Energy

New energy-efficient homes and humidity issues: How to avoid costly dehumidifiers

By Michael Brown, ICF

Modern homes are often more energy efficient, but that doesn't necessarily make them more comfortable. High indoor humidity can cause rot, mold, and other costly problems in new construction.

Construction of new homes is pushing the eco-friendly envelope through advances in International Energy Conservation (IECC) codes, above-code programs like ENERGY STAR, and utility energy efficiency efforts. Though new houses use significantly less energy, builders are more frequently encountering indoor relative humidity (RH) above the recommended maximum of 60%—in part due to these updates. Not only is excess humidity uncomfortable, but it also leads to serious issues like mold growth and rotting materials.

Our team has worked on the growing indoor humidity issue directly. We've participated in every IECC code development hearing since 2009 and supported the U.S. Environmental Protection Agency's (EPA) ENERGY STAR program for over 25 years. While implementing 20 utility-sponsored new home programs, ICF experts have helped utilities, builders, and home energy raters understand the causes and potential solutions.

With energy efficiency targets set only to become more stringent, utilities must have a technical understanding of how to meet these goals without compromising the standard of living customers expect.

What causes high indoor humidity?

When a home experiences high indoor humidity, it is often related to its cooling load and how air conditioning equipment responds.

Cooling load is made up of a sensible and latent load. A sensible load is based on the air temperature—the hotter it is, the higher the sensible load. The latent load is based on the amount of moisture in the air—the more humid the air, the higher the latent load. A larger latent load means a home is more likely to experience high indoor humidity.

Sensible Load = Temperature	Latent Load = Humidity

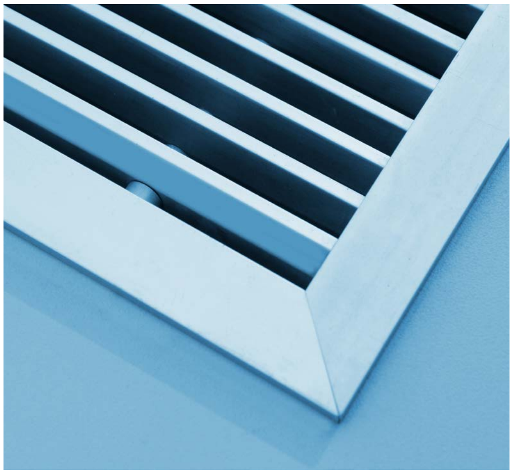
Cooling loads

Air conditioners both cool air and dehumidify, meaning they address the sensible and latent loads simultaneously. However, an air conditioner typically only operates when it's too hot, thus responding only to the sensible load. This control strategy can sometimes lead to high indoor humidity because the equipment isn't designed to activate in response to a humidity setpoint.

The size of an air conditioner relative to the home's cooling load also impacts its effect on humidity. Large air conditioners tend to cool down homes quickly and shut off when they reach the target temperature. But, this is also why bigger units aren't as effective at dehumidifying. To draw the moisture out of the air, the whole system needs to be sufficiently cool. It takes a long time for the system to get cool enough to start sucking water out of the air. If the air conditioner is too large, it will reach the desired temperature quickly and not run long enough to remove moisture.

On a hot and humid summer day, a properly-sized air conditioner will cool and dehumidify a home effectively. But during the spring and fall shoulder seasons, there may be mild damp days (e.g., spring showers where it is 70°F and 100% relative humidity). This causes a low sensible load and a relatively high latent load. Even an air conditioner of the correct size won't turn on for adequate periods of time to dehumidify the home due to the mild temperature and low sensible load. This is why it's more common for homes to see high indoor humidity during the shoulder seasons.

Another cause of high indoor humidity is related to better building envelopes. Most home efficiency improvements lower the sensible load, decreasing the amount a home will heat up in the summer. Higher insulation levels and windows with a lower solar heat gain are good examples of this.



Some efficiency improvements lower both the sensible and latent loads, like reducing infiltration of outdoor air into the building. But in modern, efficient homes, outdoor air is intentionally brought into the home using mechanical ventilation to maintain good indoor air quality, which increases the latent load—offsetting some of the infiltration improvements. Plus, there will always be some latent loads from occupant activities like cooking and showering.

In sum, as homes become more efficient, sensible loads go down but latent loads remain relatively constant—resulting in a higher portion of latent loads in total cooling. This trend means an energy-efficient home is more likely to see high indoor humidity, unless there is a plan and systems in place to mitigate this risk.

How do you address high indoor humidity?

High indoor humidity appears in several ways. Homeowners may simply feel that it's too humid or have a thermostat that displays relative humidity and see that it's high. They could also witness condensation on cold surfaces like ductwork, or even start to see mold growth.

Many industry experts recommend either a standalone dehumidifier or one integrated into the heating ventilation and air conditioning (HVAC) system as the only guaranteed way to ensure proper humidity control year-round. In warm, humid climates, the EPA's Indoor airPLUS program requires HVAC equipment to actively keep indoor humidity below 60%.

Unfortunately, homeowners have to pay the ongoing energy cost for a dehumidification system and an up-front cost ranging from a few hundred to a few thousand dollars depending on the type of system. Before spending the money, there are many low- or no-cost solutions that can reduce the need for a dehumidifier, or eliminate the need completely. Consider these before—or in addition to—installing a dehumidifier.

Low- or no-cost solutions

Low- or no-cost solutions address high indoor humidity in two ways:

1. improving an air conditioner's ability to respond to the latent load, and
2. reducing the latent load.

Many of the solutions are changes in practices or require small investments. They fit into three main categories:

1. air conditioner solutions;
2. ventilation solutions; and
3. homeowner education solutions.

Air conditioner solutions

Equipment sizing: Cooling loads and equipment sizes should be calculated using industry standards such as ACCA Manual J and S. Load calculations should reflect the actual home to be built as closely as possible and include the expected infiltration rate, mechanical ventilation, number of occupants, and other key drivers of loads, such as those on the ENERGY STAR Certified Homes checklist. Select equipment that has enough capacity to meet the calculated sensible and latent loads.

Oversizing of equipment should be limited as much as possible, as it is worse at controlling humidity. Oversized equipment suffers from "short-cycling," or only running for a short period before shutting off. Short cycling can lead to high indoor humidity because of the limited time that the coils stay cool. Failure to keep them cool for a long period stops the moisture in the air from condensing on the coils and draining away. As such, short cycling will address the sensible load but not the latent load.

Sensible heat ratio: Pay attention to the sensible heat ratio (SHR) of equipment, and consider selecting equipment with lower SHRs. SHR indicates the latent capacity of the equipment, or the ability of the air conditioner to remove latent loads. A lower SHR means more of the equipment's capacity is latent capacity. For example, a 0.70 SHR means 30% of the equipment's capacity is latent capacity. Two otherwise identical air conditioners should not be treated the same if they have different SHRs. The one with the lower SHR is better suited for controlling indoor humidity.

Lower design airflow rate: Typically, HVAC designers specify an airflow rate of 400 cubic feet per minute (cfm) per ton capacity. In humid regions, some HVAC designers choose to go below that and design to a value around 300 to 350 cfm per ton. This is because equipment becomes better at dehumidification when it operates at a lower airflow. Equipment designed with lower airflow rates can dehumidify more effectively because it will have a lower SHR and lower total capacity. It will run longer and be less likely to short cycle like oversized systems. But, the HVAC designer should consider the full impact of lower airflows because they will reduce total system capacity and can lead to more energy use.

Supply fan overrun: Most air conditioners have a supply air fan overrun feature, where the fan will continue to run for a short period after the compressor turns off. This provides a little extra cooling and results in a higher seasonal energy efficiency ratio (SEER) rating. Supply fan overrun can be harmful to controlling humidity, but HVAC contractors can disable this feature and reduce the chances of high indoor humidity.

The supply fan overrun is harmful because it doesn't remove any latent heat—it's actually doing the opposite and adding moisture back into the air. Water vapor that had condensed on the coils and would have been removed is evaporated and sent back out into the living space, undoing the dehumidification by the air conditioner. Modeling for a home in Miami has shown that, if the supply fan overrun was set for 90 seconds, disabling it can mean almost 1,300 fewer hours a year above 60% RH.

Enhanced dehumidification controls: Some air conditioners can be paired with enhanced dehumidification (or overcooling) controls. When high indoor humidity is detected, these controls temporarily improve the air conditioner's ability to dehumidify by reducing the system airflow and overcooling the air by 2-3 degrees. Modeling has shown this to significantly reduce the number of hours above 60% RH in humid climates. But, it does increase energy use and can lead to discomfort because it cools spaces below setpoints.

Return air: Ductwork should be designed so that air has a clear return path back to the air handler. This ensures that air makes it back to the air conditioner to be dehumidified. Contractors should ensure that return ducts are properly sized using industry-standard approaches like ACCA Manual D. It is also a best practice to ensure that air can make its way out of bedrooms to the return ducts.

The ENERGY STAR Certified Homes Program requires that the measured pressure between the bedroom and the main body of the home be less than 3 Pa, or 5 Pa for high-airflow rooms. This can be achieved through several approaches, like transfer grilles, jump ducts, dedicated returns in the bedrooms, or undercut doors. These steps help ensure air has a clear path out of a bedroom and back to the air handler to be dehumidified.

Commissioning: Using industry standard practices like ACCA QI 5, HVAC contractors should commission systems to make sure that they are properly charged with refrigerant and have the correct total system airflow. This allows the installed system to deliver the designed capacity and meet sensible latent cooling loads.

Evaluate off-peak conditions: In addition to sizing equipment to meet peak cooling loads, ACCA Manuals J and S can help evaluate how a system will perform during typical shoulder season conditions. Standard peak load sizing procedures can be modified to determine how equipment will perform at part-load conditions and assess if additional dehumidification is needed.

Ventilation solutions

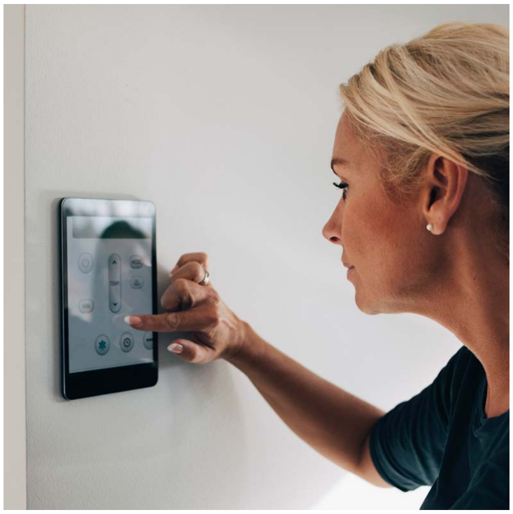
Whole-house ventilation: To improve indoor air quality, programs like ENERGY STAR Certified Homes and newer building codes require whole-house mechanical ventilation to bring in a known amount of fresh air. All mechanical ventilation will increase latent and sensible loads, but selecting the right type of ventilation strategy can help minimize the impact on humidity.

Typical ventilation strategies include exhaust, supply, and balanced. Exhaust systems are often only a bathroom fan that continuously pulls air out of the home, meaning air will enter the home through unknown paths. Supply systems—called central-fan-integrated supply ventilation—contain ducts that bring outdoor air directly into the return of the air handler, filter it, condition it, and send it to the living spaces. They also have a motorized damper and a controller to open and close the damper and run the blower fan to precisely meet ventilation needs.

Finally, there are balanced systems which use two fans to simultaneously pull in and push out air. These include heat recovery ventilators (HRVs) and energy or enthalpy recovery ventilators (ERVs), which can recover sensible and latent heat and transfer it to the incoming air. It's important to note that ERVs do not dehumidify, but they will add the least amount of latent loads to a home.

ERVs are recommended as the best ventilation strategy for use in humid climates but are also expensive. The next best option is a supply system because it enables the HVAC system to condition and dehumidify incoming air at least some of the time before it's distributed into the home. The last option is an exhaust system. It cannot condition, filter, or dehumidify air before it enters the home, and will likely lead to the most hours with high indoor humidity.

It is important to ensure that whole-house ventilation is compliant with ASHRAE 62.2 and measured in the field to verify ventilation rates. Under-ventilating can harm indoor air quality, and over-ventilating can increase energy use and potentially make controlling high indoor humidity more difficult. For example, ASHRAE 62.2-2013 requires as much as 40% more ventilation compared to 62.2-2010 for a tightly built home. This extra air is needed for indoor air quality, but can lead to noticeable increases in energy use and latent loads if not planned for when designing systems and selecting equipment.



Local exhaust: Local mechanical exhaust removes moisture and other pollutants directly from the source, like kitchens and bathrooms. If not removed, this moisture remains in the house and increases the likelihood of high indoor humidity. Local mechanical exhaust should be verified to exhaust directly outdoors, and measured to ensure it removes the necessary rate as prescribed in ASHRAE 62.2.

The ENERGY STAR Certified Homes program also recommends ventilation that meets sound requirements to encourage their use. For example, if a kitchen exhaust is too loud and bothers a homeowner, it's less likely that they would use it.

Homeowner education solutions

Use local exhaust: Builders should explain the benefits of local mechanical ventilation in bathrooms and kitchens to homeowners. These should be used whenever moisture-producing activities are occurring (e.g., showering or cooking). This will remove moisture directly from the source and reduce the chances of high indoor humidity. To automate the use of local exhaust, bathroom fans are available with built in humidistat controls that turn on automatically when humidity rises. This guarantees benefits of bathroom local exhaust without requiring that a homeowner remember to use it.

Temperature setpoints: If a homeowner experiences high indoor humidity, builders should explain that increasing the thermostat setpoint will not help. Air conditioners cool and dehumidify a home at the same time, so increasing the setpoint causes it to operate less and miss the chance to reduce humidity.

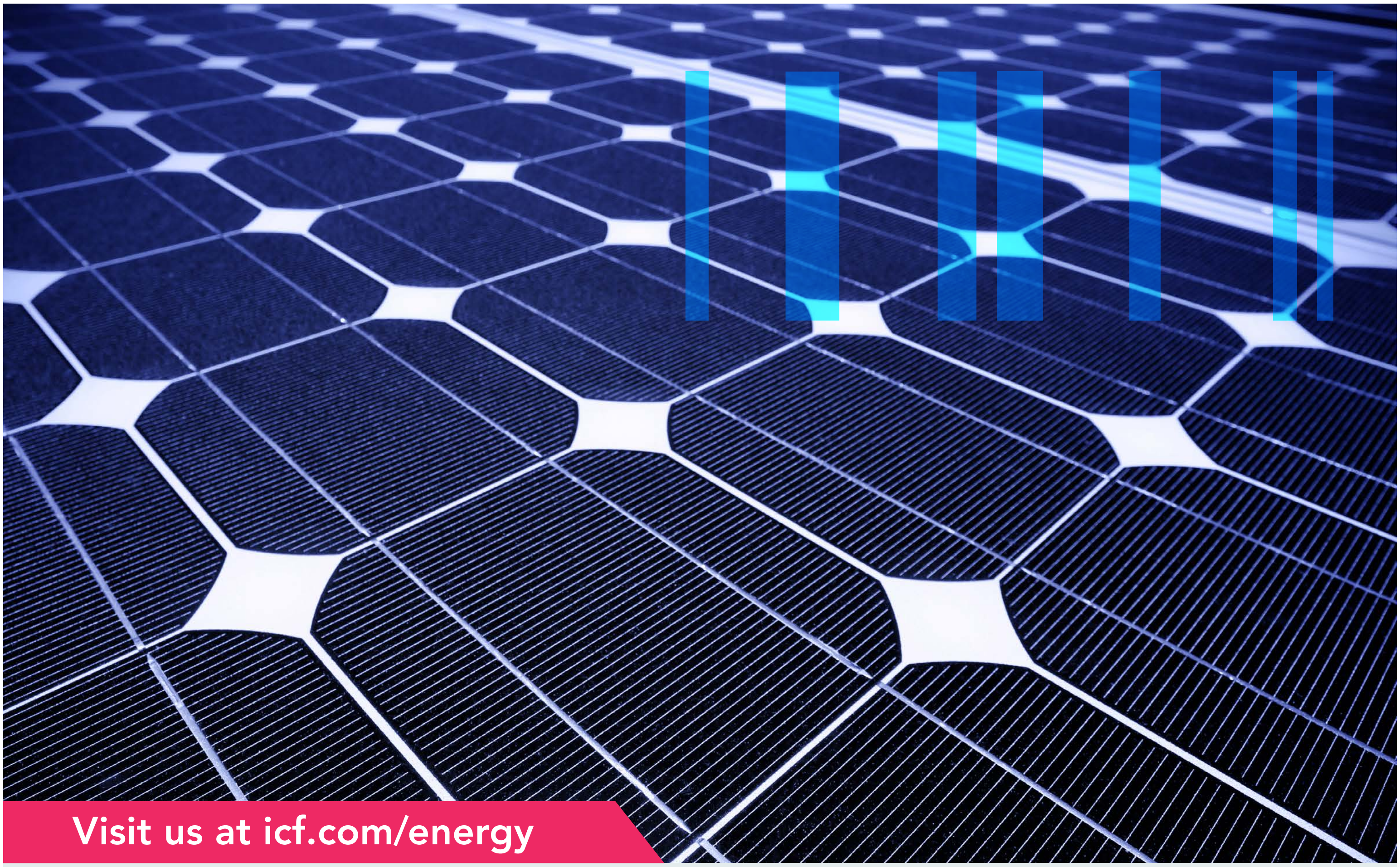
Fan mode: The thermostat should be set to have the fan operate in "AUTO" mode, not "ON" mode. Modeling has shown that operating in the "ON" mode can increase energy use by roughly 30-50% and approximately double the number of hours with high indoor humidity.

Final words

While increased energy efficiency offers many benefits, the high indoor humidity problem poses risks to health and home. The initial and ongoing cost of a dehumidification system is prohibitive for many homeowners. Fortunately, the options discussed here provide alternatives to combat rising humidity and suit any new home construction project.

About the Author

Michael Brown is a manager at ICF with over 9 years of experience in residential and commercial building energy efficiency policy planning and implementation. He leads ICF's technical and analytical support of EPA's ENERGY STAR Certified Homes program, and helps various other state, local, and utility clients plan for and address obstacles of implementing energy efficiency policy. Michael holds a B.S. in Mechanical Engineering from the University of Virginia.



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