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GRIDOPTIMAL-INDIA:
GUIDANCE FOR UTILITY BUILDING-GRID INTEGRATION PROGRAMS

CONTENTS

INTRODUCTION AND VALUE PROPOSITION

South Asia's energy systems are rapidly transforming, but there is much work to succeed in energy decarbonization while improving reliability, safety, and affordability. Buildings are at the center of the region's electricity systems and benefit from unlimited power availability. As a result, utilities and system operators are vulnerable to spiking energy generation costs during peaks and increasing capacity needs as demand grows from new construction, building electrification, and electric vehicles. While much of the grid is built to serve the peak demand of buildings, those same facilities also have the potential to act as a demand flexibility resource by reducing total energy demand. Even basic HVAC control strategies can deliver up to 20% demand reductions during peak times. Demand response programs recognize this untapped resource and incentivize building systems and devices to shed load during peak periods. The success of grid decarbonization plans and the future of the utility business model depends on, in part, widespread programmatic deployment of behind-the-meter demand flexibility. Passive strategies, including some traditional "energy efficiency" strategies, can help shape building energy demand profiles to minimize peak demand. Active strategies, including today's "demand response" tools, can empower buildings to shed and shift demand. Utility programs in India should leverage both passive and active behind-the-meter measures in an integrated, optimized manner to save costs on both sides of the meter, reduce carbon emissions today, enable faster and deeper decarbonization tomorrow, and enhance resiliency.

The built environment can either hinder or enable and accelerate energy grid transformation. Building-grid integration is essential and becoming more critical every day. It is more economically feasible and far easier in terms of actual physical systems integration to absorb high levels of variable renewable energy (wind, solar) onto a grid whose buildings have a relatively high degree of demand flexibility and with time-oriented energy efficiency strategies implemented. New Buildings Institute (NBI), a US-based nonprofit organization, is bringing its GridOptimal metrics and utility program framework to South Asia. NBI will work with government agencies, utility companies, and private sector leaders to develop and deliver India-specific metrics and analysis methodologies that promote energy efficiency and decarbonization of energy systems.

This project, supported under USAID's South Asia Regional Energy Partnership (SAREP) Partnership Fund, (SPF), leverages NBI's extensive experience in the US to help accelerate the transformation of South Asia's energy sector.

This project's big-picture, long-term goal is to enable leading utilities and policymakers in India and across South Asia to accelerate the transformation and decarbonization of electricity energy systems through the deployment of buildings and associated behind-the-meter distributed energy resources as grid assets. The central objective of this project is to develop, deliver, and disseminate India-specific GridOptimal metrics and analyses that facilitate building-grid optimization by identifying critical behind-the-meter, time-oriented, energy efficiency and demand flexibility strategies in major building typologies and grid contexts.

The goal of this guidance memo is 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 memo highlights effective strategies that utilities can prioritize to help limit peak system loads, grow the collective demand response potential of served loads in buildings, and address other priorities (e.g., emissions).

KEY ANALYSIS RESULTS

To estimate the impact of various energy efficiency and demand flexibility measures, the project team, including the South Asia Regional Energy Partnership (SAREP) New Buildings Institute (NBI), and EDS India, engaged with utility company and other stakeholders and conducted an energy modeling analysis. NBI and EDS modeled the impacts of various energy efficiency and demand response interventions in buildings. A total of 11 interventions were modeled across 10 building types (9 commercial building types and a residential building prototype). The hourly impacts of these interventions were analyzed in terms of coincident peak demand savings and other metrics to identify strategies that "punch above their weight class" by delivering higher benefits based on their time-of-use energy efficiency or demand flexibility characteristics. Across building types and climate zones, several measures consistently emerged above the rest, either by targeting typical system peak hours or by providing significant demand flexibility during those same high-priority hours. The DF measures require a minimum level of connectivity and controllability that not all buildings may have, such as digital HVAC controls, smart thermostats, and/or networked appliances and power supplies.

Table 1 shows the modeled interventions that can deliver benefits above and beyond their typical flat annual site energy savings.

TABLE 1. HIGH-RELATIVE-BENEFIT MODELED INTERVENTIONS

SECTOR	SYSTEM PEAK DEMAND REDUCTION	DEMAND FLEXIBILITY
Commercial	Efficient HVAC	HVAC demand response ("HVAC DR")
	Efficient Lighting	Daylighting and occupancy sensors ("Lighting DR")
Residential	Efficient HVAC Efficient Lighting Efficient Appliances Efficient Ceiling Fan	HVAC demand response ("HVAC DR")

The impacts offered by these measures can vary. Figures 1 and 2 show coincident peak reduction impacts from each measure. The box and whisker plots below show the minimum, 25th percentile, median, 75th percentile, and maximum values modeled across commercial building types for each measure, in each utility territory. Impacts with a large range of results suggest a high degree of building type dependence. Only one residential building type was modeled, so the results are represented by a single data point. The modeling results are available in two dashboards, customized for each utility, here:

- Indore: https://public.tableau.com/app/profile/newbuildingsinstitute2/viz/IndoreLoadData/Intro
- Haryana: https://public.tableau.com/app/profile/newbuildingsinstitute2/viz/HaryanaLoadData/Intro

Figure 1. Change in Building Electricity Demand During Grid Peaks Compared to Baseline: **Haryana**

Grid peak window is defined as 2PM-5PM May-August

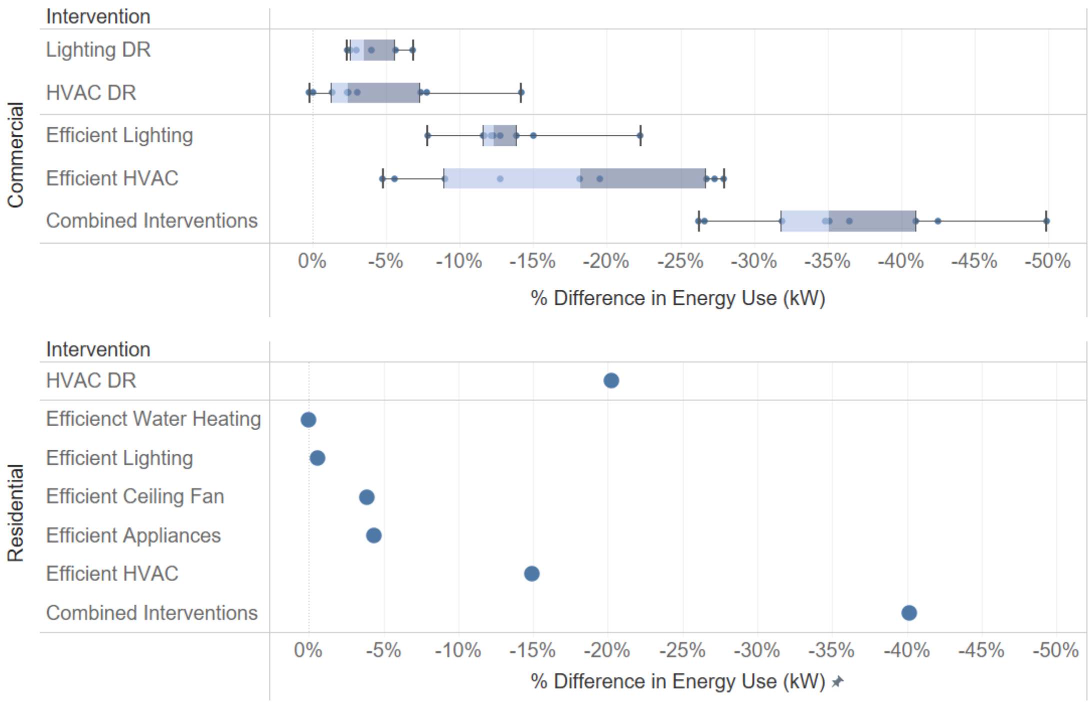


Figure 2. Change in Building Electricity Demand During Grid Peaks Compared to Baseline: **Indore**

Grid peak window is defined as 2PM-5PM May-August

The individual energy efficiency measures listed above can passively reduce building demand during grid priority hours by up to 30% in commercial buildings and 15% in residential buildings in the utility regions analyzed. Results are dependent on building type, baseline system type, operations, and climate. A comprehensive measure package containing all individual measures could reduce demand by up to 50% during the selected priority hours. The demand flexibility measures deployed during the same high-priority hours provided 15% savings on average, with the HVAC demand response measure in Indore providing a much higher reduction of nearly 30%. Although automated, dispatchable flexibility is available for thermostats, not all buildings have this capability. If operator intervention is required, it may be difficult to achieve these results.

In the modeling analysis that was used to generate the charts above, the modeled HVAC demand response intervention was a 2°C thermostat set point reduction, with scheduling varying by building type as follows. This accounts for a substantial part of the variability in HVAC DR savings in the above charts. Table 2 shows specific schedules modeled for this intervention.

TABLE 2. MODELED HVAC DEMAND RESPONSE SCHEDULES

BUILDING TYPE	SETBACK SCHEDULE
Assembly	13:00-17:00
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
Strip mall	15:00-20:00
Shopping Mall	16:00-19:00
Hotel	15:00-19:00
Residential	13:00-17:00

INCENTIVE PROGRAM IMPLICATIONS

In order to reduce system peaks and recruit additional flexible loads behind the meter, we recommend utility incentive and rebate programs include the following:

- **Passive measures** that lower overall building load, primarily focused on envelope choices or upgrades such as efficient windows, shading, cool roofs, and roof insulation (especially critical in new construction).
- **High-efficiency equipment selection, replacement and upgrades** including Five-Star Efficiency HVAC equipment and appliances, low-power office equipment, and plug load controls to cut equipment loads when not in use or after-hours.
- **HVAC controls commissioning and retro-commissioning** for digital controls as well as to update control sequences to the latest standards (i.e. ASHRAE Guideline 36) for low-to-no-cost energy savings.
- **Demand response capable HVAC controls** that *enable automated demand response*, either at the central building management/automation system or as smart thermostats
- **Process load measures and controls** for specific end-uses may also provide significant peak savings and demand response potential, including electric vehicle fleet charging, battery exchange station managed charging, industrial processes, water pumping, and other loads with inherent time-of-use flexibility.
- **Onsite solar PV installation** to reduce net building demand during grid peak hours, particularly during summer afternoons and evenings. Incentivizing smart inverters can help bring down the upfront cost to the customer.
- **A trusted installer network** to ensure that incentivized measures are properly installed and commissioned.
- **Established M&V plans and the ability to execute them,** to assess if incentivized technologies are performing to expectations.
- **Messaging regarding building-grid interactivity** and how it benefits both the customer and the planet, in terms that are understandable to the customer.

In addition to the recommendations above, the following considerations could be included in the future, once the technology becomes mor readily available:

- **Energy storage installation (battery and thermal)** to increase demand flexibility capacity. With proper controls and agreements in place, the utility may dispatch the energy storage to ensure firm demand response availability.
- **Grid-connected appliance installation** or replacement at end-of-life, including smart heat pump water heaters and residential appliances in order to automatically shift load on a daily basis in response to real-time signals from the grid or utility.

The general program flow is as follows:

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

Developed standards are available for smart grid communications and interconnectivity. Table 3 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.

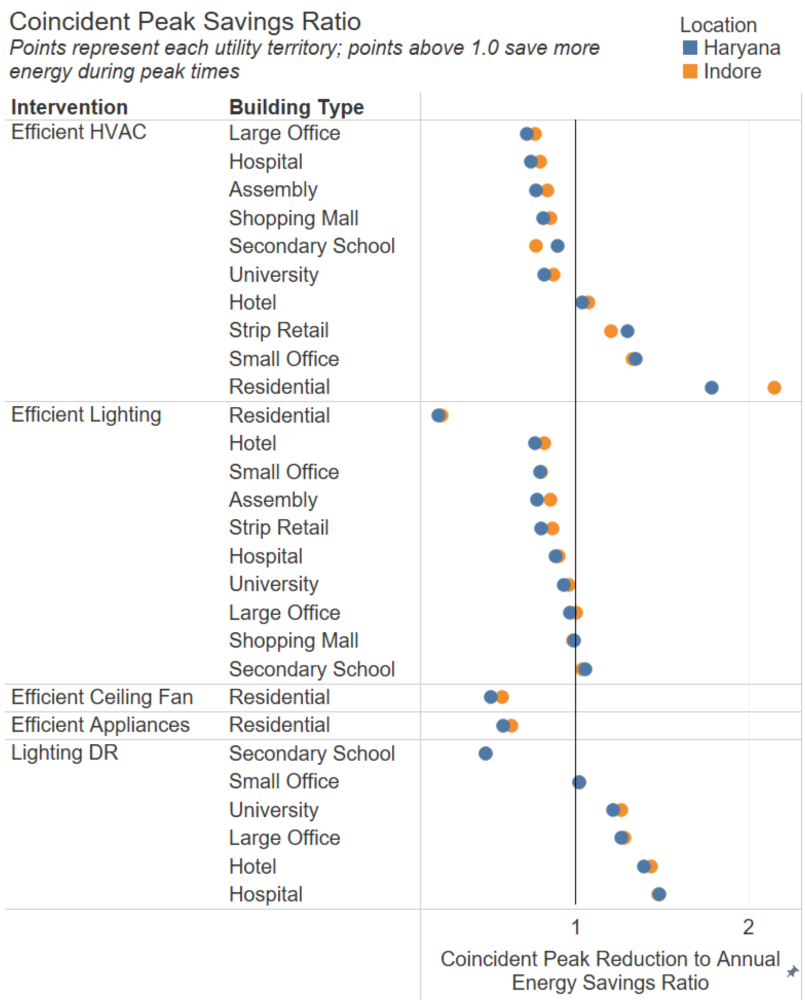
TABLE 3. MODELED HVAC DEMAND RESPONSE SCHEDULES

EQUIPMENT	COMMON STANDARD(S)
Electric Vehicle Charger	OCPP 2.0 OpenADR 2.0b/3.0
Smart Thermostat	OpenADR 2.0b/3.0
Heat Pump Water Heater	ANSI/CTA-2045-B, Level 2
Smart Inverter	IEEE 2030.5 IEEE 1547

PROGRAM APPROACHES AND GRIDOPTIMAL METRICS

This information can be used to establish new programs or tune existing programs in a way that reduces energy procurement and distribution cost, improves grid resilience, maximizes coincident peak demand reduction, maximizes hourly upstream (electricity grid) carbon emissions savings, or delivers other outcomes. Figure 3 compares coincident peak demand reduction to "flat" annual energy efficiency savings for each of the modeled measures across building types and grid regions. Evaluated cases (measure/climate/grid combinations) with relatively more coincident peak demand impact per flat annual kWh saved appear farther to the right on this chart, and cases with less appear to the left.

Figure 3. Coincident Peak Savings Comparison across Interventions, Building Types, and Locations



This chart can be used to identify building types and measures with relatively greater coincident peak reduction per kWh saved. For example, upgrading to efficient HVAC in strip retail, small offices, and residential buildings offers relatively more coincident peak reduction per annual kWh saved than some other building types. This may be because the baseline load shapes for those buildings are more coincident in the first place – that is, their loads are higher during grid peak hours, so there are more options for coincident peak load reduction through a variety of measures. Programs seeking coincident peak demand reductions should consider focusing more aggressively on building types with highly coincident load shapes. Similarly, certain measures in certain building types are highly impactful. For example, in secondary schools, improved Lighting efficiency is relatively impactful, but the Lighting DR measure (which adds daylight and occupancy sensors) is not as impactful in this building type, likely because classrooms are occupied during peak grid hours with minimal ability to reduce lighting load. Programs targeting retrofits may thus want to focus on certain interventions based on building type.

The use cases for this analysis vary between prescriptive and custom program types.

PRESCRIPTIVE PROGRAMS

Prescriptive programs pay incentives per device. The chart above can be used to help identify high and low priority measures (but must be taken with a grain of salt – after all, these are modeled results and some of the assumptions such as equipment schedules can make a large difference in the results here). For example, a program offered by a utility seeking to achieve greater coincident peak load reductions might be interested in commercial lighting controls, which offer significant opportunity for coincident peak load reductions in five building types (as shown in the chart above), whereas residential ceiling fan and appliance upgrades offer relatively lower reductions in coincident peak loads. The next action for this program could be to more deeply investigate customer and pre/post equipment load shapes. This must be balanced against other portfolio needs and goals, such as efficiency savings or customer cost impacts. Careful attention should be paid to program design, customer targeting, and incentive/rate structure choices to be confident in measure prioritization. This analysis is mainly intended to provide a starting point for programmatic adjustments and to inform key areas to improve programs based on industry-wide observed best practices.

CUSTOM PROGRAMS

Custom programs pay incentives based on the calculated project energy savings (i.e., ₹/kWh saved). In some cases, a peak ₹/kW savings is also included; this is typically system or whole-building peak but is not usually coincident peak. This analysis may be used to adjust incentive levels by project type, if a light touch is desired. Going deeper, programs could adjust the incentive basis (₹/kWh and/or ₹/kW) metric itself or add additional metric(s) such as *coincident* peak demand savings and upstream carbon emissions to calculate part of the incentive payment.

GRIDOPTIMAL RESEARCH AND MARKET-ORIENTED METRICS

The full suite of GridOptimal metrics includes nine dimensions, including grid impacts, carbon emissions, resiliency, and demand flexibility. This comprehensive set of metrics addresses the needs of buildings owners and operators as well as utilities and grid operators. In this memo, we focus on grid-impact metrics for utility programs, namely grid peak contribution (coincident peak demand reduction) and short-term demand flexibility (1-hour load shed duration). These two metrics are energy-based to fit within typical utility program mandates. The underlying methodology prioritizes peak hours on the grid, which are often disproportionately high-carbon hours as well. These metrics are useful for research purposes and for programmatic (back-of-house) applications but may be too confusing and complex for many customers.

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/m^2) during high-priority grid peak hours. The high-priority hours can be defined as specific hours (e.g., weekdays May through August from 3 to 8 pm) or may be defined as the annual hours when total system load is highest (e.g., the top 5% or peak 438 hours of the year).

The grid-delivered power to the building (i.e., net demand) during that subset of hours forms the entire basis for the metric. Measuring or calculating this index requires hourly net demand data available via building energy modeling or hourly building metering (smart meters).

- **Demand Flexibility Index:** a measure of how much load a building can shed (W/m²) based on a utility signal over a one-hour period, much like a demand response call. Demand flexibility (DF) is estimated based on the building's peak-day conditions. Buildings can provide DF several ways, including HVAC setpoint changes, onsite battery dispatch, using stored thermal energy to limit chiller or boiler power, cutting power to selected lighting/plug loads, or cutting power to tank-based water heaters. Measuring or calculating this index may in some cases require an estimate of load shed potential based on parametric energy simulation modeling, customized technical assessments by facility managers, energy storage capacity evaluation, or other approaches.

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

UTILITY-SCALE PROGRAMMATIC COST/BENEFIT CALCULATIONS

This analysis may also be used to support utility demand side management (DSM) program-level cost/benefit calculations. These calculations may be conducted using customized spreadsheets and/or by using commercial software tools. The information used to produce this analysis, including the library of 8760 pre- and post- load shapes, can be used to expand the scope of the cost/benefit analysis so that more detailed hourly benefits are captured, and to capture the value of non-financial priorities (e.g., resilience, greenhouse gas emissions, deferral of distribution grid investment, risk reduction, etc.).

CONCLUSION

Utility programs are well positioned to both increase behind-the-meter demand flexibility and mitigate system peaks by incentivizing targeted retrofits to build controls capability, install storage, or upgrade building systems shown to reduce energy demand during common system peak periods. We recommend programs assess the monetary value of coincident (and noncoincident) peak load reduction, assign values to resilience, evaluate the potential of demand -side strategies to enable transmission grid investment deferral, and price in savings from upstream electricity grid greenhouse gas emissions in their service territory to establish appropriate incentive levels to reach these program goals.