Measure Information Template –

Displacement Ventilation

2008 California Building Energy Efficiency Standards

PIER Program - EnergySoft, LLC February 2, 2006

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Overview

Description	Displacement Ventilation (DV), a space conditioning technology in use in Europe since the 1970's has the ability to reduce energy usage in buildings due to a number of energy saving strategies not found in conventional overhead mixing systems. Research and development of modeling procedures done by the CEC PIER group are presented to facilitate the inclusion of DV into the Standards for energy analysis purposes.
Type of Change	This measure proposal is a Compliance Options proposal for modeling of Nonresidential buildings in the standards. Just as the Nonresidential ACM manual now includes optional modeling for underfloor air distribution systems, it is proposed to incorporate the DV systems in to modeling procedures.
Energy Benefits	The fundamental principle involved in a DV system is to supply significantly warmer supply air temperatures during cooling mode, typically 63°F to 68°F. With the use of higher supply air temperatures comes the ability to operate in economizer mode many more hours each year. When producing the higher supply air temperatures, chilled water systems have the ability to operate at much higher chilled water temperatures, thus resulting in a significant increase in the chiller efficiency when producing chilled water. In addition, for systems that will be requiring reheat, additional heating and cooling energy is saved since they will be reheating air that is cooled to only 65°F versus a conventional system that has cooled the air to 55°F. By not mixing the air in the room, the DV system results in more of a stratification effect. Thus, much of the heat in the space will rise towards the ceiling, where it will be exhausted by the high return air register. Thus, a portion of the cooling load in the space, including occupant heat gain, lighting and equipment, never appears as a cooling load. Overall, DV systems have the potential to save from 30-50% of the cooling energy based upon demonstrated savings in the case study buildings in the reports. With a carefully designed DV system, the potential increase in fan energy usage associated with moving larger volumes of air can be mitigated. By taking advantage of the reduction in space loads from the use of the DV system, there is a downsizing potential for the cooling system. Much of the potential energy increase from the fan system will be recouped when this reduction is factored into the system design and fan selection.
Non-Energy Benefits	Because DV does not mix air like a conventional overhead system, there is a significant improvement in indoor air quality. By not mixing pollutants, and circulating them around the room, school classrooms in particular can benefit from this type of system. In addition, because this system is very low velocity, there are acoustic benefits associated with this type of system. A third benefit is the ability to downsize the mechanical system. Since a large portion of heat gain in the space is simply exhausted out the return air, this heat gain never actually shows up as a load on the mechanical system. This results in a smaller, more efficient system.

Environmental Impact	The only environmental impacts associated with the use of this system are positive benefits such as IAQ.
Technology Measures	Displacement Ventilation does not require the use of any particular manufacturer's equipment, nor any special technology that has not been available for years. It is simply the application of currently available cooling systems, designed in a fashion that utilizes the benefits of a stratified, non-mixing cooling system. It is anticipated that the measure life will be improved with this type of system, since it will have higher hours of operation in economizer mode, and a lot less hours of operation of the cooling system.
Performance Verification	Since this is a nonresidential measure recommendation, it is expected that the new Certificate of Acceptance (COA) forms will encompass the performance verification of the system in the field. Currently, the MECH-2-A, MECH-3-A and MECH-4-A encompass testing procedures that will cover the mechanical system verification necessary for this type of system.
Cost Effectiveness	Not a lot of data is available on the cost effectiveness of this type of system, since the use of DV in the United States is fairly new. However, several California pilot projects have demonstrated significant energy savings, with only a minor increase in overall system design cost. San Diego Unified School District is embarking on an evaluation project for DV technology in which five campuses will be used for sample installations of the technology.
Analysis Tools	The current reference method, DOE-2.1E, as well as derivatives such as DOE-2.2 are not well suited to modeling these types of systems. Simplifications can be made in the modeling to approximate the energy benefits, however, these approximations will underestimate the true energy savings of this system. Newer programs such as EnergyPlus have been enhanced through work by the PIER group to more accurately represent the performance of the DV systems. However, since EnergyPlus is not scheduled to be implemented as the reference method in the 2008 Standards, this measure template has been written in a more general format to encompass the current modeling tools, as well as future products like EnergyPlus.
Relationship to Other Measures	No other measures are impacted by this compliance option.

Methodology

This measure change proposal does not propose to make any changes to the standard system comparison flowchart for this system. Instead, it proposes to include an additional optional system type in Section 3.3.5 of the Nonresidential ACM manual. Based upon modeling procedures developed by the PIER team and outlined in the report, this measure change proposes that additional language be included in the ACM manual to allow the modeling of these systems. However, it should be noted that different software tool vendors may approach this modeling issue from a different perspective, as outlined in the materials. Therefore, rather than describing the more detailed

EnergyPlus modeling that has been developed, which would preclude the use of the simplified models, this template provides latitude for modeling with the tools currently in the marketplace.

Analysis and Results

Several examples of DV system have been completed recently. The Blue Valley North High School in Overland Park Kansas is one example of an application to classroom cooling. In this case, DV was applied as a retrofit. Despite the need to increase the ventilation relative to the older system to meet newer codes, the new DV system still showed a 20% electricity savings on the project.

Another example of a DV system installed north of Sand Diego, in Cardiff, is the Cardiff Public Library project. Designed to take advantage of the cool, Oceanside location, this system relies on a 17.7 ton VAV system, and delivers air between 62°F to 67°F.

Recommendations

This is proposed as a compliance option, so only changes to the Nonresidential ACM manual are proposed.

Material for Compliance Manuals

In Chapter 2, it is suggested that the supply air temperatures for conventional systems be fixed at 55 degrees. In tables N2-11 through N2-14, the following would be changed:

Min Supply Temp: ~~50 ≤ T ≤ 60 DEFAULT:~~ 55

In Chapter 3 of the Nonresidential ACM Manual under optional systems the following language is suggested based upon the referenced studies:

3.3.16 Displacement Ventilation Systems.

Description: An HVAC system, usually using chilled water coils, provides air (typically 63°F to 68°F) to a space at very low velocities, delivered close to the floor. Air is exhausted from the space near the ceiling, and due to the low velocity of air delivered, there is a stratification of air in the space. Although this system uses warmer supply air temperatures it only has about 20% higher air delivery volume compared to a conventional overhead system as it provides displacement of some of the thermal loads.

The ACM shall automatically assign the portion of heat gain from occupants, lighting and equipment to the plenum zone, or some other zone defined to represent the stratification effect of the DV system. Default assignment fractions for the portion of heat to the space versus the portion to the plenum shall be as follows:

Load Component	Percent to Space	Percent to Plenum
People	67%	33%
Lights	50%	50%
Equipment	50%	50%

The ACM shall allow the use of a higher supply air temperature, as well as the application of supply temperature reset by either demand or outdoor dry-bulb temperature. Additionally, the ACM may also optionally accommodate higher chilled water temperatures on systems that utilized chilled water coils.

The ACM shall make an entry in the special features and remarks section of the PERF-1 report noting the use of a displacement ventilation system.

DOE Keyword:	LIGHTING-W/SQFT EQUIPMENT-W/SQFT AREA/PERSON MIN-SUPPLY-T CHILL-WTR-T
Input Type:	Default
Tradeoffs:	Yes
Modeling Rules for Proposed Design:	The ACM shall model all optional displacement ventilation system features as input by the user according to the construction documents for the building.
Modeling Rules for Standard Design (New):	The ACM shall model the standard design according to the requirements of the Required Systems and Plant Capabilities.
Modeling Rules for Standard Design (Existing Unchanged & Altered Existing):	ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

Bibliography and Other Research

Information for this measure template has been taken from the PIER research project number 500-03-097-A9 report and the Energy Design Resource work. This PIER report is available from the California Energy Commission's PIER group as an Adobe Acrobat file, and includes the detailed background and research related to this measure template proposal.

One PIER report which is almost 8 MB is available at:

http://www.energy.ca.gov/reports/2003-11-20_500-03-097F-A09.PDF

An additional PIER report which documents the modeling is available at:

http://www.energy.ca.gov/reports/2003-11-20_500-03-097F-A07.PDF

In addition, work done for the Energy Design Resources (EDR) group was also the basis of the change proposal. The EDR report which includes case studies is available at the following links:

http://www.energydesignresources.com/docs/db-05-displacementventilation.pdf

An additional report produced by the EDR group which describes similar modeling techniques is available at:

http://www.energydesignresources.com/docs/hg-underfloor.pdf