

Grid-Interactive Buildings for Decarbonization

Design and Operation Resource Guide

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Grid-Interactive Buildings for Decarbonization

Design and Operation Resource Guide

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Peachtree Corners

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Acknowledgments

This *Grid Interactive Buildings for Decarbonization: Design and Operation Resource Guide* is the second in a series of guides developed by ASHRAE's Task Force for Building Decarbonization (TFBD), which is aimed at addressing the challenge of decarbonization in the built environment. Grid interactivity is still a relatively new practice for most ASHRAE members; therefore, this guide provides information to enable readers to maximize carbon reduction through a building's interaction with the electric power grid. Buildings have a role in decarbonizing the power grid and managing their carbon budget.

The guide was initially envisioned and outlined by the 15 members of the TFBD Grid-Building Intersection working group, which included building energy industry experts, electric utility engineers, academics, and U.S. government laboratory and federal representatives.

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inspiration and much-needed background to anyone interested in understanding and implementing grid-building intersection strategies for decarbonization. It was created to equip readers with the information they need during the design or renovation of a building to help them make informed operational and design decisions that drive deeper building decarbonization and provide equitable outcomes for all involved.

At a time when we must use every avenue available to us to decarbonize our world, we believe informed design and operational decisions, based upon the carbon content of the electrical power grid, will have tremendous impact on our environment in the short and long term.

Katherine Hammack
Grid-Interactive Buildings for Decarbonization Guide Chair
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Abbreviations and Acronyms

AC	alternating current
ADR	automated demand response
ALMS	automated load management system
AMI	advanced metering infrastructure
API	application programming interface
ARC	automatic receptacle control
ASPE	American Society of Plumbing Engineers
ASO	automated system optimization
ASSE	American Society of Sanitary Engineering
BACnet	Building Automation and Control Network
BAS	building automation system
BESS	battery energy storage system
BPS	building performance standard
BTL	BACnet Testing Laboratories
CHP	combined heat and power
CSA	CSA Group; formerly Canadian Standards Association
DC	direct current
DCFC	direct current fast charger
DCW	domestic cold water
DER	distributed energy resource
DHW	domestic hot water
DOE	U.S. Department of Energy
DRCM	dynamic recovery cycle management
EIS	energy information system
EMIS	energy management information system
EPMS	electrical power management system
EV	electric vehicle
EVSE	electric vehicle supply equipment
FDD	fault detection and diagnostics
FEMP	Federal Energy Management Program
FERC	Federal Energy Regulatory Commission
GEB	grid-interactive efficient building
GHG	greenhouse gas

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HVAC	heating, ventilation, and air conditioning
IEC	International Electrotechnical Commission
IECC	International Energy Conservation Code
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
kW	kilowatts
kWh	kilowatt-hours
LAN	local area network
LED	light emitting diode
Modbus RTU	Modbus remote terminal unit
Modbus TCP	Modbus transmission control protocol
MW	megawatts
MWh	megawatt-hour
NFPA	National Fire Protection Association
NIBS	National Institute of Building Sciences
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
OCPP	Open Charge Point Protocol
OpenADR	Open Automated Demand Response
PCC	point of common coupling
PCM	phase change material
PCS	power conversion system
PPL	plug and process load
PV	photovoltaics
REST	representational state transfer
RTP	real-time pricing
SCADA	supervisory control and data acquisition
SGIP	Self-Generation Incentive Program
SSL	Secure Sockets Layer
TES	thermal energy storage
TLS	Transport Layer Security
TOU	time of use
UCM	universal communication module
UL	UL Solutions; formerly Underwriters Laboratories
USB	universal serial bus
V2B	vehicle to building
V2G	vehicle to grid
V2H	vehicle to home
VEN	virtual end node
VFD	variable-frequency drive
VRF	variable refrigerant flow

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1

Introduction

Achieving climate goals set by enterprises, cities, states, and nations will require a combination of building electrification (i.e., the replacement of on-site fossil fuel combustion devices with electric substitutes) and decarbonization of the electric grid. Building decarbonization will also be necessary to meet emerging net zero carbon targets set by jurisdictions globally.

Decarbonizing the electric grid will require a shift to a dynamic, two-way relationship between buildings and the grid that allows buildings to respond dynamically to grid conditions, including time-varying carbon emissions rates. This two-way communication has just come into focus in the last few years as renewable energy integration and grid reliability issues, particularly around peak conditions brought on by extreme weather conditions, variability of renewable generation, and increased loads, have spurred utilities, grid operators, and the building community to reconsider the role buildings can play in supporting grid reliability and decarbonization by reshaping their energy consumption patterns.

Smart, flexible buildings will play an important role in scaling cost-effective decarbonization by optimizing building operations and energy consumption behavior. These outcomes must be achieved without compromising building service quality or occupant comfort. The carbon emissions associated with the electricity generation on the grid change continuously, as does the cost for utilities to provide that electricity. These grid-interactive buildings use permanent, passive solutions, such as high-performance building envelopes, and active solutions that can react to temporary grid constraints via smart controls, energy storage, and other distributed energy resources (DERs).

Grid interactivity is not limited to new, large, or complex buildings—every building in operation with one or more controllable energy-consuming system, such as heating, ventilation, and air conditioning (HVAC); lighting; and water heating. can make impactful adjustments to energy usage patterns with the right communications and controls infrastructure in place. Grid interactivity in buildings is a scalable solution to reduce carbon emissions from electricity generation, limit energy costs, maximize renewable energy utilization, and improve the resiliency of the grid and buildings, all with little to no impact to or awareness from occupants. Controls providing demand flexibility in buildings can represent an estimated 59 GW of peak load reduction in 2030 (Langevin et. al 2021).

1.1 Purpose and Scope

The purpose of this *Grid-Interactive Buildings for Decarbonization: Design and Operation Resource Guide* is to provide building designers and operators with a set of current best practices and guidance to maximize the value streams afforded by grid interactivity, including carbon emission reductions, reduced energy costs, and resiliency. This guide is focused on commercial and

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multifamily buildings, though aspects of it apply to residential and industrial sectors. Beyond design guidance, this guide provides operational guidance for new and existing buildings to make the best use of their available demand flexibility in practice.

This guide builds upon ASHRAE's *Smart Grid Application Guide* (2020d), which captures the grid-side or front-of-the-meter considerations for a utility audience. That application guide covers the basics and lays the foundation for building-grid interaction, including DERs, communication protocols and structures, the regulatory environment around grid integration, revenue streams, microgrids, and other related topics. This guide also heavily references other ASHRAE guides to complement these existing resources and limit undue duplication.

"Grid-interactive efficient building" and "GEB" are common terms for the buildings described in this guide; however, those terms are not commonly used in this guide. Although grid-interactive buildings can and should follow an efficiency-first approach to reduce their reliance on the grid and limit carbon impacts, this guide only highlights select energy efficiency recommendations that have a significant impact on grid interactivity (e.g., envelope design[1]). The term used throughout this guide to reflect the focus on grid interactivity is "grid-interactive building." For energy efficiency design guidance, the *Advanced Energy Design Guides* (AEDGs; ASHRAE 2023a) and the *International Green Construction Code* (IgCC; ICC 2021b) are recommended. Further, this guide does not go into detail on precommercial or emerging technologies. For information on regulatory considerations, refer to chapter 2 of the *Smart Grid Application Guide* (ASHRAE 2020d) and section 3.3 of this guide.

To get the most out of this guide, review the reader orientation in chapter 2 to navigate to the pertinent chapters for specific use cases.

At a glance, this guide includes the following information:

- Foundational guidance applicable to all grid-interactive buildings
- Best practices and specification guidance for both simple standalone and integrated building systems
- Special considerations for campuses/districts and portfolios
- Grid-interactive software solutions
- An infographic summarizing the steps for successful grid-interactive design and operation
- Additional resources, references, and a glossary of terms

[1] High-performance building envelopes support stable internal temperatures, which allow a building to effectively adjust set points while maintaining occupant comfort

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