

Indoor air quality (IAQ) is a growing concern for homes, schools and businesses. Tighter building construction over the past 15 to 25 years has reduced energy consumption to achieve energy efficiency and lower operating costs. However, as buildings have become more efficient, occupants' health, comfort, and productivity have suffered at times. As a result, complaints about the indoor environments of today's energy efficient homes and buildings have steadily risen, and the costs of air quality problems in terms of health and property damage now exceed \$1 billion a year in Minnesota alone.

Virtually any type of new or existing building can develop indoor air quality (IAQ) problems: homes, condominiums and apartment buildings; schools, hospitals and office buildings; and retail, manufacturing and warehouse facilities. When a building has good indoor air quality, occupants will be healthier, more comfortable and productive. When IAQ problems exist, however, occupants can experience a series of physical symptoms, including headaches, fatigue, nausea, eye and throat irritations, respiratory problems and allergic reactions. Health problems are the most significant result of polluted indoor air and children, frail or elderly persons often suffer the worst effects. Another expensive consequence is the premature deterioration of building materials, furnishings and equipment.

## Identifying IAQ problems

Some sources estimate that 30 to 70 percent of facilities nationwide exhibit some type of indoor air quality problem, often dubbed "sick building syndrome." The Environmental Protection Agency (EPA) estimates that indoor air may be two to five times, even as high as 100 times, more polluted than outdoor air. The EPA ranks IAQ among the top five environmental risks to public health. But identifying the sources of IAQ problems is not an easy task, nor is finding solutions. Causes and cures are often inter-related – eliminating one problem can often lead to another, so a comprehensive approach to resolving and preventing air quality problems is very important.

## Sources of IAQ problems

IAQ problems stem from an array of biological and particulate contaminants; volatile organic compounds (VOCs) that can be emitted from building materials, furnishings and household chemicals; dust mites and pollen; air that is too moist or dry; or various gases and combustion by-products, such as carbon monoxide. The most widespread and severe problems involve humidity extremes, inadequate ventilation and growth of microorganisms, all of which can be especially troublesome during Minnesota winters when people may spend up to 90 percent of their time indoors. In homes with central air conditioning, the same problems can occur in summer.

## Humidity extremes can indicate and cause IAQ problems

High relative humidity, for example, creates an ideal growth medium for mold, mildew, fungi, bacteria, pollens or other living organisms they release. They can thrive almost anywhere – in carpeting, ceiling tiles, porous wall and duct materials or other mediums. Once wet, they can take days, weeks or even months to dry. Even then, they will continue to release spores into the atmosphere long afterward and can cause multiple health problems, including respiratory and skin allergies, lowered immune defense, and sometimes serious disease. They also can prove detrimental to building materials, which can result in costly repairs.



Many experts suggest that moisture control is the single most important factor in achieving healthier indoor air. But it isn't an easy task. A single moisture problem might have several sources, or one moisture source could cause several seemingly unrelated problems. Signs of excess moisture include:

- Musty odors or unpleasant smells that linger
- Frost, ice or other condensation on cold surfaces such as windows
- General dampness or cold, clammy air
- Discoloration or texture changes in building materials
- Warped, cracked or rotting woodwork
- Pipes that sweat, leak or drip
- Cracked or peeling paint
- Crumbling or deteriorating masonry

Moisture problems have many sources, including:

- New construction materials
- Insufficient ventilation
- Faulty HVAC or other equipment
- Household activities such as showering, cooking and doing laundry
- Large numbers of house plants
- Inadequate insulation or vapor barriers
- Excess groundwater or improper drainage
- Damp foundations
- Attic bypasses

### Overview of household moisture sources

| Moisture source by type                                | Estimated moisture amount (pints)     |
|--|---------------------------------------|
| Bathing (tub)  | 0.12 per standard size bath           |
| Shower   | 0.52 per five-minute shower           |
| Clothes washing  | 0+ per load (usually 0)               |
| Clothes drying (vented outdoors)                       | 0+ per load (usually 0)               |
| Gas cooking (family of four, average)                  | 2.84                                  |
| Dishwashing, breakfast (family of four, average)       | 1.05                                  |
| Firewood storage indoors (cord of green firewood)      | 400 to 800 per six months             |
| House plants (5 to 7 average plants)                   | 0.86 to 0.96 per day                  |
| Humidifiers  | 0 to 120+ per day (2.08 average/hour) |
| Pets   | Fraction of human adult weight        |
| Respiration and perspiration (family of four, average) | 0.44 per hour                         |
| Refrigerator defrost                                   | 1.03 per day (average)                |

Cold Climate Housing Information Center, University of Minnesota

## Gases, combustion by-products and other problem sources

**Carbon monoxide (CO)** is a poisonous gas that is colorless, odorless, tasteless and non-irritating. It is produced by the incomplete combustion of any fuel or combustible material, including gasoline, coal, wood, charcoal, kerosene, natural gas, propane, heating oil – even tobacco, fibers and paper. CO deprives the body of oxygen, and can cause headaches, nausea and other flu-like symptoms, or in cases of severe exposure, can lead to death.

**Carbon dioxide (CO2)** is exhaled as humans and animals breathe and is also a by-product of combustion and photosynthesis. When CO2 levels are regularly too high, headaches, increased seasonal illnesses and other problems can result.

**Caustic chemicals**, including formaldehyde, are used in many building products and are released into the atmosphere as materials dry and age. Paint, stain, sealants and new furniture or carpeting are often problem sources; some of these chemicals are known carcinogens or contribute to other health difficulties.

**Radon or soil gas** exists in the soil of many areas and is a known carcinogen – the second most common cause of lung cancer nationally. Levels that may accumulate within a structure are influenced by soil type and condition, building construction and ventilation.

**Nitrogen dioxide (NO2)** is a by-product of the combustion of any fuel. Though colorless and tasteless, it has a sharp odor. Exposure can result in eye and throat irritation and respiratory infections.

## Think of your house as an integrated system

From design and construction to building materials, equipment and appliances – everything in your home must function cooperatively to achieve optimum indoor air quality and energy efficiency. Today's homes should function as complete systems and must be designed and maintained as such. Everyone involved with the home – architects and builders, equipment manufacturers and installers, code officials and homeowners – must work together to ensure better IAQ.

Proper building techniques and appropriate mechanical ventilation can help resolve indoor air quality problems while meeting Energy Code requirements, but may increase initial construction and energy costs. Most builders believe, however, that homes built to energy code requirements will be a better long-term value, exhibiting fewer problems and offering greater durability.

## Functional relationships of the house system



Joseph Lstiburek, P. Eng.; *Builder's Guide: Cold Climate*; Building Science Corporation et al; Westford, MA, 1997; p.5.

## Proper ventilation is key

Good ventilation provides an adequate exchange of fresh air, controls moisture, dilutes common contaminants and harmful fumes such as radon and formaldehyde and helps maintain a comfortable indoor environment. Experts recommend that your home's air be replaced every three hours. However, with today's tighter construction practices, establishing and maintaining proper ventilation can be difficult and complex; sometimes the very mechanical systems and equipment designed to relieve problems can compound them instead.

Several different ventilation methods can provide adequate air flow for homes, depending on conditions and requirements:

- Passive ventilation, providing air flow into the structure through existing openings or properly sized ducts
- Mechanical ventilation, for kitchens, baths or other concentrated areas
- Balanced mechanical ventilation (for the whole house)
- "Make-up" air must be provided for large exhaust devices or when several exhaust devices are used at the same time.

Because of its moisture content, vented air is best directed outdoors; it should never be directed into attic or soffit spaces where the clash of warm and cold air can cause moisture condensation and contribute to problems. High quality filtration equipment and regular cleaning and maintenance of filters, cooling and heating coils, rooftop units and ductwork is crucial for maintaining suitable ventilation and healthy indoor air.

## Old and new houses alike can develop IAQ problems

Though new homes are more tightly constructed from the outset, many older homes have been remodeled with added insulation, weatherstripping, powerful exhaust fans and other features and equipment that can cause the same air quality problems as in new homes.

## All parts of the system must work together

Homes with more amenities and modern, energy efficient construction have a higher potential for indoor air problems making proper ventilation systems essential. Tighter building construction can create pressure changes and affect the operation of atmospherically drafted fuel burning equipment, allowing combustion by-products to spill into homes or buildings (backdrafting). For instance, in an improperly ventilated home, powerful kitchen or bathroom exhaust fans, fireplaces and clothes dryers, used in combination, can change the air pressure and cause backdrafting in water heaters, furnaces, fireplaces and wood stoves. This backdrafting then pulls exhaust fumes back into living spaces rather than allowing them to vent to the outside.

Even attached garages can pose a problem. Studies have shown that vehicles or other fuel-burning equipment running for very short periods of time, even with the garage door open, can allow CO and other contaminants to seep into the house.

## Planning for indoor air quality and energy efficiency

Good indoor air quality starts with comprehensive planning and design. To help ensure energy efficiency and air quality, it's important to build tight and ventilate right.

Find a reputable builder or remodeler or, if purchasing an existing home, have a thorough home inspection done by a qualified professional. Then check this list for items that can reduce the potential for air quality problems (some might apply only to new construction):

**Continuous warm-side air-vapor retarder** keeps warm, moist air inside the home from seeping through walls and affecting building materials.

**Continuous exterior weather barrier (house wrap)** prevents wind and water from penetrating the home.

**Full-coverage, high-grade thermal insulation** separates heated living spaces from unheated areas such as attics and crawl spaces.

**Energy-efficient windows and doors** with high-performance glass that resists condensation.

**Ground moisture and soil gas control** uses air-vapor retardants or sub-slab ventilation to protect against water and soil gas penetration.

**Efficient space heating, water heating and air conditioning systems**, especially direct-vent or power-vented models, minimize backdrafting potential. Units should be easily accessible for regular cleaning and maintenance.

**Balanced mechanical ventilation**, when properly installed and maintained, balances air intake and exhaust and helps ensure adequate supplies of fresh air; many units also include heat recovery.

**Compatible exhaust fans and appliances** help ensure that ventilation and equipment work together to avoid backdrafting of combustion gases into the home.

**HVAC systems designed to avoid underground forced-air ducts**, when possible.

**High-quality air filtration systems** help keep indoor air clean, not just the furnace.

**Energy efficient appliances and lighting.**

**Ridge and soffit vents and raised-heel or energy roof trusses** supply even ventilation, better insulation and help prevent ice dams.

**House design and landscaping** that maximizes sun exposure and drainage.

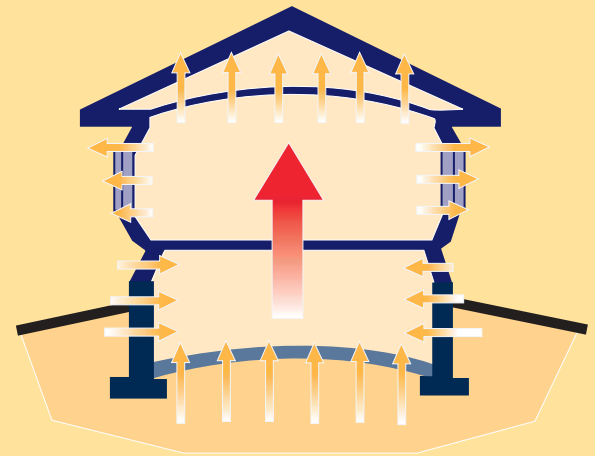
## Selecting, installing and maintaining equipment to improve IAQ

Following these equipment guidelines can help ensure better air quality in your home, whether it's new or existing:

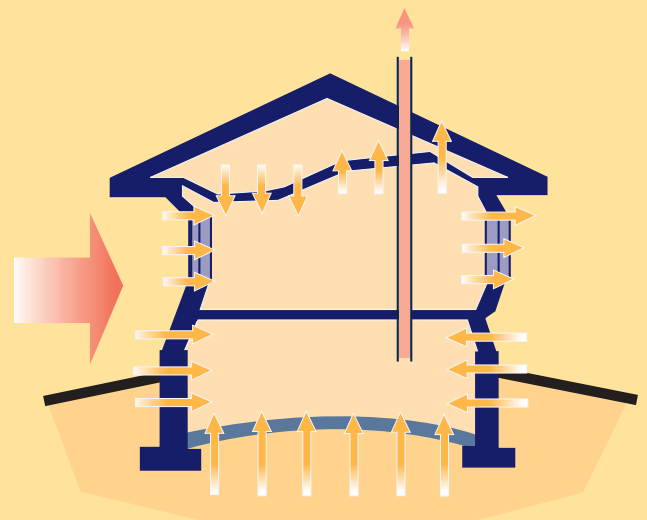
### Gas heating systems

- Select a direct-vent or power-vent heating system to avoid backdrafting of combustion gases, condensation and other problems. Direct-vent units bring outside air directly into the combustion chamber without drawing air from within your home. Direct-vent and power-vent units do not require a chimney since the exhaust gases are vented directly outside, virtually eliminating any mixing of air between the combustion chamber and the home.
- Have a qualified professional conduct an annual tune-up and safety inspection of your heating system and other fuel-burning appliances to check for carbon monoxide or other problems.
- Conduct your own routine maintenance: clean and change furnace filters regularly (once a month during the heating and cooling seasons); clean the blower at least once a year; keep ductwork clean and free of dust; insulate and seal air leaks in ductwork; bleed air from radiators annually.
- When replacing an existing furnace with a new direct-vent or power-vent unit, make sure your heating contractor checks and adjusts water heater venting and operation of bath and kitchen exhaust fans or other mechanical venting to help prevent backdrafting.

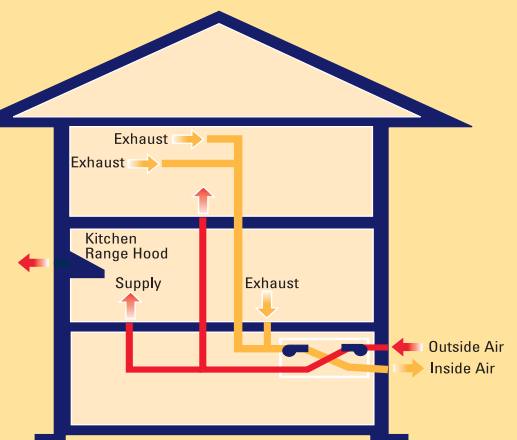
### Natural house ventilation



### Natural house ventilation affected by wind and a chimney



### Balanced ventilation system with heat recovery via air-to-air heat exchanger



## Gas water heaters

- Direct-vent or power-vent water heaters provide maximum energy efficiency and safety in today's homes. Direct-vent water heaters draw outside air in for proper combustion and to avoid backdrafting. Power-vent water heaters are exhausted to the outside with powerful blower fans. Because direct-vent and power-vent water heaters don't require the usual chimney connection, they allow greater installation flexibility.
- Routinely inspect your water heater for problems and replace old, malfunctioning units when necessary.

## Range, oven and dryer

- Be sure to keep your range, oven and other cooking equipment well-tuned and use kitchen exhaust fans to ventilate pollutants and particulates to the outdoors.
- Vent clothes dryers to the outside. Clean lint screens after each load and keep dryer vent flap clear of debris.

## Ventilation and humidity control

- Install a heat recovery ventilator (HRV) or energy recovery ventilator (ERV), sometimes called air-to-air heat exchangers. Both bring fresh air into your home with minimal heat loss, and ERVs provide additional moisture control.
- Use high-quality air filters or air cleaners to help remove airborne dust, dirt, smoke, pollen and other irritants so occupants can breathe easier.



- Add humidifiers for warmth without dryness during the heating season to help reduce skin, respiratory and other irritations caused by dry air.
- Use mechanical or chemical (desiccant) dehumidification in warm weather to help control humidity. Mechanical dehumidification removes moisture by cooling the air and condensing water vapor so it can be collected and emptied. Desiccant dehumidification uses desiccant material, outside air and heat to absorb more moisture, more efficiently, venting it outdoors.

## Choose and use other products and materials wisely

- Select and install home furnishings, carpeting, paint, wall coverings and other materials with low emissions or volatile organic compounds (VOC).
- When remodeling homes containing lead-based paint, consult a professional about proper handling of hazardous materials to avoid problems.
- Be sure to use household chemicals and other hazardous materials safely and dispose of them properly, according to manufacturer specifications.

## Homeowner tips for better air quality

When it comes to indoor air quality, prevention is the best cure. There are many steps you can take to help prevent or resolve air quality problems in your home; consult a professional before making changes or improvements.

- Make sure your home's equipment and appliances are inspected and maintained regularly by experienced professionals. In most cases, carbon monoxide buildup or other problems can be prevented with annual maintenance. Replace or repair malfunctioning equipment before serious problems develop.
- Provide adequate combustion air for all your fuel-burning appliances and install carbon monoxide detection devices with digital readouts and audible alarms in your home.
- Keep chimneys and vents clear of debris or blockages and never leave an unattended fire smoldering in your fireplace.
- Exercise safety when using appliances; never try to heat a room with your range, oven or clothes dryer.
- Never operate a car, lawn mower or other combustion engine inside your home or garage, even for brief periods or with garage doors open.
- Use high efficiency filters in ventilation and air handling systems.



Heat recovery ventilator

- Caulk, seal and insulate your home, including air ducts and attic bypasses (electrical wiring, plumbing, chimney chaseways or other penetrations) and vent the attic through the roof for better air circulation. These steps can sometimes cause air quality problems, but, when combined with proper mechanical ventilation, will help control air flow to improve efficiency and air quality.
- Keep basements clean and dry. Keep windows closed during humid months. Seal leaks, add dehumidifiers and use fans to circulate air. Waterproof leaky basements with air, vapor and moisture barriers to seal foundations and crawl spaces.
- Landscape around your home's foundation to help maintain proper drainage and wick moisture away; install gutters and rain spouts with long extensions to channel water away from the house.
- Have main drain and storm sewers inspected to be sure they are functioning properly.
- Eliminate smoking within your home; burning tobacco smoke emits a complex mixture of toxic and carcinogenic compounds that can linger.

## Call us for other helpful information

CenterPoint Energy has other publications available free of charge to provide you with more information on ways to improve indoor air quality and home safety, including:

- A carbon monoxide (CO) brochure with more information about CO, its sources and prevention.
- Fact sheets on humidity, ventilation, combustion air, using natural gas safely, and more.

Or, for energy code information, visit the *Trade Allies* section of our Web site at [CenterPointEnergy.com](http://CenterPointEnergy.com).

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