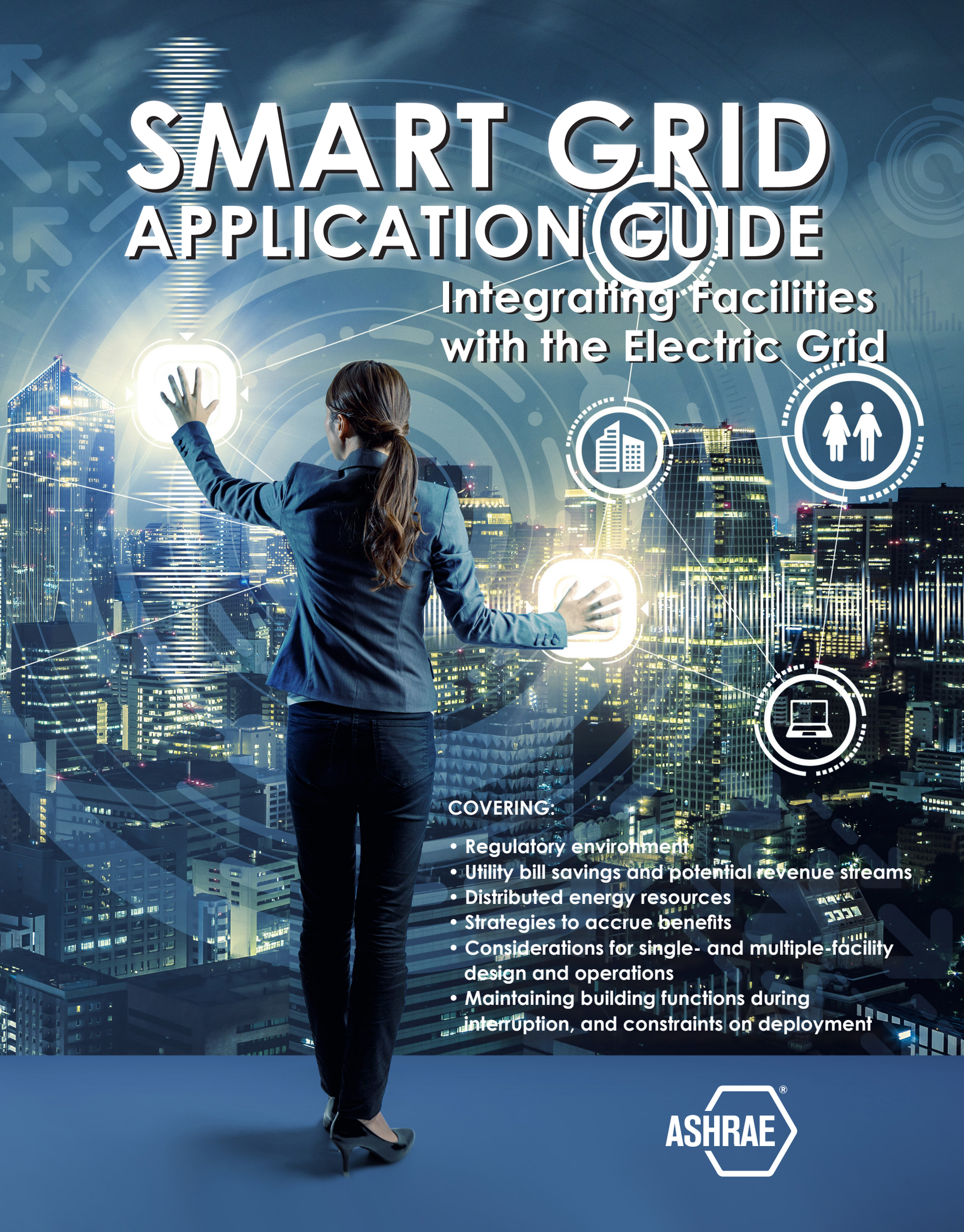


SMART GRID APPLICATION GUIDE

Integrating Facilities with the Electric Grid

COVERING:

- Regulatory environment
- Utility bill savings and potential revenue streams
- Distributed energy resources
- Strategies to accrue benefits
- Considerations for single- and multiple-facility design and operations
- Maintaining building functions during interruption, and constraints on deployment

ASHRAE®

Smart Grid
Application Guide
Integrating Facilities with the Electric Grid

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PREFACE

Changes occurring in the electric grid infrastructure will require new design and operation considerations for buildings and how they interact with the electric grid. Facilities can be operated in ways that support grid operations (economic efficiency, environmental protection, and/or reliability) while potentially lowering their own costs of operation by managing loads and storage to contribute to balancing grid-wide demand and changes to the generation mix. As the modern grid develops, building automation systems are able to receive signals about the condition of the grid and current prices and values for electricity and grid services. Building operators will have increasing economic and reliability incentives for responding appropriately to grid conditions. A key requirement for success of the smart grid will be communication and cooperation between electric service providers and building energy management systems to effectively manage supply and demand.

An effective energy user/energy provider partnership will depend on bidirectional communications—the ability to manage facilities' equipment, process systems, and controls in response to communication with a smart electrical grid and communicate information about those electrical loads and on-site resources for generating electricity. The expected results will be more efficient and reliable power system operations and designs. A building manager able to coordinate building operations with the grid stands to reap significant economic benefits by sharing in the resulting improvements in grid operational and investment efficiencies. Such energy user/energy provider integration must support a wide range of energy management applications and electrical service provider interactions, including on-site generation, demand response (defined in The U.S. Code of Federal Regulations as "a reduction in the consumption of electric energy by customers from their expected consumption in response to an increase in the price of electric energy or to incentive payments designed to induce lower consumption of electric energy" [GPO 2019]), electrical storage, peak-demand management, direct load control, and other related energy management functions.

However, building operators often do not have a good understanding of the complexity of utility rate structures and resource management programs. Moreover, as the smart grid develops, the nature of the grid services that building owners may be able provide will continue to evolve, and the value propositions, tariffs, and requirements will vary with locality. ASHRAE, the Smart Electric Power Alliance (SEPA), and the OpenADR Alliance have participated in the develop-

ment of this guide. The partnership is committed to helping facility owners, designers, and operators provide safe, comfortable, efficient, and affordable conditions in the built environment. There is an immediate need to provide useful resources for facility personnel to identify and evaluate the myriad of smart-grid-related options and opportunities as they become available. *Smart Grid Application Guide: Integrating Facilities with the Electric Grid* provides guidance to building owners, managers, and designers for understanding the smart grid and applicable standards and regulations. It also offers guidance on the design and operation of systems in this new smart-grid environment. The guide focuses on the decisions and actions needed to prepare a building for the smart grid.

Acknowledgments

This smart grid application guide is a product of the vision, dedication, and hard work of many people. It began with discussions among the President Elect Advisory Committee assisting presidential member Sheila Hayter prepare a theme and priority activities for her presidential year. The ideas and guidance from Sheila, Hugh Crowther, and Malcolm Dennis Knight were particularly helpful as I was tasked to turn the idea into a reality.

In addition to the considerable task of providing meaningful information and guidance to building professionals, one of the goals of the guide was to open the door for ASHRAE to build partnerships with other organizations that are playing central roles in making the future smart grid a reality. Special thanks are due to the Smart Electric Power Alliance (SEPA) and the OpenADR Alliance for their partnership in this effort and the contributions of their representatives Brenda Chew and Rolf Bienert throughout the process.

To manage the process, a Presidential Ad Hoc Committee was formed from people drawn from key constituencies within ASHRAE. Their names are listed at the front of this guide. Each of these individuals freely contributed their time and talents by attending monthly web meetings and reviewing drafts provided by the authoring team throughout the process. Although not formally authors, each of these people made important contributions to the final product.

The authoring team collectively represents a range of technical and policy expertise, including building automation and control, building system commissioning, product design, standards development and utility regulatory matters. This team developed the content of the guide and their breadth of expertise was a critical factor in creating a useful and comprehensive end product. The authoring team would like to thank the following researchers and industry experts for providing relevant resources and references, sharing their expertise on the states of the arts, and for answering questions from the team:

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I would also like to acknowledge the contributions of some ASHRAE staff members. Lilas Pratt provided excellent logistical support and thoughtful suggestions throughout the process, based on experience from similar projects. Cindy Michaels and Mary Bolton ably transformed the manuscript into a high-quality, professional publication.

The industry is in the early stages of a dramatic transition to a time when building loads, generation resources, and energy storage will be managed in ways that cooperate with and support the needs of a smart electric grid based on renewable energy sources. The hope is that this guide will provide a valuable jump start to the building professionals who will make this transition happen.

Steven T. Bushby, Fellow Member ASHRAE
Chair

1 INTRODUCTION

Traditionally, electric utilities provided electricity, which buildings consumed. The only interaction between these entities was the utility bill. This is rapidly changing. In 2018, buildings accounted for approximately 75% of the nation's electricity consumption (EIA 2019b). Buildings around the world are increasingly generating electricity or dynamically modifying their electricity consumption to control building operating costs. And, electric utilities/systems operators are increasingly using more detailed electricity usage data to optimize the operation of the electric grid. This has been enabled by the ongoing development of the "smart grid." The U.S. National Institute of Standards and Technology (NIST) defines the *smart grid* as "a modernized grid that enables bidirectional flows of energy and uses two-way communication and control capabilities that will lead to an array of new functionalities and applications" (NIST 2014b). These two-way communications can be at many points in the electricity supply chain from generation, to transmission, to distribution, to consumption. This smart grid guide is concerned with those two-way communications and control capabilities that involve interactions between facilities and the electric grid. ASHRAE Standard 201, *Facility Smart Grid Information Model,* states a *facility* is "any kind of building or collection of buildings, and all of the electrical loads or local generation sources contained within them or controlled by the facility owner" (ASHRAE 2016b). The electric grid can include not only electric utilities, but also energy wholesalers, retailers, and aggregators.

These smart grid interactions make it possible for facilities to be active participants in the supply and demand of electricity rather than just their historical role as passive consumers. This enables facilities to be providers of electricity and ancillary services to the grid, to reduce demand during periods of high demands and electricity prices, or to be compensated for assisting with grid reliability and power quality.

1.1 PURPOSE OF THIS GUIDE

The purpose of this guide is to assist building owners, designers, and operators in understanding smart grid basics and identifying and evaluating the myriad of smart-grid-related options and opportunities currently available. This guide will also provide resources and references to applicable codes, standards, and regulations as well as steps needed to prepare a building for the smart grid. Specifically, it will outline:

- The value of smart grid technologies—the regulatory environment and utility bill savings and potential revenue streams;
- The ongoing deployment of smart grid technologies—distributed energy resources, strategies to accrue benefits, maintaining building functions during interruption, and constraints on deployment;
- Building design and operation considerations—individual building design considerations and multiple-facility design and operations;
- A glossary of smart-grid-related terms and a list of acronyms; and
- Additional resources and references.

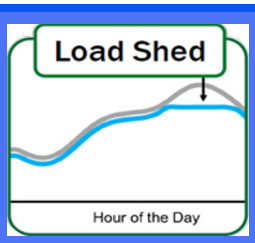
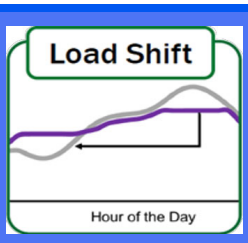
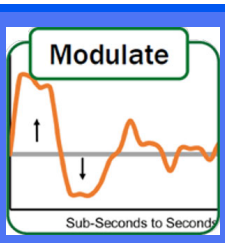
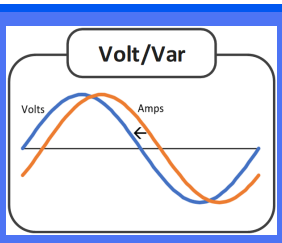
1.2 WHAT IS NOT COVERED?

One challenge with developing a smart grid guide is choosing what topics not to include, as an exhaustive document would be excessively long. This guide uses the two-way communications and control requirement expressed in the NIST definition of the smart grid to help guide which topics to include. Topics such as demand limiting to avoid demand and ratchet charges only receive limited coverage because these can be done based on a prior knowledge of the applicable electric tariffs and do not require two-way communications with the grid. At the same time, if a facility has invested in the metering and control equipment needed for demand limiting, they have almost everything necessary to participate in demand response programs that are triggered by signals or pricing information received from the grid. This fine line of distinction was chosen to keep this guide from becoming an encyclopedia instead of a guide. However, totally ignoring these closely related topics would not be helpful either. As a compromise, this guide references these topics and lists other sources for more detailed information.

1.3 GRID SERVICES DEFINED

An important concept to the guide is understanding how smart grid components allow facilities to interact directly with the electric grid. Given this interaction, important services can be provided by a facility with smart grid to the grid. Those grid services are varied and can be defined differently in the energy industry. Table 1.1 defines the grid services that a facility might be able to provide and gives example market programs and smart grid components associated with those services. Throughout the guide, reference will be made to these services.

Table 1.1 *Definitions and Examples of Grid Services*

				
What the facility provides	• Reduction in peak demand to keep the grid from being overloaded • Reduction in peak demand to lower prices	• Reduction in peak demand with increase in minimum demand	• Frequency regulation • Ramping	• Voltage compensation for distribution circuits
Why is it needed by the grid?	• Replaces expensive peaker plants • Defers need for transmission or distribution capacity upgrades • Allows the grid time to respond to temporary generator or transmission problems.	• Minimizes need to curtail renewable generation • Lowers costs by shifting energy usage from high cost periods to low cost periods	• Grid needs to buy time for slower responding generators to respond to unplanned generator outages • Grid needs to buy time for slower responding generators to ramp	• Inductive loads on long distribution circuits can cause line voltage problems and equipment overheating.
Example Market Programs	• Capacity programs • Non-wires solutions	• Time-of-use rates • Real-time rates • Non-wires solutions	• Ancillary services	• Ancillary services
Example Applicable Systems	• Dispatchable distributed generation • Lighting systems • Elevator systems	• Energy storage systems	• Variable-frequency drives (VFDs) • Advanced inverters	• Advanced inverters

Note: Graphics from DOE (2019).