, etc.	Residential
Combined intervention	A combined package of all efficiency measures applicable for the given building type	All
Lighting demand response	Daylight and occupancy sensors to minimize daytime lighting loads.	All, except Assembly, Shopping Mall, Strip Retail
HVAC demand response	Setback setpoint temperature 2C during peak load hours.	All, except Assembly, Shopping Mall, Strip Retail

The scheduling of the setback for the HVAC demand response measure was tailored by building type, as shown in Table 2 below.

TABLE 2. SUMMARY OF MODELED HVAC DEMAND RESPONSE SETBACK SCHEDULE BY BUILDING TYPE

BUILDING TYPE	SETBACK SCHEDULE
Hospital	13:00-17:00
Secondary School (classrooms only)	08:00-15:00
University (classrooms only)	10:00-13:00
Small office	15:00-18:00
Large office	14:00-17:00
Hotel	15:00-19:00
Residential	13:00-17:00

The project team leveraged the utility-provided data, and the building model outputs to develop the GridOptimal metrics calculator, an Excel spreadsheet intended to help project teams and other stakeholders evaluate the impacts of various building-grid integration strategies by building type and utility service area. The tool provides a set of inbuilt parameters based on collaboration with the partner DISCOMs, which includes pre-loaded hourly utility data, peak load periods, tariffs, and building models. The tool also offers a custom input option to offer flexibility to users who wish to input their own custom-building models or utility information.

The modeled data was also integrated into the Tableau dashboards mentioned above, which enables DISCOMs and other user groups to explore the grid load details and building model information side-by-side. Snapshots from these dashboards are shown in the “Key Findings and Results” section below.

The project team held a stakeholder workshop in August 2024 to disseminate the findings of this effort and solicit input from stakeholders on enhancing building-grid integration in India, including barriers/challenges and mitigation strategies. The workshop brought together stakeholders from the building industry, distribution utilities, policymakers, nonprofit organizations, and government agencies.

The key findings from this research and the first stakeholder workshop are summarized below.

KEY RESULTS AND FINDINGS

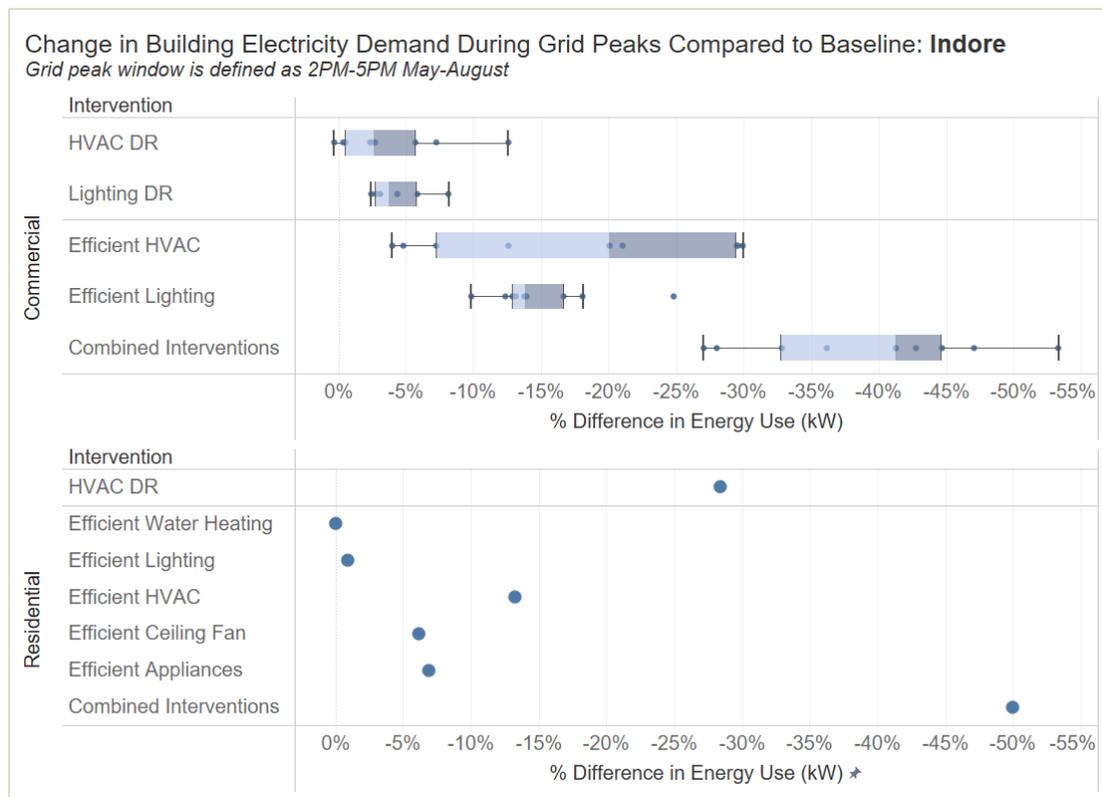
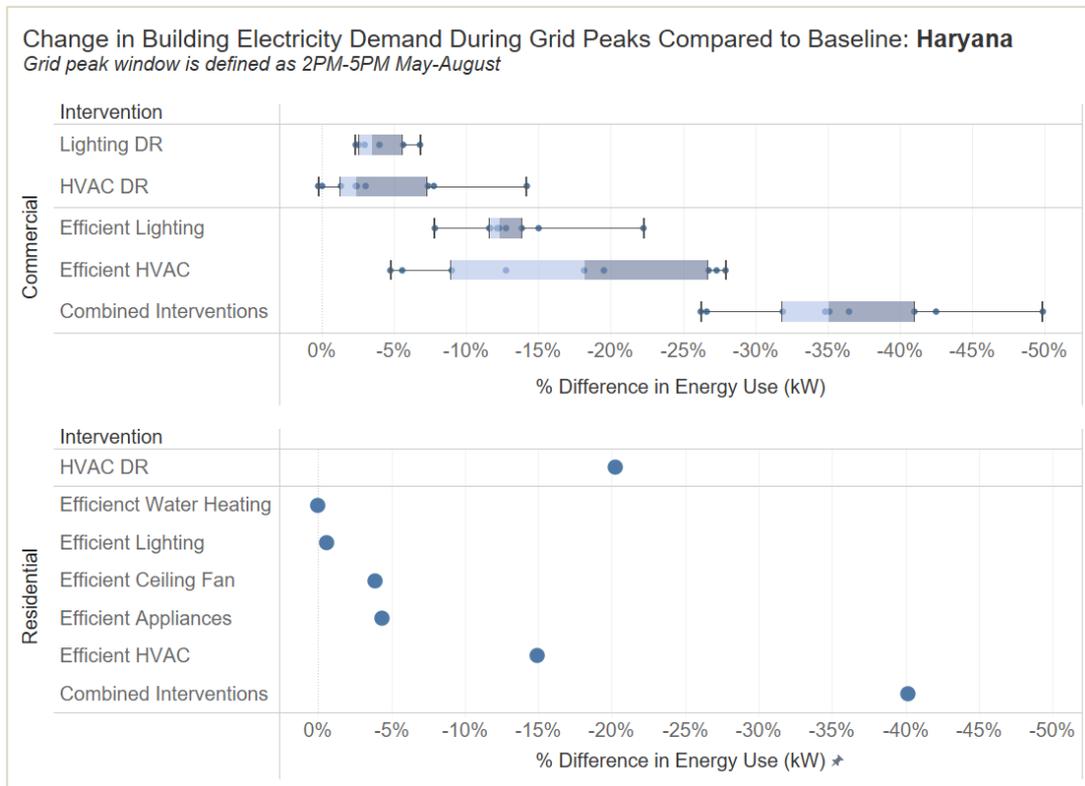
The key findings from the project activities thus far are summarized below.

ENERGY MODELING FINDINGS AND RESULTS

- I. With broad adoption, the potential coincident peak demand savings of GridOptimal interventions are notable.** In June 2024, the DHBVN system peak demand reached more than 14,000 MW. Assuming that buildings comprise approximately half of all energy unit sales and applying the combined GridOptimal interventions (described in the modeling section above) to the sector, such interventions could result in coincident peak demand savings of 2,000 – 3,800 MW.

2. The most impactful measures varied somewhat between utility regions, but the findings were similar overall.

- The most impactful measure in reducing annual electricity is a combined intervention that includes multiple individual system efficiency upgrades.



- Of the individual interventions, efficient HVAC systems yielded the greatest savings in commercial buildings, especially in the Large Office, Shopping Mall, and University building types.

Building Type	HVAC DR	Lighting DR	Efficient HVAC	Efficient Lighting	Combined Interventions
Assembly	-2.7%		-25.3%	-10.1%	-36.3%
Hospital	-0.2%	-1.6%	-24.5%	-13.9%	-40.2%
Hotel	-0.4%	-1.9%	-12.3%	-15.1%	-27.9%
Large Office	-0.2%	-4.4%	-37.3%	-13.2%	-52.7%
Secondary School	-2.1%	-6.1%	-10.0%	-21.1%	-32.8%
Shopping Mall	-0.1%		-34.4%	-12.2%	-47.2%
Small Office	-1.6%	-6.7%	-4.2%	-17.5%	-25.9%
Strip Retail	-3.6%		-3.7%	-18.8%	-25.5%
University	-0.3%	-3.3%	-33.3%	-12.5%	-48.2%

Building Type	HVAC DR	Lighting DR	Efficient HVAC	Efficient Lighting	Combined Interventions
Assembly	-2.8%		-24.8%	-11.4%	-39.2%
Hospital	-0.4%	-1.7%	-25.6%	-14.7%	-42.3%
Hotel	-0.6%	-2.0%	-11.7%	-16.1%	-28.3%
Large Office	-0.2%	-4.6%	-38.1%	-13.8%	-54.3%
Secondary School	-2.4%	-6.9%	-9.4%	-24.0%	-35.4%
Shopping Mall	-0.1%		-35.1%	-12.7%	-48.5%
Small Office	-1.9%	-7.7%	-3.6%	-20.1%	-28.5%
Strip Retail	-3.7%		-3.4%	-20.7%	-27.1%
University	-0.5%	-3.5%	-34.1%	-13.4%	-50.4%

- The modeled measures had a smaller impact on total energy use and peak demand reduction percentages in the residential building as compared to the commercial buildings.
- Efficient appliances were the most impactful single intervention in terms of total annual electricity savings in the Indore context, while efficient HVAC was most impactful in Haryana, closely followed by efficient appliances and efficient ceiling fans.

Building Type	HVAC DR	Efficient Water Heati..	Efficient Appliances	Efficient Ceiling Fan	Efficient HVAC	Efficient Lighting	Combined Interventions
Residential	-3.4%	-0.1%	-7.5%	-7.6%	-8.4%	-2.8%	-28.2%

Change in Annual Building Electricity Savings Compared to Baseline Case (Indore)

Building Type	HVAC DR	Efficient Water Heati..	Efficient Appliances	Efficient Ceiling Fan	Efficient HVAC	Efficient Lighting	Combined Interventions
Residential	-4.9%	0.0%	-11.2%	-10.9%	-6.1%	-4.0%	-35.7%

- Conversely, HVAC demand response was more impactful on peak demand reduction in the residential models, with a 22-24% reduction in building electricity demand during grid peak periods depending on utility.

Change in Building Electricity Demand During Grid Peaks Compared to Baseline (Haryana)
May-August, 2PM-5PM

Building Type	HVAC DR	Lighting DR	Efficient HVAC	Efficient Lighting	Combined Interventions
Assembly	-7.7%		-19.5%	-7.8%	-34.8%
Hospital	-2.4%	-2.3%	-18.2%	-12.3%	-36.5%
Hotel	-2.4%	-2.6%	-12.8%	-11.6%	-26.7%
Large Office	-3.1%	-5.6%	-26.7%	-12.8%	-49.9%
Secondary School	0.2%	-2.9%	-9.0%	-22.3%	-31.9%
Shopping Mall	-1.3%		-27.9%	-12.1%	-42.5%
Small Office	-14.2%	-6.8%	-5.6%	-13.9%	-35.1%
Strip Retail	-7.3%		-4.7%	-15.0%	-26.3%
University	0.0%	-4.0%	-27.3%	-11.6%	-41.0%

Change in Building Electricity Demand During Grid Peaks Compared to Baseline (Indore)
May-August, 2PM-5PM

Building Type	HVAC DR	Lighting DR	Efficient HVAC	Efficient Lighting	Combined Interventions
Assembly	-7.5%		-20.7%	-9.8%	-40.6%
Hospital	-2.7%	-2.4%	-20.3%	-13.3%	-42.3%
Hotel	-3.7%	-2.9%	-12.5%	-13.2%	-28.7%
Large Office	-2.2%	-5.8%	-29.0%	-13.8%	-52.6%
Secondary Sch..	0.2%	-3.3%	-7.2%	-24.9%	-33.0%
Shopping Mall	-0.7%		-29.9%	-12.5%	-45.3%
Small Office	-16.3%	-7.8%	-4.7%	-16.1%	-38.6%
Strip Retail	-7.9%		-4.0%	-17.9%	-28.8%
University	0.0%	-4.4%	-29.6%	-12.9%	-45.3%

STAKEHOLDER ENGAGEMENT FINDINGS

The first stakeholder workshop conducted on August 29, 2024, included keynote presentations from representatives of the National Smart Grid Mission, USAID, and both participating utilities, as well as presentations from the GridOptimal India project team. This was followed by interactive breakout

discussions focusing on key building-grid integration topics. The audience was asked to focus on challenges and opportunities for improving building-grid integration in India. The breakout sessions focused on gathering feedback from various stakeholders on considerations related to Regulatory & Policy, Building Design & Technologies, Grid Management & Utilities, and Renewables & Distributed Energy Resources. After each group reported on their key discussion points, the day concluded with a Q&A from a panel of experts.

Key takeaways from the workshop included:

- 1. Advancing building-grid integration requires a clear value proposition for DISCOMS.** At first glance, building-grid integration and even energy efficiency itself can be a difficult sell for distribution utilities – lowered customer consumption means less revenue. However, as both overall and peak load continues to grow, distribution utilities can find value in building-grid integration at scale through reduced and/or avoided network augmentation costs and through reduced power purchasing costs. While these pathways exist in theory, across India there is generally not currently an established methodology to forecast the costs associated with avoided network augmentation. This lack is a barrier to defining a compelling case to invest in building-grid integration strategies and programs. Avoiding the procurement of power at high-cost times on the short-term power market may be a more compelling case for DISCOMs. Guidance on and examples of correlating the power saved (MW) on the customer side with the cost for short-term power purchase on the grid side would be a helpful resource. This cost differential would be much more impactful if long-term power purchase agreements covered less of the peak load, and instead only covered base demand.
- 2. Improved data collection and M&V practices are needed.** Lack of data is a key barrier to the advancement of building-grid integration strategies. There is currently no single source of information regarding building stock details on the building side, and each distribution utility has their own methods of tracking hourly data on the grid side. Where hourly distribution grid data does exist, it is difficult to obtain. Mandating digital data in a central could provide one pathway to improved research and analyses in the area of building-grid integration. Similarly, where utility programs do exist, measurement and verification (M&V) data are lacking. This makes it difficult to determine if the given technology is operating properly, how its performance compares to the expected performance, and if performance expectations need to be fine-tuned. It is currently challenging to quantify the impact of programs in the face of changing demand patterns such as earlier seasonal peaks and higher peaks overall. Mandatory data requirements and interoperability standards are two areas of opportunity.
- 3. Increased solar adoption poses both challenges and opportunities.** Distributed solar PV was discussed in detail, as a strategy that can provide resiliency to customers and peak demand management as well as reduce additional grid infrastructure needs. However, it poses a variety of challenges and complexities. On the utility side, large-scale solar impacts power procurement trends, and thus the hours of the day that utilities are looking to manage demand (gross and net-of-solar). On the building side, distributed solar PV could work in tandem with electric vehicles (EVs) and battery storage to act as a grid asset, but there are many challenges in the residential sector (e.g., lack of roof area and poor roof condition). DISCOM-funded installations at customer sites could create a business model, but DISCOMs lack the ability to fund such projects upfront and worry about losing sales revenue. There are a variety of

program pathways that could be explored via pilots, including virtual net metering, group net metering, and peer-to-peer solar.

- 4. Regulators are a key component to increased building-grid integration.** The importance of regulatory influence was emphasized throughout the discussions summarized thus far. Regulators play a key role as a market catalyst by establishing appliance efficiency standards, driving mandates (digital data, referenced above, is one such example), earmarking funds, and setting tariff rates. However, regulators face a significant challenge in trying to balance stakeholder interests. Despite these challenges, the group identified several opportunities for regulators to advance building-grid integration efforts, including support for capacity-building, more advanced tariffs, price signals, and providing funding for programs. One example raised in the workshop was a bulk-purchasing program for utilities to procure smart grid technologies such as smart thermostats, which brings down the upfront cost to pass through to the customer.
- 5. Greater awareness is needed.** A common thread throughout the breakout groups and panel was the lack of awareness about building-grid integration, the value it can provide, and how to successfully deploy and operate technologies that support building-grid interactivity. Panelists noted that money and technology have been areas of focus for current efforts, but there is a lack of people in place to complete the work. Utilities face challenges recruiting staff for energy efficiency and demand response programs. On the building side, awareness is also lacking. The utility is often out of the loop during project design and energy efficiency is an afterthought, not to mention demand response. One panelist anecdotally shared that this workshop was the first time they had seen both the buildings sector and DISCOMs sit together.

While many barriers are identified in the summary above, there are also opportunities and existing success stories. For example, Tata Power Delhi Distribution Limited has successfully implemented a demand response program that has enrolled over 100,000 customers and has achieved a cumulative load shed of 560 MW. Additionally, the National Smart Grid Mission has deployed over 14 million smart meters to customers, with multiple pilot projects underway. Continued coordination and communication amongst stakeholders will support the current momentum.

NEXT STEPS

The project team will leverage the findings described above to develop a utility programs guidance memo that provides guidance on utility program framework options, recommendations, and strategies. This will be developed concurrently with a pilot project methodology recommendations memo. A final workshop will be held before the project concludes.

LEARN MORE

Key project materials, including the Excel GridOptimal tool, tool documentation, Tableau dashboards, and project brochure are available in the Google Drive folder [here](#). The location of these materials is expected to change to a location on SAREP's website at a later date.

For any query please contact:

Apurva Chaturvedi
Senior Clean Energy Specialist
USAID/India
achaturvedi@usaid.gov

Namrata Mukherjee
Chief of Party
USAID's SAREP
nmukherjee@sarep-southasia.org