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# ASHRAE's Residential IAQ Guide: Practical Guidance for Home Builders and Occupants

**Lawrence Schoen, PE**
*Fellow/Life Member ASHRAE*

**Terry Brennan**
*Member ASHRAE*

**Amy Musser, PhD, PE**
*Member ASHRAE*

## ABSTRACT HEADING

*ASHRAE's Residential IAQ Guide, published in 2018, contains practical and actionable strategies directed at multiple audiences, including builders, designers, occupants, whether they rent or own, and managers of multifamily buildings. It does this while also providing a compendium of sound scientific information for professionals who specialize in IAQ, home energy, commissioning, and those who develop programs and standards intended to transform industry practices.*

*ASHRAE's Environmental Health Committee initiated development of the Guide because it saw a particular need to penetrate the builder and designer marketplace. The Guide does this with accessible and cost-effective information and a focus on simple actions with high impact. Building a dwelling with good moisture control, a tight envelope, correctly sealed unoccupied spaces such as crawl spaces, free of significant indoor contaminants, and with the required ventilation, need not cost much more than one without these features. An appendix with ten case studies of real ventilation, heating and cooling systems compares how to install them, their suitability for various climates, use in existing and multifamily dwellings, how they work, and what can go wrong with each system.*

*Once a high IAQ dwelling is occupied, much depends on occupant activities and operation of systems including ventilation and exhaust. Notable features of the Guide include a checklist for homebuyers and potential renters when evaluating a prospective dwelling, instructions to correctly use kitchen and bath exhaust, improving air filtration, a comprehensive section on pest management, and correct use and potential misuse of low-cost sensors.*

*Consistent with the conference theme, the Guide covers the impact of thermal environmental conditions on contaminant release, on occupants and their perception of IEQ, and the interactions among IAQ and other factors.*

## INTRODUCTION AND CONTEXT

ASHRAE's Environmental Health Committee initiated a special project to produce a 253-page Residential Indoor Air Quality Guide in 2018, to complement a similar guide it published in 2009 for non-residential buildings. A prime motivation was to have a positive health impact on people, since so much time is spent in the home. People spend most of their time indoors, and continue to perform more and more activities, such as work and exercise, in their homes.

This trend has been accentuated during the COVID-19 pandemic, with its widespread "stay-at-home" orders and recommendations, making indoor air quality (IAQ) in the home even more important. Furthermore, COVID-19 has been transmitted readily in the home when one family member becomes infected, a phenomenon that could be repeated in future pandemics. A new white paper, published in 2022, uses principles in the 2018 Guide as a starting point to make the home a safer refuge during such community disease outbreaks.

**Lawrence Schoen** is President and Principal Engineer at Schoen Engineering Inc, Columbia, MD. **Terry Brennan** is Principal at Cemroden Associates, Inc., Westmoreland, NY. **Amy Musser** is Principal at Vandemusser Design, PLLC, Asheville, NC.

IAQ is typically addressed through compliance with building codes, which are minimum legally required standards. The codes containing some, but not all the requirements of industry consensus standards, most notably, ANSI/ASHRAE Standard 62.2 (ASHRAE 2019a). Many dwellings do not meet even the code, and even fewer meet Standard 62.2. Furthermore, codes and standards do not cover operation and maintenance practices well or help residents, builders, and designers achieve better-than-acceptable IAQ and do not fully address all the IAQ issues that contribute to human health and comfort in the dwelling.

These gaps are the primary motivations for the development of the guide. This paper summarizes the content of the guide, motivations for it, the audiences, expected outcomes, and some specific examples of the content.

## WHAT IS GOOD IAQ?

The guide is intended to help move beyond current practice to provide good IAQ in dwellings. A dwelling with good IAQ provides air in occupied rooms that contains no known or expected contaminants at concentrations likely to be harmful, does not create conditions likely to be associated with health or comfort complaints, and results in satisfaction of most occupants. Good IAQ requires consideration of both indoor air pollution levels and thermal environmental parameters.

However, the limits of existing knowledge about the health and comfort effects of specific contaminants and contaminant mixtures, addition of unstudied chemicals to manufactured products, and variations in human susceptibility make it impossible to develop a single IAQ metric that can provide a summary measure of IAQ in dwellings. There is no single comprehensive consensus method to measure or evaluate IAQ in any indoor environment. Health data are limited, at best, on dwelling features that enhance health and well-being across large populations, except for environmental tobacco smoke exposure. A day may come when definitive tools exist and dwellings can have automatic protective features similar to those for preventing vehicle collisions and protecting drivers and passengers in modern automobiles.

Given the above uncertainty and lack of metrics, the guide considers that good IAQ results from:

- Diligent compliance with both the letter and intent of building codes and ASHRAE Standard 62.2 (ASHRAE 2016b)
- Technically sound and well-executed efforts to meet or exceed these minimum requirements
- Application of IAQ-sensitive practices in design and construction
- Efforts by the occupants to avoid generating contaminants indoors, and to utilize systems designed to remove these contaminants when they occur.

## MAKING THE CASE FOR GOOD IAQ

Although builders and the general public might recognize the importance of IAQ, they often do not appreciate the impact of routine decisions. In addition, they might assume that achieving good IAQ is very costly and requires novel or even risky technical solutions. In other cases, they might seek a "silver bullet" device, test, or one-time activity to improve their dwelling's IAQ, sometimes at significant cost, with limited success. The manufacturers and sellers of products for cleaning the air might make questionable claims based on little or no evidence, and their products might therefore not achieve the desired result.

IAQ related health effects include increased rates of allergy and asthma from exposure to indoor pollutants (particularly those associated with dampness and biological growth), colds and other infectious diseases from microbes transmitted through the air, and cardiovascular risks related to particulate matter exposure. These effects, when widespread, have the potential to affect large numbers of people and are associated with significant costs in the form of health-care expenses, sick leave, and lost productivity at work and school.

Given the very real benefits of good IAQ and the potentially serious consequences of poor IAQ, residents, builders, designers, contractors, and building managers can all benefit from an increased focus on achieving good IAQ in design, construction, maintenance, and operation of dwellings. The guide presents practical information on how to achieve good IAQ without excessive expenses using readily available best practices to maximize IAQ while addressing budget constraints and other functional requirements, and without use of untested technologies.

## CONTENT OF THE GUIDE

The guide addresses the IAQ problems that have been occurring and the opportunities to improve IAQ in dwellings covered by ASHRAE Standard 62.2 (ASHRAE 2019). It is organized into eight sections that address each of eight objectives:

Objective 1 – Acquire, Design, Construct, and Operate a Dwelling to Achieve Good IAQ
Objective 2 – Manage Moisture
Objective 3 – Limit Contaminant Entry into the Living Space
Objective 4 – Control Moisture and Contaminants Related to Mechanical Systems
Objective 5 – Limit Contaminants from Indoor Sources
Objective 6 – Keep Contaminants in Their Place
Objective 7 – Reduce Contaminant Concentrations Through Ventilation, Filtration, and Air Cleaning Objective 8 – Minimize Energy Use, Maximize Comfort, and Address Interactions of Factors that Affect IAQ

*Objectives and strategies*. Each section offers details on several strategies to help achieve each objective. The overview section at the beginning of each objective explains why the objective is important for good IAQ. Each overview is followed by descriptions of the strategies that can be used to achieve that objective and often provides a visual depiction of the strategies.

For example, Objective 2 - Manage Moisture has 4 strategies: 2.1 – Avoid Water Penetration and Moisture Problems in the Enclosure, 2.2 – Control Indoor Humidity, 2.3 – Select Suitable Materials, Equipment and Assemblies for Unavoidably Wet Areas, and 2.4 – Manage Effects of Landscaping and Indoor Plants.

Case studies describing ten different ventilation system and filtration options are included in an Appendix. They provide insights into system selection and integration, advantages and disadvantages of each and guidance for practical implementation.

## COMMON CAUSES OF POOR IAQ

Sometimes, even if intentions to achieve a high-quality dwelling with good IAQ are high, things can go wrong. The guide discusses problems that can be avoided by addressing their root causes. The guide discusses these in more detail in the individual strategies.

**Lack of Quality Control in Construction** is covered in Strategies 1.3 - Schedule and Manage Construction and Renovations to Facilitate Good IAQ and 1.4 - Observe, Verify and Test Dwelling Construction. Although a good design is critical to good IAQ, neglecting to install and test the HVAC system and building enclosure so that they operate as designed often compromises IAQ. Therefore, a key factor in achieving good IAQ is a serious commitment to the comprehensive commissioning of HVAC systems and in some cases, building enclosures, that are critical to good IAQ. This commitment must start in the design phase and continue well into occupancy.

**Moisture in the Enclosure** is covered in Strategy 2.1 – Avoid Water Penetration and Moisture Problems in the Enclosure. Many notable cases of IAQ problems have been associated with excessive levels of moisture. These problems can be very difficult to fix without major renovation efforts and costs. Moisture problems arise for a variety of reasons, including leaks where a roof meets a wall and in roofs and windows, designs that respond inappropriately to ambient moisture (e.g., low-permeability wall coverings in hot and humid climates), and poor air pressure control. These problems are largely avoidable but require an understanding of building moisture movement and attention to detail in enclosure design and construction and in mechanical ventilation system selection, installation, and operation.

**Poor Outdoor Air Quality** is covered in Strategies 3.1 – Determine Regional and Local Outdoor Air Quality and 3.2 – Locate Outdoor Air Intakes to Minimizer Introduction of Contaminants. The traditional way to promote IAQ is through outdoor air ventilation, which can dilute indoor contaminants but is only effective when the outdoor air is cleaner than the indoor air. In many locations and for many contaminants, this is not the case, and insufficiently treated ventilation air can make IAQ worse. Outdoor air quality is poor when outdoor contaminant levels and local contaminant sources (e.g., motor vehicle exhaust from nearby roads and contaminants generated by activities in adjacent buildings) are high. Whether to increase outdoor air ventilation rates above minimum requirements should consider the potential effects of outdoor air quality.

Even ASHRAE Standard 62.2 (ASHRAE 2019a) does not require an assessment of outdoor air quality in a dwelling's vicinity. Given the key role of outdoor air ventilation in IAQ control, the guide covers outdoor air quality and air-cleaning

alternatives.

**Moisture and Dirt in Ventilation Systems** is covered in Strategy 4.1. Dirt accumulation in ventilation systems combined with poor water management can lead to biological growth in the airstream and serious IAQ problems. These conditions generally result from inadequate particle filtration, poor filter maintenance, pooling of cooling coil condensate, or other moisture sources. ASHRAE Standard 62.2 (ASHRAE 2019a) has some requirements related to dirt and moisture management in ventilation systems. The guide addresses the topic in Strategy 4.1.

**Indoor Contaminant Sources** are covered in all the Strategies in Objective 5, which cover material selection, limiting the impact of material emissions, cleaning and maintenance avoiding bringing certain contaminants into the dwelling.

Normal building materials and furnishings release many contaminants, especially when these materials are new, as do materials and substances brought into the dwelling once it is occupied. Unusual, unexpected, or atypically high contaminant emissions from indoor sources are associated with many IAQ problems. The guide addresses material selection, cleaning, and other indoor sources.

IAQ problems can also result from improper equipment operation, inadequate exhaust ventilation, and use of inappropriate materials for activities in the dwelling. The guide contains information on how to decrease the likelihood of such problems.

**Inadequate Ventilation Rate** is covered in Strategy 7.1 – Implement Appropriate Outdoor Air Ventilation Strategies and Quantities. Although building codes and standards have addressed outdoor air ventilation for decades, many dwellings are poorly ventilated, which increases the likelihood of poor IAQ. The many potential causes of inadequate ventilation include lack of compliance with applicable codes and standards, installation or maintenance problems that prevent delivery of the target ventilation rate, or incorrect use of the installed systems by occupants. Also, even when system-level outdoor air intake rates are adequate, poor air distribution can under-ventilate some portions of the dwelling. ASHRAE Standard 62.2 (ASHRAE 2019a) covers the determination of target ventilation rates, and this guide offers additional advice to help address these issues. The case studies Appendix, in particular, illustrates the relevant techniques using ten sample systems.

**Ineffective Filtration and Air Cleaning** is covered in Strategy 7.2 – Provide Particle Filtration and Air Cleaning. Filtration and air cleaning are effective ways to control many indoor air pollutants, particularly those associated with poor outdoor air quality. Air filtration or air cleaning, therefore, is an important adjunct to outdoor air ventilation. This guide provides information on filtration and air-cleaning that, when properly implemented and maintained, can both improve IAQ and reduce energy use.

## AUDIENCE

The guide was written for the following audiences:

- Homeowners and renters who might choose a dwelling and/or its custom features or work with designers to build a dwelling from scratch and who can choose materials, products, and activities that improve or at least do not reduce IAQ
- Architects, home designers, and builders who can apply the recommended practices during design, construction, and renovation
- Developers of multifamily building (e.g., duplex, rowhouse, or low- or high-rise apartment or condominium) projects and other decision makers who direct the work of the above professionals
- Home energy raters and commissioning authorities who determine whether design elements, construction observation, functional testing, and the finished dwelling meet IAQ-related goals and requirements
- Organizations with sustainable building rating programs and/or that conduct training for these programs
- Multifamily building managers and operators who need to understand the IAQ implications of existing heating, ventilation, and cooling (HVAC) systems (the components in a dwelling that that heat, cool, ventilate, and/or dehumidify it) and operations and maintenance practices

### Developers, Designers, Builders, Owners, and Operators

IAQ is one of many issues that building developers, designers, and builders (the "development team") must address to meet their needs and those of the dwelling occupants. When IAQ is good, it is nearly invisible; when IAQ is poor, it can have

a negative effect on the health and well-being of children and adults. This is clearly important to the family in the dwelling, but the guide argues that it is also important to businesses who provide that housing because:

- Better IAQ leads to more satisfied residents, better referrals, and fewer complaints. The general public often has incomplete knowledge about IAQ. Buyers and renters depend on professionals to deliver high-quality dwelling units and sound advice.
- IAQ problems that get out of hand can be quite costly by distracting developers, designers, and builders from other business goals, requiring expensive building or mechanical system repairs, incurring legal costs, and resulting in bad publicity. IAQ problems and their consequences can be dramatic. Even less severe problems can affect occupancy and/or rent levels.
- Many of the measures that are used to achieve good IAQ also contribute to durability of the building.
- The development team can play an important role in educating occupants.

With good IAQ, builders retain an unblemished reputation and rental housing occupancy rates remain strong. Poor IAQ, or even questions raised about IAQ in a new dwelling or multifamily housing can require the developers, designers, and managers to devote considerable resources to addressing resident complaints, making major repairs, engaging in expensive legal actions, and, in extreme cases, relocating residents. The costs of poor IAQ can include legal fees and damages.

Despite these effects, many dwelling design and construction decisions are made without an understanding of the potentially serious consequences of poor IAQ or consideration of the well-established body of knowledge on how to avoid IAQ problems and achieve good IAQ. Although controlling indoor contaminants, providing adequate ventilation and achieving thermal comfort has been part of the construction and use of dwellings for centuries, awareness of and concerns about IAQ have increased in recent decades, as severe IAQ problems have received media coverage. But in most cases, IAQ is still not a high priority for dwelling design or management compared with function, cost, living space, aesthetics, location, and accessibility.

The most important message for the development team is to incorporate IAQ at the start of the development and design processes, which is not typical of most dwelling building and renovation projects. Incorporating IAQ at the very beginning of the conceptual design process—on par with function, aesthetics, and energy use—enables the design team to consider high-performance design concepts that can support good IAQ, energy efficiency, and other important design goals and make informed decisions that will affect the project throughout the construction and occupancy phases. The two primary reasons to include IAQ considerations in the earliest stages of project planning are to avoid problems when IAQ is treated as an afterthought and to allow consideration of alternative design concepts that require decisions early in the design process.

By the time a dwelling's basic layout (schematic design) is complete, many opportunities to achieve good IAQ have been foreclosed, which can easily result in unintended consequences or expensive and inadequate "force fitting" of solutions. The issues owners and residents need to consider and decisions they must make include their expectations for IAQ, outdoor contaminant sources in or near the dwelling, activities expected to occur in the dwelling, such as work-at-home and contaminants that might be associated with them, and resident characteristics (e.g., age range; health status; and how they heat, cool, and ventilate the dwelling). If these considerations are not addressed until after the building layout has been determined and the ventilation system is designed, it will be difficult to meet the needs of the dwelling and its occupants.

Examples of decisions made in the early phases of design that can promote good IAQ include:

- Mechanical systems that provide outdoor air ventilation independently of heating and cooling
- High-efficiency air cleaning strategies
- Selection of low-emitting materials based on sound technical consideration of options
- Opportunities for natural ventilation

Decisions made in the early phases that can lead to poor IAQ include the following:

- Site selection, building orientation, and surface grading that can lead to moisture problems
- Poor location of outdoor air intakes (locations where air is pulled into a fan or duct system) that introduces unwanted contaminants into the building

- Inadequate space for mechanical equipment, limiting the types of systems that can be selected, making it more difficult to filter and distribute air
- Limited access for inspection and maintenance, which can result in IAQ problems going undiscovered and unaddressed
- Use of materials that can lead to high levels of volatile organic compound emissions

Making a commitment to good IAQ at the beginning of a project and maintaining that focus throughout the design and construction will result in a dwelling that more successfully achieves its design goals and the desired level of performance throughout its lifespan.

### Homeowners, Renters and Other Occupants

Opportunities for the occupant, the "end user," to achieve better indoor air quality at all the stages of occupancy occur in the following situations:

- When choosing features of the dwelling design or construction
- When choosing a dwelling to acquire or rent
- When renovating, retrofitting, or painting a dwelling
- When purchasing appliances, equipment, and furnishings
- When choosing activities to perform inside the dwelling
- When purchasing and using cleaning, pest control, maintenance, and personal care products
- During daily activities, such as bathing and cooking

Homes built to current codes and standards or that are retrofitted for energy purposes are much tighter (have lower air and energy leakage) than in the past. Yet they require outdoor air to dilute contaminants produced by people and their activities as well as by the building and its fixtures and furnishings. Because these new homes cannot depend on natural leakage, they have mechanical ventilation systems for this purpose. These systems need to be operated as designed, and operation of local exhaust (kitchen and bath) fans is particularly important in tight homes.

It is essential to avoid smoking indoors, limit the burning of candles and incense, and use the kitchen range hood. Windows need to be closed when outdoor air quality is poor, and consideration should be given to opening them when outdoor air quality and temperature are good.

Probably the most important message for the home occupant is to incorporate thinking about IAQ into all the other activities that make the home comfortable. There is no "silver bullet" device, test, or one-time activity to improve a dwelling's IAQ, despite claims of manufacturers and sellers of products and services. However, a variety of small actions will improve IAQ at a low or even no added cost.

## LOW-INCOME HOUSING

Development and ownership teams need to be aware of special IAQ concerns related to low-income housing and to take steps to reduce the risks associated with them. Socioeconomic disparities related to indoor exposure to particulate matter are large (Adamkeiwicz et al. 2010). Many building and occupancy characteristics associated with greater particulate matter exposure are more pronounced in lower-income housing. These features include greater building age, peeling paint, heavy street traffic nearby, factories and industrial buildings nearby, uncomfortable temperatures, small floor area, high occupant density, and visible cracks in the building enclosure (roofs, ceilings, above-grade and below-grade walls, windows, and floors that separate the indoors from outdoors).

Indoor smoking adds significantly to indoor particulate matter in units in which smoking occurs and in adjacent multifamily units, including those occupied by nonsmokers. The risk of poor IAQ can disproportionately affect housing and multifamily dwellings occupied by elderly and low-income populations. A best practice is therefore to ban or at least discourage smoking in multifamily dwellings (HUD 2018).

Furthermore, residents of these buildings often have limited choice in where they live and less empowerment to demand repairs, and they might be affected by the decisions of other people who live in the same unit. In addition, occupants with

limited financial resources or access to transportation need to be able to buy replacement filters locally and inexpensively because ordering products online might be expensive and difficult to accomplish without a credit card (Singer 2016). If management does not change filters, it should make it easy for residents to obtain them.

The housing and shelters for homeless people are often substandard in many ways, including IAQ, and affects public health, shortens lifespans, reduces productivity, and increases health care costs, even in developed nations like the United States. While many of the strategies in the guide can be applied to the challenges in these facilities, the guide does not specifically cover them.

## USE OF THE GUIDE FOR DISEASE OUTBREAKS

Many of the recommendations of the guide can make dwellings more resilient in extraordinary incidents, either natural (e.g., earthquakes, fires, and floods) or intentional (e.g., terrorist attacks). This is not the primary focus of this guide and it certainly does not guarantee safety or good IAQ in these circumstances. Information planning for such events in building designs is available from several sources, including the Federal Emergency Management Agency and the National Fire Protection Association.

While disease outbreaks were not in the original scope of the Guide, much of the information it contains can be used by developers, designers, builders and occupants to prepare for future outbreaks. To enhance the use of the Guide for such outbreaks, the US Department of Energy commissioned a white paper overseen by ASHRAE's Epidemic Task Force, that is due to be published in 2021.

Disease transmission in individual dwellings is a significant route of community spread. The white paper will address methods to limit this. Transmission is also highly possible in shared and congregate spaces in multifamily residential buildings that are outside the dwelling unit, such as mailrooms, lobbies, corridors, exercise rooms, natatoriums, offices, or storage and equipment rooms. The white paper describes the following techniques to reduce such transmission both in the dwelling and congregate spaces. More guidance on ventilation and IAQ in non-residential space types, including such congregate spaces, is found in the *Indoor Air Quality Guide* (ASHRAE 2009) and ASHRAE 62.1 (ASHRAE 2019b).

## CONCLUSION

Good IAQ in dwellings requires forethought and action by developers, designers, builders and occupants of homes. ASHRAE's Residential IAQ guide provides practical solutions to fill gaps between how dwellings are actually built and used, and what will avoid IAQ problems and enhance health of occupants. The guide makes a stong case for the actions described within, in part by demonstrating that they are not difficult or costly. At the same time, it debunks myths about metrics or "silver bullets" to achieve resicential IAQ. A white paper supplement ties strategies in the Guide to actions that can be taken in preparation for disease outbreaks.

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