Demand Control Ventilation

By Kurt W. Roth, Ph.D., Associate Member ASHRAE, **John Dieckmann, P.E.,** Member ASHRAE,
and **James Brodrick, Ph.D.,** Member ASHRAE

This is the fifth article covering new energy-saving technologies evaluated in a recent U.S. Department of Energy report available at www.eren.doe.gov/buildings/documents.

The 2001 version of ANSI/ASHRAE Standard 62, *Ventilation for Acceptable Indoor Air Quality,* offers two options for maintaining adequate ventilation: the ventilation rate procedure and the indoor air quality (IAQ) procedure. Building codes throughout the United States are in the process of adopting the standard.

The ventilation rate procedure uses the traditional prescriptive method, i.e., a minimum quantity of *cfm* per person based on maximum occupancy. In contrast, the IAQ procedure allows designers to vary the outdoor ventilation rate (from 0% to 100% of the design OA) if the carbon dioxide (CO_2) level remains below a recommended level, i.e., 700 ppm greater than outdoor CO_2 levels. In this case, CO_2 levels serve as a proxy for building occupancy and the rate of human-generated indoor pollutants, e.g., odors.

The addition of the IAQ procedure to the standard allows for demand control ventilation (DCV) in buildings. In the same way that thermostats regulate the amount of cooling or heating supplied to a building space, CO_2 sensors measure and regulate the amount of OA supplied to the space for buildings that use a DCV strategy.

Since its creation, the IAQ procedure has sparked controversy. Although CO_2 levels tend to correlate well with human occupancy and human-generated pollutants, they do not reflect the buildup of pollutants not related to occupancy, such as fumes from copiers and printers; out-gassing from building materials, carpets and furniture; and vapors from cleaning supplies. Whereas the ventilation rate procedure "is deemed to provide acceptable indoor air quality, ipso facto," the IAQ procedure "provides a direct solution by restricting the concentration of all known contaminants of concern to some specified acceptable levels."[1]

Consequently, building operators using the IAQ procedure need to ensure that *all* potential contaminants remain at safe levels. An addendum to Standard 62 (62*n*) is under review that specifies ventilation rates as a function of both floor space and occupancy to address nonhuman indoor air pollutant sources.

Energy Savings Potential

If a DCV strategy calls for less outdoor air over the course of the heating and cooling seasons than does a prescriptive ventilation strategy, then the annual energy required to heat or cool the OA decreases. In addition, lower OA requirements decrease the fan energy expended to introduce and expel the air from the building. It is widely believed that actual occupancy levels in U.S. buildings are significantly lower than the design occupancy levels that conventional ventilation systems are set to handle. Field experience indicates that actual occupancy levels are at least 25% to 30% lower and perhaps as much as 60% to 75% lower in some buildings than design levels.[2,3] The ultimate energy savings in a given application depend on the actual (vs. design) occupancy level patterns, as well as building type and climate.[2,4,5] Available data suggest that DCV reduces ventilation, heating, and cooling loads by 10% to 30%.[4] Buildings and spaces with large swings in occupancy, e.g., movie theatres and conference rooms, tend to realize the largest savings. On a national scale, DCV has an estimated maximum energy savings potential of between 0.4 and 0.5 quads.

DCV reduces peak electricity demand when actual occupancy levels fall below design occupancy levels during peak demand periods. Lower levels of OA translate into decreased cooling (and, to a lesser extent, ventilation) loads and, therefore, air-conditioning power draw. In some cases, DCV may allow building operators to close fresh air dampers for short periods during the hottest hours in the summer (typically coinciding with peak electric load). In general, peak reductions vary from building to building, depending on occupancy patterns. Consequently, the average peak demand reduction likely will mirror the cooling energy savings potential.

Market Factors

The CO_2 sensors required to implement DCV cost approximately \$400 to \$500 a piece (installed), with typically one sensor installed per zone (~2,000 to 3,000 ft^2 [~185 to 280 m^2]). Additional expenses likely will be required to integrate the sensors into building controls.[4,6] In practice, DCV has reduced annual energy costs by \$0.05 to \$1 per square foot (\$0.54 to \$10.75 per m^2), with large variations reflecting the range in building types studied. On average, DCV appears to have a two to three year payback period, which should make it attractive for many applications.

Currently, most buildings do not use DCV because of concerns about nonhuman indoor pollutants mentioned previously. DCV is a new concept for standards, and local building codes have been slow to adopt it. Once adopted, additional permitting and verification often is required. Contractors and designers have concerns about liability for systems that do not meet IAQ standards, when designed to the IAQ procedure. This could occur because of improper CO_2 sensor installation or sensor failure, or because one of the many non-human indoor pollutants rises above acceptable levels. In contrast, the prescriptive standard offers less room for liability because it is deemed to provide acceptable IAQ.[1] Other issues discouraging widespread DCV adoption include the need for savvy system installation and operational personnel, which cost more and are hard to find; CO_2 sensor maintenance issues; and the limited number of control systems that support CO_2 sensor input for ventilation control.

Clearly, there must be a substantial reduction in the real and perceived risks of implementing the IAQ procedure for DCV to realize its considerable energy savings potential.

References

1. ANSI/ASHRAE Standard 62-2001, *Ventilation for Acceptable Indoor Air Quality*.
2. Brandemuehl, M.J. and J.E. Braun. 1999. “The impact of demand-controlled and economizer ventilation strategies on energy use in buildings.” *ASHRAE Transactions* 105(2).
3. Roth, K.W., et al. 2002. “Energy consumption characteristics of commercial building hvac systems – volume III: energy savings potential.” Final Report by TIAX LLC to U.S. Department of Energy, Office of Building Technology, State and Community Programs.
4. Schell, M., S.C. Turner, and R.O. Shim. 1998. “Application of CO_2-based demand-controlled ventilation using ASHRAE Standard 62: optimizing energy use and ventilation.” *ASHRAE Transactions* 104(2):1213–1225.
5. Schell, M. and D. Int-Hout. 2001. “Demand control ventilation using CO_2.” *ASHRAE Journal* 43(2):18–29.
6. Turk, B.H., et al. 1987. “Indoor air quality and ventilation measurements in 38 Pacific Northwest commercial buildings.” Lawrence Berkeley National Laboratory Report LBL-22315.

Kurt W. Roth, Ph.D., is a project manager at the Appliance and Building Technology sector of TIAX, Cambridge, Mass. John Dieckmann, P.E., is a principal at the HVAC and Refrigeration Technology sector of TIAX. James Brodrick, Ph.D., is a project manager, Building Technologies Program, U.S. Department of Energy, Washington, D.C.

◆