Standards and Codes and Wizards...Oh My!

Every three years, the International Code Council® (ICC®) publishes the *International Energy Conservation Code*® (IECC®) which is the model energy code in many states. The 2021 IECC references 107 other codes and standards from 27 different organizations including 19 from the Air-Conditioning, Heating and Refrigeration Institute (AHRI®) and nine from the ASHRAE® (American Society of Heating, Refrigerating and Air Conditioning Engineers, www. ashrae.org/about).

This newsletter aims to add clarity on United States codes and standards, discuss the typical steps engineers take to review building HVAC system designs against building regulations, and suggest practices and tools that may simplify the internal review process.

How are Codes Influenced by Standards?

Many of us may recall the Saturday morning cartoon *Schoolhouse Rock!* episode "I'm Just a Bill" which tells the story of how a bill introduced in Congress becomes a law[1]. Interestingly, some of the cartoon's scenes reflect the development process that standards and codes must follow. Unlike that of a bill, there is no president of HVAC codes that can veto a proposed standard. But there is Federal Government involvement, such as by the Department of Energy (DOE), at key points in the standards and codes development process. So how does a standard become referenced by a building code in a state or municipality and in turn become a job requirement?

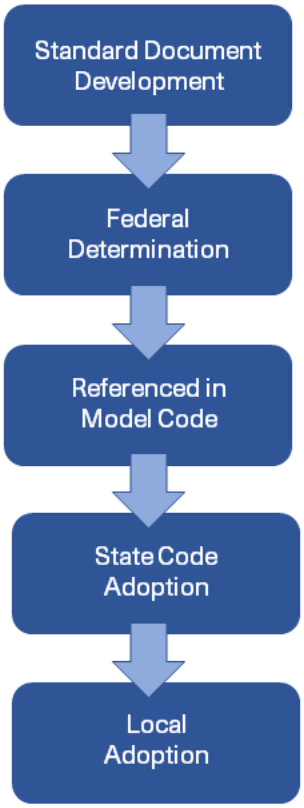
The 1999 *Engineers Newsletter*, titled "The Tortuous Path...From Industry Standard to Local Code", identified three instruments that shape the building regulations enforced by local code authorities: state codes, model codes, and standards [2]. It also pointed out that states may adjust requirements from a model code or standard to suit their needs. In addition, municipalities may amend the code by ordinance.

In the next section, we'll walk through the step-by-step process used to update ASHRAE Standard 90.1-2013, *Energy Standard for Buildings, Except Low Rise Residential Buildings*[3] as an example.

Initiating change

From 2013 to 2016, ASHRAE Standing Standards Project Committee (SSPC) 90.1 received, created, debated, vetted, and voted to publish 120 addenda for inclusion in the Standard. Public review of the proposed addenda generated hundreds of comments either in support of or against the proposed content. The SSPC then met with the commenters in order to resolve their concerns for each addendum. Upon conclusion of the SSPC review process and subsequent public reviews, the ASHRAE Board of Directors (BOD) approved the addenda to the Standard and therefore Standard 90.1-2016 was published in October 2016 [4]. At this time, unresolved commentors or project committee members who cast negative votes on publication are afforded an appeal to ASHRAE and subsequently the American National Standards Institute (ANSI) if an appeal at ASHRAE was not upheld.

Note: ASHRAE is accredited by ANSI as a developer of American National Standards.



Review process

Following BOD approval, the DOE then initiated a review and determination process of Standard 90.1-2016 as statutorily required by the Energy Policy and Conservation Act (EPCa). The outcome of this review was published in June 2017 in a draft report that stated:

> "Commercial buildings meeting the requirements of Standard 90.1-2016 exhibit national savings of approximately (compared to Standard 90.1-2013): 8.2 percent energy cost savings, 7.9 percent source energy savings, and 6.7 percent site energy savings." [5]

Given this positive result, the SSPC 90.1 made the recommendation to the ASHRAE Code Interaction Subcommittee (CIS) to submit a code change proposal to the ICC, updating the references to Standard 90.1-2016. After CIS approval, ASHRAE submitted a code change proposal to the ICC that Standard 90.1-2016 be referenced in the latest edition of the code. Public hearings and comment periods followed and ultimately the 2018 IECC was published in August 2017 following the final action hearing. 2018 IECC, Chapter 4, is titled "Commercial Energy Efficiency" and the code provides several commercial building compliance paths with ANSI/ASHRAE/IES 90.1-2016 listed first (Section C401.2).[6] At this point, Standard 90.1-2016 was referenced by a model energy code.

State adoption

The final step in the process is for states to adopt the code. For example, the State of Nevada regulations require adoption of the IECC on a triennial basis following its publication (NRS 701.220 and NAC 701.185 (R153-17AP)) [7,8] which they did in 2018. Given that, Standard 90.1-2016 was required by its reference in 2018 IECC.

At the local level, refinements to the law were made when on August 18, 2018 the city of Las Vegas passed seven pages of amendments to 2018 IECC. These refinements included;

- adding definitions for lighting (i.e. luminaire),
- amending the list of buildings exempted from certain exterior lighting requirements to include casinos, and
- setting specific source energy multipliers used in performance based compliance.[9]

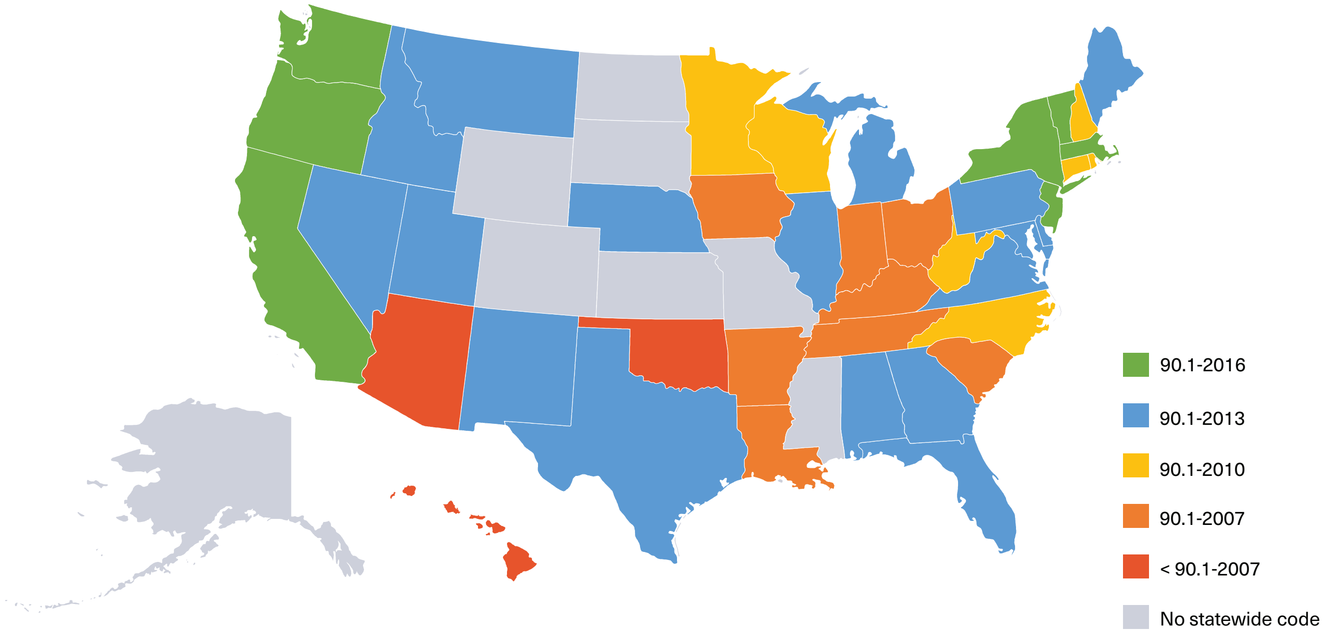
Recently, Nevada issued a notice of adoption of 2021 IECC, which references 90.1-2019.[10] Maine has also made provisions for municipalities to adopt 2021 IECC as a stretch code[11], which the cities of Portland and South Portland have done.[12] And, of this writing, over 30 addenda have been published to Standard 90.1-2019, starting the cycle again.

The next section covers resources that can help identify state specific requirements.

Which Code Applies to my Building Project?

From an energy standpoint, the IECC and by reference, ASHRAE Standard 90.1, has broad adoption in the US. Figure 1 illustrates the status of state adoption of the energy code as of October 1, 2021. The map takes into account a state's building profile and energy code amendments to reflect the state's "operating energy code", which may be different from the state's adopted energy code. For instance, Wisconsin's current code is 2015 IECC and Standard 90.1-2013, but considering state amendments, it is operating to an energy profile consistent with ASHRAE Standard 90.1-2010. As noted above, Nevada recently adopted 2021 IECC, and Maine has made stretch code provisions which means they are some of the first states to reference ASHRAE 90.1-2019.

Figure 1. State adoption of energy codes of commercial buildings, as of October 1, 2021 [13]



This Engineering Newsletter is focused on the IECC and 90.1, but many other model codes also reference ASHRAE Standards of interest. Table 1 is taken from information published by the ASHRAE Standards Code Interaction Subcommittee and shows where codes and ASHRAE Standards are related in key building areas.

Table 1. How model codes and ASHRAE standards interact[14]

Code-Code Body	Building and Subject Area	Related ASHRAE Standards
IFC—ICC	Fire suppression, mechanical	15
IPC—ICC	Plumbing	188
IMC—ICC	Mechanical	15, 34, 62.1, 170, 180, 188
UMC—IAPMO	Mechanical	15, 34, 62.1, 62.2, 90.1, 111, 128, 170
UPC—IAPMO	Plumbing	90.1, 188
IECC—ICC	Energy	90.1, 90.4
NFPA	Fire suppression, mechanical	15, 34, 55, 62.1, 62.2, 90.1, 90.2

Monitoring state energy code adoption, as well as state legislative moves, can help the engineer keep abreast of current and near-term building code requirements. The DOE maintains an extensive database of state energy code information through the Building Energy Codes Program at www.energycodes.gov. Information on a given state's energy code, amendments, and history are readily available. This represents one of the best resources for US energy code awareness. Additonal code adoption resources are included below.

- BuildingsGuide—State-by-State Building Code Resources, https://www.buildingsguide.com/blog/resources-building-codes-state/
- Insurance Institute for Business & Home Safety®, https://ibhs.org/public-policy/building-codes-by-state/

Engineers can also subscribe to specific standard listservs to gain a sense of code trends. To receive e-mail notification of proposed addenda being issued for public review, you can subscribe to the ASHRAE Listserv at www.ashrae.org/technical-resources/free-resources/listservs.

And, ultimately, participation in the standards development process is the best way to help form the future and understand why changes are made. Visit www.ashrae.org for more information on how to join project committees.

Designing for and Checking Compliance with Standards

So how does an engineer ensure that the design for a specific building complies with the requirements of the energy code? Assuming one is designing in a state that has adopted the IECC (which in turn references ASHRAE 90.1), or that has codified 90.1 directly (e.g., New Jersey) several 90.1 compliance paths are available (Table 2).

During the design process and especially after the compliance path has been chosen, design reviews are important to ensure code compliance. Reviewers should not only be experienced in the pertinent HVAC system, but also be familiar with the permitting jurisdiction. In the words of one design professional:

> "During the building design process, engineering firms typically conduct several internal design reviews relying on the technical and code expertise of internal reviewers. Requirements also depend greatly on the building permitting jurisdiction so it's also beneficial that the internal reviewers have code expertise in the permitting municipality. While equipment performance compliance can be checked relatively easily, HVAC system performance compliance is more complicated." [15]

To that end, several simulation programs are available to aid the engineer in evaluating the more complicated compliance paths, some of which are noted below.

Compliance Path	Tool
Prescriptive	COM*check-Web*™
Performance	eQuest® TRACE3DPlus® HAP DesignBuilder© IESVE© EnergyPlus®

Note that a given simulation program may or may not cover the version of the standard or code required by the jurisdiction, so be sure to check with the simulation program vendor. Also, each of the performance-based simulation programs utilize either public or proprietary calculation engines; public engines include DOE-2™ and EnergyPlus™.

Performance simulation programs are generally required to comply with ASHRAE Standard 140, *Method of Test for the Evaluating Building Performance Simulation Software.* [16] Proposed ASHRAE Standard 229P, *Protocols for Evaluating Ruleset Implementation in Building Performance Modeling Software* [17] will likely also be required once it is completed.

Table 2. Compliance paths in ASHRAE 90.1

Compliance Path (90.1 sections)	General Description	Partial List of Limits
Simplified approach (6.3)	Packaged equipment meeting minimum efficiency requirements, simple systems with certain features	• Building $\leq$ 2 stories, $<$ 25,000 ft^2 • Meet requirements of Section 6.3
Prescriptive path (6.5)	Requirements on systems include: Economizers, Simultaneous Heating and Cooling, Air System Design and Control, Hydronic System Design and Control, Heat Rejection Equipment, Energy Recovery, Exhaust Systems, Radiant Heating Systems, Refrigeration Systems	• Any building • Meet all mandatory requirements of Section 6.4 plus requirements on select systems
Performance path (11, Appendix G)	Whole building analysis with trade-offs to prescriptive paths compared on an energy cost basis (11) or energy performance basis (G)	• Any building • Meet all mandatory requirements of Section 6.4 plus design energy cost of proposed building $<$ energy cost budget of baseline building

Performance path example

If a new building is being designed to comply with ASHRAE 90.1 using the Performance Path, performance models are required that predict the energy usage of the "proposed" building as well as the 90.1 minimally compliant "baseline" building. Most software platforms allow the user to model a building in multiple ways for comparison using different alternatives. For this example, both buildings are modeled as separate "alternatives" in the software. Since the proposed building is typically well developed at this point, the task for the engineer is to model the baseline building in order to enable the required energy use and cost comparison.

Requirements for the baseline building, as well as the energy use comparison, are stated in ASHRAE 90.1 Appendix G and include many challenging modelling elements. One such element is reducing the glazing percentages on a building whose proposed alternative has more glazing than the baseline is limited to. Vertical glazing on the baseline is limited to the values defined in Table G3.1.1-1 based on building type.[18] If the proposed building has a higher vertical glazing percentage, it will need to be reduced on the baseline. Different software programs have varying methods for inputting vertical glazing, for example, windows can be input using window dimensions or percent of wall area. This can prove to be a challenge for the modeler due to the multiple steps involved. First, the percentage of vertical glazing for the proposed building needs to be determined. Sometimes this can be gleaned from output reports, otherwise it can be calculated using the window and wall dimension inputs. This process can be lengthy depending upon how the information is presented to the modeler. If the information for each building face is not readily available, then a hand calculation will need to be done for each additional room.

Second, after determining that the proposed building has a higher glazing percentage, the user will need to reduce the glazing percentage on the baseline. This is generally done room-by-room or even window-by-window, depending upon how the glazing dimensions were input. If the glazing was entered as a percentage of wall area, the user can simply reduce the percentage. Otherwise, if the actual dimensions of the windows were entered, those dimensions will need to be correctly reduced for every window in the building. This will need to be done while maintaining the same distribution of glazing for each face of the building (per Table G3.1.5c).[19] If the building model is significant in size, this process can be very time-consuming!

To address this issue, simulation programs incorporate software automation which can greatly simplify tasks related to standards and code requirements. Based on the example above, software automation allows the user to enter the baseline glazing percentage and the program will automatically adjust the inputs for the windows on the baseline alternative, so that they comply with the required percentage.

Software automation features are sometimes referred to as a "wizard". For those who have toiled through doing it the "old manual way" the "new automated way" seems to defy space and time! Next, we'll discuss the benefits of software automation for codes and standards compliance using TRACE® 3D Plus Standards Wizard as an example.

Overview of TRACE® 3D Plus Standards Wizard

Codes and standards can be very complicated and creating a baseline alternative using a computer simulation program is not always the most straightforward process. Simulation programs are consistently evolving to make the process of keeping up with changing codes and standards more efficient and accurate for the modeler. As an example, TRACE 3D Plus has a Standards Wizard that assists the user in creating an ASHRAE 90.1 baseline by leveraging some automation as well as built in libraries.

Scope

The Standards Wizard in TRACE 3D Plus can assist the modeler in creating an ASHRAE 90.1 baseline for 2007, 2010, and 2013 versions (2016 version coming soon). The user can model the actual proposed building first and then use the software tool to create a 90.1 baseline model to compare to the proposed building.

With inputs from the user, such as building type and climate zone, the tool can copy the proposed building and update it with the appropriate 90.1 construction assemblies and lighting types. Glazing percentage is reduced according to requirements in Appendix G as explained previously. Ventilation is calculated for the proposed building design and the ventilation rates are applied to the baseline. This allows the proposed and baseline models to use the same rates. Other items, such as weather and utility rates, should be modeled the same on the proposed and baseline buildings. These features are simply copied over by the wizard to the baseline alternative without modification.

Built in libraries are another way to simplify the modeling process. Many tools come with libraries for equipment, construction assemblies, internal loads, etc. that users can reference in their models. Rather than inputting every value referenced by tables throughout 90.1, libraries can come prepopulated with the correct construction U factors and equipment efficiencies as required by the standard.

It is also important to have output available for the user to check compliance with standards. TRACE 3D Plus includes a Leadership in Energy and Environmental Design (LEED®) Report in the format of the Minimum Energy Performance Calculator that is specific to LEED, but the information is also pertinent to 90.1 baseline models.[20] There are also input reports available, per the documentation requirement in Standard 90.1 Appendix G, which can assist reviewers in understanding the model inputs without the need for a software license.

What can't be automated

It would be very challenging for a software program to have a single "easy button" to generate a baseline alternative without any additional input from the user. Many sections of the standard come with exceptions, and the tool typically cannot determine which exceptions apply to a particular project. There are also sections of the standard where the user needs to make certain decisions, and those decisions dictate how some part of the baseline should be configured, for example, lighting trade-offs. For this reason, most programs don't have a single button to create an entire baseline, but instead they create some parts automatically while relying on the user to make modifications as needed.

Summary

Many resources exist to aid the engineer's understanding of which codes and standards apply to a given building project. The engineer should check local ordinances in addition to state codes early in the project to ensure the design tracks all compliance requirements. One of the best resources for state codes is www.energycodes.gov.

During the HVAC design process, reviews are important, and reviewers should not only be experienced in the pertinent HVAC system, but also be familiar with the permitting jurisdiction.

Software automation functionality continues to expand and supplement existing project quality assurance practices. Proper use of software automation wizards can significantly reduce the time required for engineering tasks, improve the quality of design submissions, and better ensure design compliance with codes and standards.

And lastly, participating in the US codes and standards process is the best way to form the future of building requirements.

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[20] U.S. Green Building Council, Minimum Energy Performance Calculator-ASHRAE 90.1-2010. Washington D.C. USGBC. 2016.

TRACE 3D Plus Version 4 is Now Available!

The new TRACE® 3D Plus Version 4 update addresses industry regulation, sustainability and building modeling complexities with a spectrum of new features designed to make this complex process easier to understand, faster to create, and less error prone.

Take advantage of this *and* improve program usability with the latest updates, including:

- **New! Undo/Redo capabilities** in the building drawing canvas, saving significant time correcting complex building creation mistakes.
- **New! Enhanced standards guide** includes fully integrated documentation with updated codes and standards, making it even easier for customers to walk step-by-step through the baseline creation process.
- **New! Automated fan calculations and library updates** utilize ASHRAE® 90.1-2016, demonstrating adherence to performance ratings and code compliance.
- **Updated! Cloud-driven data sweep analytics capabilities** help users understand models faster and at a deeper level, visually and dynamically analyze the complex relationships between model input parameters and key performance metrics and turn massive amounts of model data into useful knowledge.
- **Improved! Library filtering, viewing and selection options** for better model creation efficiency and reduced chance for input errors.

For a trial version of the software, please visit: https://www.trane.com/commercial/north-america/us/en/products-systems/design-and-analysis-tools/trane-design-tools/trace-3d-plus.html#downloads

2021 Engineers Newsletter *Live!* program schedule

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MAY—Now available on-demand

ASHRAE Standard 62.1-2019.

SEPTEMBER—Now available on-demand

Air Cleaning Devices for IEQ.

NOVEMBER

ASHRAE Standard 15. ASHRAE Standard 15, *Safety Standard for Refrigeration Systems*, focuses on the safe design, construction, installation, and operating of refrigerating systems. And the standard now includes requirements for systems with Class A2L (lower flammability) refrigerants. This ENL will overview the 2019 version of Standard 15 and explain how its requirements apply to various types of refrigerating systems, including packaged units, VRF systems, and water chillers.

Contact your local Trane office for more information or visit www.Trane.com/ENL.

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