"Using Smart and Healthy Ventilation to Improve Your Building's Energy Efficiency"

By Gordon Sharp of Aircuity

As the idea of green buildings, energy retrofits and using sustainable materials has hit mainstream America and becomes a part of any construction discussion, property owners have explored several different ways to make their buildings more green—be it by the choice of materials used, the way things are demoed, or by embracing technology meant to regulate the energy usage in the building itself. Recent research has pointed to buildings being responsible for roughly 40% of global energy consumption, underscoring the value of optimizing energy expenditures in commercial buildings for both the savings and the reduction of environmental impact. However, what is beginning to emerge in the burgeoning green building industry is that some solutions and practices are greener than others. One example of an area garnering a lot of attention is building ventilation.

Ventilating At Pre-Set Values Increases Energy Expenditures

Typical design practices predominantly in use today hold that the way to properly ventilate a building is to fix the amount of outside fresh air being delivered within a building at the design or peak occupancy level of a given area without regard for how the actual occupancy will vary dramatically throughout the day.

This pre-set value is usually determined by multiplying the expected or design value for the number of building occupants by a recommended amount of outside air, expressed as cubic feet per minute (CFM), per occupant and then adding an amount of outside air related to the square footage of the area= ventilated. The result of this calculation is a recommended amount of outside air that is generally in the range of 15 to 20 CFM per person for an office environment (although it can be much higher for certain more critical environment spaces such as operating rooms or research laboratories).

The problem with this conventional approach lies in fact that by pulling in outside air based on the design or peak values —rather than the fluctuating actual occupancy levels of the building which are always less than peak —buildings are generally over ventilated. And with the cost to heat or cool outside air and then push it throughout the building, over-ventilation translates to potentially significant energy waste.

Compounding the problem – and the energy waste – is the customary response of further increases in the level of outside air in response to any air quality complaints by building occupants, regardless of whether such additional ventilation is warranted.

Smart and Healthy Ventilation

The smart solution for proper control of a building's ventilation is to measure the changing levels of occupancy within the building and then vary the level of outside air brought in to the building in response to these changes in occupancy throughout the day. This approach, known in the industry as demand control ventilation (DCV), allows building owners to save energy by maintaining a fresh air ventilation setpoint equal to the difference between the indoor and outdoor levels of carbon dioxide.

With DCV, the volume of outside air brought in to the building increases and decreases as the indoor levels of carbon dioxide generated by people within the building rises above or falls below the ambient outdoor levels of carbon dioxide.

In the past this DCV approach has been implemented by deploying individual carbon dioxide sensors throughout a building space and integrating the individual CO_2 sensor readings into the building control system. When the carbon dioxide level is lower than a pre-set value, outside air is automatically reduced until the building ventilation requirement is met. Although this approach has been discussed and occasionally used for many years it is not necessarily a "healthy" approach to ventilation and these previous implementations have worked poorly causing many demand control ventilation installations to be abandoned.

Requirements for Effective Implementation of Smart and Healthy DCV

In order to successfully implement DCV at your facility, there are three issues that must be addressed:

1. The accuracy of your carbon dioxide sensing;
2. The sensing and control of humidity and non-human pollutants (such as volatile organic compounds); and
3. The scheduled calibration and maintenance of the sensors.

Sensor Accuracy

The main concern in a DCV system is the avoidance of inaccurate carbon dioxide or contaminant readings which could throw the whole system off and waste energy. Independent industry research by both the Lawrence Berkeley National Labs (LBNL) and the Iowa Energy Center has shown that individual CO_2 sensors, even those with automatic calibration software have very large accuracy drift even over short periods of time. In fact the LBNL study of actual field mounted sensors showed an average accuracy drift across all the evaluated sensors that if they were used in a DCV approach would have erroneously increased (not decreased) ventilation in total by over 180%! This level of inaccuracy not only would have offset any expected energy savings, it would have resulted in an enormous energy penalty or waste.

Additionally, to be successful, DCV systems also need sensors to accurately measure both indoor and outdoor carbon dioxide levels (as well as other contaminants) since proper control of ventilation is based on the increase of carbon dioxide levels from people (a differential measurement) vs. an absolute level measurement of CO_2. Assuming a fixed outdoor level and measuring only indoor concentrations leads to problems since outdoor levels can vary considerably due to, for example, to carbon dioxide emissions from sources such as traffic or flue exhaust, variations in CO_2 absorption from trees and plants, and even re-entrainment from the air handler's own exhaust outlet or other nearby air handlers' exhaust outlets. Using two or more different CO_2 sensors to measure indoor and outdoor levels can lead to the more than doubling of the potential error of the system in terms of the sensed differential CO_2 or other sensed parameter.

One proven solution to the ever present accuracy and drift problems of using sensors is to use a multiplexed sensing system, where packets of air samples are routed from up to 20 or 30 different locations sequentially, in a multiplexed fashion, to a shared set of sensors. This unique approach of using one set of sensors to make multiple indoor and outdoor measurements makes true differential measurements possible, and reduces or eliminates accuracy concerns. Since the same sensor is used for both indoor and outdoor carbon dioxide and other contaminant measurements nearly simultaneously, any sensor errors will be the same from both measurements and will thus cancel out, enabling a very accurate differential measurement. Additionally, since only one sensor is required for many locations, more accurate industrial or lab grade sensors can be used for even more precise measurements—and due to the limited number of sensors deployed, and their central location, calibration expense is minimized.

Non-Human Pollutants

If non-human pollutants or humidity are not accounted for, a DCV system that is controlling on CO2 only, could reduce ventilation levels to a point where building contaminant concentrations—such as cleaning materials, out-gassing from construction materials or new furnishings or even dust or food spills—increase and occupants complain. This would occur in areas where these contaminants are present, yet the occupancy level is low. In response to such complaints building managers would likely immediately increase the amount of outside air by overriding the DCV control and thereby negate any energy management benefits of the DCV system. To prevent this from happening, DCV implementations need to respond not only to changes in carbon dioxide levels, but also to the real-time levels of multiple contaminants in an area or space. This multiparameter
DCV approach enables the system to not only save energy when occupancy levels are low and the air is "clean" but also to increase the fresh air into the building when needed to dilute contaminants. This delivers healthier ventilation to the building and its occupants.

Calibration and Maintenance

DCV systems depend on accurate, reliable sensors to properly control building ventilation, yet the cost of checking sensors every six months and recalibrating them as needed is significant. Many sensors offer auto-calibration and claim to need very little calibration, which may be acceptable for applications other than DCV control —but extensive independent testing as described above for buildings potentially employing a DCV system has shown that much more frequent recalibration is needed to ensure accurate differential readings required to save energy. These uncorrected sensor errors can be costly and more than eliminate the expected energy savings. Twice a year sensor checking and recalibration is recommended by recent industry standards and is simply necessary and appropriate to ensure the achievement of desired energy savings.

Summary

Healthy DCV properly implemented with the right technology approach and appropriate sensor maintenance is a smart ventilation solution that can maximize a building owner's energy savings while still maintaining excellent indoor environmental quality for occupants. Maintaining lower levels of outdoor air until increased levels of either non-human pollutants or carbon dioxide are sensed is a strong approach to establishing an indoor environment that is both healthy and operating at optimal energy efficiency.

About the Author
Gordon P. Sharp has over twenty five years of wide-ranging entrepreneurial experience and more than 25 U.S. patents to his name in the fields of energy efficiency and laboratory controls and currently serves as the Chairman for smart airside efficiency company Aircuity. Gordon served as the president, CEO and founder of Phoenix Controls, guiding it to become a world leader in laboratory airflow controls before being acquired by Honeywell in 1998. In 2000, Mr. Sharp founded Aircuity, which was spun out of Honeywell and Phoenix Controls. Mr. Sharp is a graduate of MIT with bachelors and masters degrees in electrical engineering. He is a member

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