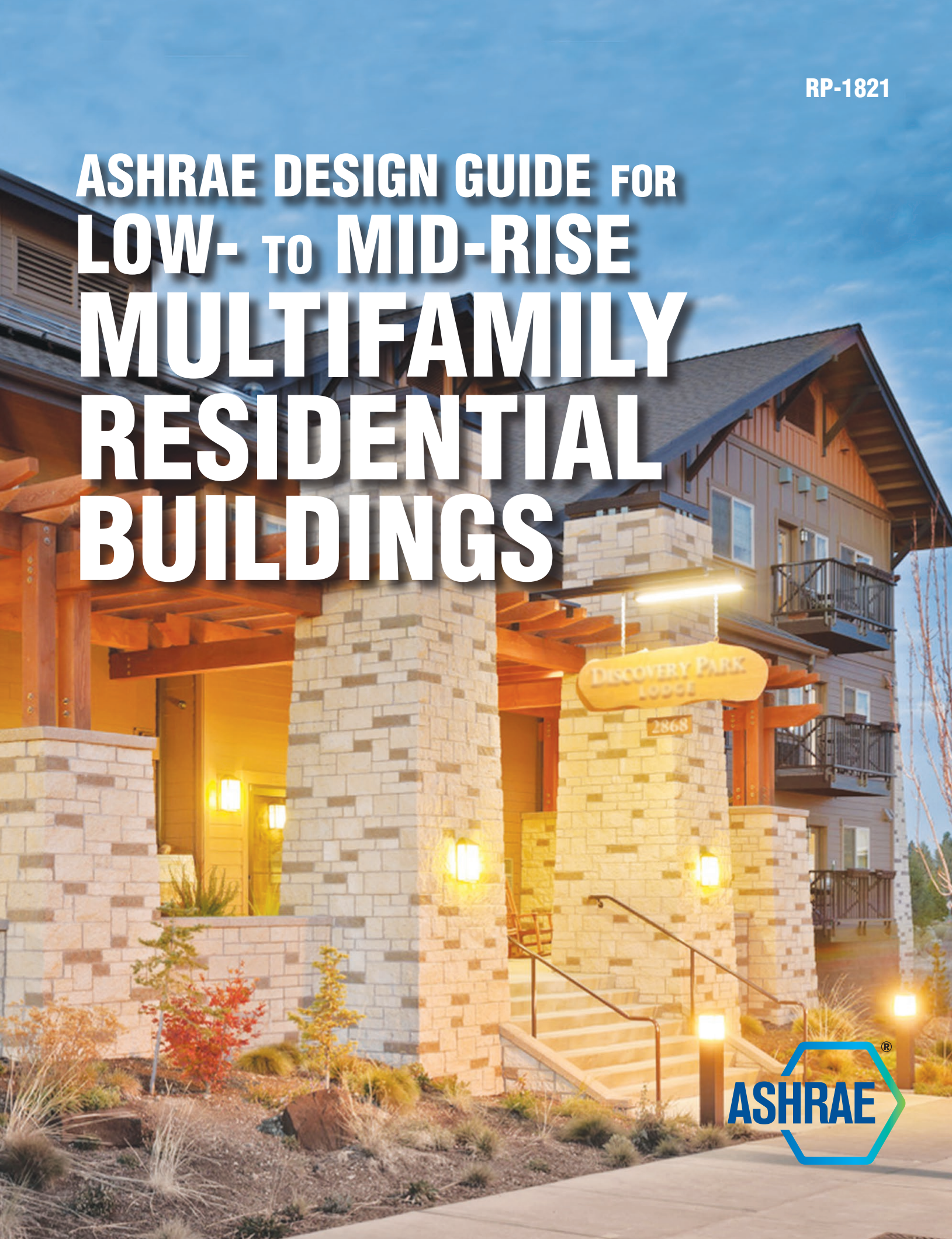
RP-1821

ASHRAE DESIGN GUIDE FOR LOW- TO MID-RISE MULTIFAMILY RESIDENTIAL BUILDINGS



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Foreword

As energy use in residential buildings is greater than in commercial buildings, ASHRAE decided four years ago to increase the Society's activities related to the residential marketplace. At that time ASHRAE had already been producing a standard for indoor air quality and ventilation in residential buildings, ANSI/ASHRAE Standard 62.2, and a standard for energy performance of residential buildings, ANSIASHRAE/IES Standard 90.2, for several years. To extend ASHRAE's presence in the residential market, the Residential Building Committee was formed. This design guide for multifamily buildings is one of the first results of this effort.

Because we spend more than 50% of our time at home, indoor environmental quality is very important for our comfort, health, and well-being. As sleep quality is important for next-day performance, the indoor environment at home may even influence our performance at work. Both bedroom temperature and air quality (ventilation) may impair sleep quality. The trend for more people to work out of their homes further increases the importance of indoor environmental quality in homes. ASHRAE has initiated research in this area, and those research results may be integrated into residential standards in the future. This design guide includes a chapter on indoor environmental quality and a chapter on ventilation, where the main issues for design are described.

Occupant behavior in homes significantly influences both the indoor environment and energy use and can be addressed in design, control, and user feedback in residential buildings. In multifamily buildings, who pays for the energy use can also influence behavior. People living in units where the energy use (heating, cooling, ventilation, and domestic hot water) is metered and paid for by each unit often operate at lower room temperatures in the winter (heating season) and at higher room temperatures in the summer (cooling season) and have less ventilation (window openings) compared to those in buildings without individual metering. These usage trends may lead to decreased indoor environmental quality.

Even in well-designed buildings, occupant behavior can lead to increased energy use and decreased indoor environmental quality. Many people do not know how to properly operate the systems in their homes. Often very little guidance is given on how to avoid increased energy use and decreased indoor environmental quality. In residential buildings, the designer has no influence on people's activities and what type of products (carpets, furniture, cleaning products, etc.) they bring into their apartment, which may increase the emission of pollutants. Occupant activities (cooking, burning candles, painting, using glue, etc.) also influence the indoor air quality. With

today's technology, it is easier to give users feedback on their behavior to enable them to optimize both energy use and the indoor environment. This guide includes a chapter related to operation of the building both for facility managers and for occupants.

People's preferences regarding indoor environment and home use vary widely. For example, some prefer to wear lightweight clothing indoors year round and maintain higher room temperatures during winter. Some buildings/apartments are especially designed for retired people, who may prefer higher room temperatures due to less active lifestyles. Therefore, it is important that the occupants have the ability to individually adjust thermostat settings and preferably even have individual thermostats in each room.

The aim in many places is to go beyond minimum energy standards and design zero energy buildings. This guide has a separate chapter to address zero energy design. In addition, the Advanced Energy Design Guide series (www.ashrae.org/aedg) may also be useful for reducing energy use towards the goal of a zero energy building.

While commercial buildings may look quite similar around the world, there are major differences in residential buildings in both design and building technologies. It is very difficult to cover the breadth of residential buildings worldwide in a single document. This guide therefore primarily focuses on the residential market in the United States; however, parts of the guide apply to multifamily housing worldwide.

Bjarne W. Olesen
2017–2018 ASHRAE President

Preface and Acknowledgments

ASHRAE Design Guide for Low- to Mid-Rise Multifamily Residential Buildings is a long-needed modern resource for the building community. The guide was written under the contract of Research Project 1821 with the New Building Institute (NBI). Along with project partners TRC Companies and Steven Winter Associates, Inc., Primary Investigator Sean Denniston worked extremely hard to compose this concise guide encompassing a broad topic. Denniston and his collaborators brought to this project many years of experience in design, codes, standards, construction, commissioning, research, and facilities management. Their creativity and persistence produced a guide that moves well beyond today's norms and will help lead the building industry into the future.

NBI's efforts were guided by the Project Monitoring Subcommittee (PMS) made up of members of the Residential Building Committee (RBC): Patricia Graef (PMS Chair), Paul Francisco, Paul Haydock, Pankaj Dharkar, Chris Grey, and Richard Karg. Thank you for your extensive knowledge, diligence, and persistence. There was much support from RBC Chair Theresa Weston as well.

A number of ASHRAE staff members played key roles in the success of this guide with their assistance, organizational skills, and dedication to the project. Their efforts are greatly appreciated. Major contributions were made by Lilas Pratt, Manager of Special Projects, whose organizational skills and dedication helped identify needed resources. She arranged our webinars and face-to-face meetings. Her tireless and positive attitude kept us motivated during the process. Michael Vaughn, Senior Manager of Research and Technical Services, was a great asset. He patiently answered countless questions (some questions multiple times) and offered advice that helped streamline the process and thereby kept us out of the weeds. Cindy Michaels, Editor of Special Publications, was responsible for the final publication work on this book. As always, Cindy did a tremendous job.

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We want to extend our personal thanks and appreciation to everyone for the extraordinary effort they poured into this guide. The manuscript could not have been developed without all of their contributions.

I am very proud of the guide that has been developed and amazed at the accomplishment completed in such a short time period. The authors and each of the PMS members should be proud of their individual contributions to this most worthwhile document. We hope you find it useful.

Patricia Graef
PMS Chair
ASHRAE Research Project 1821
March 2019

Introduction

The rapidly growing multifamily building sector represents a major opportunity to advance the goal of improving the energy performance and indoor air quality (IAQ) of the residential building stock. A recent analysis by the American Council for an Energy-Efficient Economy (ACEEE) estimates that the value of the cost-effective energy savings available in the multifamily sector is $3.4 billion per year (ACEEE 2012). Unfortunately, the energy performance of multifamily buildings has been relatively neglected in the broader industry push for high-performance buildings, and many strategies for reducing energy use in this sector remain underrepresented in new construction. Additionally, indoor environmental quality (IEQ), especially IAQ, has become a greater concern in multifamily buildings.

ASHRAE Design Guide for Low- to Mid-Rise Multifamily Residential Buildings provides practitioners with foundational guidance for improving the energy performance, IAQ, sustainability, and overall quality of low-rise and mid-rise multifamily projects. The recommendations in this guide may also be useful to building operators and owners seeking better energy performance and IEQ in their multifamily projects.

The first half of the guide is focused on fundamental concepts while the second half is focused on more in-depth, specific topics:

Chapter 1, Environmental Context and Sustainability, provides the impetus behind, and the larger context for, designing and building sustainable multifamily buildings.

Chapter 2, Culture and Demographics, introduces the varying cultural and demographic factors that might influence building design.

Chapter 3, Building Codes, Standards, and Guidelines, provides an introduction to the codes that regulate multifamily buildings—especially energy and IEQ—and the additional standards and guidelines for multifamily projects available to design teams.

Chapter 4, Building Science, provides a basic understanding of building science issues to provide a foundation for the later chapters of this guide.

Chapter 5, Design Skills, details the different skills that a design team must have to successfully design an energy-efficient and healthy building.

Chapter 6, Integrated Design, summarizes key elements of the integrated design process, including how specific groups of professionals can work together to optimize the complete design.

Chapter 7, Indoor Environmental Quality, introduces key IEQ concepts, including IAQ issues, health, and comfort, and offers best practices for multifamily buildings.

Chapter 8, Energy, introduces a wide range of energy-performance issues and opportunities for multifamily buildings and provides the foundation for subsequent chapters that go more in-depth into the various energy systems in multifamily buildings.

Chapter 9, Envelope, describes the primary issues for delivering envelope systems that are energy efficient and ensure indoor environmental quality, including building configuration, thermal performance, infiltration, and thermal bridging issues.

Chapter 10, Space Conditioning, covers space conditioning and focuses considerable attention on ventilation, including both fundamentals and best practices.

Chapter 11, Ventilation, covers ventilation strategies and systems, including energy efficiency best practices.

Chapter 12, Water Heating, covers the fundamentals of water-heating systems in multifamily buildings, including the implications of different system approaches as well as best practices.

Chapter 13, Lighting Systems, focuses on high-performance lighting, including high-efficacy light sources, and the opportunities for deploying effective controls in multifamily projects.

Chapter 14, Plug Loads, provides guidance on how designers can approach this highly occupant-driven load, focusing on strategies available during the design phase that can reduce plug loads and provide opportunities for better plug-load management.

Chapter 15, Building Handoff and Operations, provides guidance for facilitating and encouraging effective operation and maintenance of multifamily buildings so that performance goals set during the design phase can be met.

Chapter 16, Getting to Zero Energy in Multifamily Buildings, includes background information and definitions for zero energy as well as guidance on how to bring together the information and best practices of the rest of the guide to support the design and operation of a zero energy multifamily building.

Appendix A, Sample Design Process Forms, includes forms that can be used and adapted as part of the design process to implement the guidance and recommendations contained herein. These forms are also available in fillable Adobe® Acrobat® PDF format as well as editable Microsoft® Excel® spreadsheet format online. (If the files or information at the link are not accessible, please contact the publisher.)

Appendix B, High-Performance Equipment Requirements, includes tables that list the requirements for efficient equipment provided in the New Buildings Institute (NBI) multifamily building guide (NBI 2017). These requirements cover a wide selection of equipment types and sizes and are generally aligned with CEE Tier 2 in order to ensure both savings and wide availability.