Return Ductwork Requirement For Airborne Pathogens

I disagree with the conclusion of June's *ASHRAE Journal* column, "ASHRAE TC 5.2 White Paper: Return Ductwork Requirement for Airborne Pathogens Through the Airstream," by John Constantinide, P.E., Member ASHRAE, and Christopher Ruch, Member ASHRAE.

I do not believe a ducted return system will in general benefit occupants. Non-ducted return systems have great advantage over ducted return systems in terms of cost, simplicity and energy efficiency.

Ducted return systems should only be used in hospitals and labs where room pressure control and return air static pressure control are important. Maintenance workers can wear respirators if they believe they are in danger entering a return air plenum.

Robin J. Rader, P.E., Member ASHRAE, Fairbanks, Alaska

The Author Responds

Thank you for your response. The column was an introduction to the associated white paper with the same title available on the ASHRAE Technical Committee 5.2 website (https://tinyurl.com/cmhwksh3).

The benefits of open ceiling plenum return systems are presented in the white paper. They are compared to multiple energy and health concerns with open ceiling plenum returns and the benefits of ducted return systems. Concerns include reduced exposure control, infiltration, reduced source control and cleaning and disinfecting.

The pandemic shined a light on the importance of all design considerations. Health and safety benefits along with energy concerns should be considered for every project. After an evaluation of concerns and benefits, the Technical Committee recommends ducted return systems in all buildings as prioritized by occupancy classification and use.

Priority 1: Medical Facilities—Institutional (Group I), Medical Office Buildings, buildings used for medical purposes, or any building that has high chance to be commandeered during a pandemic to act as a medical facility.

Priority 2: Educational Facilities (Group E).

Priority 3: Assembly Areas (Group A), Business (Group B), Factory (Group F), Mercantile (Group M), Residential (Group R).

This recommendation would include new construction and shell and core renovations and additions. Return duct retrofits should be considered for Priority 1 buildings.

Regarding hazard to maintenance workers in air plenums, the use of respirators does limit airborne particulates and contaminants from being directly breathed in by maintenance workers. As noted in the white paper, maintenance activities can agitate particles and fungal spores. Along with potential introduction to the airstream, this agitation can contaminate maintenance workers' clothing and equipment, causing potential contaminant exposure to workers once respirators are removed, and occupants outside of the plenum area. Ducted returns would reduce the presence of these particulates.

Thank you for the opportunity to share our thoughts on this recommendation.

John Constantinide, P.E., Member ASHRAE, Merritt Island, Fla.; Christopher Ruch, Member ASHRAE, Falls Church, Va.

School Pushes IAQ, Efficiency Boundaries

In the the fine article "School Pushes IAQ, Energy-Efficiency Boundaries" by Lee Harrelson, P.E., Associate Member ASHRAE; Ray Beaufait, Member ASHRAE; Brice Watson, P.E., Associate Member ASHRAE; Brian Turner, P.E., Member ASHRAE in May's *ASHRAE Journal*, the use of CO_2 scrubbers seems to be particularly helpful for improving the IAQ in schools.

The authors also mention that the innovative CO_2 scrubbers in the ventilation system reduce the outdoor air supply to reach ASHRAE Standard 62.1-2010 by reducing the ambient VOC elements and CO_2.

This method reduces energy consumption. However, harmful compounds and CO_2 are flushed back to the ambient air when the scrubber elements reach their maximum capacity. Therefore, the environmental footprint of the building is not reduced, and this flush-back method does not contribute to the global warming issue, while the same amount of CO_2 and VOC elements are still kept in the ambient air.

It would be much better to use CCS methods (carbon capture and storage for use). More important, the scrubbing approach may be admissible in normal times, which does not necessarily apply for COVID-19 and like viral pandemics, especially in schools.

To reduce the indoor spread of viral infections, ASHRAE has already put limits on a minimum 100% fresh air supply, and this limit may void the energy savings offered by scrubbing by reducing the fresh air supply. See, for example, ASHRAE Epidemic Task Force Schools & Universities, Updated 5-14-2021 (https://tinyurl.com/4fafdyx3).

Especially on the verge of reopening schools, the latest ASHRAE recommendations should be checked while COVID-19 and its variants still lurk in the buildings and affect humans.

The second issue that needs more clarification is the COP of the ground-source heat pumps used in this school. Data about COP values for heating and cooling operations are not provided. The missing data raise the question of whether these heat pumps indeed contribute to decarbonization in a holistic view, even if the electricity for driving the heat pumps is from renewable energy sources, which in this case is the solar PV systems.

Of course, heat pumps are energy efficient according to the First Law of Thermodynamics as long as the COP (including electric power demand of the circulation pumps between the heat pump and the geothermal wells) is greater than one. However, the First Law does not guarantee that the heat pump system is environmentally useful for reducing the global warming potential in its proportionate capacity by reducing CO_2 emissions.

The Second Law differentiates that heat pumps consume electricity with a unit of useful work potential of about 0.95 kW/kW and supply (in heating) or extract heat (in cooling), which have much lower useful energy potential, aka exergy.

For example, if in the heating mode a heat pump provides hydronic heat to the building at T_{sup} of 323 K (50°C, 581.4°R), and returns at T_{ret} of 308 K (35°C, 554.4°R), the maximum useful work obtained is 0.046 kW/kW according to the ideal Carnot Cycle.

The difference between the two useful work potentials of electricity used and heat supplied translates to nearly avoidable CO_2 emissions (by increasing COP), even if the on-site PV systems satisfy all the electricity demand of the heat pumps and their ancillaries.

The authors should have provided necessary technical and operational data to arrive at more conclusive results. For example, the COP of the heat pumps they use in the heating mode should satisfy the following simple condition:

COP > 0.95 divided by $(1 - T_{ret}/T_{sup})$

Birol Kilkis, Ph.D. Fellow/Life Member ASHRAE, Ankara, Turkey

The Author Responds

As Dr. Kilkis mentions, the CO_2 scrubbers will eventually reach maximum capacity in a daily operation. In this application, several units were installed to provide the school a full day of operation at the minimum before reaching this capacity.

When maximum capacity is met, the scrubber units close dampers to the recirculation airstream and begin a cleaning cycle in which the excess CO_2 and compounds are vented to the atmosphere. In this approach, these compounds are not reintroduced into the school airstream while the scrubbers are at max capacity. Carbon capture and storage (CCS) for use would be ideal for all captured carbon. However, CCS is currently only viable at an industrial scale and is not financially feasible for a school of this size.

As stated in the article, the ventilation equipment, ductwork and airflow for the school were not reduced based on the Standard 62.1-2010 IAQ Procedure (IAQP) method. Instead, the design is based on the Ventilation Rate Procedure (VRP), which means the ventilation system does not have reduced capacity or airflow and thus operates with the code minimum ventilation, even if the CO_2 scrubbers are deactivated for any reason.

The COPs for the submitted water-to-air heat pumps vary based on their capacity. Most units are between 2 tons and 6 tons in size, with a minimum submitted COP of 5.32 to a maximum of 6.44. Comparing the efficiency of these units to alternate HVAC systems that use energy modeling and data collecting from the existing installation determined the geothermal heat pump system was the most efficient system attainable within the project's budget. These efficiencies allowed the low energy use intensities (EUIs) listed in the article to achieve Zero Energy certification with the electricity produced by the PV panels.

The design team's primary goal was to reduce the continued energy consumption of the completed school to reduce electricity costs and provide a building with a net positive production of energy yearly. Geothermal heat pumps with decoupled DOAS for ventilation is the most efficient system that met the project's design criteria.

This overall reduction in energy and removal of combustion from the site helps reduce the building's lifetime operational carbon footprint by reducing the total amount of energy used from the power grid. The best way to reduce operational carbon emission is to not consume power to begin with, thus the use of one of the most efficient HVAC systems available.

Lee Harrelson, P.E., Associate Member ASHRAE, Richmond, Va.; Ray Beaufait, Member ASHRAE; Brice Watson, P.E., Associate Member ASHRAE; Brian Turner, P.E., Member ASHRAE, Louisville, Ky.

Modeled Energy Vs. Actual Performance

I strongly disagree with the conclusion of "Modeled Energy vs. Actual Performance: Does the Lab Building Follow the Model?" by Kelley Cramm, P.E., Member ASHRAE, in the July issue of *ASHRAE Journal*.

Cramm states, "Many factors make predicting actual laboratory energy performance difficult, if not impossible." This reads like a denouncement of energy models as viable predictive tools. It stems from a false dilemma. We act as if accurately predicting energy is a yes/no question. It is not; it is a continuum.

There are better questions than yes or no. How accurately can a model predict energy? Which energy parts can a model predict with higher or lower accuracy? How accurately can a model predict cooling energy, and under what conditions? How can we improve predictive accuracy? How accurately can a model predict cooling energy, given outdoor temperature?

Weather variation itself should not be insurmountable. Figure 1 and Figure 2 are *reductio ad absurdum*. To show a 20% to 40% spread in cooling and heating energy, Cramm compares a year full of record low temperatures to a year full of record high temperatures. Both years are absurd. The point is valid, albeit to a much lesser degree. A model's prediction of cooling energy won't be dead-on accurate; we should expect a range. I think 20% to 40% is too broad; a competent professional should be able to do better than that. (And, If the variance is based on weather, it can be stated as a sensitivity, not an error.)

I challenge Cramm to find fault with the following logic. At a given outdoor temperature and time of day, a model can predict cooling energy to about 15%. Once built, the owner can validate cooling energy, hour by hour, comparing conditions to the model. If the measured cooling energy doesn't fall in the control range predicted by the model for at least 80% of observed hours, then either the model or the installation is a failure.

Used correctly, a model should be categorically invaluable during commissioning. Think about it: if the model says chiller energy should be 250 kW at 10 a.m. with it 80 degrees outside, and, during commissioning, we measure 750 kW at those conditions, something has clearly gone wrong! Heck, if it's 300 kW, something has gone wrong, and everyone should be working on fixing it.

Likewise, occupant behavior also shouldn't kill viable accuracy. Of course, density, activity and equipment diversities are variables, as Cramm rightly points out. But they don't vary wildly or unpredictably. Figure 4 shows variability of about 20%. Moreover, in Figure 3, the plug loads are 23% of the overall energy signature. So, even if they vary by 20%, the overall impact is only about 5%.

As an energy professional, my advice is to state the accuracy of models. For example, instead of telling a client cooling energy will be 231,254.7 kWh/yr, tell them it will be between 210,000 kWh/yr and 265,000 kWh/yr. Tell them what factors affect the range, and by how much. No investment should be made without knowing (and, frankly, beating) the margin of error on the model.

Concluding energy models are poor predictive tools is self-defeating. As a buyer, if you tell me a model "… cannot be used to accurately predict future use or cost" that literally makes it sans value. Also, if a model is a poor predictive tool, logically, it cannot be "an effective design tool when used for comparative analysis." What's the use of comparing two possibly not credible models to each other? Only a comparison between credible models can be valuable.

Rather than writing a column complaining how energy models are poor predictive tools, I wish Cramm had written one telling us how to make and use them better.

Travis R. English, P.E., Member ASHRAE, Fountain Valley, Calif.

The Author Responds

I want to thank Travis English, P.E., for his thoughtful response to my column on energy modeling for laboratories being used to predict costs. I want to be clear that my column is not intended to be a denouncement of energy modeling. I believe energy modeling is an important tool that can be used to compare alternative systems and inform system analysis.

I agree with Mr. English's position that predicting energy is a continuum and not binary.

Weather is not consistent over time. The example weather charts I used were selected at random to illustrate the differences in observed temperatures in a given year versus "normal" and record temperatures. The point I attempted to make is that when you have 100% outside air, energy consumption is highly dependent on weather, which can vary dramatically from one year to the next. The real weather will differ from the typical meteorological year (TMY) weather data used in building simulation. This weather sensitivity will affect the performance of the model.

I agree with Mr. English's statement that a model can predict cooling energy at a given outdoor temperature and that it can be a valuable tool during commissioning. I also agree that putting a tolerance on the expected accuracy of a model is helpful. However, in my experience, I have encountered owners who expect a model to provide a highly accurate prediction of the energy bills for a building. This forward-looking expectation is what I am challenging in my column. There are many factors well outside of the modeler's control. The factors outlined should be communicated to set building owners' expectations.

Kelley Cramm, P.E., Member ASHRAE, Lenexa, Kan.

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