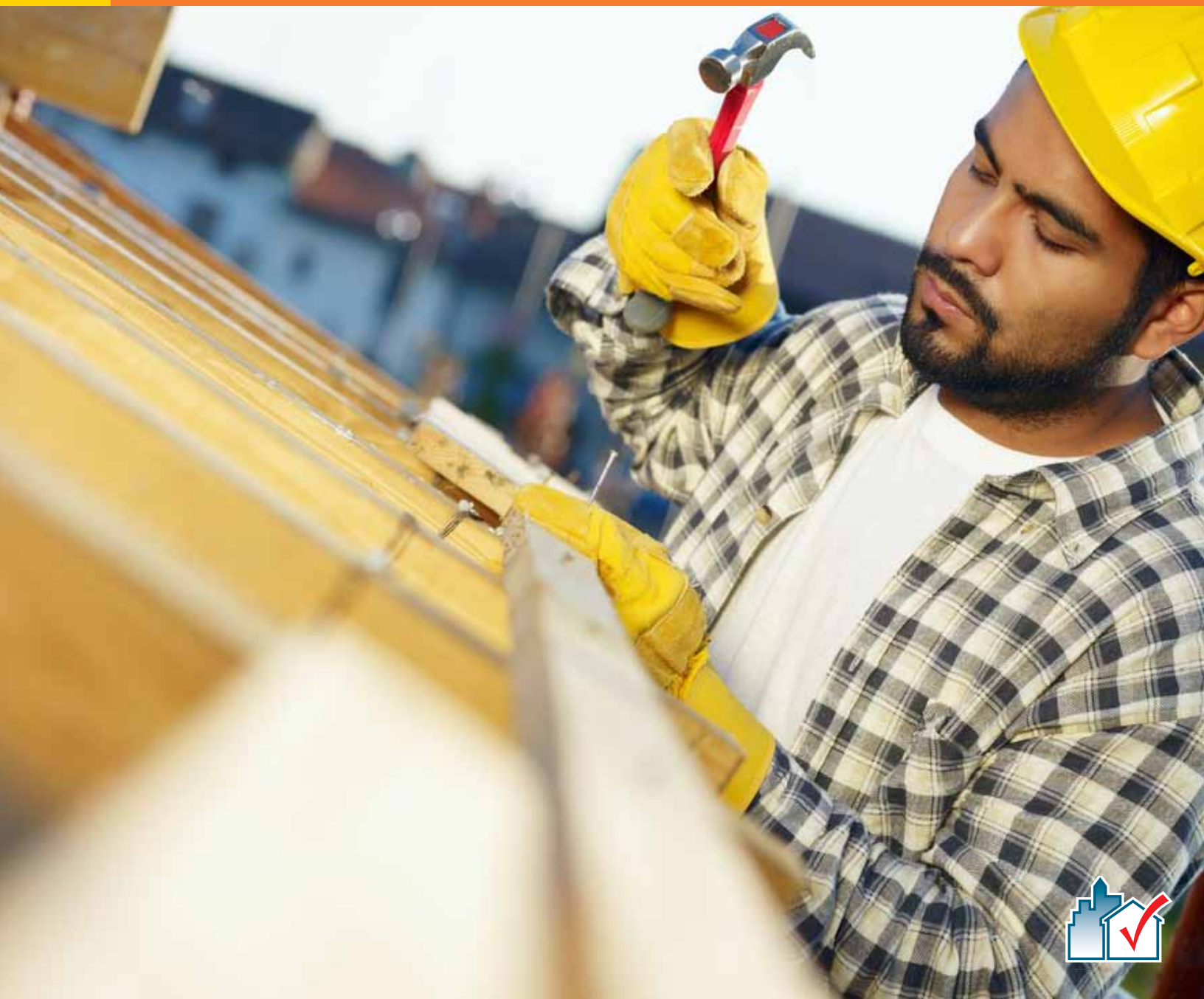
U.S. DEPARTMENT OF
ENERGY
Energy Efficiency &
Renewable Energy

Building Energy Codes 101

Training Manual



In order to provide a basic introduction to the varied and complex issues associated with building energy codes, the U.S. Department of Energy's (DOE's) Building Energy Codes Program (BECP), with valued assistance from the International Codes Council (ICC) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), has prepared *Building Energy Codes 101: An Introduction*. This guide is designed to speak to a broad audience with an interest in building energy efficiency, including state energy officials, architects, engineers, designers, and members of the public.

For these purposes, the term "Building Energy Codes" is used within this document as a generic term that includes ASHRAE 90.1 (a standard), the IECC (a code), and other forms of building energy standards, guidelines, laws, rules, etc. that are adopted as part of the larger body of building codes and required to be satisfied as a condition for approval to construct and occupy buildings.

For a more comprehensive discussion of building energy codes, please refer to the additional resources referenced in the Appendix, on the BECP website (**www.energycodes.gov**).

Introduction

The effects of energy use in buildings are nationwide, worldwide, and varied. Having a fundamental impact on people's lives, these effects include the economic well-being of the nation, the United States' dependence on foreign oil, and national security. On an individual basis, even human health can be affected by building energy use when rising energy costs render a conditioned, comfortable, healthy indoor environment unaffordable. On a larger scale, carbon emissions, which are directly tied to building energy use, affect the health of our planet.

The adoption and enforcement of more stringent building energy codes in communities across the country are critical components to curbing the significant and ever-growing impacts of building energy use. This document provides a basic introduction to the many aspects of building energy codes, including their:

- Benefits in terms of current energy, economic, and environmental challenges facing our world today
- Challenges in terms of adoption, implementation, compliance, and enforcement
- Development processes led by the International Code Council (ICC) and American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
- Adoption and incorporation into building design and construction by states and jurisdictions
- Enforcement at the state and local level.

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What are **building energy codes**?

Energy codes are:

- Minimum requirements for energy-efficient design and construction:
  - new and renovations
  - residential and commercial.
- A component of a complete set of building regulations:
  - structural, plumbing, electrical, energy, etc.
- Energy-efficiency baselines for:
  - building envelope, lighting systems, and equipment.

Energy codes apply to:

- Building envelope walls, floors, ceilings, doors and windows;
- Heating, ventilating, and cooling systems and equipment
- Lighting systems and equipment; and
- Water-heating systems and equipment.

For **building envelope**, the energy code:

- Includes requirements that vary by climate (i.e., location of the building)
- Specifies insulation levels in floor, ceiling, and walls
- Has the intent to seal the building against air leakage and moisture migration.

For heating, ventilating, and cooling, the energy code:

- Provides minimum criteria for the size of systems and equipment,
  - taking into consideration the energy demands of the building space.

Most energy codes include exceptions.
Some possible examples of exceptions: *Buildings on a historical register and "low energy" buildings* (as defined by the code).

Building envelopes = the building components that separate conditioned space from unconditioned space or the outdoors.

HVAC = heating, ventilating, and air conditioning

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HVAC systems are composed of equipment that:

- Creates conditioned air or tempered liquid
- Conveys air or liquid through passageways (ducts and plenums) or pipes
- Automatically regulates the amount to be conveyed via recirculation or exhaust.

HVAC system efficiency can be improved by adding equipment that can convert delivered gas or electric power efficiently or by using **economizers**.

> **Economizers allow the automatic use of outside air.**

For lighting and electrical systems, the energy code:

- Provides minimum criteria to provide effective lighting control
- Covers motor and transformer efficiency (commercial buildings).

Energy efficiency for lighting is gained by using efficient sources of illumination, considering:

- The number and location of lights throughout the space
- The control systems for appropriate operation.

For water-heating systems, the energy code:

- Provides minimum criteria to effectively heat and deliver hot water.
- Water-heating energy efficiency depends upon
  - Water-heating equipment
  - Delivery
  - Operational controls.

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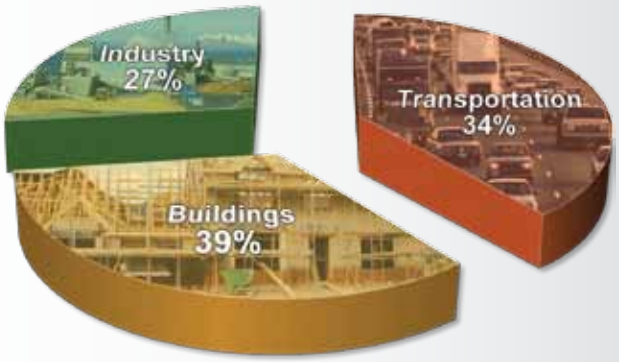
Why are **building energy codes important?**

Stringent building energy codes offer considerable benefits that can be felt far into the future.

Buildings use a lot of energy and create a lot of emissions:

- Nearly 5 million commercial buildings and 115 million residential households in the U.S. consume nearly 40 percent of the nation's total primary energy[1]
- Buildings consume 70 percent of electricity in the U.S.[2]
- In 2007, carbon dioxide (CO_2) emissions attributable to lighting, heating, cooling, cooking, refrigeration, water heating, and other building services totaled 2517 million metric tons[3] – this is 40 percent of the U.S. total and 8 percent of the global total.

More stringent building energy codes are part of the energy solution.



Research[4] shows that if the 2006 International Energy Conservation Code® (IECC) and ANSI/ASHRAE/IESNA Standard 90.1-2004 were upgraded to be 30 to 50 percent more stringent, adopted among states, and effectively implemented, significant benefits would be gained in terms of energy consumption, CO_2 emissions reductions, and cost savings.

ANSI/ASHRAE/IESNA = The American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers/ Illuminating Engineering Society of North America.

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Reduced energy consumption:

- The effects of improved residential and commercial building codes would reduce primary energy use in buildings by approximately:
  - 0.5-quadrillion Btu per year by 2015 and
  - 3.5-quadrillion Btu per year by 2030.

This is equivalent to power generated by 260 medium (450-MW) power plants.[5]

Reduced CO_2 emissions:

- CO_2 emissions would be reduced by roughly 3 percent in terms of the projected national CO_2 emissions in 2030.

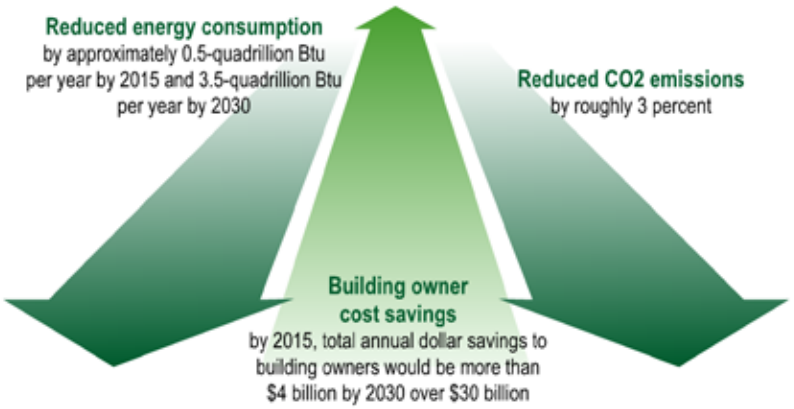
Building owner cost savings:

- By 2015, total annual dollar savings to building owners would be more than $4 billion. That figure may rise to over $30 billion by 2030. Even accounting for the increased investment cost of the measures, the net benefits to the nation are large.

Why are more stringent building energy codes a challenge?

Once developed, codes must still be adopted, implemented, complied with, and enforced.

- Adoption is not automatic in most states. Without statewide adoption, jurisdictions are left without state guidance or resources, and builders can face a patchwork of codes across their region.
- Challenges of implementation, compliance, and enforcement vary by jurisdiction:
  - Lack of training
  - Lack of manpower.



Training is critical. There is a need for understanding new code language, new construction techniques, and new materials and technologies.

Savings resulting from more stringent building energy codes occur in the future, while choosing less energy-efficient methods saves money now. Builders are therefore often challenged to justify the first-cost of energy-efficient measures.

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What are the **baseline energy codes**?

ICC's IECC

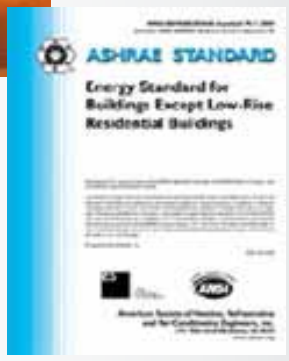
- Covers residential and commercial buildings
- One of 14 model codes developed under ICC
- Revised every three years
- Written in mandatory, enforceable language, easily adoptable by states and local jurisdictions.

ASHRAE's Standard 90.1

- Covers commercial buildings and high-rise, multifamily residential buildings
- Complete standard published every 3 years
- Supplement published every 18 months
- Continually maintained through development, review, and issuance of addenda—approved addenda are collected for the new edition
- Co-sponsored by the Illuminating Engineering Society of North America.

CODE LANGUAGE EXAMPLE: *"Recessed luminaires installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces."*

IECC



ASHRAE Standard 90.1

ICC = International Code Council
IECC = International Energy Conservation Code
Examples of other "I" codes:
IRC = International Residential Code
IBC = International Building Code
IMC = International Mechanical Code

NOTES

How is the IECC developed?

The IECC is developed using a **government consensus process**.

- Allows all interested parties to participate.
- Final vote on the content is made by individuals associated with federal, state, or local governments (who are also members of the ICC).

How is ASHRAE 90.1 developed?

ASHRAE 90.1 is developed using the American National Standards Institute (ANSI) consensus process, which requires a **balance of interests**.

- There is a 90.1 project committee which is made up of subcommittees, including Envelope, Lighting and Power, Mechanical, Energy Cost Budget, and Format and Compliance.
- All interested parties can participate by addressing the committee during deliberations, participating in the committee or subcommittees, or commenting during the public review period.
- Final vote of the project committee includes members from a balance of all interests, and is not limited to government representatives.

Who are the stakeholders involved in maintaining these codes?

- **The design community**, including architects, lighting designers, and mechanical and electrical engineers
- **The code enforcement community**, including building code officials, representatives of code organizations, and state and local regulatory agencies
- Builders and contractors
- Building owners and operators
- Industry and manufacturers for the building industry
- Utility companies
- Energy advocacy groups
- The academic community
- Federal agency staff, including the Building Energy Codes Program (BECP)

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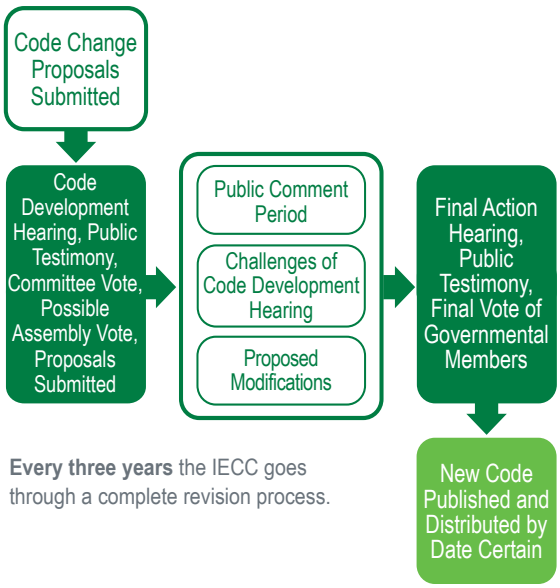
What are the steps involved in revising the IECC?

- Anyone may propose a revision by submitting code text and supporting documentation.
  - The form is available at **www.iccsafe.org**
- ICC publishes proposed changes and distributes to public for review.
  - The review happens approximately 6 weeks before an open public hearing held to discuss the proper revisions.
- At the public hearing, testimony for and against each code change proposal is presented to the IECC Code Development Committee.
  - Committee is typically composed of 7 to 11 individuals appointed by the ICC.
  - Committee is made up of government members, code officials, home builder representatives, industry groups, and other interested and affected parties.
- After testimony, the committee votes to recommend a disposition on each change. They may:
  - Approve
  - Deny
  - Approve as modified.
- The committee's decision may be overturned by a "**floor action**."
- ICC publishes results of the first hearing;
  - These results may be challenged by submitting a public comment.



Every three years the IECC goes through a complete revision process.

The ICC process allows for an appeal to the ICC Board of Directors concerning the action of the second hearing.

- All public comments are published.
  - Interested parties may present additional information on each change at a second public hearing.
- A second public hearing is held.
  - The final disposition of all changes is decided by a vote of the governmental members (as distinguished from industry members) of ICC in attendance.
- Approved changes from the second hearing are implemented in the IECC, and the finished documents represent the next edition of the IECC.

Floor action = two-thirds affirmative vote of ICC members in attendance at hearing.

NOTES

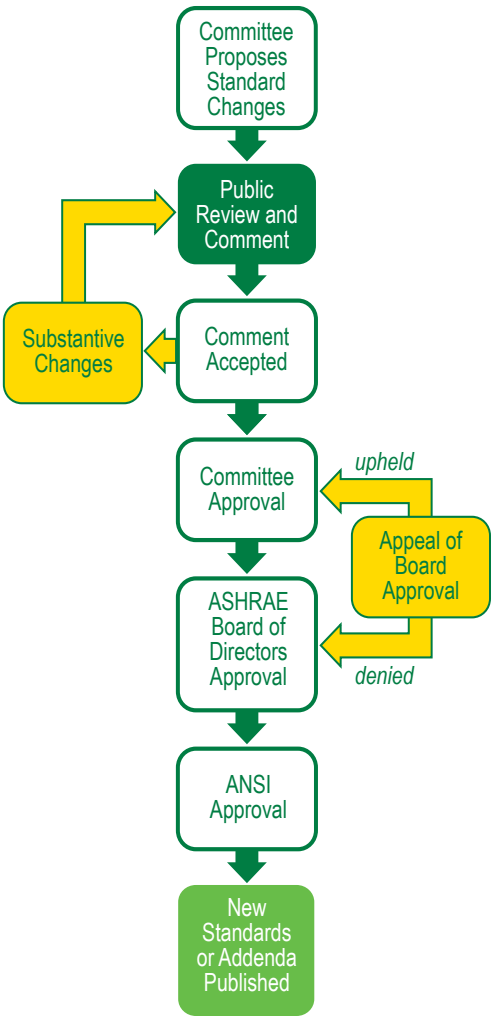
What are steps involved in revising ASHRAE 90.1?

- Any interested party, including the project committee, may propose a change to the standard.
- The project committee develops and approves addenda for public review.
- The Standards Project Liaison Subcommittee approves addenda and makes them available for public review.
- Written comments are accepted from the public.
- The committee must address *every* comment and attempt to resolve either by:
  - Accepting the comment in some manner, or
  - Advising the commenter why their comment can't be accepted.
- Resolution with commenters can result in a further revision to the proposed addendum or an impasse may be reached.
- Proposed changes are deemed either substantive or non-substantive:
  - If non-substantive, another public review isn't necessary and revision moves forward for publication approval
  - If substantive, additional public review is required.

Once all commenters indicate the issues are:

- Resolved
- Unresolved (but don't wish to delay publication), or
- Unresolved,

the revision to the standard moves forward for approval.



ASHRAE 90.1 is continually maintained through the development, review, and issuance of addenda, with approved addenda collected and a new edition published every three years.

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Occasionally, when the committee maintaining and revising 90.1 feels the changes can be approved (either because there are no outstanding unresolved comments, or if there were some, they are resolved or cannot be resolved), the revisions to the standard are submitted for approval to the ASHRAE Standards Committee, the Technology Council, and then the Board of Directors.

ASHRAE 90.1 Appeals Process

Those commenters who remain unresolved can appeal to the Board of Directors.

- An ASHRAE Appeals Panel reviews the record and addresses the appeal:
  - If upheld, the revision goes back to 90.1 committee for further work.
  - If not upheld, the Board of Directors' approval stands, the addendum is sent to ANSI for approval.
  - Unresolved commenters that have completed the ASHRAE appeals process may appeal the ANSI approval of the addendum. If the appeals at ANSI are denied or no appeals are received, then the addendum is published.

NOTES

How do the **energy codes** get adopted at the state or local level?

Adoption can occur directly through legislative action or by regulatory action through agencies authorized by the legislative body to oversee the development and adoption of codes.

- **By legislation**: A committee may be appointed to provide recommendations and/or draft the legislation.
- **By regulatory process**: States and local governments often appoint an advisory panel comprising representatives of the design, building construction, and enforcement communities.

The panel:

- Recommends revisions that should be considered for adoption
- May also serve as a source of information during the adoption process.

> **Advisory panel recommendations typically account for local preferences and construction practices**

Recommendations then enter a public review process.

Timing the Adoption

Some states will:

- Adopt or revise energy codes in concert with the publication schedule for IECC and 90.1
- Automatically adopt "the most recent edition" without any formal action needed.

The effective date of a new adoption can also be tied to the publication date of IECC or 90.1.

Other states review the new editions on a case-by-case basis to consider adoption, without a designated timeline for adoption.

CODE LANGUAGE EXAMPLE: *"This regulation shall take effect one month from publication of the adopted model energy code."*

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Once adopted, what do energy codes mean for architects and designers?

Buildings they design must meet code and be within the building owner's budget.

Systems within the buildings must comply:

- Building envelope
- HVAC
- Lighting.

Complying materials must be selected for the building, such as:

- Windows with correct efficiencies
- Proper insulation levels
- Lighting controls.

Buildings must be designed to take advantage of the increased efficiencies in the building.

EXAMPLE: *Increased insulation levels and efficient windows coupled with an efficient lighting system will reduce the heat loss from the building and heat gain from the lighting system.*

The HVAC contractor can then optimize the heating and cooling system to reduce the higher first-costs of the building's increased efficiencies.

Once adopted, what do energy codes mean for builders?

- Buildings they build must meet code and stay within the building owner's budget.
- Materials and products must be selected that best fit the design of the building and satisfy the energy code requirements.
- Collaboration among subcontractors is a must to take advantage of efficiencies installed in the building.

EXAMPLE: *The builder may use 2"x 6" studs (instead of 2"x 4") for walls in a home so that higher insulation levels can be installed to meet the code. Increasing the wall framing size will impact the cost of finish materials used in the building and may affect its design.*

NOTES

What about **energy code** enforcement and compliance?

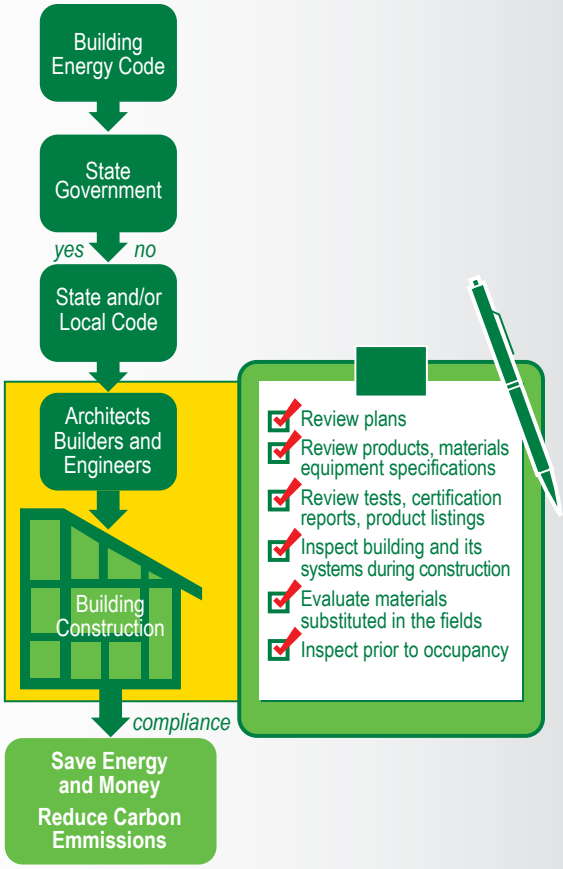
Energy Code Enforcement and Compliance

Compliance and enforcement are critical to realizing energy efficient buildings.

- States and jurisdictions have responsibility for enforcement.
- Developers, designers, and contractors have responsibility for compliance.
- Education and communication regarding energy codes are vital to both enforcement and compliance.
  - Need to include all stakeholders involved, and
  - Need to occur in advance of an energy code change.

Enforcement strategies vary according to a state or local government's regulatory authority, resources, and manpower, and may include all or some of the following activities:

- Review of plans
- Review of products, materials, and equipment specifications



The responsibility to enforce the building energy code falls upon states or jurisdictions, and the responsibility to comply with the building energy code falls on building owners, developers, designers, and contractors.

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- Review of tests, certification reports, and product listings
- Review of supporting calculations
- Inspection of the building and its systems during construction
- Evaluation of materials substituted in the field
- Inspection immediately prior to occupancy.

State Enforcement

- Generally for state-owned or state-funded construction
- May enforce for certain building types or locations
- Plan review is typically performed by one office.
- Both review and inspection agencies are controlled by one organization
  - Gives the building community a single point of contact
- State resources determine the extent of building plan reviews and construction inspections
- Fire and safety ("health and life safety") codes take precedence over energy code enforcement.

Local Enforcement

- Resource limitations can affect enforcement.
- Proximity to construction sites and design community offers the potential for more regular enforcement.
- Because jurisdictions vary, local enforcement may lead to differences in the rate of compliance across a state.

Some states allow local jurisdictions to conduct enforcement activities that are usually the state's responsibility.

This strategy:

- Offers advantages associated with state enforcement
- Recognizes those local governments with equivalent enforcement capabilities
- Helps ensure comparable levels of compliance.

> **A hybrid approach to enforcement is also possible and may involve the state conducting the plan review, and the local authority conducting the construction inspection.**

How is compliance demonstrated?

Several common methods include:

- Prescriptive forms
- Software-generated forms
- Software modeling runs.

Prescriptive forms are usually 1-2 pages and may be generated by the local jurisdiction (typically for residential construction).

These forms:

- List the minimum requirements for that location.
- 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 programs such as RES*check*™ and COM*check*™ offered by the Department of Energy's Building Energy Codes Program (BECP):

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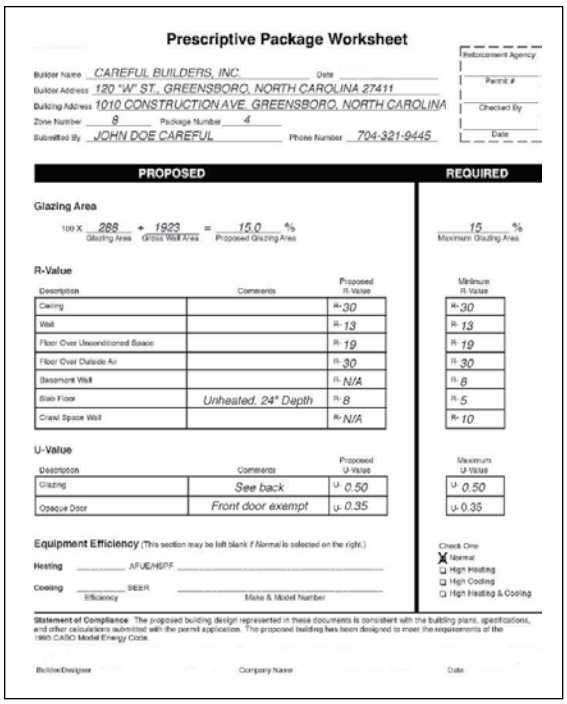

Prescriptive Package Worksheet

Builder Name: CAREFUL BUILDERS, INC. Date:
Builder Address: 120 "W" ST., GREENSBORO, NORTH CAROLINA 27411
Building Address: 1010 CONSTRUCTION AVE. GREENSBORO, NORTH CAROLINA
Zone Number: 8 Package Number: 4
Submitted By: JOHN DOE CAREFUL Phone Number: 704-321-9445

Reference Agency | Permit # | Checked By | Date

PROPOSED	REQUIRED

Glazing Area

100 X 288 (Glazing Area) ÷ 1923 (Gross Wall Area) = 15.0 % (Proposed Glazing Area)

15 % Maximum Glazing Area

R-Value

Description	Comments	Proposed R-Value	Minimum R-Value
Ceiling		R-30	R-30
Wall		R-13	R-13
Floor Over Unconditioned Space		R-19	R-19
Floor Over Outside Air		R-30	R-30
Basement Wall		R-N/A	R-8
Slab Floor	Unheated, 24" Depth	R-8	R-5
Crawl Space Wall		R-N/A	R-10

U-Value

Description	Comments	Proposed U-Value	Maximum U-Value
Glazing	See back	U-0.50	U-0.50
Opaque Door	Front door exempt	U-0.35	U-0.35

Equipment Efficiency (This section may be left blank if Normal is selected on the right.)

Heating _____ AFUE/HSPF _____
Cooling _____ SEER _____
Efficiency Make & Model Number

Check One
X Normal
☐ High Heating
☐ High Cooling
☐ High Heating & Cooling

Statement of Compliance: The proposed building design represented in these documents is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the requirements of the 1995 CABO Model Energy Code.

Builder/Designer Company Name Date

REScheck Software
Compliance Certificate

Project Title: Model 123
Report Date: 06/28/07
Data filename: C:\Program Files\Check\REScheck\Model 123.rck

Energy Code: 2006 IECC
Location: Hickman, Kentucky
Construction Type: Single Family
Conditioned Floor Area: 400 ft2
Glazing Area Percentage: 10%
Heating Degree Days: 4004
Climate Zone: 4

Construction Site: Orchard Hills Subdivision
Owner/Agent:
Designer/Contractor: ABC Construction, Hickman, KY

Compliance: Passes on UA
Maximum UA: 115 Your Home UA: 110 = 4.3% Better Than Code

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Glazing or Door U-Factor	UA
Ceiling 1: Flat Ceiling or Scissor Truss	400	30.0	0.0		14
Wall 1: Wood Frame, 16" o.c.	640	13.0	0.0		46
Window 1: Vinyl Frame:Double Pane SHGC: 0.40	64			0.300	19
Door 1: Solid	20			0.600	12
Floor 1: All-Wood Joist/Truss:Over Unconditioned Space	400	19.0	0.0		19

Compliance Statement: The proposed building design described here is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the 2006 IECC requirements in REScheck Version 4.1.0 and to comply with the mandatory requirements listed in the REScheck Inspection Checklist.

Name - Title Signature Date

EXAMPLE: *A designer may choose to include a greater glass area on a particular wall and compensate for heat loss/gain by increasing insulation levels elsewhere.*

- Involve user inputs for building component areas, efficiencies and other specifications and generate a compliance report.
- Allow flexibility and trade-offs among components.

What is DOE's role in energy codes?

Federal law requires DOE to determine whether revisions to

- The residential portion of the IECC would improve energy efficiency in the nation's residential buildings
- ANSI/ASHRAE/IESNA Standard 90.1 would improve energy efficiency in the nation's commercial buildings.

When DOE determines that a revision would improve energy efficiency, each state has two years to review the energy provisions of its residential or commercial building code.

NOTES

- **Residential buildings.** A state has the option of revising its residential code to meet or exceed the residential portion of the IECC.
- **Commercial buildings.** A state is required to update its commercial code to meet or exceed the provisions of Standard 90.1.

> **The statement issued concerning the energy efficiency of the revision is referred to as "DOE's determination."**

Building Energy Codes

DOE's Building Energy Codes Program (BECP) supports states and local governments in their efforts to implement and enforce building energy codes. This support includes:

- Developing and distributing easy-to-use compliance tools and materials
- Providing financial and technical assistance to help adopt, implement, and enforce building energy codes
- Participating in the development of baseline energy codes; and
- Providing information on compliance products and training, and energy code-related news.

What are beyond-code programs?

- Codes that build upon the baseline building energy codes, IECC and 90.1
- May include more rigorous requirements beyond the baseline codes and/or address additional issues not covered in the baseline codes
- Are referred to in various terms – beyond-code programs, green building programs or codes, stretch codes, and above-code programs
- Elements of beyond-code programs become the baseline codes of tomorrow.

Complying with beyond-code programs often requires verification by a third party.

> **Progressive states and local jurisdictions with a focus on energy efficiency and/or sustainability are increasingly building upon the baseline building energy codes and adopting beyond-code programs, either as their minimum codes or as a component of a program that provides incentives to those that comply.**

Conclusion

Building energy codes can play a key role in reducing building energy costs, our nation's reliance on foreign oil, and carbon emissions, as well as increasing the comfort of our homes and offices.

Though the building energy codes world is not without its challenges, the benefits far outweigh the barriers.

Crafted in open public forums, all stakeholders and interested and affected parties are welcome to participate in the building energy codes development process.

The processes used to update both the IECC and ASHRAE 90.1 are designed to make sure the interests of various stakeholders are considered.

Building energy codes are readily available for states and jurisdictions to adopt, and a broad range of enforcement and compliance tools are available to help policy makers, designers, builders, and the enforcement community successfully implement building energy codes.❖

NOTES

[1] Energy Information Administration, *Annual Energy Review 2007, Figure 2.1a, Energy Consumption by Sector Overview.* **http://www.eia.doe.gov/emeu/aer/consump.html**.

[2] U.S. Energy Information Administration. Electric Power Annual Report. Table 7.2. Retail Sales and Direct Use of Electricity to Ultimate Customers by Sector, by Provider, 1996 through 2007 (Megawatthours). **http://www.eia.doe.gov/cneaf/electricity/epa/epat7p2.html**.

[3] Source: U.S. Energy Information Administration, *Electric Power Annual 2007, State Electricity Profiles 2007*, United States.

[4] Belzer D, M Halverson, and S McDonald. 2009. *A Retrospective Analysis of Commercial Building Energy Codes: 1990-2008, Draft.* Building Energy Codes Program, Pacific Northwest National Laboratory, Richland, Washington.

[5] 450 MW as a typical power plant size was based on the range in size of power plants installed in 2006. Refer to the following to see the complete range: *Buildings Energy Data Book, Table 6.2.7, "Characteristics of New and Stock Generating Capacities, by Plant Type."* **http://buildingsdatabook.eere.energy.gov/TableView.aspx?table=6.2.7**.

The U.S. Department of Energy's Building Energy Codes Program is an information resource on national model energy codes. We work with other government agencies, state and local jurisdictions, national code organizations, and industry to promote stronger building energy codes and help states adopt, implement, and enforce those codes.

BECP Website:
www.energycodes.gov

BECP Technical Support:
techsupport@becp.pnl.gov
www.energycodes.gov/support/helpdesk.php

For more information, contact:

Jean Boulin, Program Manager
Phone: 202-586-9870
Email: Jean.Boulin@ee.doe.gov

Contact the EERE Information Center 1-877-EERE-INF
(1-877-337-3463) or visit **eere.energy.gov/informationcenter.**

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PNNL-SA-72837 • May 2010