Displacement ventilation shows promise for Minnesota commercial buildings

Sustainable Engineering Group (SEG) has just completed a CARD project which evaluated the energy conservation potential of displacement ventilation (DV) in Minnesota commercial buildings and identified possible barriers to its market adoption. DV is a technology that provides ventilation air directly to occupant breathing zones via floor level diffusers (Figure 1). When cool, low-velocity air enters an occupied zone, it flows horizontally until a warm object causes a natural upward air flow. As the warmed air rises it carries pollutants with it through a ceiling level outlet

Figure 1: Diffuser for the DV system is shown in the lower part of the column in this photograph (photo courtesy of SEG).

The primary benefits of DV are direct, efficient delivery of clean air to occupants and reductions in fan energy due to low discharge velocities. In regions that exhibit mild summers such as the upper Midwest, DV can also offset a significant portion of the cooling load by virtue of its comparatively low supply air temperatures. Simulations of this technology predict significant energy savings resulting from its use in commercial buildings.[1] Although DV is widely utilized in some parts of the world, it has not yet fully penetrated the U.S. market.

To gather information for the report, SEG conducted owner surveys on 26 Minnesota commercial buildings with DV systems; for 24 of these sites, they were also able to analyze energy use. In addition, SEG conducted market surveys among a broad subset of the Minnesota buildings' community in order to evaluate current attitudes toward DV. SEG also estimated the first cost increase for DV systems and analyzed how savings varied monthly and seasonally.

Figure 2: An example of one of the Minnesota buildings with DV that was investigated (photo courtesy of SEG).

One finding from the study was that DV exhibited significant variability in the amount of energy savings achieved. The bulk of this variability could be traced to a particular subset of the sample that was designed and operated by the same entities. This suggests that design and/or operation play a major role in achievement of savings with this technology. The remainder of the sample exhibited whole building energy use intensity (EUI) savings of 16 ± 4%. Monthly analysis indicates that the greatest savings are achieved during summer months, likely due to cooling benefits associated with DV's low supply air temperatures.

Estimated utility cost savings resulting from the use of DV are \$0.32 ± \$0.08/ft^2/yr. Added first costs associated with this technology range from \$0-2/ft^2. Using the median added cost (\$1/ft^2) results in payback timescales of 2 to 4 years, an estimate generally consistent with existing predictions in the literature.[2]

Overall, owners tend to be pleased with DV technology, and a majority (86%) would choose the technology again. The most frequently cited reason for choosing DV is improved air quality, followed by energy savings and occupant comfort. Maintenance concerns were the main source of any negative perceptions toward the technology among owners; however, these concerns were voiced by only 28% of participants.

Although Minnesota building professionals (architects, engineers, etc.) had minimal exposure to DV technology, they tended to exhibit positive attitudes toward it. A lack of market penetration and general unfamiliarity with the technology are viewed as its greatest barriers. Lack of owner exposure to DV is a particularly important challenge to its market success, and this persists despite the fact that current owners tend to be very pleased with the technology's performance in their buildings.

The final report, "The Energy Conservation Potential of Displacement Ventilation Technology in Minnesota Climate Conditions" (pdf), provides a thorough characterization of the performance potential and market status of DV technology in Minnesota. For further information, contact project manager Mark Garofano or CARD program administrator Mary Sue Lobenstein.

References

[1] Bourassa, N.J., Haves, P. and Huang, Y.J., “Simulation-Based Appraisal of Nonresidential Low Energy Cooling Systems in California-Phase I,” Report to the California Energy Commission, 2002; Holland D. and Livchak A., “Improving indoor air quality in schools by utilizing displacement ventilation system,” Proceedings of Indoor Air, 2002; and Chen, Q., Glicksman, L.R., Yuan, X., Hu, S., Hu, Y., and Yang, X., "Performance evaluation and development of design guidelines for displacement ventilation," Final Report for ASHRAE RP-949, 1999.

[2] Hicks, A., Morner, S., Mueller, E., Evans, J., DeRocher, A., Von Bank, K. and Campbell, J., “Evaluation of Advanced HVAC Technologies,” Wisconsin Focus on Energy, Environmental and Economic Research and Development Program, 2014; Hamilton, S.D., Roth, K.W. and Broderick, J., “Displacement Ventilation,” ASHRAE Journal, September 2004; and Roth, K.W., Westphalen, D., Dieckmann, J., Hamilton, S.D. and Goetzler, W., “Energy Consumption Characteristics of Commercial Building HVAC Systems Volume III: Energy Savings Potential”, Prepared for DOE Building Technologies Program, July 2002.