TECH TIPS

Natural Ventilation: Raising the Bar on Energy Efficiency and Occupant Thermal Comfort

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Increased focus on sustainability and the environmental impact of energy use has resulted in natural ventilation becoming an attractive option for many buildings. Historically, prior to the development of forced air conditioning, buildings used natural ventilation to provide fresh air and maintain thermal comfort. Design of traditional natural ventilation strategies relies on the wind and buoyancy-driven stack effect to move ventilation air through the building. The energy consumption of a naturally ventilated building can be less than half that of a fully air-conditioned, mechanically ventilated one, while maintaining an acceptable level of occupant comfort. Figure 1 shows the energy consumption of the San Francisco Federal Building, which utilizes natural ventilation around 75% of the year.

With careful attention early in the design, a natural or hybrid ventilation system can be a viable option for many systems and climates. As our energy codes evolve, more consideration of hybrid solutions will be necessary to obtain the higher levels of energy savings. Natural ventilation combined with radiant heating and cooling can be a very energy efficient solution with a high level of occupant satisfaction.

ASHRAE Research Project 884 demonstrated that occupants in naturally ventilated spaces tend to be comfortable even when conditions vary from what is classically considered comfortable. This expanded comfort range can be attributed to the occupants having control over their local environment and the expectation that when it is warmer outside, it will be warmer inside.

ASHRAE Standard 55 includes a method of determining thermal comfort in naturally

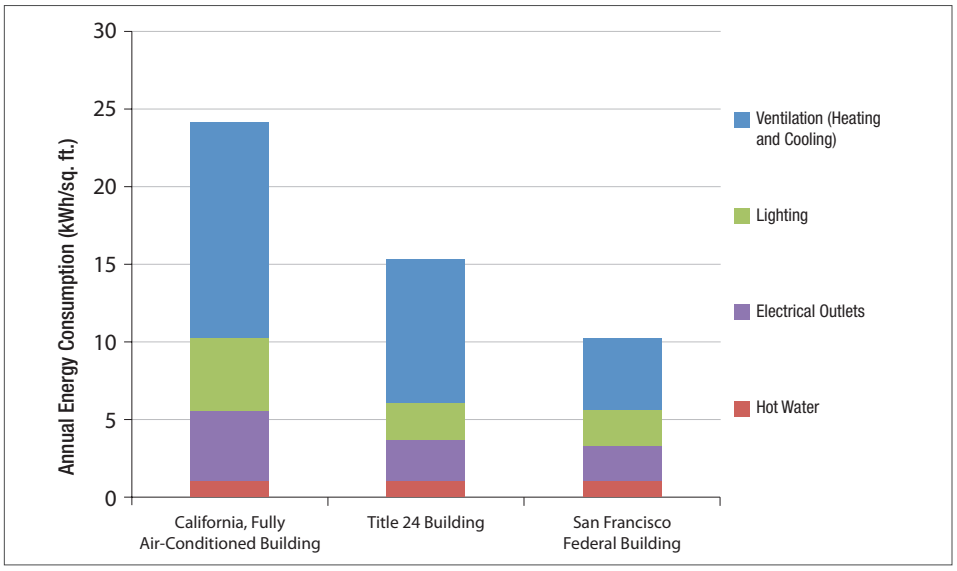

Figure 1: Annual energy consumption comparison for the San Francisco Federal Building. (Source: Natural Ventilation in High Rise Office Buildings, Salib and Wood. 2013)

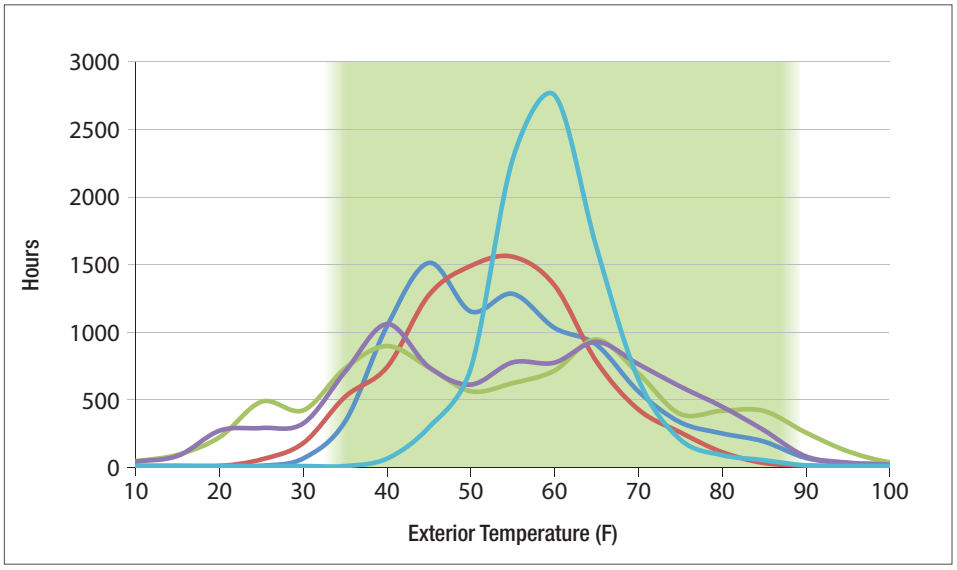

Figure 2: Hybrid natural ventilation opportunity for multiple climates

ventilated spaces based on adaptive thermal comfort. This method allows for a wider range of acceptability limits where occupants can open or close windows and vary closing in response to the indoor and outdoor conditions.

Evaluating the suitability of a location for natural ventilation involves examining the number of hours the exterior air temperature is between 50°F and 78°F. This is the range where a natural ventilation system provides the largest benefit. Examining the extremes beyond this range determines whether a natural ventilation strategy makes sense, or if a hybrid system is required. It should be noted that for the ambient temperature range of 35°F to 50°F some form of auxiliary heat, such as radiant, will most likely be required. Looking at energy balance analyses of typical spaces shows that there is often enough heat generated in the space that could be used to warm entering ambient air at temperatures as low as 45°F. For the ambient temperature range of 78°F to 90°F some form of auxiliary cooling, such as radiant, may be required. Figure 2 shows the opportunity for natural ventilation in various climates.

Every building has thermal mass, which is either designed explicitly into the structure in the form of exposed concrete, or just through the normal building materials and finishes. This mass can be leveraged in warm seasons to offset the total cooling load through night cooling. Cooler night air can be used to reject heat accumulated during the peak loads of occupied hours. On warm days, as internal temperatures rise, the building material absorbs heat, reducing further rises in the internal temperatures. The heat is then purged with lower temperature night air from the building material when the space is not occupied. The use of thermal mass within a building can provide significant benefits in terms of both thermal comfort and energy use.