

# Filling the Gaps:

*Practitioner Insights and Advanced Tactics for Indoor Air Quality Action*





## **Contributors**

This whitepaper was developed primarily by design professionals in the Sustainability Leaders Peer Networks convened and facilitated by Green Commons, LLC. The following individuals took a leading role in drafting and reviewing this whitepaper (in alphabetical order):

Kena David – Consigli Construction  
Sarah Gudeman – BranchPattern  
Luke Leung – SOM  
John Mlade – Wight & Company  
Ashley Mulhall – Grace Design Studios  
Jim Newman – Linnean Solutions  
Kim Shinn – TLC Engineering

## **About Green Commons**

Green Commons, LLC, is a consultancy and convenor of AEC professionals for peer support, peer-to-peer learning, and collective action. Green Commons' Peer Networks offer shared space where leaders support one another and work together toward sustainable solutions as a community – intent on moving projects, the industry, and the world forward in the best possible way. We recognize the need and value in transcending competition as we work together, professionally and collectively, to advance our common cause, with a shared commitment to collaboration and improvement.

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# Executive Summary

The importance of indoor air quality (IAQ) has emerged as a central consideration in building design, construction, and operations. Once treated as a single factor among many competing priorities in sustainable design, IAQ gained heightened visibility following the COVID-19 pandemic beginning in 2021 and has remained a critical concern amid increasingly frequent and severe wildfire events. Together, these forces accelerated research, expanded industry guidance, and elevated expectations for how buildings protect occupant health and wellbeing.

In response, industry organizations, research institutions, and standards bodies have produced a growing volume of white papers, frameworks, and technical resources. While this body of work has advanced understanding and awareness, it has also created a complex and sometimes fragmented landscape that can be challenging for even experienced practitioners to navigate.

Building on two prior publications developed through Green Common's *Peer Networks* series—including *“Considerations for Continuous Air Quality Monitoring: Simple Tips for*

*Getting It Right, According to IAQ Consultants”* and *“So, You Have Some IAQ Monitors. Now What?”*—this paper focuses on practical, additive strategies for improving IAQ performance in commercial buildings. It is intended to complement, not replicate, existing high-level frameworks by translating established principles into field-tested guidance that reflects the realities of existing buildings and complex operating conditions, directed at an audience focused on building owners, facility managers, tenants, and others seeking clear, actionable direction to support healthier indoor environments.

The established hierarchy for improving indoor air quality remains clear: **source control**, followed by **ventilation and dilution, filtration, and air cleaning as needed**. What is new—and urgently needed—is greater clarity on how to apply these strategies in retrofit contexts, as this work is still emerging. This paper also highlights common pitfalls observed in practice and proven solutions drawn from real-world implementation.

For a comprehensive review of the market context, business case, and strategic pathways for IAQ monitoring, readers are directed to *Driving Action on Indoor Air Monitoring in Commercial Buildings* (USGBC/CBE, 2025). That report provides an essential foundation

for understanding why IAQ monitoring matters and how organizations can deploy it at scale. This paper builds on that foundation by offering targeted technical clarifications and practitioner insights not addressed in that work, with a particular emphasis on improving delivered IAQ performance.

While outdoor air quality is widely monitored and regulated, indoor air quality in most buildings remains largely invisible—often addressed only after complaints or adverse events trigger reactive investigation. As monitoring tools become more affordable and accessible, and as expectations for healthy buildings continue to rise,

stakeholders across the building industry—including policymakers, investors, owners, facility managers, researchers, and product manufacturers—are increasingly asking the same question: has the time come to proactively monitor and optimize clean air delivery across commercial building portfolios?

This paper argues that the answer is yes—and that doing so requires moving beyond awareness toward practical, implementable action grounded in current standards, emerging policy trends, and lessons learned from the field.

# Introduction

We spend most of our time indoors, so good indoor air quality is vital for our health. When air quality problems arise, action is necessary. It can be hard to know where to start, especially since increasing ventilation can impact energy use.

This report outlines the best ways to improve indoor air quality, listed in order of preference:

1. **Source control:** Eliminate the source of pollutants.
2. **Ventilation or dilution:** Introduce fresh outdoor air.
3. **Filtration:** Remove particles and allergens from the air.
4. **Air cleaning:** Use advanced technologies for gaseous contaminants, biological inactivation, or other contaminants requiring advanced air cleaning methods.

## 1. Source Control

Source control is the foundation of indoor air quality management, focusing on minimizing or eliminating pollutant sources before they enter the occupied space. This approach encompasses both the selection of materials and the design, construction, and operation of the building enclosure and systems.

For a comprehensive review of the rationale, market context, and strategic pathways for IAQ monitoring, see recently released 'Driving Action on Indoor Air Monitoring in Commercial Buildings' (USGBC/CBE, 2025). This paper focuses on additive guidance, technical clarifications, and practitioner insights not covered in that report.

We direct readers to *USGBC/CBE (2025)* for the comprehensive business case and deployment pathway. This paper provides concise, additive recommendations to improve delivered IAQ performance—especially in existing buildings and complex operating contexts.

This strategy focuses on minimizing or eliminating indoor pollutant sources. It involves selecting low-emitting or formaldehyde-free building materials and furniture, as well as addressing indoor activities that may generate pollutants such as cleaning and cooking. Also, evaluate whether

potential contaminants enter through outdoor air intakes. Vehicle exhaust and wildfires are two common exterior sources of contaminants. Comparing indoor air quality data to outdoor air quality data may reveal if contaminants are entering through air intakes.

Moisture control is crucial for preventing mold and microbial growth, which can contribute to poor indoor air quality. Strategies include fixing leaks promptly, improving drainage systems, using moisture barriers, and ensuring proper ventilation in areas prone to moisture.

Retrofitting existing buildings with source control measures can be challenging, as it often requires replacing or modifying existing mechanical system configurations. Older materials or products generally do not offgas as much as new do, and may not be worth replacing as a source control measure. Having said that, new construction offers greater flexibility to incorporate low-emitting materials from the start, resulting in better IAQ with potentially lower energy impact.

**No/Low-Emitting Materials:** Choosing no/low-emitting building materials effectively minimizes indoor air pollution from volatile organic compounds (VOCs). Many traditional construction materials and finishes, such as paints, adhesives, composite wood products, and furnishings, can release VOCs and other pollutants into the air. Choose formaldehyde-free and low-emitting and/or low-VOC

alternatives that comply with recognized industry standards such as California Air Resource Board (CARB) 2007, South Coast Air Quality Management District (SCAQMD) Rule 1113, and SCAQMD Rule 1168, to significantly reduce harmful substance release. Look for products that have passed the California Department of Public Health (CDPH) Standard Method for emissions testing, Standard Method v1.2-2017. Alternatively, inherently nonemitting, salvaged, or reused materials can be considered.

**Retrofitting Considerations:**

Implementing source control in existing buildings can be challenging, often requiring modifications to mechanical systems or enclosures. Older materials may offgas less than new products and may not warrant replacement unless they are known sources of hazardous emissions. Retrofitting also raises concerns about disturbing encapsulated contaminants such as lead dust, asbestos, or PCBs which must be mitigated following local regulatory guidance. Renovations themselves also pose additional indoor air quality considerations, including potentially high levels of particulate matter that should be managed through source control/direct capture, pathway interruption, and filtration, especially if the building will be occupied during construction/renovation.

**Green Cleaning:** Green cleaning is another important aspect of source control that can prevent impacts to indoor air quality. Green cleaning

involves using environmentally friendly cleaning products and practices that minimize harmful chemicals (direct emissions) and reduce their impact on human health and the environment, as well as reduce risk and potential for chemical reactions that generate secondary pollutants.

#### **Integrated Pest Management:**

Implementing integrated pest management (IPM) practices can help minimize pesticide use both inside and outside the building, which can introduce harmful chemicals into indoor spaces. Strategies include sealing entry points, maintaining cleanliness, and using non-chemical pest control methods.

#### **Occupant Behavior and Indoor**

**Activities:** Educating building occupants about IAQ, promoting healthy behaviors, and encouraging responsible actions can significantly impact air quality. This includes practices such as not smoking indoors or near building openings, proper waste disposal, and avoiding harsh chemicals or strong fragrances. Additional indoor activities can also have significant impacts on IAQ (common examples include high-volume printing, 3D printing, cooking, or the use of markers or art supplies). These activities should have special attention paid during new building design, but can also be mitigated during ongoing operations as usage changes over time. Finally, it is important to consider duration of exposure when managing occupant

behavior and activities. Periodic or episodic indoor air contaminants or activities might occur, and will typically be cleared through existing ventilation and air quality strategies, but ongoing contamination or sustained activities necessitate specific, targeted mitigation or corrective actions.

#### **Building Envelope / Reducing**

**Infiltration and Moisture Control:** A well-designed and well-maintained building envelope is critical for source control. Sealing gaps, cracks, and penetrations in the enclosure reduces uncontrolled outdoor air infiltration, which can carry in pollutants such as vehicle exhaust, wildfire smoke, pollen, and humidity. Thermal bridging can result in interior condensation on surfaces. Improved insulation and air barriers also enhance energy efficiency and thermal comfort. Effective moisture control in the enclosure is essential to prevent mold and microbial growth, which are significant contributors to poor IAQ. Strategies include:

- Installing continuous air and vapor barriers.
- Providing adequate drainage planes and flashing to direct water away from the structure.
- Using moisture-tolerant materials in high-risk areas.
- Promptly repairing leaks and monitoring for condensation or water intrusion.
- Ensuring proper ventilation in areas prone to moisture (e.g., bathrooms, kitchens, basements).

- Continuous insulation and analysis to address thermal bridging.

By reducing infiltration and controlling moisture, the enclosure acts as the first line of defense against both outdoor and indoor-generated contaminants.

## 2. Ventilation / Dilution

After minimizing indoor air pollutants through source control, the next step is dilution, achieved by introducing outdoor air into indoor spaces. When fresh air is brought in, it helps flush out and exhaust indoor-generated contaminants outdoors to maintain air balance, thereby enhancing IAQ. When fresh outdoor air is introduced, an equivalent volume of indoor air - containing accumulated contaminants - is exhausted or displaced from the building. This exchange is fundamental to maintaining healthy IAQ in most commercial buildings, as it prevents the buildup of pollutants indoors.

Ventilation strategies can have a moderate to high energy impact, depending on the system type, climate zone, and energy efficiency measures in place. In new construction projects, systems can be designed for optimal outdoor air delivery, energy recovery, and distribution. In existing buildings, retrofitting or upgrading ventilation systems can be challenging. It may require modifying or adding ductwork, increasing fan capacity, upgrading controls, or integrating new equipment (like ERV/HRVs). Physical constraints, limited space, and the need to maintain

operations during construction can add complexity and cost.

### **Outdoor Air Quality Considerations:**

Before implementing the dilution strategy, it is crucial to evaluate the outdoor air quality of the building's location. The U.S. Environmental Protection Agency (EPA) establishes the National Ambient Air Quality Standards (NAAQS) for significant air pollutants, subject to periodic revisions. It is vital to determine if your project falls within a nonattainment zone, where the air quality fails to meet the NAAQS criteria. The EPA offers mapping data for locating such zones. If your project is in a nonattainment area or a region with high outdoor air pollution, consider this before relying predominantly on unfiltered outdoor air as an IAQ solution.

ASHRAE Standard 62.1 Observational Survey: An observational survey of the building site and its surroundings, as required by ASHRAE Standard 62.1, aims to identify local pollutants from adjacent facilities that might affect the building's IAQ. This survey, carried out during usual occupancy hours, provides valuable information about the suitability of outdoor air quality and

helps plan ventilation strategies. The survey typically covers:

- Compliance status of regional air quality
- Information from local surveys
- Dates and times of observations
- Descriptions of the site and facilities on adjacent properties
- Observations of odors, irritants, visible plumes, or air contaminants
- Descriptions of vehicle exhaust sources on-site and on neighboring properties
- Identification of potential pollutant sources, including those operating seasonally
- Conclusion on outdoor air quality suitability, supported by relevant information

An in-depth observational survey provides building owners and designers with valuable insights into potential outdoor air quality challenges that may impact IAQ and ventilation strategies.

### 3. Filtration

In response to the pandemic, ASHRAE Standard 241-2023 was developed to establish equivalent clean airflow rates. The metric's premise is to control the spread of infectious aerosols in buildings by ensuring occupied spaces have enough non-infectious air to reduce infection risk. Such calculations and considerations can help building

The combination of source control, filtration, and dilution through ventilation forms the basis of effective IAQ management in commercial buildings. Although the dilution strategy is crucial, it should be approached with caution, especially in areas with high outdoor air pollution.

Ensure outside air, adjusted for environmental conditions, is introduced at sufficient rates to dilute bioeffluents, VOCs, and other pollutants, thereby maintaining acceptable indoor air quality and occupant comfort.

Understanding the outdoor air quality and conducting site surveys are key to making informed decisions on the quantity and treatment of outdoor air to ensure a healthy and comfortable indoor environment. Review your site's classification in the [EPA Green Book](#), which provides detailed information about National Ambient Air Quality Standards (NAAQS) designations, classifications, and nonattainment status.

operators plan for future instances of infectious aerosols to maintain safe indoor environments.

The concept of "equivalent clean airflow rate" offers an alternative approach to maintaining indoor air quality without relying exclusively on outdoor air for dilution. In traditional

systems, outdoor air ventilation dilutes indoor contaminants, but this can be energy-intensive, as outdoor air often requires conditioning—cooling, heating, humidifying, or dehumidifying—before entering the indoor environment. By implementing advanced filtration to clean recirculated indoor air, facilities can reduce dependence on outdoor air, achieving effective contaminant control while also reducing the energy load associated with conditioning outdoor air.

Depending on your existing mechanical system type and capacity, you might not be able to bring in outdoor air, condition it effectively, or increase the amount of outdoor air you bring into the building. Additionally, there are cases where outdoor air may introduce more contaminants to the indoor environment. In these cases, filtration may be your primary strategy.

Retrofitting existing buildings with upgraded filtration systems typically involves replacing existing filters and potentially modifying HVAC systems to accommodate changes. Equipment sizing, fan power, and space considerations should be evaluated to understand retrofit opportunities.

Provide greater filtration in both the return and outdoor air supply. Filtration involves capturing and removing particulate matter and allergens from the indoor air using air filters. Higher efficiency filters (such as HEPA filters) can provide better IAQ, but they may also increase energy consumption due

to higher airflow resistance. A MERV 13 filter is often considered a good compromise between cost and good filtration. Coupling it with a MERV 8 prefilter can extend its life and make the MERV 13 more effective.

Filtration may also be best for systems with less control, such as single-zone systems in spaces that do not exchange air, like hotels/multifamily buildings. It is typically measured in supply air. Static pressure from higher filtration could cause an issue in existing systems.

In commercial buildings, ensuring good indoor air quality (IAQ) can be challenging due to various factors, including mechanical system limitations and the potential introduction of outdoor contaminants. In cases where bringing in outdoor air or increasing ventilation rates is not feasible or may introduce more pollutants, filtration becomes a primary strategy for improving IAQ.

Here are some key points to consider regarding filtration in commercial buildings:

- **Mechanical System Limitations:** Depending on the existing mechanical system type and capacity, there may be constraints on the ability to effectively bring in outdoor air or condition it adequately. This can occur in systems with limited outdoor air intake or where the

capacity to condition and distribute outdoor air is limited. In such situations, increasing ventilation rates may not be viable, and alternative strategies like filtration become crucial.

- **Contaminant Introductions:** In certain scenarios, outdoor air quality may be compromised and introduce more contaminants to the indoor environment than are persisting indoors. This can be due to factors such as high levels of outdoor pollution, nearby construction activities, or industrial emissions. In such cases, relying on outdoor air as the primary means of improving IAQ may not be effective. Filtration becomes a key strategy to remove particulate matter and pollutants from the outdoor air before it enters the building.
- **Filtration as the Primary Strategy:** When ventilation options are limited, filtration takes on increased importance. It involves using air filters with higher efficiency to capture and remove particulate matter, allergens, and other pollutants from the supply air. Higher-efficiency filters, such

as HEPA (High-Efficiency Particulate Air) filters, can effectively remove a wide range of contaminants from the air.

- **Consideration for Existing Systems:** In commercial buildings with existing mechanical systems, retrofitting higher-efficiency filtration can present challenges. Single zone systems, particularly in spaces like hotels or multifamily buildings, may have limited air exchange and require special considerations. The static pressure associated with higher-efficiency filtration can strain existing systems, potentially affecting their performance. It's important to assess the compatibility of filtration upgrades with the existing system's design, capacity, and static pressure capabilities.
- **Maintenance and Monitoring:** Filtration effectiveness depends on regular maintenance and filter replacement. Establishing a maintenance schedule and monitoring filter conditions is crucial to ensure optimum performance. Filters should be replaced at appropriate

intervals to prevent airflow restrictions and maintain their

efficiency in removing pollutants.

## 4. Air Cleaning

As an after-effect of the 2020 Covid pandemic, there continues to be an increasing variety of high-tech air cleaning options for integration into HVAC systems or as stand-alone devices. While IAQ advocates are generally encouraged to consider simpler approaches first, like improving ventilation or upgrading basic filters, certain conditions can make air cleaning solutions worth considering—such as when increasing outdoor air supply would introduce more pollutants. This can occur during high-smog days in urban centers like New Delhi and Beijing, or during wildfire seasons in regions like California and Canada, where outdoor air may be heavily contaminated.

Types of Advanced Air Cleaning Technologies addressed by ASHRAE:

1. Ultraviolet germicidal irradiation (UVGI) using UV-C light is designed to deactivate pathogens like bacteria and viruses in HVAC systems or standalone units. This technology uses a specific UV wavelength to disrupt the DNA of microorganisms, preventing them from replicating. UVGI is generally

more effective for microbial control rather than removing particulate or gaseous pollutants. It requires careful calibration and maintenance to ensure safety and efficacy, as prolonged exposure can damage human skin and eyes.

2. Electrostatic Precipitators (ESPs) use an electric charge to attract and capture airborne particles, which are then collected on plates within the device. This method is effective for particle filtration but can produce small amounts of ozone, a respiratory irritant, depending on the model and maintenance level. While newer ESPs are often designed to minimize ozone generation, ensuring compliance with safety standards (like UL2998 for zero-ozone certification) is recommended to avoid potential health risks.
3. Photocatalytic Oxidation (PCO) involves a chemical

reaction between a light source and a catalyst, usually titanium dioxide, to break down organic pollutants. This process can neutralize VOCs and some pathogens, but it may produce secondary pollutants as byproducts. Studies have shown that while PCO has potential in lab settings, its real-world application is still controversial due to concerns about the possible generation of reactive byproducts, which may reduce its efficacy and safety.

4. **Activated Carbon and Chemical Filtration:** These filters are designed to absorb and neutralize gaseous pollutants, like VOCs, by using materials that chemically bond with these contaminants. Activated carbon filters are particularly useful in environments with high levels of odors or chemicals, though they are often more effective in tandem with particulate filters.
5. **Reductive Technology Filtration:** Also known as advanced oxidation processes, these systems aim to reduce pollutants using chemical reactions that

involve hydrogen peroxide, hydroxyl radicals, or other reactive agents. Similar to PCO, these systems are generally marketed for their effectiveness in breaking down complex pollutants. However, concerns about the safety of byproducts persist, and thorough assessment is recommended before installation.

The variety of air-cleaning technologies, along with differing marketing claims, makes it challenging for consumers and professionals to determine the best solution. While many devices are advertised as "air purifiers," each technology works differently and may target specific pollutants more effectively than others. Additionally, the efficacy and safety of these systems can vary based on product quality, installation, and usage patterns.

New and emerging technologies should be used with caution due to the lack of comprehensive industry-wide standards and long-term research impacts on human health from ongoing use of these products. IAQ professionals, therefore, recommend reviewing established standards and guidelines. ASHRAE Standard 62.1-2022 and its Addendum N provide guidance on ventilation and acceptable IAQ, and ASHRAE's Position Document on Filtration and Air Cleaning offers further insights into filtration and

advanced cleaning technologies. Compliance with UL2998—a standard for zero-ozone air cleaners—can also ensure that selected products minimize ozone emissions, which is crucial for health and safety. Consulting with IAQ professionals can also help navigate the complexities of these technologies and find solutions that best fit a building’s specific needs and conditions.

Less available are publications for non-technical audiences, but the USGBC’s Center for Green Schools includes a series of [IAQ Fact Sheets](#) “designed to help people without a technical background understand details about indoor air quality (IAQ) so that they can make important decisions for their schools.” And though they were specifically written for K-12 schools, the concepts are applicable to other building types as well

## **Indoor Plants: Great for Biophilia, but Use with Care**

Incorporating indoor plants into buildings can positively impact indoor air quality (IAQ) by leveraging plants' natural abilities to filter and purify the air. Plants are known to absorb carbon dioxide and release oxygen during photosynthesis, which helps maintain oxygen levels indoors and can support a healthier, more refreshing environment. Furthermore, plants can absorb certain indoor air pollutants, including VOCs such as benzene, formaldehyde, and trichloroethylene.

Research by NASA in the 1980s, known as the "NASA Clean Air Study," highlighted several plants effective at reducing indoor air pollutants under controlled lab conditions. English ivy, spider plants, and peace lilies are among the varieties shown to remove certain airborne toxins. However, while these studies suggest that plants can

reduce toxins in laboratory settings, real-world results in home and office environments are more complex and often less dramatic due to factors like air exchange rates and pollutant levels that differ from controlled experiments.

Adding plants is relatively easy in both existing buildings and new construction, offering a low-energy way to enhance air quality while simultaneously providing aesthetic and psychological benefits. Indoor plants contribute to a biophilic environment, which can reduce stress, boost productivity, and support a sense of connection to nature.

However, successful integration of plants requires careful maintenance. Overwatering is one of the most common issues in indoor plant care, and consistently moist soil can create

an environment conducive to mold growth. Mold spores, which thrive in damp conditions, can be released into the air, potentially negating some of the air quality benefits by introducing allergens and other irritants and pests.

While plants do offer some air-cleaning benefits, they are not considered a substitute for ventilation systems or more intensive air purification technologies. The primary contribution

of plants to IAQ lies in their potential to improve general environmental comfort and support low levels of pollutant reduction. For substantial air quality improvements, especially in buildings with high levels of pollutants or low ventilation, relying solely on plants may not be sufficient. Nonetheless, plants can be a valuable addition to a holistic IAQ strategy, enhancing both the physical and psychological environment.

# Mitigation Strategies Summary

	Source Control	Ventilation / Dilution	Filtration	Air Cleaning Technologies
CO <sub>2</sub>		X		X
TVOC	X	X	X (carbon)	
PM	X	X	X	
CO	X	X		
Ozone	X	X		
Formaldehyde	X	X	X (carbon)	
Radon		X		

\* See previous papers in this series for additional information on indoor air quality contaminants.

## Carbon dioxide (CO<sub>2</sub>)

- Regularly inspect and maintain HVAC systems to ensure proper function and air quality. An increase in CO<sub>2</sub> levels, either abruptly or gradually over time, can strongly indicate degradation of outside air control, especially the operation of outside air dampers or relief systems.
- Implement demand control ventilation systems that modulate ventilation based on occupancy and CO<sub>2</sub> levels.
- Introduce natural ventilation through operable windows or vents to increase fresh air circulation, if outdoor air conditions are mild. Exercise caution, as increasing outside air in this way may cause a loss of temperature or humidity control.
- Encourage occupants to take breaks in outdoor spaces or well-ventilated areas.
- Vent combustion appliances to the outside, or transition to electric systems, to reduce CO<sub>2</sub> emissions. Exercise caution, as venting combustion exhaust is often regulated by codes and other standards.

## TVOC

- Source control is the simplest and most effective means of controlling TVOC exposure. Use low-emitting products. Maintain indoor temperature conditions (TVOC emissions tend to increase with increasing temperatures).
- When possible, permit new products and furnishings to off-gas sufficiently before occupants are exposed to associated products.
- Ensure proper ventilation to dilute and flush TVOC emissions.
- Activated carbon impregnated filters are widely available for most, if not all, ventilation equipment – additional rack space may not be necessary. Exercise caution when adding filtration, as this may restrict airflow and/or increase energy consumption.

## Particulates (PM)

- Minimize and control activities that produce dust, such as construction work, within the building. For construction projects in occupied buildings, implement SMACNA best practices for dust control both within the space and potentially connected spaces for renovation products.
- Enforce no-smoking policy indoors and near the building, especially where outdoor air enters the building, such as at doors, windows and ventilation intakes.
- Implement a routine cleaning schedule, including vacuuming with HEPA-filtered vacuums.

- Use wet methods, such as damp mopping or wiping, to minimize dust resuspension.
- Implement walk-off systems (mats or grates) in vestibules at building entrances. If walk-off systems and vestibules are impractical, encourage occupants to remove shoes at the entrance.
- Seal gaps, cracks, and leaks in the building envelope to minimize outdoor PM infiltration. Use weather stripping around windows and doors to reduce air infiltration.
- Use higher efficiency (MERV 13 or better) filtration in air handling systems.
- Install and maintain proper exhaust systems for kitchens, bathrooms, and other areas with potential sources of PM while ensuring balanced make-up air.
- Electrostatic precipitators can be considered for specific applications. Exercise caution, however, as some of this equipment can emit ozone.

## Carbon monoxide

- Carbon monoxide exposure is best mitigated by source control. Identify and remove the source of the carbon monoxide. Increased ventilation only masks a serious problem. Carbon monoxide filtration is extremely costly.

## Ozone

- Choose low-emitting office equipment and ensure proper maintenance.
- Avoid ozone generators and consult your indoor air quality professional about the use of ionizers as air cleaning devices.
- Limit the use of products that emit VOCs and other ozone precursors.
- There are no mechanisms or technologies to remove ozone from indoor air. Concentrations of ozone can be controlled through additional ventilation, but is subject to outdoor ozone levels.

## Formaldehyde

- Minimize or eliminate formaldehyde sources by selecting low-emitting and formaldehyde-free building materials, furniture, and household products.
- Maintain indoor humidity levels between 30% and 50% to reduce formaldehyde off-gassing from materials and minimize the growth of mold and mildew, which can also release formaldehyde.
- Allow new furniture, carpets, or building materials to off-gas in a well-ventilated area before

introducing them into occupied spaces.

- Consider using air purifiers equipped with activated carbon or formaldehyde-specific filters to remove formaldehyde from the indoor air.
- Improve ventilation in indoor spaces to dilute and remove formaldehyde. Exercise caution when increasing ventilation rates, recalling that additional exhaust must be balanced with appropriately treated (tempered and filtered) outdoor air. Open windows only if outdoor air conditions are appropriate.

## Radon

- Existing Building Source Control: If high radon levels are detected, install a radon mitigation system. These systems typically involve sealing cracks and openings in foundations, adding ventilation systems to redirect radon gas outdoors, and using specialized radon mitigation techniques.
- New Construction Source Control: Implement radon-resistant construction techniques in new buildings. This may include using vapor barriers, sealing foundations, and installing radon mitigation systems during construction.

# Conclusion

Ultimately, improving indoor air quality is not a single intervention or product choice; it is an ongoing practice that integrates design intent, operational discipline, and continuous learning. By focusing on actionable, additive measures grounded in real-world constraints, this paper aims to support building owners, operators, and practitioners in closing the gap between IAQ ambition and IAQ performance—delivering cleaner air, more resilient buildings, and healthier indoor environments over time.

Indoor air quality has moved from a secondary sustainability consideration to a core performance expectation for commercial buildings. The events of recent years—public health crises, climate-driven air quality impacts, and growing scientific consensus—have made clear that clean indoor air is not optional. Yet despite increased awareness and improved tools, IAQ outcomes in many buildings remain inconsistent, reactive, and insufficiently tied to day-to-day operational decision-making.

As continuous monitoring becomes more common, the industry must move beyond data collection toward informed action. Sensors alone do not improve air quality; outcomes improve when monitoring is paired with clear performance targets, operational protocols, and an understanding of how

HVAC systems actually behave in the field. Avoiding common implementation pitfalls—and applying proven, incremental fixes—can meaningfully improve delivered IAQ without requiring wholesale system replacement.

Momentum is also building beyond individual buildings. Emerging standards, guidance, and policy initiatives—including evolving ASHRAE requirements and state-level efforts such as those underway in California—signal a shift toward greater accountability for indoor air performance. Organizations that act now to integrate practical IAQ strategies into design, operations, and capital planning will be better positioned to meet future regulatory expectations, manage risk, improve asset value, and support occupant health and resilience both now and into the future.



Green Commons  
57 Organ Street  
Brattleboro, VT 05301

[www.greencommons.net](http://www.greencommons.net)

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