DESIGN GUIDANCE FACTSHEET

GRIDOPTIMAL®
BUILDINGS INITIATIVE

NREL Research Support Facility | Golden, CO
Credit: Dennis Schroeder

Optimizing Building-Grid Integration in Office Buildings

This factsheet recommends selected high-impact building design and operational strategies for office buildings.

Factsheets are available for other building types and for specific regions across the US. Office buildings can save costs, reduce carbon emissions, and help advance energy system decarbonization through time-of-use energy efficiency, smart devices, connected controls, and distributed energy resources such as onsite/community solar and energy storage. The recommendations in this factsheet are based on a wide variety of research, including building-scale and grid-scale simulation modeling and on-the-ground GridOptimal pilot project experience.

Top 5 GridOptimal Building Design and Operation Strategies:

Office Buildings

Efficiency and demand flexibility strategies have widely varying impacts across multiple building types, climates, and grid paradigms. High-impact strategies like these can deliver time of-use energy efficiency and demand flexibility while minimizing or avoiding occupant disruption.

Energy efficiency. Envelope measures like insulation, air-sealing, high-performance windows, and mechanical systems (HVAC and water heating) offer both year-round savings and peak demand reduction during times of high grid demand and carbon emissions. Energy efficiency is an enabler and impact multiplier for demand flexibility.

Plug load management. Plug loads can account for more than half of all energy consumption in ultra-high-performance offices. Because plug load schedules in offices tend to align well with times of high grid load and emissions, efficient appliances, devices, and plug load controls can have benefits in terms of reducing peak demand on the grid as well as avoiding carbon emissions.

Smart HVAC controls. Temperature setpoint and schedule adjustments such as setbacks, precooling, and preheating can deliver peak demand savings and shift load toward low-cost, low-carbon hours. Communications standards such as OpenADR 2.0b enable current and future participation in demand response and similar programs.

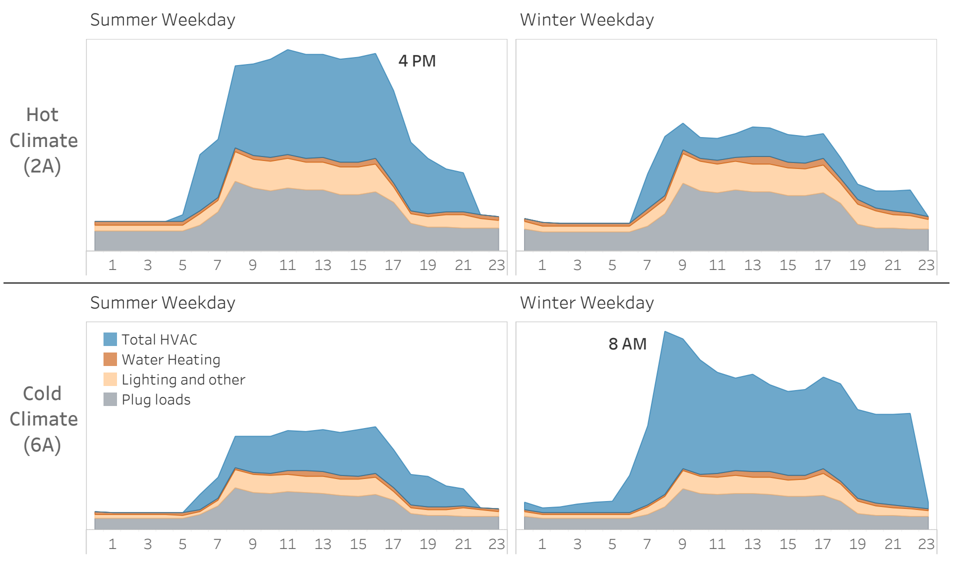
Energy storage. Both battery electric and thermal (e.g., ice, hot water) storage systems can enable load shifting away from high-cost, high-carbon hours. Key benefits include energy cost savings, emissions reductions, and resilient operations. Co-optimize schedules to achieve cost, emissions, and resiliency benefits, and specify grid-integrated communications.

Managed EV charging. Electric vehicles are a key decarbonization solution but unmanaged charging can add substantial demand. Charging during off-peak hours, and reducing or staging charging peak-hour charging, mitigates the impact. Special rates and generous incentives are often available for smart EV chargers.

Where the Energy Goes: Typical Office End-Use Demand Profiles

To find the highest-impact opportunities for time-of-use energy efficiency and demand flexibility, identify key hours in terms of energy cost, carbon, and/or overall grid net load, then search for opportunities when those times overlap with high building demand.

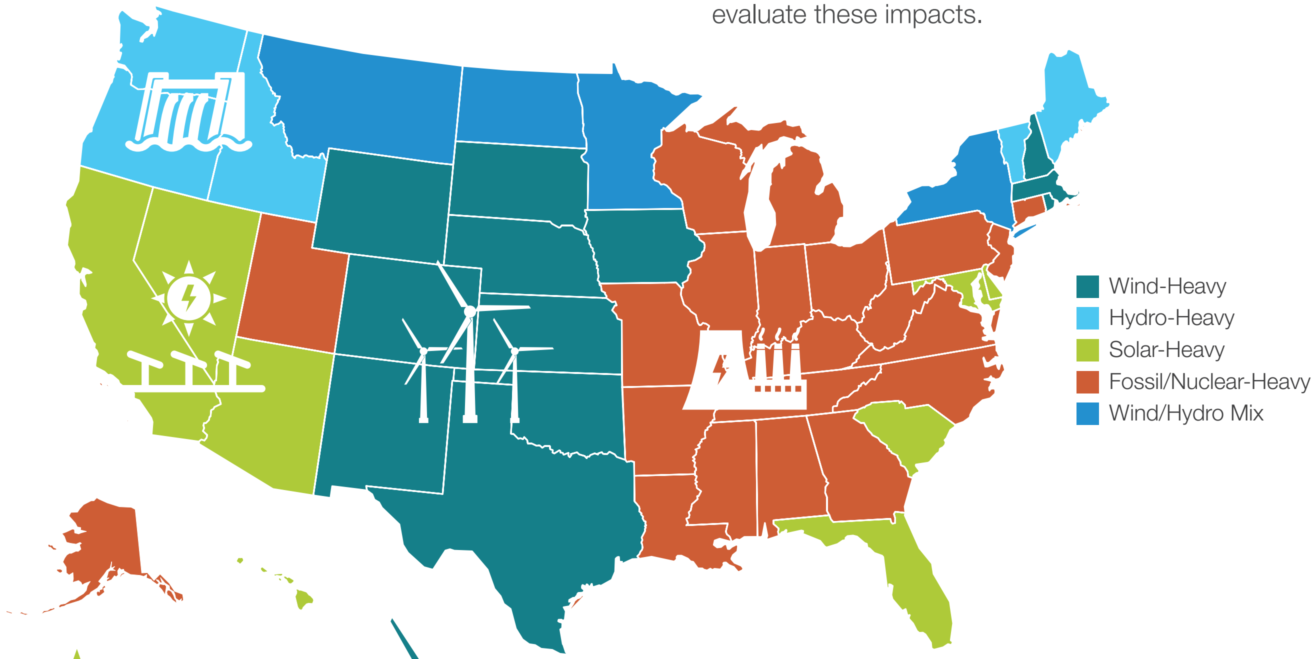
These charts show typical summer and winter demand profiles for a medium office building in a hot climate (zone 2A) and a cold climate (zone 6A).

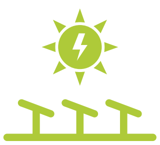


Designing for the Local Grid

Across the nation and the world, electricity grids are changing fast, and variable wind and solar are the fastest-growing resources. There are many pathways to decarbonization, and which resources are dominant at the regional level impacts both rate structures and carbon emissions patterns. Broadly, most regions can be considered either solar, wind, hydro, or fossil-heavy (in reality, all grids use a unique mix of resources; this framework is intended mainly for at-a-glance comparisons).

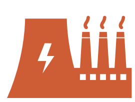
In general, buildings should seek to **minimize demand during the highest net load hours** on the grid and **shift load toward periods of low net demand.** High net load occurs when less renewable energy is on the grid—often evenings in summer. The times of low net load vary depending on the local grid conditions. Buildings can co-optimize targeted energy efficiency and flexibility strategies to achieve both cost savings and carbon emissions reductions by considering both their cost and carbon implications; the GridOptimal Buildings LEED Credit calculator spreadsheet can help designers evaluate these impacts.





Solar-Heavy: PV panels produce more energy during mid-day hours, but grid peak demand often comes later in the day, especially in summer. Consider strategies that enable the building to shift energy away from morning and evening and toward 10am-2pm, such as grid-integrated heat pump water heaters and batteries. Target energy storage duration of 2-8 hours.

Wind-Heavy: Onshore wind in many locations tends to be stronger at night; offshore wind tends to be stronger during the day. Day to day variability can be high: prioritize demand flexibility. Consider strategies to leverage abundant, clean daytime and/or overnight energy for use during afternoons and evenings, with energy storage durations in the 8-16 hour range.



Fossil/Nuclear-Heavy: Emissions are typically highest during grid system peak demand hours but often remain relatively high during off-peak hours. Overnight and baseload hours may be very carbon-intensive (coal) or lower-carbon (nuclear). Focus on deep energy efficiency and target demand flexibility during grid peak hours, typically during summer afternoons and evenings.

Hydro-Heavy: Abundant clean energy is available during spring and early summer months as snow melts and rivers run high but limited during summer and fall. Large dams offer grid balancing and buffering ability to minimize electricity demand and supply variability. Electrification offers high carbon savings impacts. Target energy efficiency and demand reduction during summer afternoons.

Key Considerations: Office Buildings

Plug Loads and Data Centers

Office buildings of all sizes have substantial plug loads: computers, monitors, printers, etc. Many large office buildings have onsite data centers, driving high internal equipment energy usage and adding substantially to cooling demand year-round. Plug load energy efficiency is foundational. Connected appliances and building management systems with demand response capabilities facilitate load shifting and can leverage a greater portion of the building's demand compared to manual adjustments. Consider including thermal energy storage in the cooling system for data centers to enable shifting IT cooling load away from high-cost, high-carbon hours. Design storage systems to co-optimize for both cost and carbon impacts either through real-time carbon signals or by programming in a time-varying synthetic cost of carbon.

The Banner Bank Building, Boise, ID | Credit: HDR Architecture, Inc.

Ventilation and Indoor Air Quality

To reduce the risk of disease spread in the wake of the COVID-19 pandemic, and to improve indoor air quality in general, building designers and operators are focusing on ventilation and air filtration. These strategies are important for occupant health and safety, but if not implemented carefully they can add substantially to energy demands, especially during high-cost, high-carbon hours. Good HVAC controls are critical, and the building controls installation or upgrades offer a prime opportunity to integrate HVAC, lighting, and shading systems as well as to include grid-connected communications equipment.

Electric Vehicles

Because many office workers drive in and park their car at the office all day, vehicle electrification is an important consideration in this building type. Electric vehicle charging can add substantial whole-building loads and if not managed carefully can contribute to higher energy costs and carbon emissions. Specify smart EV chargers that can communicate with the utility or a third party. Bidirectional chargers are an emerging technology that can enable EV batteries to support electricity grids and buildings.

Program Information

The GridOptimal Buildings Initiative aims to improve building-grid interactions across the built environment by empowering building owners, designers, utilities, and other key players with dedicated metrics, tools, and guidance.

Up to three LEED points are available for buildings that improve their building-grid integration outcomes through the GridOptimal Buildings Pilot Alternative Compliance Path. See: usgbc.org/credits/gridoptimal-152-v4.1

For more information, contact alexi@newbuildings.org

Read more: newbuildings.org/gridoptimal

nbi new buildings institute

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 and reduce carbon emissions. We also develop and offer guidance and tools to support the design and construction of energy efficient buildings. Learn more at newbuildings.org

NBI developed this GridOptimal design guidance factsheet.

The GridOptimal Buildings Initiative is supported by these organizations:

Austin Energy · DEED Public Power Research & Development, American Public Power Association · Efficiency Vermont · Energy Trust of Oregon · PG&E · SMUD · Southern California Edison, Energy for What's Ahead