Measure Information Template –

Natural Ventilation for Cooling

2008 California Building Energy Efficiency Standards

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CONTENTS

Overview

Description	In recent years, much interest has been focused on environmentally friendly buildings. As green building standards such as LEED (Leadership in Energy and Environmental Design) and GGHC (Green Guidelines for Health Care) have become more popular, there has been a push to utilize naturally ventilated buildings instead of using traditional forced air cooling systems. Clearly, the energy savings potential for this type of approach to cooling a building is substantial; however, one obstacle to this approach has been a lack of recognition by the Title 24 energy standards for this design strategy. Recently, the PIER group has completed a number of research projects related to low energy cooling of buildings, and one in particular focuses on algorithmic enhancements to the EnergyPlus energy modeling software to allow modeling of natural ventilation. This measure template proposes modifications to the Nonresidential ACM manual that will provide some level of recognition in the modeling tools for a naturally ventilated building.
Type of Change	This change template is proposed as a modeling change to the Title 24 Standard Building. It is not proposed that natural ventilation be considered a compliance option, since we do not have enough sophistication in the current tools to model the thermal interactions that are associated with the natural ventilation modeling described in the PIER study. Once EnergyPlus becomes the reference method, it would be suggested that a compliance option be developed that does recognize the sophistication contained in the modeling as referenced in the PIER report.
Energy Benefits	In the past 20 or 30 years, there has been a significant move towards air conditioning buildings in coastal climates. What used to be considered a luxury, is now the norm in these areas. Yet, the potential for using natural ventilation as a strategy still remains. As green building compliance becomes a criteria for many building owners, designers are seeking ways to reduce energy usage, particularly cooling energy. Many recent examples of naturally ventilated buildings in coastal areas of California have demonstrated massive energy savings; one strategy contributing to the savings is natural ventilation. Since cooling and fan power can consume more than 30% of the building energy usage, and the majority of this energy is consumed during peak conditions, the savings potentials are huge.
Non-Energy Benefits	When design properly, naturally ventilated buildings can provide a much more pleasant working environment for the occupants. Given occupants individual control over their operable windows, and hence their climate has been shown to be much more desirable than simply pumping a building full of conditioned air. Naturally ventilated buildings will have improved indoor air quality, since the building will be totally reliant upon outside air. By eliminating the cooling system, we eliminate the maintenance associated with it, and the harmful refrigerants used within the cooling system.
Environmental Impact	By encouraging the use of natural ventilation for cooling in buildings the state will realize on positive environmental benefits.

Technology Measures	Measure Availability and Cost There is no special technology being promoted, other than the proper design of a building to permit natural ventilation to function as the cooling source. Obviously, the cost is much lower than a conventional cooling system, since the main factors involved will be operable windows and floor plan design. Useful Life, Persistence and Maintenance Persistence is probably the one sticking point to this proposal. Will the building owner and occupants be satisfied with the use of natural ventilation, or will they eventually retrofit the building and add cooling? For this reason, this measure template does not propose a wholesale credit of cooling energy and fan power for buildings that utilize natural ventilation. Rather, it proposes a very modest credit associated with the fan power, with the assumption that perhaps someday, a cooling system might be added to the building. It is suggested that restrictions be placed on the design of the building and any potential mechanical systems that might provide cooling when this credit is applied. This is discussed further under the Methodology section.
Performance Verification	It is recommended that this measure appear as a feature on the PERF-1, under the special features and modeling assumptions section. The building department would be alerted to the credit taken for a naturally ventilated space, and the restriction would indicate that no cooling systems be present, and no fan systems for ventilation.
Cost Effectiveness	This measure has lower first cost to the building owner, and lower operating costs, so it will always be cost effective.
Analysis Tools	This proposal does not require any changes to the analysis tools that we use, nor to the reference method. Although it would be more desirable to adopt an entirely new reference method such as EnergyPlus that can model natural ventilation, this would be an unrealistic proposal at this point.
Relationship to Other Measures	This change is a slight modification to the way the reference building energy use is calculated but does not impact other measures.

Methodology

Back in 1992, the Nonresidential ACM manual included language which provided credits to buildings that utilized low fan power cooling systems. This language was revised in the 1995 Standards change, and credit was removed. The proposal in this template is to restore that language, but to add additional qualifying criteria to the credit.

One obvious criticism of the suggestion to credit natural ventilation is that certain building types already utilize natural ventilation. As an example, a warehouse application in most instances would not rely on a forced air system to provide cooling. For this reason, this measure change proposes to

restrict the credit to only Office and School occupancies. Other, denser occupancy types will probably not be a good candidate for this application given the larger amounts of internal heat gain and ventilation needs. It may even be argued that schools are not a good candidate, but work done by the California High Performance Schools group has focused on low energy cooling applications in K-12 schools. With proper classroom design, this strategy could be accomplished. In particular, college and university campuses would be good candidates for this strategy.

The next issue surrounds what climates would benefit from this strategy. Obviously, inland valley and desert climates would not be a good application of this feature. Even if we allowed the credit, chances are pretty good that after a certain period, the building owner would be forced to retrofit the building with cooling. For this reason, this change proposal recommends only coastal climates be included. These include climate zones 1, 3, 5 – 7 and 16. Note that 16 was included even though it is not coastal, since it is a cold climate similar to 1.

It is recommended that the following additional restrictions be place on the use of natural ventilation and that notes appear on the PERF-1 to this effect, when this credit is applied:

> Plans and specification shall show minimum ventilation requirements have been met per Standards section 121.
>
> No supply air fans or exhaust fans (other than bathroom exhaust fans) shall be used for cooling or ventilation.

The modeling methodology suggested here is not the change the way we model the proposed building. If it has natural ventilation, and no fans for ventilation, we would leave that modeling exactly as it appears in the Nonresidential ACM Manual.

However, on the reference building, when we eliminate the fans that provide ventilation, there is no recognition of this energy savings measure. Current ACM procedures have the reference building fan power track the proposed, all the way to zero. Hence, the elimination of the fans is not recognized. The proposal here is to have the reference building still include a very minor fan power allotment, 0.40 watts per square foot. This value was not chosen arbitrarily, but rather dates back to the 1992 ACM Manual procedures. The net result of this change is that we will see as modest energy credit for these types of systems.

Recommendations

The following changes are recommended in Chapter 2 of the Nonresidential ACM Manual:

2.5.3.5 Fan Power

Description	ACMs shall model all HVAC fans in the system that are required to operate at design conditions. These include supply fans, exhaust fans (that operate during peak), return fans, relief fans, and fan power terminal units (either series or parallel). The reference program models the fan system power demand using the fan power index (FPI). Fan power index is defined as the

power consumption of the fan system divided by the volume of air moved (W/cfm).

For each fan that operates during normal HVAC operation (except for the fan-coil system serving the residential unit of a high-rise residential building or a hotel/motel guest room), ACMs shall require the user to input: 1) the design BHP; 2) the design drive motor efficiency; and, 3) the design motor efficiency, all at peak design air flow rates. Exhaust fans that are manually controlled (such as bathroom fans) may not operate at design conditions and therefore shall **not** be included in the fan system power demand calculations. The reference method calculates the FPI for each fan system according to the following equation:

Equation N2-1

$$FPI = \frac{746}{CFMs}\left[\frac{BHPs}{\eta ds \times \eta ms} + \frac{BHPr}{\eta dr \times \eta mr} + \frac{BHPo}{\eta do \times \eta mo}\right]$$

where:

FPI	=	fan power index, [W/cfm]
CFM_S	=	peak supply air flow rate, [ft³/min]
BHP_S	=	brake horsepower of supply fan at CFM_S [hp]
BHP_r	=	brake horsepower of return fan at CFM_S [hp]
BHP_O	=	brake horsepower of other fans at CFM_S [hp]
η_{ms}	=	supply motor efficiency [unitless]
η_{mr}	=	return motor efficiency [unitless]
η_{mo}	=	other motor efficiency [unitless]
η_{ds}	=	supply drive efficiency [unitless]
η_{dr}	=	return drive efficiency [unitless]
η_{mo}	=	other drive efficiency [unitless]

If the user does not input the design brake horsepower (BHP) and the peak supply air flow rate (cfm) for forced air systems, the ACM shall assume that no mechanical compliance will be performed and shall model the default mechanical system according to the rules in Section **Error! Reference source not found.** (modeling default heating and cooling systems).

ACMs shall allow the modeling of naturally ventilated spaces, in which case, the fan power input by the user shall be allowed to be zero. The following criteria must be met to qualify as a naturally ventilated space:

a) Only buildings in Climate Zones 1, 3, 5-7 and 16 shall qualify.
b) Only Office and School occupancies shall qualify.
c) Plans and specification shall show minimum ventilation requirements have been met per Standards section 121.
d) No supply air fans or exhaust fans (other than bathroom exhaust fans) shall be used for cooling or ventilation.

Modeling Rules for Standard Design (New):	The ACM shall note any spaces that use natural ventilation in the special features and modeling assumptions section of the PERF-1. The reference method determines the standard design fan power as follows for forced air systems : a) For systems 1, 2, and 5 with proposed FPI $\leq$ 0.80: The standard design FPI shall be the same as the proposed design. b) For systems 1, 2 and 5 and proposed FPI > 0.80: The standard design FPI shall be 0.80. c) For systems 3 and 4 and proposed FPI $\leq$ 1.25: The standard design FPI shall be the same as the proposed design. d) For systems 3 and 4 and proposed FPI > 1.25: The standard design FPI shall be 1.25. The reference method determines the standard design fan power as follows for spaces that meet the criteria for naturally ventilated spaces: a) For systems 1-5: The standard design FPI shall be 0.40. The reference method shall use the appropriate minimum nominal full-load motor efficiency from **Error! Reference source not found.**.

Material for Compliance Manuals

This measure is recommended as a compliance option, so no changes to the compliance manuals will be required.

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.

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

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