Controlling Humidity in Warm Climates

Without air conditioning, life as we know it in the warmer parts of the United States would be hard to imagine. Air conditioning may not be an absolute necessity, even on the Gulf Coast, but it might as well be: Today, the majority of new homes nationwide, and virtually 100% of new homes in the South, get central air conditioning systems.

And there's a reason it's called "air conditioning" and not just "cooling." Air conditioners dry the air at the same time they cool it. By improving comfort, controlling indoor humidity reduces the need for cooling. It's also important for building durability, because moisture can damage the building envelope. In addition, evidence is piling up that controlling humidity is important for human health.

Building consultant and mechanical systems engineer Kristof Irwin, a principal at Positive Energy in Austin, Texas, stressed the health-based case for humidity control in a recent interview with *JLC*. "What is the main output of your house?" asked Irwin. "It's healthy, productive human beings. The main output is you. So all the stuff we do around buildings really should be around you. And the main thing I need to do for you is to deliver healthy air for you to breathe."

Excessive humidity threatens that healthy air quality, Irwin argued. In a moist indoor environment, fungi and bacteria flourish, he said: "Those two are mortal enemies, and they continually fight for turf using chemical and biological warfare." The toxins produced in that turf war, Irwin said, are harmful to people. So in a damp house, people can become collateral-damage casualties in a microbe-on-microbe war.

"In building science," said Irwin, "it might be safer and friendlier to talk about moisture accumulation in materials, and 'should we do a vapor retarder,' etc.—but it's much more important to talk about upper respiratory infections, asthma, and sleep apnea." For support, Irwin pointed to a 2016 report called *Microbiomes of the Built Environment*, from the National Academies of Sciences, Engineering, and Medicine. "There's a table in that book, where down the left side it lists all these health issues," he said—things like wheezing, coughing, respiratory infections, or allergic rhinitis. Across the top, the table

Above, an Ultra-Aire 155H dehumidifier sits next to the air handler of a 6-ton geothermal heat pump, part of a whole-house climate-control system designed by Austin-based Positive Energy. The unit can remove as much as 155 pints of water at 7 pints per kWh and can effectively dehumidify air as cool as 56°F, according to Ultra-Aire specifications.

Photos by Tom Dugan

BY TED CUSHMAN

This Ultra-Aire SD12 split-system dehumidifier's indoor coil (top) and outdoor coil (above) were installed at the home of David Treleven, who has since started working for Ultra-Aire maker Therma-Stor. The unit gives Treleven's Passive House dry air without adding excess heat to the living space.

lists broad-based medical literature reviews published in 2004, 2009, and 2011. "By 2011," said Irwin, "for every major issue they looked at, sufficient evidence existed to show correlation" between a damp indoor environment and negative health symptoms.

"As an industry, we've forgotten about the occupants of our buildings," said Irwin. "And as soon as I put the occupants in, it is super important to keep air dry in a humid climate. So this is the elephant in the room that I design for. I'm going to put a system in there dedicated to controlling humidity, that I can count on, that's simple and controllable. You take the other stuff off the table."

MAKING SYSTEMS WORK

Air conditioners remove "sensible" heat (the heat you can feel in the form of air temperature) as well as "latent heat" (the heat that's contained in the form of evaporated moisture in the air). But during the spring and fall "shoulder seasons" in a place like Louisiana or Texas, when only latent cooling (dehumidification) is needed, traditional air conditioning struggles to get the air-drying job done without overcooling the space.

Louisiana State University (LSU) professor Claudette Reichel made the point in simple language in a 2012 YouTube video for the university's LaHouse demonstration home: "You want to build tight and vent right. You need good-quality fresh air," said Reichel. "But when we bring in fresh air, we are bringing in excess humidity. You do want to dehumidify. But there's not much need for cooling in a very energy-efficient home. So the air conditioner may not run enough to take out that humidity. So the ultimate is to separate air conditioning and dehumidification, especially for the spring and the fall."

This is not a new message. As far back as 2005, building scientists Armin Rudd, Joe Lstiburek, and Kohta Ueno brought clarity to the issue in a report for the Department of Energy (DOE) Building America program, *Residential Dehumidification Systems Research for Hot-Humid Climates*. After testing and monitoring 20 different homes and evaluating various strategies for maintaining acceptable indoor conditions, the team summed up this way: "Energy efficiency measures, combined with controlled mechanical ventilation, change the sensible and latent cooling load fractions such that supplemental dehumidification, in addition to that provided by the central cooling system, is required to maintain indoor relative humidity below 60% throughout the year. The

system providing the best overall value, including humidity control, first cost, and operating cost, involved a standard dehumidifier located in a hall closet with a louvered door and central-fan-integrated supply ventilation with fan cycling."

The team's conclusion is as true as ever. In the 15 years since Rudd, Lstiburek, and Ueno conducted their Houston study, building envelopes have continued to get tighter and better insulated. Windows have also improved, and strategies such as shading have continued to reduce sensible heating loads. And mechanical fresh-air-supply ventilation, with its associated humidity load, has become, if anything, even more important.

At the same time, however, HVAC equipment has evolved. Today's most advanced cooling equipment has variable control of fan and compressor operation. Compared with earlier generations of air conditioners, it does a better job of adapting to changing sensible and latent load conditions, hour by hour and day by day.

But even the best cooling equipment has limits. Said Irwin: "The reality is that when you don't have much of a cooling load at all, you don't need your air conditioner to run. But you still could need substantial drying. And in that situation, asking either a mini-split or a central cooling system to just dry your air without overcooling does not work. Some manufacturers have told me, 'Oh, if you have variable refrigerant flow (VRF) equipment, you don't need a dedicated dehumidifier.' But I have found that not to be true. Good luck drying something without overcooling it."

Kimberly Llewellyn, who worked with Kristof Irwin for six years at Positive Energy and is now a Performance Construction Manager with mini-split-heat-pump-maker Mitsubishi, told *JLC* that Mitsubishi is clear with builders that its cooling equipment needs help any time the space doesn't call for much sensible cooling. "In partial load conditions," she explained, "the coil is generally not running cold enough to effectively dehumidify. If you are in peak load conditions, it does a great job at removing humidity. But whenever you are at partial load conditions, then you are running at partial capacity, which means that the coil is warmer."

Although she works for an equipment supplier now, Llewellyn said, "I'm on a high-performance construction team. I still consider projects holistically. So while I am helping project teams—owners, developers, engineers—understand where HVAC fits in to the whole picture, we do have to talk about the whole picture."

That picture's not complete without dehumidification, Llewellyn said. During spring and fall in many parts of the country, she explained, "outdoor ambient conditions have absolute humidity above what we are trying to maintain inside. And when you're introducing constant ventilation loads into a house, well, then you've got this whole other load that you have to address. So dehumidification is really the only answer at this point."

"Some of the builders I talk to think that putting a dehumidifier in the house is a Band-Aid," said Therma-Stor's Nikki Krueger. "That's wrong. You've tightened up the house as much as possible, which is good; so you're bringing in fresh-air ventilation, as you should. You sized the air conditioning system according to best practices. If you need a dehumidifier, it's because you did everything right."

PIECING SOLUTIONS TOGETHER

In the commercial market, vendors have started to provide equipment that can cool air down enough to dry it out, then reheat the delivered air stream to return it to design temperatures for people in the space. But on the residential side, no single company today makes both the cooling equipment and the dehumidification gear to solve the shoulder-season humidity problem in houses.

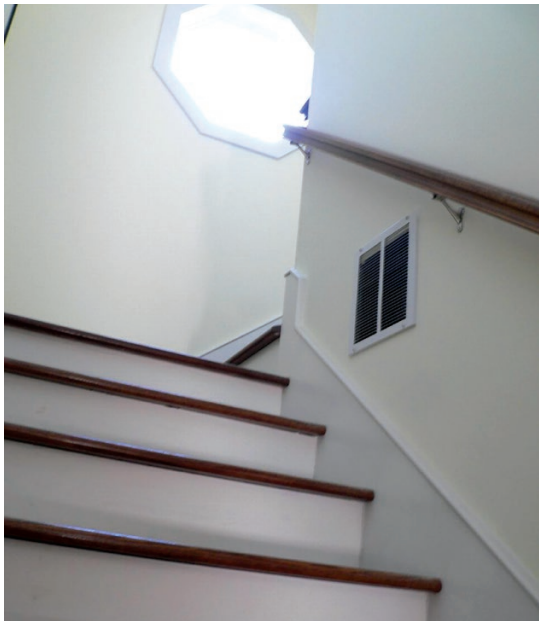
That means designers and contractors need to custom-craft solutions that mix and match equipment from different companies, and devise control systems that can effectively manage the whole shebang. A fairly widespread approach is to choose an air conditioner for cooling—either a central system or one or more mini-split heat pumps—and team up that cooling equipment with a dehumidifier for air drying and an energy recovery ventilator (ERV) for fresh air.

On some days during the hottest part of the year, the air conditioner alone may adequately control humidity as well as temperature. The ERV will also help, in any season, by passing moisture from the incoming air stream to the exhaust stream. But for many hours out of the year (especially in spring and fall), the dehumidifier will shoulder a load that the home's other equipment can't handle.

"In the high-performance market, this hybrid integrated approach using all three systems, often utilizing integrated duct systems, is common," said Mitsubishi's Llewellyn. "And with projects that are determined to be high performance, there's a fairly high tolerance for putting systems together, or having to figure it out."

North Carolina builder Tom Dugan installed this Ultra-Aire 70H in his own home. The unit is rated at 70 pints per day and 5 pints per kWh. Dugan tied the dehumidifier into his already installed fan-powered air-mixing duct, which sends air from the home's highest point down to the ground level.

Photos courtesy Positive Energy



A grille at the peak of Dugan's top-story living room draws air into the dehumidifier (top) whenever the dehumidistat activates it. An always-on air-mixing fan pushes the dried air down to a basement stairwell register (above).

Llewellyn's team at Mitsubishi communicates often with companies that manufacture ERVs or dehumidifiers and is happy to point builders and developers toward those vendors, she said.

There is no "typical" solution yet, Llewellyn said. But in a house with relatively high loads, one approach that seems to work well is to tie a dehumidifier into the ductwork for the central air conditioner, as seen on page 26. The dried air is mixed into cooled air coming out of the air conditioner's cooling coil, and sent out to the house.

But there's a hitch. When standard dehumidifiers condense moisture out of the air, they do it by taking heat out of the water vapor. That "heat of evaporation" goes back into the home's air in the form of sensible heat: That is, it raises the temperature. In a highly insulated airtight building in the South, the warm air produced by a dehumidifier can be a problem, no matter how you mix it in. So for houses with very low sensible loads, designers are now likely to choose a "split" dehumidifier, which sends heat from the indoor coil to an outdoor condenser coil and fan, using warm refrigerant. The Ultra-Aire SD12, shown on page 27, was the first split dehumidifier unit on the market; David Treleven, who worked at the time for Advanced Energy in Raleigh, N.C., installed one when he built his own Passive House. (Treleven now works for Therma-Stor.)

Architect Corey Saft built the first certified Passive House in Louisiana in 2010, equipped with a mini-split heat pump and an Ultra-Aire dehumidifier. "They said the dehumidifier would only raise the air temperature in the house 2°F," said Saft, "and that was true—on average. But it raised the outgoing air stream 10°F." When the Ultra-Aire SD12 split dehumidifier came onto the market, Saft swapped one in to the building. That took some load off the home's heat pumps, he told *JLC*. In fact, he said, the SD12 provides more than 4,000 Btu/hr of cooling—enough to carry the home's entire cooling load for much of the cooling season, without the mini-split. Saft is now designing his second Louisiana Passive House, with help from Passive House consultant John Semmelhack and with Positive Energy on the team as the HVAC designer. The home will have two ducted mini-splits, two SD12 dehumidifiers tied into the mini-split ductwork, and an ERV.

But you don't have to get that fancy. One step above the "dehumidifier in a closet" is the solution implemented by North Carolina builder Tom Dugan for his own home. Dugan's house is cooled with a ducted mini-split, but he knew that hot, humid air would tend to accumulate at the open-plan building's peak in the upstairs living room. So when he built the house, his HVAC contractor lined one stud bay in the home's elevator shaft with metal duct material and installed a fan to pull air from the home's peak down to the entry stairwell at ground level. Later, Dugan tied a dehumidifier into the air-mixing system, with a dehumidistat at the upper story's peak. A simple meter on Dugan's desk tells him the relative humidity in the living space. "We've had some really foggy cool mornings this spring," Dugan told *JLC* in April. "It's sitting right at 100% dew point and it's 60°F outside, and right now my indoor humidity is 45%. I say, OK. I like that."

Ted Cushman is a senior editor at JLC.