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Understanding ASHRAE 189.1
Standards and codes for high-performance green buildings
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Many are following the development of the International Green Construction Code *(*IGCC*), but the first code-intended commercial green building standard in the United States has already been released.*

In January 2010, ANSI/ASHRAE/USGBC/IES 189.1-2009, *Standard for the Design of High-performance Green Buildings*, was published. The co-sponsors—the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE), the U.S. Green Building Council (USGBC), and the Illuminating Engineering Society (IES)—developed the standard over 3.5 years using the American National Standards Institute (ANSI) consensus process.

The *IGCC*, on the other hand, is being developed by the International Code Council (ICC), and should be finalized after an action hearing next month. Currently, the following jurisdictions have adopted the code, mostly as a voluntary path for building projects:

- Phoenix, Arizona;
- State of Maryland;
- State of Rhode Island;
- Kayenta Township, Arizona;
- Fort Collins, Colorado;
- Boynton Beach, Florida;
- Keene, New Hampshire; and
- Richland, Washington.[1]

In April 2010, ASHRAE 189.1 became a jurisdictional compliance option to the public comment version of *IGCC*. This means a jurisdiction can choose whether the standard can be used as a compliance path. However, ASHRAE 189.1 does not need to be used as part of *IGCC*—universities, corporations, and local and international communities can specify compliance with it. For instance, the U.S. Army announced in October 2010 its adoption of the standard as the core of its Sustainable Design and Development (SDD) Policy for Army Facilities. Further, Leadership in Energy and Environmental Design (LEED) and other rating systems and green standards could choose to use it as a baseline.

ASHRAE 189.1 is not a point or rating system like LEED; rather, it has minimum requirements. This provides a more direct application for its use and its adoption into local codes. To apply it, all mandatory requirements must be met, along with those of either the prescriptive or performance path. The former specifies a relatively simple method for showing compliance that generally involves little or no calculations; the latter involves an alternative method typically more complex than the prescriptive path.

Public versions of *IGCC*, also written in ‘code language,’ require compliance with mandatory and prescriptive or performance options, along with a certain number of project electives. In codes, standards, and rating systems, multiple options (*e.g.* LEED credits or IGCC project electives) often lead to the selection of the least-expensive compliance requirements, rather than the ones that provide the greatest reduction in environmental impact. ASHRAE 189.1 does not have these options to select, but there is some flexibility in the form of alternative paths and exceptions.

Standard 189.1's impact has already been widespread. Many of its requirements have been incorporated or modified and included in California's *CALGreen* code, the public comment version of *IGCC*, and ASHRAE 90.1-2010, *Energy Standard for New Buildings Except Low-rise Residential Buildings*. It covers topics familiar to LEED, as well as others, grouped into these categories:

- site sustainability;
- water efficiency;
- energy efficiency;
- indoor environmental quality (IEQ);
- impact of materials and resources;
- construction and plans for operation; and
- integrated design.

Energy efficiency

On an aggregate basis for all building types in all climates, buildings complying with Standard 189.1-2009 save approximately 30 percent more energy than those designed to ASHRAE 90.1-2007. About 10 percent of this is from the renewable energy requirements in ASHRAE 189.1, and about 20 percent from the energy requirements in the prescriptive portion in its energy chapter (Section 7.4). Most of this energy savings is for buildings located in cold climates. Additional significant savings are attributed to equipment and appliances meeting the EnergyStar requirements. Also important are energy savings for lighting controls and to turn off plug loads (*e.g.* televisions and lights) in empty motel/hotel guest rooms.

The standard is following ASHRAE's continuous maintenance procedures. The committee meets on a regular basis to consider continuous maintenance proposals generated by the public and proposals developed within the committee. Between January 2010 and July 2011, the Standing Standards Project Committee (SSPC) 189.1 published about 25 addenda for public review and considered the ensuing comments. Later this year, the standard is scheduled to be republished, incorporating the addenda that have completed the public review process. (This will include addenda that started public review in August 2011 that received no comments, as well as addenda that have comments that were resolved by the end of that month. New continuous maintenance proposals will be considered for the standard's next version, tentatively scheduled for 2013.)

The most significant change in terms of energy savings come from the addendum that updates ASHRAE 90.1 to the 2010 version. This standard saves approximately 20 to 25 percent more energy compared to its 2004 predecessor, but not in the same ways as ASHRAE 189.1. Therefore, this provides an estimated 10 percent increase in energy savings for ASHRAE 189.1. Additionally, the portion of the standard that references EnergyStar requirements will be updated.

The mandatory and prescriptive renewable energy requirements (Sections 7.3.2 and 7.4.1.1) were also revised so onsite renewable requirements for both are based on roof area rather than conditioned space. Previously, mandatory criteria were based on the former and the prescriptive on the latter. Both now have requirements for single-story buildings and a greater requirement for buildings that are more than one story. However, the mandatory items call for a renewable-ready building while the prescriptive path requires onsite renewable energy. Additionally, buildings that meet the prescriptive requirement are now deemed to comply with the mandatory requirement. (This change was made because some single-story buildings meeting the prescriptive requirement did not comply with the mandatory requirement.)

The renewable energy requirement in ASHRAE 189.1 has long been controversial and debated at length by SSPC (although the membership has changed over time as members leave and new ones join). One side contended it is less expensive to add insulation and upgrade equipment to save energy, while the other wanted to encourage renewables such as wind and solar to drive down their costs and eventually get to net-zero. Further, reaching a compromise on the details of the requirements is a challenge since this type of requirement is new to mandatory code language. In November 2010, a detailed explanation of how the original committee reached consensus on a renewable-ready mandatory requirement and a prescriptive requirement was given by one of this article's authors at a U.S. House of Representatives Committee on Science and Technology Field Hearing in Chicago to kick off that year's Greenbuild.[2]

The 2011 version of ASHRAE 189.1 also updates the performance option for energy efficiency (Appendix D) to reference Appendix G of ASHRAE 90.1 with changes to make it applicable. Previously, ASHRAE 90.1-2007 Appendix G on performance rating was informative and not normative, so it could not be referenced. Instead, large portions of ASHRAE 90.1 Appendix G were copied into Standard 189.1 Appendix D.

ASHRAE 90.1 Appendix G has since gone through the public review process and is a normative Appendix in ASHRAE 90.1-2010. This referencing increases 189.1's usability by making it more familiar. While Appendix G of ASHRAE 90.1 is intended to apply only to projects exceeding the requirements of that standard, in Standard 189.1 it is for projects both meeting and exceeding the requirements.

Site sustainability

In the site hardscape portion of ASHRAE 189.1's urban heat island mitigation section (5.3.2.1), requirements for systems such as permeable pavements will no longer be based on solar reflectance index (SRI). In particular, open-graded (uniform-sized) aggregate and porous pavers (*e.g.* open-grid pavers) will qualify as a hardscape surface for heat island mitigation with no further testing. Permeable pavement and permeable pavers must have percolation rate greater than or equal to 100 L/min•m^2 (2 gal/min•sf).

Percolation rate is used both as a surrogate for porosity and because it is employed elsewhere in ASHRAE 189.1 (*i.e.* Section 5.4.1.1). Materials with greater porosity mitigate the heat island effect due to:

- lower heat absorption capacity;
- greater water storage capacity and resultant evaporative cooling; and
- more communication with the ground and its evaporative cooling capacity.

SRI was developed as indicator of temperature effects due to the sun on flat, non-porous surfaces. Studies have shown porous and permeable pavement systems store less heat energy when exposed to the sun.[3] This results in lower daytime and nighttime temperatures when compared to traditional pavements with the same SRI.

Additionally, there has been some confusion related to Exception 1 to Section 5.3.2.2 of ASHRAE 189.1, which states:

> The requirements of this section are satisfied if 75% or more of the opaque wall surfaces on the east and west have a minimum SRI of 29.

Section 5.3.2.4 states:

> The SRI shall be calculated in accordance with ASTM E 1980 [*Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-sloped Opaque Surfaces*] for medium-speed wind conditions.

While the title and scope of ASTM E 1980-11 refer to horizontal and low-sloped surfaces, SRI is allowed to be calculated using this method because no standard exists for vertical ones (*i.e.* walls). The SRI is calculated in ASTM E 1980 based on the solar reflectance, thermal emissivity, wind speed, and other factors. The difference between the SRI of a vertical and horizontal surface is primarily in the surface film resistances. ASHRAE 189.1 was written with full knowledge of these differences. Therefore, SRI values for horizontal surfaces calculated in compliance with ASTM E 1980 are allowed to be used to meet this requirement for walls.

Indoor environmental quality

The updated ASHRAE 62.1-2010, *Ventilation for Acceptable Indoor Air Quality* is referenced in this chapter of Standard 189.1*;* the minimum ventilation rates and other indoor air quality (IAQ) criteria (Section 8.3.1) require compliance with certain modifications.

ASHRAE 62.1 is also referenced in:

- Chapter 3 on definitions;
- Section 7.4.3 on prescriptive HVAC energy requirements;
- Section 10.3.1.4 on indoor air quality management; and
- Section 10.3.2.1.4 on ventilation system operations and maintenance.

The IEQ chapter of Standard 189.1 also references the updated ASHRAE 55-2010, *Thermal Comfort Conditions for Human Occupancy*. In Section 8.3.2, it requires buildings comply with Sections 6.1 on design and 6.2 on documentation of ASHRAE 55-2010 (with some exceptions). Section 10.3.1.2.1 also requires documentation according to ASHRAE 55-2010.

Impact of materials and resources

This part of ASHRAE 189.1 currently includes a lifecycle assessment (LCA) alternative (Section 9.5 performance option) to the prescriptive path (Section 9.4.) The latter demands a specified recycled, regional, or bio-based content for materials in the building. These prescriptive measures are single-attribute criteria that are relatively easy to quantify, but have flaws because they only take into account one specific measure. For instance, recycled content does not consider the energy required to recycle old material into a new product.

LCA is considerably more complex, but also more accurate than any single-attribute criteria. However, it is only precise when it considers a complete range of impacts for the life of the building. ASHRAE 189.1 requires the analysis include the impact categories of:

- land use (or habitat alteration);
- resource use;
- climate change;
- ozone layer depletion;
- human health effects;
- ecotoxicity;
- smog;
- acidification; and
- eutrophication.

The performance path requires an LCA on a base building and the proposed project building in accordance with International Organization for Standardization (ISO) 14044-2006, *Environmental Management: Life Cycle Assessment–Requirements and Guidelines*. The proposed project building is required to show at least a five percent improvement in two of nine impact categories required for the analysis. An analysis period of at least 75 years is required for most projects, based on the average life of a U.S. building, according to the Department of Energy (DOE).[4]

An analysis period of at least 25 years is required for industrial buildings and standalone parking structures. A shorter period is allowed for temporary buildings (defined as non-permanent construction buildings, like sales offices and bunkhouses) and temporary exhibition buildings. The standard requires a service life of not less than "up to 10 years," which can be interpreted to mean any time period for these temporary buildings. A longer time period for an LCA will put more emphasis on energy use and maintenance during the life of the project.

The LCA is not required to include the energy use over the building's life, but results are likely to be incorrect without this data. For instance, more insulation or thermal mass saves energy over the long term. However, unless this reduced consumption is noted, only the negative effects of having additional material impacts would be included.

An LCA is a complex process requiring computer software and analysis. After defining the boundary conditions in an LCA, the next step is a lifecycle inventory (LCI). This is an accounting of the materials and energy consumed (*i.e.* inputs), as well as the emissions to air and water and solid wastes (*i.e.* outputs) during the building's life. The LCI includes these inputs and outputs from extraction and harvesting of raw materials and fuel sources, through manufacturing and transporting of components, construction, repair and maintenance, replacement, and finally, deconstruction, demolition, recycling, reuse, and disposal. Once the LCI has been calculated, environmental impacts can be calculated using available simulation programs.[5]

Construction and plans for operation

The plan for operation in ASHRAE 189.1 must include a service-life plan for the structural, building envelope, and hardscape materials. The objective is to make the owner aware of any materials that might be chosen because they are 'greener' or less expensive, but require more maintenance and replacement during the building's service life.

The service-life plan is based on similar requirements in Canadian Standards Association (CSA) S478-95, *Guideline on Durability in Buildings*. It requires identification of materials that need to be inspected, repaired, or replaced during the design life—generally at least 50 years. For structural, building envelope, and hardscape materials, one must identify the estimated service life, maintenance frequency, and access for maintenance. The completed service life plan is submitted to the owner at the completion of design.

States, counties, cities, and international communities should consider adoption of *Standard for the Design of High-performance Green Buildings* or *IGCC*'s jurisdictional compliance path that includes this standard. ASHRAE 189.1 was developed under the ANSI consensus process and received more than 2800 comments from interested parties during four public reviews in a 3.5-year period. Despite being under continuous maintenance for 1.5 years, most of the requirements remain the same. This is a testament to its applicability and robustness as a green code or standard.

Notes

[1] For more information, see the International Code Council (ICC) release, "*International Green Construction Code* Gains Momentum throughout the U.S.," issued on June 16, 2011. Visit www.iccsafe.org.

[2] For Martha VanGeem's presentation, visit www.access.gpo.gov/congress/house/house14ch111.html or www.ctlgroup.com/Publications/Detail/91.

[3] See J.T. Kevern, L. Haselbach, and V.R. Schaefer's article, "Hot Weather Comparative Heat Balances in Pervious Concrete and Impervious Concrete Pavement Systems." Visit heatisland2009.lbl.gov/docs/211340-haselbach-doc.pdf.

[4] For more information, see DOE's 2008 *Buildings Energy Data Book*. Visit buildingsdatabook.eren.doe.gov/DataBooks.aspx.

[5] Examples include SimaPro (www.pre.nl) and Gabi (www.gabi-software.com).

Additional Information

Authors

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