U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

Building Energy Codes COMPLIANCE TOOLKIT

Building Energy Codes

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LEARNING SERIES

Building Energy Codes COMPLIANCE TOOLKIT

Prepared by:
Building Energy Codes Program (BECP)

The U.S. Department of Energy's (DOE) Building Energy Codes Program (BECP) is an information resource on energy codes and standards for buildings. They work with other government agencies, state and local jurisdictions, organizations that develop model codes and standards, and building industry to promote codes that will provide for energy and environmental benefits and help foster adoption of, compliance with, and enforcement of those codes.

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Building Energy Codes

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This toolkit was developed by the U.S. Department of Energy (DOE) for use by the residential and commercial build communities. This toolkit is intended to help the communities design and construct buildings that achieve compliance with energy codes and to help them document that their buildings do indeed achieve those efficiency levels. DOE has developed a similar toolkit for the enforcement community with the same goal of achieving higher levels of compliance with energy codes.

This toolkit describes the steps that should be taken by the build community to make sure that their buildings meet the requirements of the energy codes in effect where the buildings are being built and that the building designs are well documented so that the enforcement community can quickly and easily determine if the building meets the requirement of the energy code.

Current national model energy codes and standards are limited to the design and construction of buildings. The operation and maintenance of the building—however important that might be to the overall energy usage of the building—is not considered in current national model energy codes and standards.

Current model energy codes cover design, construction, and testing up to and including commissioning for some buildings. These model energy codes and standards also include options for whole-building performance approaches.

Future model energy codes and standards may involve actual building energy usage and will therefore likely require consideration of commissioning for all buildings, operation and maintenance, and occupant behavior.

DEFINITIONS

1 **TOOLKIT means a mixed media assemblage of information helpful for designing and constructing residential and commercial buildings that comply with the appropriate energy code for a particular location, the year for which construction starts, and the building type (as applicable).**

2 **COMMERCIAL BUILD COMMUNITY** means those practitioners engaged in the design and construction of commercial and high-rise multifamily residential buildings that fall under the requirements of commercial building energy codes.

3 **RESIDENTIAL BUILD COMMUNITY** means those practitioners engaged in the design and construction of low-rise residential buildings that fall under the requirements of residential building energy codes. Practitioners include architects, engineers, and designers, as well as subcontractors responsible for various energy-related systems in a building.

4 **COMPLIANCE WITH ENERGY CODES** means that buildings are designed, constructed, inspected, and tested to meet the requirements of the applicable energy code so that a certificate of occupancy can be issued by a code official.

5 **ENFORCEMENT COMMUNITY** means those practitioners engaged in ensuring that the design and construction of buildings meet the requirements of building energy codes. These practitioners are typically code officials, but they could also be peers in the commercial or residential build communities.

Organization of the Compliance Toolkit

This toolkit is organized around ten important steps for achieving compliance. These steps are:

Steps for Compliance

1. **Know** which energy code is applicable to a particular project
2. **Choose** a compliance path within the applicable energy code
3. **Know** the requirements of the applicable energy code
4. **Design** a building to meet the requirements of the applicable energy code
5. **Document** the design of the building in plans and specifications
6. **Construct** the building to meet plans and specifications
7. **Document** the "as-built" building in plans and specifications
8. **Ensure** the building operates as intended by the build community
9. **Provide** energy code compliance documentation to the code official and building owners
10. **Get** assistance on energy code and compliance questions

Each step in this toolkit provides a general description, discussion of the issues faced by the build community, and a listing of resources for the build community.

This toolkit is focused on the codes and standards called out in the American Recovery and Reinvestment Act of 2009 (ARRA). For the *residential* build community, ARRA requires states to meet or exceed the 2009 International Energy Conservation Code (IECC) or achieve equivalent or greater energy savings to qualify to receive federal funding. For the *commercial* build community, states must meet or exceed ANSI/ASHRAE/IESNA Standard 90.1-2007 (ASHRAE Standard 90.1-2007) or achieve equivalent or greater energy savings to qualify to receive federal funding. The 2009 IECC contains two options for commercial buildings: (1) ASHRAE Standard 90.1-2007 by reference, or (2) a set of requirements directly in the IECC. The commercial requirements in ASHRAE Standard 90.1-2007 and the 2009 IECC are similar but not identical; this toolkit will discuss some of those differences.

Both ASHRAE Standard 90.1-2007 and the 2009 IECC have been superseded by newer versions that require higher levels of energy efficiency. ASHRAE Standard 90.1-2010 was published in August 2010, and the 2012 IECC was published in May 2011. This toolkit also addresses compliance issues that may arise in ASHRAE Standard 90.1-2010 and the 2012 IECC.

Acronyms and Abbreviations

AIA	American Institute of Architects
ANSI	American National Standards Institute
ARRA	American Recovery and Reinvestment Act of 2009
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BCAP	Building Codes Assistance Project
BECP	Building Energy Codes Program
BIM	building information modeling
BTP	U.S. Department of Energy, Building Technologies Program
DOE	U.S. Department of Energy
EISA	Energy Independence and Security Act of 2007
GBI	Green Building Initiative
HERS	Home Energy Rating System
HVAC	heating, ventilation, and air conditioning
ICC	International Code Council
IES	Illuminating Engineering Society
IECC	International Energy Conservation Code
IgCC	International Green Construction Code
LEED	Leadership in Energy and Environmental Design
NFRC	National Fenestration Rating Council
SHGC	solar heat gain coefficient
SWH	service water heating
USGBC	U.S. Green Building Council
WBDG	Whole Building Design Guide

Know Which Energy Code Is Applicable to a Particular Project

The very first step in achieving energy code compliance is to know which energy code or standard is applicable to a project.

If a designer has been working in a particular jurisdiction for a long time, the answer may be obvious. On the contrary, if a designer is working on a building in a new jurisdiction, or if codes have recently changed (ASHRAE and IECC update their standards/codes every 3 years, and many states then adopt these updated codes), or if there is a question, it is good to know how to tell which energy code is applicable.

The applicable code can be identified by asking the local building department or code official or by referring to one of these sources of information: DOE's Building Energy Codes Program (BECP) Status of State Energy Codes Database (Resource 1), the International Code Council's (ICC) adoption database (Resource 2), and the Building Codes Assistance Project (BCAP) Status of Codes Database (Resource 3). Other potential sources of information are state, county, or local code websites listed in Resource 1.

SPECIFIC ISSUES

There are several specific situations where the applicable energy code or standard is harder to determine. Some of those situations include states, counties, or cities with stretch codes or locally adopted codes rather than statewide codes, projects where a green building rating system is being used, and federal building projects.

States, Counties, or Cities with Stretch Codes or Locally Adopted Codes

Some states, counties, and cities are now adopting stretch codes—codes that go beyond the minimum code required for all buildings in a state. In some states that do not adopt a minimum code, any code adopted at the county or city level could be considered a stretch code by this definition. In other states that do adopt relatively stringent codes for all their buildings (e.g., Massachusetts and Oregon), stretch codes represent an opportunity to require even better buildings.

Stretch codes may include requirements that replace or expand the corresponding requirements in the base code. For example, if the ICC's International Green Construction Code (IgCC) is used as a stretch code, it is assumed that a building will comply with the IECC and then go beyond that code to meet the additional requirements of the IgCC. Similarly, if ANSI/ASHRAE/USGBC/IES Standard 189.1 is being used as a stretch code, it is required that the building comply with ASHRAE Standard 90.1 and then go beyond that standard to meet the additional requirements of ASHRAE Standard 189.1. Thus, designers could end up showing compliance to two separate but interrelated codes in a stretch code situation—the base code and the stretch code. See Resources 1–3 for some information on where stretch codes are in use, but also plan on checking with local code officials.

Home rule states are an example of locally adopted codes. In some states, the state does not have the authority to adopt a statewide energy code. Counties and cities may choose to adopt their own energy code, but they might not choose to adopt the same code. This can lead to a patchwork of old codes, new codes, and no codes, which can be tough for the build communities to follow. Resources 1–3 can provide information on locally adopted codes in home rule states, but again, plan on checking with local code officials.

Projects Where a Green Building Rating System is Being Used

Some projects are being designed under green building rating systems, such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (USGBC LEED) rating system, the Green Building Initiative's (GBI) Green Globes rating system for commercial construction, or the National Green Building Standard (ICC 700) for residential construction.

The use of these green building rating systems may be "voluntary" in the sense that the design team or building owner has decided to go for green certification, or "mandatory" in the sense that there is an official requirement in locations that green certification be used for particular buildings.

These green building rating systems are intended for buildings being designed "better than code" and, as such, minimum energy codes are met before points are awarded for improved energy performance. It is possible that the minimum energy code or standard called out in a green building rating system will be newer or older than the minimum energy code or standard required in a particular location. In this case, designers may need to show compliance with two different minimum energy codes or standards—one for energy code compliance to obtain an occupancy permit and another code to meet the prerequisites of the green building rating system. See Resources 4–5 for information on where prominent green building rating systems may be required.

Projects Where a Home Energy Rating System is Being Used

Many residential projects are being designed under rating systems such as the Residential Energy Services Network (RESNET) and the National Association of State Energy Official's Home Energy Rating System (HERS). The use of the HERS program may be "voluntary" in the sense that the design team or building owner has decided to have the building rated, "mandatory" in the sense that there is a requirement in a particular location that these systems be used for particular buildings, or "alternative" in the sense that the HERS rating system is allowed as an alternative to the building energy code. It is possible that showing compliance with an energy code and determining a HERS rating will require two different sets of documentation. See Resource 6 for more information on RESNET HERS.

Federal Building Projects

Projects that are completely owned by federal agencies are not bound by state or local codes. Instead, they must follow the codes adopted by the federal agency. Federal agencies are subject to several statutory requirements, executive orders, and other policies surrounding sustainable buildings and campuses. Section 433 of the Energy Independence and Security Act of 2007 (EISA 2007) removed the mention of federal buildings subject to state or local building codes from Section 303(6) of the Energy Conservation and Production Act (42 U.S.C. 6832(6)); therefore, all federal buildings are now subject to federal building energy efficiency standards. See Resource 7 for more information on federal building energy efficiency standards.

CHAPTER 3 RESOURCES	
1. BECP's Status of State Energy Codes Database	www.energycodes.gov/adoption/states
2. ICC's Adoption Database	www.iccsafe.org/gr/Pages/adoptions.aspx
3. Building Code Assistance Project Status of State Energy Codes	http://bcap-ocean.org/code-status
4. USGBC List of Public Policies Adopting or Referencing LEED	www.usgbc.org/DisplayPage.aspx?CMSPageID=1852
5. GBI Map of States with Laws Recognizing Green Globes	www.thegbi.org/green-globes/green-globes-state-acceptance-map.asp
6. Residential Energy Services Network (RESNET) Home Energy Rating System (HERS)	www.resnet.us/
7. Federal Building Energy Efficiency Standards	www.energycodes.gov/regulations/federal-building-standards

Choose a Compliance Path Within the Applicable Energy Code

For some designers, an ideal energy code would tell them exactly what they need to do for their building. For other designers, being told exactly what they need to do might be viewed as limiting their creativity. Energy codes attempt to cater to both types of designers by offering multiple compliance paths within the code.

BECP's Commercial Buildings for Architects Resource Guide (Resource 1) states the issue as

> *An energy code's format can significantly influence design, sometimes more than the actual requirements. A prescriptive code clearly states what applies, but may limit design freedom and foster the view that the building is composed of separate, non-related systems. A performance-based code provides more design freedom and can lead to innovative design but involves more complex energy simulations and tradeoffs between systems. Smaller commercial buildings with singular HVAC, service hot water, and lighting systems are more likely to be designed using a prescriptive approach. Larger commercial buildings that have multiple systems or varied uses and loads provide more opportunities to follow a performance-based code.*

The 2009 IECC and ASHRAE Standard 90.1-2007, as well as the 2012 IECC and ASHRAE Standard 90.1-2010, contain a number of compliance paths. The Choosing an Energy Code Compliance Path Topic Brief (Resource 2) presents these paths in more detail.

Each compliance path may have *mandatory, prescriptive*, or *tradeoff* requirements. These terms are defined below, along with a few other terms related to compliance paths.

Mandatory requirements are requirements that must be met in every building design no matter which compliance path is chosen.

Prescriptive requirements are requirements that either must be met by every building design, or if the requirement is not met, a tradeoff must be made to "make up" for not meeting that requirement.

Envelope tradeoffs are tightly defined tradeoffs that allow trades to be made between various parts of the building envelope. An example might be that a building owner might choose to install more insulation in the roof to "make up" for putting in more window area than the code allows. ASHRAE Standard 90.1-2007/2010 provides the basic rules for this envelope tradeoff, and that tradeoff is implemented in the COM*check*™ software. A simpler envelope tradeoff is found in the 2009/2012 IECC for low-rise residential buildings in the "UA" tradeoff approach implemented in the RES*check*™ software. Both of these DOE-developed software tools are available free of charge at **www.energycodes.gov**. The 2009/2012 IECC allows you to trade off levels of insulation and glazing efficiency. For example, trade decreased wall efficiency (lower R-value) for increased window efficiency (lower U-factor), or increase the roof insulation and reduce or eliminate slab-edge insulation.

Deemed-to-comply software is software that implements major elements of an energy code, and which may be approved by a code official or authority having jurisdiction—whatever level of government adopted the code. Because Chapter 5 of the 2009 IECC and Chapter C4 of the 2012 IECC do not include specific mention of an envelope tradeoff for commercial buildings, but the 2009/2012 IECC does allow use of ASHRAE Standard 90.1-2007/2010, which does have an envelope tradeoff, the COM*check* software implements the envelope tradeoff even for the 2009/2012 IECC. COM*check* therefore does not implement all compliance options in the 2009/2012 IECC and is referred to as deemed-to-comply software for the IECC. COM*check* is also deemed to comply with ASHRAE Standard 90.1 because COM*check* does not fully implement the space-by-space envelope requirements in ASHRAE Standard 90.1. The RES*check* software is a close implementation of the IECC but is not specifically mentioned in the IECC and is therefore deemed to comply as well. Resource 3 provides a discussion of which jurisdictions

allow the use of COM*check* and RES*check* on a state-by-state basis. Whole building tradeoffs, also known as the systems performance approach or just the performance approach, implement tradeoffs that can be made between various building systems based on rules set in ASHRAE Standard 90.1 and in the IECC as applicable. An example might be that a building owner might choose to install more efficient lighting than the code requires to "make up" for putting in less insulation than the code allows. This approach allows you to compare your proposed design to a baseline or reference design that exactly meets code requirements. If the proposed design is at least as efficient as the baseline in terms of annual energy use, it complies. This approach allows greater flexibility but is more complicated, although software has been developed to assist code users. A performance approach is often necessary to obtain credit for special features, such as passive solar design, photovoltaic cells, thermal energy storage, and fuel cells. The Building Energy Software Tools Directory (Resource 4) lists tools that can be used to do an annual energy analysis of a building. The rules for these calculations are found in the 2009/2012 IECC performance alternative, or the ASHRAE Standard 90.1-2007/2010 Energy Cost Budget Method. RES*check* offers a limited performance approach for low-rise residential buildings.

It is also important to note that when an energy code has multiple compliance paths within it, a building designed to one compliance path may have different energy efficiency measures to one designed under a different compliance path. Developers of energy codes typically attempt to keep the overall stringency of the compliance paths more or less the same in terms of energy or energy cost, but there are variations between paths. Resource 2 provides some discussion on why a designer might want to consider particular compliance paths within a code.

CHAPTER 4 RESOURCES	
1. BECP Resource Guide: Commercial Buildings for Architects	www.energycodes.gov/sites/default/files/documents/BECP_Building%20Energy%20Codes%20Resource%20Guide%20Commercial%20Buildings%20for%20Architects_October2010_v00_lores.pdf
2. Choosing an Energy Code Compliance Path Topic Brief	www.energycodes.gov/sites/default/files/documents/compliance_paths_topic_brief.pdf
3. BECP's Status of State Energy Codes Database	www.energycodes.gov/adoption/states/
4. Building Energy Software Tools Directory	http://apps1.eere.energy.gov/buildings/tools_directory/

Know the Requirements of the Applicable Energy Code

Once the applicable energy code is identified, the build community must become familiar with the specific requirements of that code. Most commercial building energy codes contain similar requirements for the following components of a commercial building:

- Building thermal envelope, including opaque envelope, fenestration, and foundations
- Heating, ventilating, and air-conditioning (HVAC) systems, including equipment and controls
- Service water heating (SWH) systems, including equipment and controls
- Power systems such as transformers and wiring
- Lighting systems, both interior and exterior, including fixtures and controls
- Other equipment such as motors and elevators
- Renewable energy systems.

Not every member of the build community has to be familiar with all the requirements in a commercial building energy code.

Commercial buildings are usually (but not always) designed by a team of practitioners representing different disciplines.

Most residential building energy codes contain requirements for the following components of a residential building:

- Building thermal envelope, including opaque envelope, fenestration, and foundations
- HVAC systems, including equipment and controls
- SWH systems, including equipment and controls
- Interior lighting systems.

The single biggest issue associated with knowing the requirements of the applicable energy code is that energy codes are relatively complex documents that undergo significant changes every 3 years at the national level. *This means that practitioners responsible for knowing the requirements related to their discipline may frequently update their knowledge of the codes with which they work.*

Fortunately, a number of organizations have a vested interest in helping practitioners understand the codes. These include DOE, the national model code and standard developing organizations (ICC and the American Society of Heating, Refrigerating and Air-Conditioning Engineers [ASHRAE]), the regional energy efficiency organizations (Midwest Energy Efficiency Alliance, Northwest Energy Efficiency Alliance, Northeast Energy Efficiency Partnerships, Southeast Energy Efficiency Alliance, and Southwest Energy Efficiency Project), and states and localities that adopt energy codes. There is no lack of pertinent information available on energy codes—it is the lack of time that practitioners have available to learn about codes that can be an issue.

The Resources section of this step contains links to a large number of resources that can help practitioners learn about codes. Most of these resources are focused on the entire code or standard, so practitioners need to pick and choose the sections in which they are interested.

Table 1 lists the particular sections of the most recent commercial building energy codes and standards that a practitioner might be interested in.

Table 2 provides a similar list for residential building energy codes. Note that residential building energy codes are much simpler, so Table 2 is much simpler than Table 1.

Topic	Building Envelope	Mechanical/ HVAC	Service Water Heating	Power	Lighting	Other Equipment	Additional Efficiency Package Options
ASHRAE Standard 90.1-2007	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	NA
2009 IECC	502	503	504	505	505	NA	NA
ASHRAE Standard 90.1-2010	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	NA
2012 IECC	C402	C403	C404	C405	C405	NA	C406
Architect	X	X	X	X	X (daylighting)	X	X (reduced lighting power density, renewable energy)
Mechanical Engineer and Subcontractors	X	X	X			X	X (higher equipment efficiency)
Plumbing Engineer and Subcontractors			X				
Lighting Designer and Subcontractors	X (daylighting)				X		X (reduced lighting power density)
Electrical Engineer and Subcontractors				X	X	X	X (renewable energy)
Controls Engineer and Subcontractors		X	X	X	X	X	X (renewable energy)
Landscaping Designer and Subcontractors					X (outdoor lighting)		X
Documentation Preparer	X	X	X	X	X	X	X

Table 1. Prescriptive requirements for ASHRAE Standard 90.1-2007, ASHRAE Standard 90.1-2010, the 2009 IECC, and the 2012 IECC by section and segment of the build community

Topic	Building Envelope	Systems	Electrical Power and Lighting
2009 IECC	402	403	404
2012 IECC	R402	R403	R404
Builder	X	X	X
Architect	X	X	X
Electrical Subcontractor			X
Mechanical Subcontractor	X	X	
Plumbing Subcontractor		X	
Documentation Preparer	X	X	X

Table 2. Prescriptive requirements for the 2009 IECC and the 2012 IECC by section and segment of the residential build community

An assortment of general training resources for energy codes and standards from DOE, ASHRAE, and ICC are listed under General Resources.

SPECIFIC ISSUES

No matter which energy code or standard is being considered, there tend to be some specific issues that are problematic for many members of the build community. These issues include calculating loads and sizing equipment, fenestration labels, lighting controls, and mechanical requirements. These issues are discussed individually in the following paragraphs.

Load Calculations and Equipment Sizing

Energy codes typically require load calculations, equipment sizing, or both for HVAC and, to a much lesser extent, SWH equipment. Given that these two requirements are intimately related (i.e., it is impossible to do proper equipment sizing without doing load calculations, and there is little reason to do load calculations unless it is intended for equipment sizing), it is interesting to see how these topics are dealt with in various energy codes and standards. Table 3 shows the load calculation and equipment sizing requirements for HVAC and SWH equipment.

The bottom line is that there should be HVAC load calculations and sizing information for all building designs, no matter what type of building or the applicable code or standard. There should also be SWH load calculations and sizing information if ASHRAE Standard 90.1 is being used. Good design practice would indicate that all HVAC and SWH equipment should be properly sized, no matter what code or standard is being used. A specific topic brief on load calculations and equipment sizing has been prepared (Specific Issue Resource 1).

Code or Standard	HVAC Load Calculations	HVAC Sizing	SWH Load Calculations	SWH Sizing
2009 IECC (residential)	Section 403.6	*Implied*	NA	NA
2012 IECC (residential)	Section 403.6	Section R403.6	NA	NA
ASHRAE Standard 90.1-2007	Section 6.4.2	*Implied*	Section 7.4.1	*Implied*
2009 IECC (commercial)	Section 503.2.1	Section 503.2.2	NA	NA
ASHRAE Standard 90.1-2010	Section 6.4.2.1	*Implied*	Section 7.4.1	*Implied*
2012 IECC (commercial)	Section C402.2.1	Section C403.2.2	NA	NA

Table 3. Load calculation and equipment sizing requirements in various codes and standards

Energy codes typically require that fenestration (windows, doors, and skylights) has labels or certificates verifying the performance of those products. Table 4 compares the fenestration labeling requirements across various codes and standards.

Figure 1. Example of a window performance label from the National Fenestration Rating Council

Fenestration Labels

The confusion that can arise over fenestration labels is that the IECC requires a label, and if that label is not available, the values in the default tables for fenestration performance must be used. In ASHRAE Standard 90.1, if a permanent nameplate is not available, then a certificate must be provided. ASHRAE Standard 90.1 also allows the use of default tables for determining fenestration performance, but those default tables do not take the place of a permanent nameplate or certificate. The IECC allows the use of a default table as a substitute for the label. Many jurisdictions allow certification from the National Fenestration Rating Council (NFRC) in lieu of labels.

While the use of the default tables may seem to be an easy and quick way to deal with the issue of equipment labels, this may not be the best option for a designer. The U-factor and solar heat gain coefficient (SHGC) values in the default table do not meet many of the prescriptive requirements found in either ASHRAE Standard 90.1 or the IECC. For example, the default U-factor and SHGC in the 2009 IECC for a double-pane, metal-framed window with clear glass are U-0.8 and SHGC-0.7. This default window would meet the U-factor requirements in only Climate Zone 1 but would not meet the SHGC requirements in any other climate zone. The default tables in both ASHRAE Standard 90.1 and the IECC have been carefully constructed to represent the worst-performing window of any given description, so any labeled or certified window that has been tested will almost invariably perform better. Best practice indicates that a building designer should have some documentation of the performance of the fenestration products installed in that building, whether that documentation is a label or sticker on the window, a permanent nameplate, or a certificate on file. To make inspection of the building easier for the code official, that documentation should be available both during plan review and on-site inspection(s).

Code or Standard	Fenestration Product Labeling	Exceptions
2009 IECC (residential)	Section 303.1.3	If no label, default table may be used
2012 IECC (residential)	Section R303.1.3	If no label, default table may be used
ASHRAE Standard 90.1-2007	Section 5.8.2.2	If no permanent nameplate, may have certificate
2009 IECC (commercial)	Section 303.1.3	If no label, default table may be used
ASHRAE Standard 90.1-2010	Section 5.8.2.2	If no label, default table may be used
2012 IECC (commercial)	Section C303.1.3	If no label, default table may be used

Table 4. Fenestration labeling requirements in various codes and standards

Lighting Controls
This issue is entirely a commercial building issue, as residential codes do not currently require lighting controls. There are a lot of lighting control requirements in both ASHRAE Standard 90.1 and the IECC, and that number increases with each new version of the codes. Lighting control requirements in energy codes can be summarized as:

- Use only as much lighting power as needed to provide the necessary lighting levels in the space.
- Have controls to allow the occupants to turn off or turn down lights when not needed.
- Have controls to automatically turn off or turn down the lights when not needed.

The amount of lighting power allowed to provide the necessary lighting levels in a space has gone down steadily in codes, thanks to improvements in lighting technology over the years.

In terms of control requirements, there are requirements for manual switches, occupancy sensors, and automatic shutoff of lighting in most energy codes, for bi-level switching in some of those codes, and there are beginning to be requirements for daylighting controls as well in the energy codes. The lighting requirements in ASHRAE Standard 90.1 and the IECC are not identical, as shown in Table 5. It should be noted that exceptions apply in both ASHRAE Standard 90.1 and the IECC for emergency and egress lighting that may be required in other building codes.

Figure 2. Examples of various lighting controls

A specific topic brief on lighting has been prepared (Specific Issue Resource 2). Other good sources of lighting control information for ASHRAE Standards 90.1-2007 and 90.1-2010 (and indirectly for the 2009 and 2012 IECC) are the ASHRAE Standard 90.1 Users' Manuals available from ASHRAE (see General Resource 1).

Code or Standard	2009 IECC Residential	2012 IECC Residential	ASHRAE Standard 90.1-2007	ASHRAE Standard 90.1-2010	2009 IECC Commercial	2012 IECC Commercial
Interior Lamp Efficacy	404.1	R404.1	NA	NA	NA	NA
Interior Lighting Power Density	NA	NA	9.2.2.3	9.2.2.3	505.5.1	C405.5.1
Manual Controls	NA	NA	9.4.1.2	9.4.1.2	505.2.1	C405.2.1
Bi-Level Switching	NA	NA	NA	NA	505.2.2.1	C505.2.1.2
Automatic Lighting Shutoff	NA	NA	9.4.1.1	9.4.1.1	505.2.2.2	C405.2.2.1
Daylight Zone	NA	NA	NA	9.4.1.4, 9.4.1.5	505.2.2.3	C405.2.2.3
Sleeping Unit	NA	NA	NA	NA	505.2.3	C405.2.3
Occupancy Sensors	NA	NA	9.4.1.2	9.4.1.2	NA	C405.2.2.2
Specific Application Controls	NA	NA	9.4.1.4	9.4.1.6	NA	C405.2.3
Tandem Wiring	NA	NA	9.4.2	NA	505.3	C405.3
Parking Garage Controls	NA	NA	NA	9.4.1.3	NA	NA
Exterior Lighting Efficacy	404.1	R404.1	9.4.4	NA	505.6.1	C405.6.1
Exterior Lighting Power Density	NA	NA	9.4.5	9.4.3	505.6.2	C505.6.2
Exterior Lighting Controls	NA	NA	9.4.1.3	9.4.1.7	505.2.4	C405.2.4

Table 5. Lighting requirements in various codes

Mechanical Requirements

The issues discussed here are almost entirely commercial building issues because residential codes are not as complicated as commercial codes. Mechanical requirements typically include equipment requirements and system requirements. Mechanical requirements may also cover both HVAC and SWH systems, and there may be differences between how HVAC and SWH systems are treated in the codes. (See discussion of load calculations and sizing.) As a general rule, most mechanical requirements can be summarized as:

- Size equipment
- Use efficient equipment
- Use "free-cooling" (economizers)
- Insulate pipes and ducts to avoid uncontrolled heat loss or gain in fluids
- Have controls to automatically turn equipment off or turn it down when not needed
- Have controls to avoid mixing hot and cold fluids or reheating cooling fluids.

However, these requirements tend to be expressed in multiple tables and sections throughout the code, and it can be difficult to figure out what is required. The problem is compounded by the fact that there are a lot of very complex mechanical systems used in commercial buildings, and deciding which requirements are applicable means understanding these complex systems.

One issue related to the mechanical requirements is that the efficiency of most types of mechanical equipment is regulated by the federal government rather than by energy codes (with chillers being the major exception). Designers and code officials may be lulled into complacency by the thoughts that "all equipment available from manufacturers will meet code," which is correct except in those cases where equipment is not covered by federal legislation (e.g., chillers) or where equipment of higher-than-minimum efficiency has been proposed for use in a whole-building tradeoff or an above-code program. In these two cases, it is very important that the proper equipment efficiency be achieved.[1] Not all of the products regulated by DOE are also covered in building energy codes. For example, DOE's residential products list includes clothes washers, clothes dryers, and television sets. While these products do use energy, they are not regulated in building energy codes.

Beyond the efficiency of individual pieces of mechanical equipment, mechanical systems as a whole are also important. Mechanical systems are responsible for most of the energy used in buildings these days, so it is vital that they be designed properly, made to work properly, and inspected properly.[2] To address the "made to work properly" need, codes and standards require testing, balancing, and/or commissioning of mechanical systems. A topic brief on testing, balancing, and commissioning addresses this issue (Specific Issue Resource 3).

Also addressed within the mechanical requirements is mechanical system controls. A good resource for mechanical controls requirements is BECP's HVAC Controls Guide for Plans Examiners and Building Inspectors (Specific Issue Resource 4).

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[1] See a complete listing of residential products covered by DOE equipment standards rulemakings at **www1.eere.energy.gov/buildings/appliance_standards/residential_products.html**. See a similar list for commercial products at **www1.eere.energy.gov/buildings/appliance_standards/commercial_products.html**.

[2] See Table 1.1.4 of DOE's Building Energy Databook at **http://buildingsdatabook.eere.energy.gov/TableView.aspx?table=1.1.4** for an estimate that mechanical systems (HVAC and SWH) account for 61.5% of site energy usage and 50.1% of source energy usage in buildings.

CHAPTER 5 GENERAL RESOURCES	
1. ASHRAE Standard 90.1 User's Manual—ANSI/ASHRAE/IESNA Standard 90.1-2007 and ASHRAE 90.1 User's Manual ANSI/ASHRAE/IES Standard 90.1-2010—available from the ASHRAE Bookstore	www.ashrae.org/
2. DOE Code Compliance Software	a. COM*check* Background www.energycodes.gov/com*check*/
	b. RES*check* Background www.energycodes.gov/res*check*/
3. DOE Training Materials	www.energycodes.gov/resource-center/eLearning
4. DOE Building Tools Directory	http://apps1.eere.energy.gov/buildings/tools_directory/
5. ASHRAE Standard 90.1-2010 and Standard 189.1-2011	a. Read-only version of Standard 90.1-2010 http://openpub.realread.com/rrserver/browser?title=/ASHRAE_1/ashrae_90_1_2010_IP_1024
	b. Read-only version of Standard 189.1-2011 http://openpub.realread.com/rrserver/browser?title=/ASHRAE_1/ashrae_189.1_113009
	c. ASHRAE eLearning www.ashrae-elearning.org/
	d. ASHRAE Learning Institute www.ashrae.org/education/page/1809
6. International Code Council Resources	a. ICC training www.iccsafe.org/Education/Courses/Pages/catalog.aspx
	b. 2009 and 2012 IECC commentaries—available from the ICC Bookstore www.iccsafe.org/Store

CHAPTER 5 SPECIFIC ISSUE RESOURCES	
1. Load Calculation Topic Brief	www.energycodes.gov/sites/default/files/documents/HVAC_sizing_topic_brief.pdf
2. Lighting Topic Brief	www.energycodes.gov/sites/default/files/documents/lighting_topic_brief.pdf
3. Testing and Commissioning Topic Brief	www.energycodes.gov/sites/default/files/documents/testing_topic_brief.pdf
4. HVAC Controls Guide for Plans Examiners and Building Inspectors—Resource Guide	www.energycodes.gov/sites/default/files/documents/BECP_HVAC%20Controls%20Guide%20for%20Plans%20Examiners%20and%20Building%20Inspectors_Sept2011_v00_lores.pdf

Design a Building to Meet the Requirements of the Applicable Energy Code

Designing a building to meet the requirements of the energy code can impact the look, feel, and function of the building.

Energy codes also affect the design of all building systems separately and collectively. It is very important that the professionals responsible for designing the building envelope, lighting, and HVAC work together to consider interactions to best control overall building energy use. Integrated design, although not a requirement of the model codes and standards, is critical to minimizing initial project cost and being as effective as possible.

WBDG.org, a web-based portal from the National Institute of Building Sciences that provides information on whole-building design, defines the integrated design approach as an approach that

> *...asks all the members of the building stakeholder community and of the technical planning, design, and construction team to look at the project objectives, and building materials, systems, and assemblies from many different perspectives. This approach is a deviation from the typical planning and process of relying on the expertise of specialists who work in their respective specialties somewhat isolated from each other. Whole-building design in practice also requires an integrated team process in which the design team and all affected stakeholders work together throughout the project phases and to evaluate the design for cost, quality-of-life, future flexibility, efficiency; overall environmental impact, productivity, creativity; and how the occupants will be enlivened.*

DOE's Building America Program has for many years promoted an integrated design approach to optimize energy efficiency in residential buildings. "The U.S. Department of Energy's Building America Program strives to develop integrated energy systems that dramatically reduce annual energy use and peak energy loads in existing and new homes while also improving overall building quality, comfort, safety, and durability."

Building energy modeling is a key tool used by designers to guide design and construction decisions. Energy modeling is most often used to (1) comply with code requirements, particularly for performance paths in the IECC or ASHRAE Standards; and (2) comply with program requirements for desired outcomes (e.g., LEED certification, qualification for tax incentives, and qualification for utility incentives). Using energy modeling early and iteratively throughout the design process, the architect maintains control over the design while meeting building energy thresholds set by minimum codes or client values.

SPECIFIC ISSUES

Table 1 under "Know the requirements of the applicable energy code" indicates that designing an energy code-compliant building can be a complex task requiring a knowledgeable set of practitioners, particularly for larger commercial buildings. Two specific approaches to building design may make that task easier: integrated design teams and building information modeling (BIM; Resource 1).

Integrated Design Teams

Looking at Table 1 under "Know the requirement of the applicable energy code" again, it is clear that commercial building energy codes impact a large number of aspects of building design, and that those codes touch on a wide variety of disciplines. It would require a very well-educated practitioner to master all the necessary disciplines and code requirements associated with a large commercial building. Rather than have a single "super practitioner," most projects involve a design team of complementary practitioners.

However, Table 1 also shows that there are many areas that require cooperation among practitioners. An example:

- An architect's decisions on the location, orientation, and performance of windows may impact the lighting designer's approach to lighting due to the influence of daylighting.
- The control engineer needs to know if there will be a change in how lights are controlled due to daylighting.
- A landscaping designer may need to know about outdoor lighting specifications from the lighting designer as well.

All of this interaction implies a need for an integrated design team that works together to design the whole building. The concept of integrated design teams has been around for many years, but effective integration does not always happen. Resource 2 is a good video discussing their importance. Integrated design teams are especially important in federal construction, as current executive orders require the use of integrated design teams and new federal requirements are focused solely on whole-building energy or whole-building fossil fuel-based energy consumption. While most energy codes are still written as stand-alone prescriptive sections for different disciplines, the future of commercial building energy codes is likely to be whole-building approaches.

Use of an integrated design approach requires an integrated design team, and an integrated design team requires well-drafted contracts, subcontracts, and consultant agreements that will help project participants clearly define the roles and responsibilities necessary for code compliance and successful project completion. The American Institute of Architects (AIA) publishes a variety of standard form agreements that define the critical roles and responsibilities involved in the design and construction of projects across a variety of delivery models (see Resource 3 for more information on AIA contract documents). DOE has also prepared a Commercial Buildings for Architects Resource Guide that covers integrated design and many other topics (Resource 4).

The Whole-Building Design Guide offers a free online class on integrated design (Resource 5).

Residential buildings are generally simpler than commercial buildings and therefore the "integrated design team" may include fewer members, but the principles of integrated design still apply.

Building Information Modeling

Table 1 also provides a reminder that someone on the building team needs to be responsible for documentation of the design. Three separate sections of this toolkit focus on documenting the original design, documenting the building "as built," and providing that documentation to the code official for approval. With the ever increasing complexity and volume of documentation, the concept of BIM becomes increasingly attractive.

The Commercial Buildings for Architects Resource Guide (Resource 4) has this to say about BIM:

> *Building information modeling (BIM) software allows essentially all project-related data to be placed in an electronic library for the entire project team to see. While traditional paper-based materials can provide the same information, the ability to "see and apply" such paper-based information is very limited, even if only two people try to do it at the same time. An electronic format can provide a virtual building where designs can be evaluated for cost, schedule, conflicts of systems space, visual atmosphere, energy use, and code compliance, to name a few.*

DOE provides an excellent tool for documenting energy code compliance in the COM*check* software, but this is a stand-alone tool that requires someone to manually enter data from plans and specifications. DOE and others provide a number of whole-building energy simulation tools that can be used to predict whole-building energy usage of a proposed design. But again, these tend to be stand-alone tools that require

someone to manually enter data. The "Holy Grail" of the building design community is (and should be) a tool that allows practitioners to follow an integrated design approach and that provides any necessary energy simulation and code compliance documentation automatically. BIM tools may soon provide that "Holy Grail."

CHAPTER 6 RESOURCES	
1. BIM Topic Brief	www.energycodes.gov/sites/default/files/documents/BIM_topic_brief.pdf
2. DOE Federal Energy Management Program Integrated Design Video	www.energycodes.gov/training-courses/integrated-building-design-bringing-pieces-together-unleash-power-teamwork
3. Additional information regarding AIA contract documents	www.aia.org/contractdocs
4. Commercial Buildings for Architects—DOE Resource Guide	www.energycodes.gov/resource-center/resource-guides
5. Whole Building Design Guide Course	www.wbdg.org/education/integrated_design.php
6. State Compliance, Implementation, and Enforcement Guide (Iowa example)	www.energycodes.gov/sites/default/files/documents/IA_cie_guide.pdf

Document the Design of the Building in Plans and Specifications

Successful compliance requires the cooperation of many individuals involved in a building project: designers, engineers, architects, builders, building owners, and others.

The code gives specific responsibilities to the applicant and the building official. The DOE Resource Guide—Commercial Buildings for Architects (Resource 1) states the following.

> *Architects generate the plans and drawings related to the physical and functional characteristics of the building design systems that will be installed. Specifiers (who are often the architects as well) develop detailed specifications for the materials to be used and how those materials and components are to be assembled in making the final building. Contractors need to understand the plans and specifications that the architects provide so they know how to assemble the building from its individual components. As such, they can be confident that the building features called for in the drawings are correctly integrated into the building and that the right equipment, controls, and systems are installed to meet the design specifications.*

WHO DOCUMENTS?

An overall issue with documentation is who is responsible to complete it. It is possible for one individual to provide the documentation if they have all of the required information, and this is fairly common for residential projects. It is more common in commercial construction for the individual specialties to provide documentation for their required sections: building envelope, lighting, mechanical, and SWH. Refer to Table 1 for suggestions on who might complete documentation per code requirement category.

HOW TO DOCUMENT?

There are two common methods available to document compliance: forms and software-generated reports.

Forms

Forms are simply pieces of paper or electronic documents that are completed by the designer to document their design. These forms might be developed by the organization that developed the code,[3] by DOE to support the codes,[4] or by local jurisdictions.[5] Forms can range from simple forms listing the minimum requirements for that climate zone for a simple residential building, to multipart, multipage forms for complex commercial buildings. The basic purpose of forms is to allow the applicant to simply show the appropriate details on the submitted plans and fill out the form, noting insulation levels, efficiencies, and the like.

Software-Generated Reports

Software programs, such as RES*check* and COM*check*, can be used to demonstrate compliance for building designs. These software programs may be used to document any of the compliance approaches used within the software.

If energy modeling software is to be used, it is recommended that the code official be asked before starting the modeling process what documentation will be required to demonstrate energy code compliance. At a minimum, all modeling assumptions should be included with the documentation.

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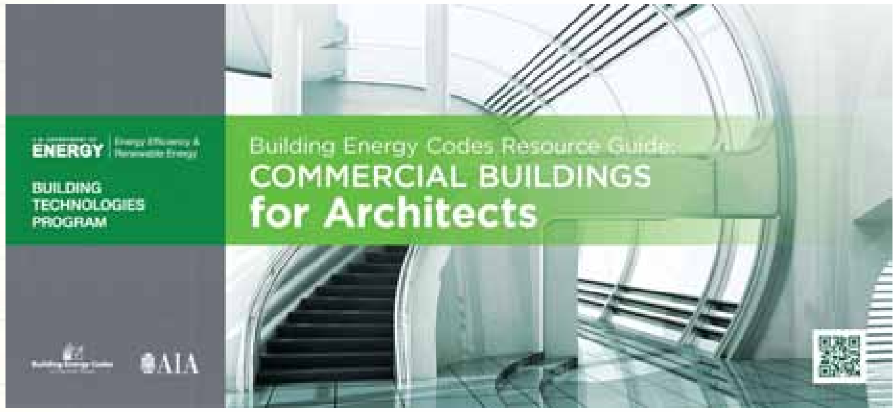
[3] See compliance forms for ASHRAE Standards 90.1-1999 through 90.1-2010 developed by ASHRAE at **www.ashrae.org/standards-research--technology/standards-forms--procedures**.

[4] See compliance forms for ASHRAE Standard 90.1-2007 and the 2009 IECC developed by DOE for use with state code compliance evaluations at **wwww.energycodes.gov/compliance/evaluation/checklists**. These forms could also be used by designers to show compliance.

[5] See for example the Washington State Nonresidential Energy Code Compliance forms at **www.neec.net/energy-codes**. Many other states and local jurisdictions have their own compliance forms.

Historically, much of the onus for compliance has fallen on the code official to take whatever information is provided and attempt to determine whether the requirements have been met. However, the code official has many of the same challenges as the build community as described elsewhere in this toolkit, most importantly, lack of time and other resources. Some states have begun to put more of the onus on the build community to demonstrate compliance with more detailed documentation. For example, Oregon requires that submitters include details of the location on the plans where compliance with requirements is documented.[6]

Compliance reports may also be generated by BIM software. See the discussion of BIM and the BIM Topic Brief discussed under "Design a building to meet the requirements of the applicable energy code."



CHAPTER 7 RESOURCES	
1. **Commercial Buildings for Architects—DOE Resource Guide**	www.energycodes.gov/resource-center/resource-guides

Where Does Documentation Go?
Compliance documentation must be submitted as part of the plan set to the authority having jurisdiction in order to obtain the necessary permits, etc. It is critical that the documentation be complete and include all of the details required by the code official to determine whether the requirements have been satisfied.

[6] See detailed compliance instructions for the Oregon commercial energy code at **www.bcd.oregon.gov/programs/energy.html#work**.

Construct the Building to Meet Plans and Specifications

Once the building is designed, it is the role of the construction team to assemble the building.

The building must comply with the building energy code, not just on paper but in practice. It is critical that each person involved in the construction of the building be aware of the requirements and the importance of not deviating from the approved plans and specifications.

DOE's Commercial Buildings for Architects Resource Guide (Resource 1) points out that "all current model codes and standards include a provision for installing materials and products per the manufacturers' instructions. In this case, energy code compliance is not ensured through plans and specifications, but by making sure that materials and products are properly installed. Designers can reinforce this by specifying that construction must meet manufacturers' installation instructions and applicable quality assurance criteria, and by having the client retain them during construction to verify that their design and specifications are properly implemented." These statements, while written for commercial architects, are equally appropriate for residential designers.

SPECIFIC ISSUES

Issues in this step typically revolve around quality of the workmanship and the subcontractors being aware of the energy code requirements and how to handle them properly.

Installation issues seem to be problematic according to information from the enforcement community. Air leakage is another specific issue that is closely related to installation issues.

Installation

Areas to pay particular attention include the installation of insulation, air barriers, and ducts. Helpful resources addressing these specific areas are referenced below.

Insulation

The recommended amount of insulation depends on the building design, climate zone, price of energy, and the cost of materials and labor. There are many insulation options that will meet the requirements of the energy codes. Regardless of the type of insulation chosen, it is critical that the insulation be properly installed in order for the full effectiveness to be realized. Even small gaps and compressed areas can reduce insulating levels significantly. For example, compressing fiberglass insulation reduces its effectiveness and does not achieve the full R-value.

RESNET has set an industry standard for insulation installation. Although this standard is not required specifically in the energy codes, it is good practice and is referenced in "ENERGY STAR for Homes Version 3" (Resource 2). RESNET assigns insulation grades based on gaps and compression or incompletely filled areas. Grade I allows for "occasional very small gaps and up to 2% of the insulated area can have compression or incomplete fill." For more information, visit RESNET (Resource 3).

DOE's Building Technologies Program (BTP) and Building America Program have several resources related to the proper installation of insulation in residential buildings. These resources do not cover the code requirements specifically but offer best-practice suggestions:

- BTP's "Wall Insulation, Provide Moisture Control and Insulation in Wall Systems" fact sheet describes effective wall insulation and the various insulation types (Resource 4).

- DOE's Office of Energy Efficiency and Renewable Energy offers an insulation fact sheet focused on homes and discusses why homes should be insulated and how insulation works (Resource 5).
- A Building America Partner, Building Science Corporation, has an information sheet, "Installation of Cavity Insulation for All Climates," which covers the installation techniques important to achieving the effective performance of cavity insulation (Resource 6).
- Another Building Science Corporation information sheet, "Slab Edge Insulation for All Climates," covers slab-edge insulation (Resource 7).
- An article in *Home Energy*, "Insulation Inspections for Home Energy Ratings: Assessing insulation gaps, compression, and incomplete fill provides a way to measure installation effectiveness," provides additional information in quality insulation installation (Resource 8).
- Southface Energy Institute's energy technical bulletins may also be of interest, which cover topics such as wall insulation, ceiling and attic insulation and ventilation, and insulating foundations and floors (Resource 9).

Air Barriers

The IECC defines an air barrier as "material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials." DOE's Building America Program has several resources related to the proper installation of air barriers. These resources do not cover the code requirements specifically but offer best-practice suggestions.

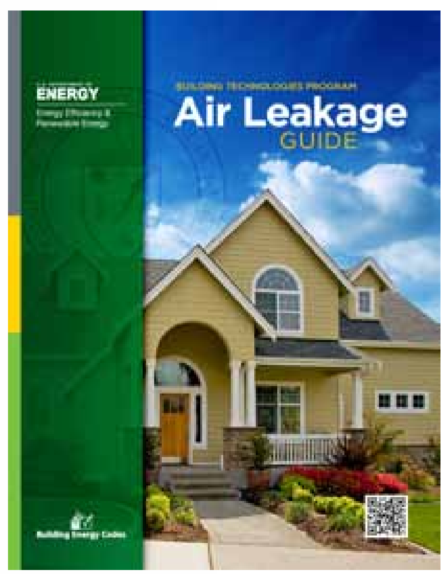
- Building Science Corporation has several valuable information sheets such as "Air Barriers—Airtight Drywall Approach for All Climates," "Sealing Air Barrier Penetrations for All Climates," and "Air Barriers—Tub, Shower and Fireplace Enclosures for All Climates" (Resource 10).
- Another Building America Partner, Consortium for Advanced Residential Buildings, offers details on the garage band joist air barrier (Resource 11).
- The Air Barrier Association of America develops specifications that provide guidance on air barriers to design professionals (Resource 12).

Ducts

The 2009 and 2012 IECC both require leakage testing of ducts in residential buildings that have any ducts that pass outside of the conditioned space (e.g., has ducts in unconditioned attics, basements, or crawlspaces). The leakage rate cannot exceed a specified limit. Southface has videos on topics including blower door testing and duct leakage testing (Resource 13). Southface also offers energy fact sheets, including "Blower Door and Duct Blaster Testing" and "Blower Door and Duct Blaster Testing for Duct & Envelope Tightness Verification" (Resource 14).

Air Leakage

The 2012 IECC requires testing of air leakage through the building envelope. The leakage rate cannot exceed a specified limit. DOE's Meeting the Air Leakage Requirements of the 2012 IECC Resource Guide was prepared primarily for use by residential builders and contractors. The air leakage requirements in residential codes are more detailed than those found in commercial codes because residential buildings tend to be smaller in size, simpler and easier to air seal, and easier to test than commercial buildings.



CHAPTER 8 RESOURCES	
1. Commercial Buildings for Architects Resource Guide	www.energycodes.gov/resource-center/resource-guides
2. ENERGY STAR for Homes Version 3	www.energycodes.gov/resource-center/resource-guides
3. RESNET	www.resnet.us/
4. BTP's Wall Insulation, Provide Moisture Control and Insulation in Wall Systems Fact Sheet	www.southface.org/factsheets/WI-Wallinsulation%2000-772.pdf
5. DOE's Insulation Fact Sheet	www.ornl.gov/sci/roofs+walls/insulation/ins_01.html
6. Building Science Corporation's Installation of Cavity Insulation for All Climates Information Sheet	http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/cavity_insulation.pdf
7. Building Science Corporation Slab Edge Insulation for All Climates Information Sheet	http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/slab_edge_insulation.pdf
8. Insulation Inspections for Home Energy Ratings: Assessing insulation gaps, compression, and incomplete fill provides a way to measure installation effectiveness (Article in Home Energy)	www.bestofbuildingscience.com/pdf/Insulation inspections for home energy ratings HEM_22-1_p20-23.pdf
9. Southface Energy Institute's Energy Technical Bulletins:	a. Wall Insulation www.southface.org/factsheets/26_insulatewalls4PDF.pdf
	b. Ceiling and Attic Insulation and Ventilation www.southface.org/factsheets/25_insulateceilings_4pdf.pdf
	c. Insulating Foundations and Floors www.southface.org/factsheets/29_insulatefloors4PDF.pdf
10. Building Science Corporation's Information Sheets:	a. Air Barriers—Airtight Drywall Approach for All Climates http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/airtight_drywall_approach.pdf
	b. Sealing Air Barrier Penetrations for All Climates http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/sealing_penetrations.pdf
	c. Air Barriers—Tub, Shower and Fireplace Enclosures for All Climates http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/tub_fireplace_enclosure.pdf
11. Consortium for Advanced Residential Buildings High Performance Building Details: Garage Band Joist Air Barrier	http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/air_sealing1.pdf
12. Air Barrier Association of America specifications	www.airbarrier.org/specs/index_e.php
13. Southface Videos:	a. Blower Door Testing Video www.youtube.com/watch?v=lHjl2Tfl5Xg&feature=related
	b. Duct Leakage Testing Video www.youtube.com/watch?v=QZTly-CTQ4o&feature=related
14. Southface Fact Sheets:	a. Blower Door and Duct Blaster Testing www.southface.org/factsheets/22blowdoor.pdf
	b. Blower Door and Duct Blaster Testing for Duct & Envelope Tightness Verification www.southface.org/default-interior/Documents/blower_door__duct_blaster_testing_factsheet.pdf
15. DOE's Air Leakage Resource Guide	www.energycodes.gov/resource-center/resource-guides
16. Southface Energy Technical Bulletin: Airsealing (residential)	www.southface.org/factsheets/8_airsealing.pdf
17. Northwest Energy Technical Bulletin: Airsealing (Residential)	www.northwestenergystar.com/sites/default/files/resources/critical-details-overview.pdf

CHAPTER 9

Document the "As-Built" Building in Plans and Specifications

When the building was originally designed and documented, and the building plans, specifications, and compliance documentation were turned in to the code official, the code official reviewed those plans in a process called "plan review."[7]

Review of the plans, specifications, and documentation by the code official results in preliminary approval of the building design and authorization to begin construction of the building. However, even the most carefully planned and designed buildings may have changes made during the construction process. Specified materials may not be available, the owner's needs may change, or the designer may have a better idea for some unique aspect of the building. All of these changes can be accommodated in the change order process commonly used in construction projects, but remember that the code official will be conducting inspections of the building during construction, and he/she needs to know about changes that may impact the energy efficiency of the building as well.

One specific issue that must be dealt with in this step is value engineering. The Whole-Building Design Guide (Resource 1) describes value engineering as

> *...conscious and explicit set of disciplined procedures designed to seek out optimum value for both initial and long-term investment. First utilized in the manufacturing industry during World War II, it has been widely used in the construction industry for many years. Value engineering is not a design/peer review or a cost-cutting exercise. Value engineering is a creative, organized effort, which analyzes the requirements of a project for the purpose of achieving the essential functions at the lowest total costs (capital, staffing, energy, maintenance) over the life of the project. Through a group investigation, using experienced, multidisciplinary teams, value and economy are improved through the study of alternate design concepts, materials, and methods without compromising the functional and value objectives of the client.*

Unfortunately, substitution of alternate materials or changes to design may result in a building that does not meet the energy code requirements. For example, substituting a window with seemingly the same general characteristics such as "vinyl-framed, double-paned" may mean code is not achieved because the U-factors and SHGCs are critical for code compliance. This means that the specifications must be very precise and detailed to make sure such substitutions do not result in a failure to comply with the energy code. If value engineering takes place before submittal of the initial design to the code official, a good plan review would reveal if alternate materials met code or not. However, if value engineering takes place after submittal of the initial design to the code official, the only opportunity to address any problems that may arise is during the on-site inspections.

Updating the plans, specifications, and code compliance documentation as changes are made to the building during construction is a vital step in ensuring that the building does comply with the energy code. One obvious implication of this step is that value engineering should be performed only by individuals who are familiar with the energy codes. This implies that they have almost the same energy code background and knowledge as the original designers of the building.

CHAPTER 9 RESOURCES	
1. **Whole Building Design Guide**	www.wbdg.org.

[7] See discussion of "plan review" in the companion *Enforcement Toolkit*.

Ensure the Building Operates as Intended

CHAPTER 10

Energy codes and standards generally cover only the construction of buildings. However, the ultimate goal is that energy is used efficiently in the actual operation the building. For example, should commissioning and testing be covered as a separate step? They could and perhaps should. If the ultimate goal of compliance is to get a building that has been designed and constructed to be an energy efficient building, then "getting it right" by commissioning might be an important step in ensuring the building is truly efficient. The 2012 IECC has system commissioning requirements in Section C408.

A topic brief is available that discusses testing and commissioning in greater detail (Resource 1). A topic brief discussing residential duct testing has also been developed (Resource 2).

CHAPTER 10 RESOURCES	
1. **Testing and Commissioning Topic Brief**	www.energycodes.gov/sites/default/files/documents/testing_topic_brief.pdf
2. **Duct Testing in New Residential Construction Topic Brief**	www.energycodes.gov/sites/default/files/documents/res_duct_testing_topic_brief.pdf

CHAPTER 11

Provide Energy Code Compliance Documentation to the Code Official

A crucial step in building energy code compliance is ensuring that the proper documentation gets to the code official.

The documentation must include everything required by the code official to have as smooth a process as possible. If there is any question as to the documentation required to demonstrate compliance, asking the code official ahead of time is recommended. Refer to the design submittal sheets in Resource 1.

SPECIFIC ISSUES

The most common issue with paperwork, according to code officials, is missing information. Keep in mind that code officials also face resource limitations and missing paperwork will cause delays in the review and approval of the submittal. A brief review of the Enforcement Toolkit is recommended so the residential and commercial build communities are aware of the steps the enforcement officials follow.

It is becoming more common to submit documentation electronically. Be aware of the jurisdiction's requirements if using electronic code compliance. Some jurisdictions require that original, hard-copy signed documents be provided as well.

If using the RES*check* or COM*check* software to demonstrate compliance, be sure to pay particular attention to the mandatory requirements that are listed in the Inspection Checklist report. The Inspection Checklist lists the mandatory requirements of the energy code that must be complied with even though the software does not list those requirements in the software user interface, only in the report.

CHAPTER 11 RESOURCES	
1. State Compliance, Implementation, and Enforcement Guide (Iowa example)	www.energycodes.gov/sites/default/files/documents/IA_CIE_guide.pdf
2. RES*check* Basics—a short video discussing the basics of using the RES*check* software for energy code compliance	www.energycodes.gov/training-courses/res*check*-basics
3. COM*check* Basics—a short video discussing the basics of using the COM*check* software for energy code compliance	www.energycodes.gov/training-courses/com*check*-basics

Get Assistance on Energy Code and Compliance Questions

Direct assistance on building energy code compliance questions is available from several sources. In addition, there are many training courses available to learn more about specific code requirements.

CHAPTER 12 RESOURCES	
1. Contact the local jurisdiction having authority	
2. BECP Helpdesk	www.energycodes.gov/resource-center/help-desk
3. ICC Technical Opinions and Interpretations	www.iccsafe.org/cs/pages/opinions.aspx
4. ASHRAE Standards Interpretations	www.ashrae.org/standards-research--technology/standards-forms--procedures/how-to-request-an-interpretation
	a. ASHRAE Standard 90.1-2007 www.ashrae.org/standards-research--technology/standards-interpretations/interpretation-for-standard-90-1-2007
	b. ASHRAE Standard 90.1-2010 www.ashrae.org/standards-research--technology/standards-interpretations/interpretation-for-standard-90-1-2010
5. BECP Training Courses	a. Residential Requirements of the 2009 IECC www.energycodes.gov/training-courses/residential-requirements-2009-iecc
	b. Residential Requirements of the 2012 IECC www.energycodes.gov/training-courses/residential-requirements-2012-international-energy-conservation-code
	c. Commercial Building Envelope Requirements of the 2009 IECC www.energycodes.gov/training-courses/commercial-envelope-requirements-2009-iecc
	d. Commercial Lighting Requirements of the 2009 IECC www.energycodes.gov/training-courses/commercial-lighting-requirements-2009-iecc
	e. Commercial Mechanical Requirements of the 2009 IECC www.energycodes.gov/training-courses/commercial-mechanical-requirements-2009-iecc
	f. Requirements of ASHRAE Standard 90.1-2007 www.energycodes.gov/training-courses/ansiashraeiesna-standard-901-2007
	g. Scope and Application Requirements of ASHRAE Standard 90.1-2010 www.energycodes.gov/training-courses/ansiashraeies-standard-901-2010
	h. Building Envelope Requirements of ASHRAE Standard 90.1-2010 www.energycodes.gov/sites/default/files/becu/90.1-2010_Envelope_BECU.ppt
	i. Mechanical Requirements of ASHRAE Standard 90.1-2010 www.energycodes.gov/sites/default/files/becu/90.1-2010_HVAC_BECU.ppt
	j. Power and Lighting Requirements of ASHRAE Standard 90.1-2010 www.energycodes.gov/sites/default/files/becu/90.1-2010_Lighting_BECU.ppt
6. Regional Energy Efficiency Organizations	a. MEEA— www.mwalliance.org
	b. NEEA— www.neea.org
	c. NEEP— www.neep.org
	d. SEEA— www.seealliance.org
	e. SWEEP— www.swenergy.org

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