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How **ASHRAE Standard 90.1** contributes to integrated design

ASHRAE Standard 90.1 is under continuous maintenance. This article focuses on the recent evolution of this standard, the impact on energy and performance, the design process, and how human interaction can improve energy efficiency.

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ASHRAE STANDARD 90.1: Energy Standard for Buildings Except Low-Rise Residential Buildings has been the benchmark for defining energy-efficiency and simulation procedures in the built environment since its inception in 1975. It is a fluid document, designed to define the minimum level of energy efficiency while being mindful of the limits of technology and value proposition of lifecycle cost.

As of the 2001 version, this standard is published in its entirety every 3 years. The period between publishing cycles allows for review, comment, and approval of new content. It is also common for addenda to be issued between the formal updates. The evolution from the 2010 to the 2013 edition helps engineers and designers understand how an integrated design process provides the most efficient means of planning for, and applying, the principles held within.

ASHRAE Standard 90.1 provides the minimum benchmark for energy-efficient design practices for building envelope, HVAC systems, water heating systems, power, and lighting. This standard also provides one of the most recognized procedures for energy simulations of facilities.

Although Standard 90.1 is respected by many jurisdictions, it is not necessarily recognized as a code for all jurisdictions in the United States. Therefore, the requirements of Standard 90.1 can be followed by the design professional, but enforcement by the local authority having jurisdiction (AHJ) is generally limited to the applicable building or energy conservation code.

Figure 1: The new Library and Student Resource Center at the Los Angeles Community College District's Harbor College is designed to achieve U.S. Green Building Council LEED Platinum certification. Its signature design element is a bold southern facade with exterior louvers that reduce solar heat gain. All graphics courtesy: DLR Group

This standard does influence many other building codes. Building envelope (sometimes called building enclosure) is a good example of how this works. In the 2007 version, the requirement for continuous insulation started to appear in many building types for most climate zones. These requirements appear in the 2009 version of the International Energy Conservation Code (IECC). These codes began to be adopted in 2010, and projects started hitting the streets in 2011. There are numerous examples of other technical features and model building codes. Many jurisdictions recognize ASHRAE 90.1 as an acceptable compliance path for energy performance.

Changes to note

The significant changes in the 2013 version include: building envelope, HVAC, energy simulation procedures, and lighting. As the design professional might expect, the modifications generally impose stricter requirements on design elements. This standard also gives more details and requirements for computer room environments. Major changes in the 2013 version include more clarifications and provisions for optimizing natural daylighting and artificial lighting control. The Dept. of Energy, in an announcement in the Federal Register on Sept. 26, 2014, estimated that the ASHRAE 90.1- 2013 energy efficiency standard contains 8.5% source energy savings and 7.6% site energy savings compared to the 2010 version.

The changes in the 2013 version that affect building envelope modify the requirements for opaque elements and fenestrations. These include a simplification of skylight requirements, requirement of double pane glazing in most climate zones, and the additional requirement of a minimum visible transmission (VT)/solar heat gain coefficient (SHGC) ratio. The point of this ratio is to balance daylighting capabilities with heat gain through fenestrations.

The HVAC equipment performance requirements are stricter in the 2013 version. Fan efficiency requirements have been added to the standard for the first time. There also are increasing coverage and strategies for systems required to be controlled by building automation systems (BAS). An example of the impact of these changes can be found in the stricter performance requirements for heat pumps. ASHRAE Standard 90.1 Table 6.8.1-2 shows performance improvements required for ground-source, water to air heat pumps (see Table 1).

The requirements for building simulation procedures continue to evolve in the 2013 version. Significant changes in simulation procedures include: new data tables for applying glazing areas; envelope infiltration calculations; modifications to calculation procedures for assembly areas; heat rejection equipment, such as cooling towers; more provisions for dealing with computer room environments; and additional information to improve the simulation of natural daylighting to predict energy conservation opportunities.

Table 1: Summary of changes in heat pump efficiencies

ASHRAE Standard 90.1 edition	Minimum efficiency (cooling – EER)	Minimum efficiency (heating – COP)
2010	16.2	3.6
2013	18.0	3.7

Table 1: This provides a summary of the data taken from various versions of ASHRAE 90.1. Data from ASHRAE Standard 90.1-2010 and 2013.

Table 2: Summary of changes in allowable power density

ASHRAE Standard 90.1 edition	Allowable power density (W/sq ft)
2007	1.2
2010	0.99
2013	0.87

Table 2: There continues to be a systematic decrease in the allowable power density used by lighting, according to ASHRAE Standard 90.1 Table 9.5.1. Data from ASHRAE Standard 90.1-2007, 2010, and 2013.

Figure 2: The Elk Grove Center in Elk Grove, Calif., is a satellite campus of the Cosumnes River College. The design combines exterior screens and a light shelf to optimize views to outside, solar gain, and natural daylight.

Lighting

One of the most notable changes to the lighting chapter of the 2013 version is the addition of control requirements for each of the space types. There also continues to be a systematic decrease in the allowable power density used by lighting. The data in ASHRAE Standard 90.1 Table 9.5.1 reveals that the allowable power density for a school/university has decreased by 32% since the 2007 version of this standard. Table 2 provides a summary of the data taken from various versions of ASHRAE 90.1.

The theme of natural daylighting and artificial lighting control is woven through most of the significant changes in Standard 90.1-2013. Many of the provisions of this standard tend to primarily affect one discipline and create a ripple through other disciplines on the way to optimizing the total energy efficiency of a facility. For instance, changes in chiller efficiency largely impact the work of the mechanical engineer, but a more efficient chiller also affects the design prepared by the electrical engineer. Similarly, allowable power densities largely impact the work of the electrical engineer, but also affect the cooling design prepared by the mechanical engineer. These examples create a cause-and-effect relationship between designers and contractors.

Solutions that optimize natural daylighting and artificial lighting control require a multidisciplinary approach. The most efficient approach still requires some iteration to formulate a solution. The team of designer, contractor, and owner must collaborate during this process. The role of the designer, architect, and engineer is to assess energy efficiency and balance performance, aesthetics, and functionality of the lighting system. The contractor's role is to evaluate cost and constructability. The owner's role is to determine if the solution is useful and meets the needs of the end user. An integrated design process when all stakeholders are involved from the beginning provides a platform for shared education, understanding of requirements and desires, and fluid testing of options until the design solution is optimized. When these parties operate in a vacuum, the final result is often frustration, uncoordinated design, and energy performance that does not meet expectations.

Figure 3: **Fayetteville (Ark.) High School earned U.S. Green Building Council LEED for Schools Silver Certification applying design techniques prescribed in ASHRAE Standard 90.1.**

Documentation

ASHRAE 90.1 can be used in two ways, prescriptive or performance, to document compliance.

The prescriptive method is largely an effort in applying the information provided in the tables and graphs of the main body of the document. Because it's often deemed the easiest approach for the design phase of a project, the prescriptive method is the most common path for achieving compliance with ASHRAE Standard 90.1.

The performance approach to this standard applies rules to the desired uniqueness that provides some flexibility based on the climate of the project location. The performance approach generally requires the use of a computer-simulation tool to evaluate the impact of design strategies for the major building features that form the path of overall compliance. It also can be argued that building designs derived strictly through implementation of the prescriptive approach may not result in the most cost-efficient solutions on bid day.

The performance approach to the 2013 version provides even more rules and implementation procedures than previous versions. This is easily seen during a quick review of the current edition of the standard. The pages defining the rules of engagement for the performance approach are much thicker than those for the prescriptive approach to compliance. The difference is that the words used to describe the performance approach allow for trade-off, compromise, and flexibility. This is the foundation of an integrated design process.

The future

ASHRAE will publish the next version of Standard 90.1 in 2016. Between now and then, there will be addendums to clarify important content and address comments from users. The natural duration before Standard 90.1 is applied to actual design situation seems to be about 4 years. It takes that long for the data in 90.1 to find its way into the building codes, for the building codes to be adopted, and for general acceptance of the material throughout the design community.

In 2020, the matrix for the Architecture 2030 Challenge will be a building energy performance target 80% better than the 2003 benchmark for consumption. ASHRAE Standard 90.1 has shown leadership in energy efficiency by defining the minimum criteria and processes for the built environment to be judged. ASHRAE Standard 189.1: Standard for the Design of High-Performance Green Buildings takes building design to the next level for projects that are on the path to achieve the goals of Architecture 2030. Facilities that achieve lofty energy performance as prescribed by Architecture 2030 typically include passive features and provisions that rely on the natural environment in the strategy for energy reduction.

The notion of human impact should be considered in any conversation regarding energy efficiency in the built environment. This topic is not directly related to ASHRAE Standard 90.1, but is one of the characteristics that elevate good building performance to great building performance. The requirements of this standard continue to advocate for automatic measures to minimize the need for human intervention. These automatic measures contribute to the high-performing buildings being constructed today.

Ensuring proper use and performance of lighting controls is an example of the importance of human impact on energy performance. An integrated design process is a useful platform to interject the human impact into the design. Involving the engineering and analysis team early in the design process can have many advantages, including sharing the requirements of ASHRAE Standard 90.1 with other design team members and users who may not be familiar with the standard. When everyone understands the design requirements and the user's expectations, good design can be elevated into a high-performance building.

Traditionally, the design team's role on a project ends when the building is built and all of the post-construction documentation is turned over to the owner. The emphasis on high-performance buildings is allowing design teams to become more engaged in post-occupancy activities such as user training, energy benchmarking, and operational feedback.

As hard as we try to simplify things, systems in modern-day buildings are complicated, especially for users with little or no training in architecture or engineering. Systems that are not understood by facility managers or users are often altered by occupants to the detriment of occupant comfort. This leads to frustration by facility managers and occupants, and results in poor energy performance.

The next big thing that design professionals can do to positively impact building energy performance is train both facility managers and occupants about how the systems work. This training is not on how to replace an air filter or perform other routine maintenance. Rather, it should train users on the ramifications of blocking the glazing intended for daylighting with cardboard; train them how to temporarily adjust the light level for a special program; and train them to be successful in the space that was designed for them.

The ASHRAE Standard 90.1 offers designers the tools and compliance criteria to create energy-efficient facilities. The application of this standard through an integrated design process should result in a facility that provides excellent value to the owner. All too often this value is not realized. While the reasons for this vary, the real problem is that a facility may operate incorrectly for years before the causes can be determined and remedied. An owner's design and energy analysis team can play a key role in the optimizing the performance of the facilities they designed through post-occupancy services like energy benchmarking and operational feedback studies. A simple comparison of actual utility data to performance expectation using energy consumption data is the first step in determining if there are real issues. Operational feedback studies use energy data—utility and submeters, user surveys and system observations—as the means to understand how energy is consumed and how efficiency can be improved.

ASHRAE Standard 90.1 is a fluid document that continues to evolve in response to changes in our industry and the desire for continuous optimization of energy performance. The application of this standard or subsequent building codes that are influenced by this standard, offer value to building owners through lifecycle cost objectives that are embedded into the information. ASHRAE Standard 90.1 and other industry trends such as integrated design, human impact on performance, and post-occupancy evaluations provide the foundation for energy optimization in the built environment. cse

Figure 4: The new Business Building on the Lisle, Ill., campus of Benedictine University is one of the first buildings permitted in Illinois under the new IECC 2012/ASHRAE 90.1-2010 code.

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