Climate Change, Energy Efficiency, and IEQ: Challenges and Opportunities for ASHRAE

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In the U.S, buildings consume approximately 39% of primary energy, including 70% of electricity [1]. Buildings are responsible for approximately 38% of U.S. carbon dioxide emissions [1]. The process of HVAC, for maintaining acceptable indoor environmental quality (IEQ), consumes 37% of the energy used in buildings [1].

Broad scale and aggressive improvements in building energy efficiency are anticipated as the U.S. strives to mitigate climate change and improve energy security. To attain the large reductions in carbon dioxide emissions considered necessary to address climate change, we will require deep energy retrofits in existing buildings plus new buildings that are nearly energy self sufficient. To meet or even approach established goals, the required pace of building energy efficiency improvement represents a dramatic change from past practice. Between 1980 and 2006, primary energy use in residential and commercial buildings increased 32%, and 69%, respectively [1]. Primary energy use per unit floor area declined on average by 1.2% per year in the residential sector but increased 0.6% per year in the commercial sector [1]. In contrast to these trends, U.S. Department of Energy, the Energy Independence and Security Act of 2007, and the American Institute of Architects call for all new buildings to consume zero net energy by 2025 or 2030. The California Air Resources Board goals are 25% and 80% reductions in carbon dioxide emissions by 2020 and 2080, respectively.

Measures taken to achieve these aggressive building energy efficiency goals will change indoor pollutant sources, heat loads, ventilation rates, HVAC equipment types, and building operating practices, all with the potential to affect indoor environmental quality (IEQ) positively or negatively. As broad-based energy-efficiency improvements are made in our buildings, ASHRAE members will need to develop and utilize HVAC technologies and practices that dramatically reduce building energy consumption while maintaining or improving IEQ. A degradation in IEQ is unlikely to acceptable in the market place given the growing evidence that ventilation rates and IEQ conditions influence health and work and school performance [2-4], each of which has important economic implications. These energy efficiency goals represent a challenge to some of the existing technologies and practices employed and marketed by ASHRAE members but also represent a very large future opportunity.

Table 1 identifies some of the expected energy efficiency strategies or measures that will be implemented, the potential impacts in IEQ, and possible associated HVAC design and practice changes and technology challenges. Many of the strategies or measures are identified within the advanced energy design guides available from the ASHRAE web site. Table 1 is not meant to be exhaustive; however, it does identify the broad range of potential changes in HVAC that will affect the practices of the ASHRAE membership. Examples include:

- increased use of mechanical ventilation systems in houses with more airtight envelopes;
- smaller capacity HVAC systems with a larger ratio of latent to sensible capacity for buildings with more thermally efficient envelopes and lower internal heat loads;
• increased use of low energy cooling systems such as those with evaporative cooling;
• more and new types of demand controlled ventilation, heat recovery, and gas phase air 
  cleaning to reduce outdoor air (OA) ventilation energy requirements;
• more radiant heating and cooling, less air recirculation, and lower pressure drop filtration 
  systems to reduce fan energy;
• hybrid HVAC systems, cooling systems with finer spatial and temporal control, and more 
  mechanical ventilation without air conditioning to reduce or eliminate air conditioning 
  energy consumption; and
• increased resources dedicated to HVAC maintenance and correction of control system 
  problems.

Table 1 does not mention the better integration of HVAC components, and better integration of 
HVAC with other building systems, which are other necessary responses to the energy efficiency 
challenge. The IEQ implications of integration practices are uncertain and are likely to be 
varied. Also omitted from Table 1 are the numerous challenges outside of the purview of the 
ASHRAE membership, such as development of building materials and products with very low 
emissions of harmful or odorous pollutants.

Many HVAC technologies and practices exist to address the challenges listed in Table 1 above 
and increases in their utilization are anticipated. However, improvements in technology 
performance, reductions in cost, and new innovations are still necessary if energy use is to be 
reduced dramatically while maintaining good IEQ. The pace of change in the HVAC field will 
need to be much faster than in recent decades if the aforementioned goals are to be met. In the 
option of the author, meeting these HVAC-related challenges should be one of the highest 
priorities for ASHRAE and the ASHRAE membership in the coming decades.

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