

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

**BUILDING
TECHNOLOGIES
PROGRAM**

Building Energy Codes Resource Guide: **COMMERCIAL BUILDINGS for Architects**



NOTES



BUILDING TECHNOLOGIES PROGRAM

Building Energy Codes Resource Guide: **COMMERCIAL BUILDINGS for Architects**

Prepared by:

**Building Energy Codes Program (BECP) and
the American Institute of Architects (AIA).**

The U.S. Department of Energy's (USDOE) 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 **who develop model codes and standards**, and **building** industry to promote codes **that will provide for energy and environmental benefits** and help **foster adoption and implementation** of and **compliance** with those codes.

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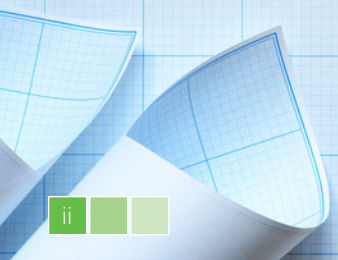
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Building Energy Codes



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Introduction

So why produce an introductory guide to Energy Codes at this time?

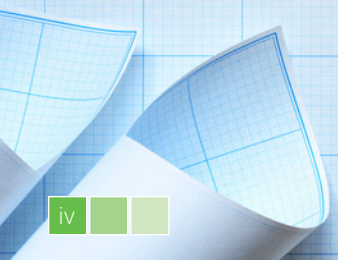
Because as an industry, and as a profession, we are at a crossroads.

Prescriptive-based codes with tables and checklists are slowly being replaced with performance based codes in support of predicting successful outcomes and by evidence-based design. This is a good thing for design professionals because it affords us flexibility to prove the performance intent of a design. However the gap between design-intent and actual performance in the use of buildings is vast; in terms of energy modeling, owner education on proper operations, and proper maintenance for continued high performance.

Another issue is that energy compliance technologies, such as sub-metering and energy use displays, as well as regulatory methodologies, like mandatory disclosure laws, are not yet widespread. As a result, proper accountability cannot always be assigned at the design phase and, worse, risks cannot be properly allocated if something goes wrong with the performance of a building, potentially leading to claims against design professionals.

This introductory guide to model energy codes sets the stage for the development and increased use of more advanced resources on both energy and green codes, as they continue to evolve.

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POLICY: Energy Codes Background

Commercial buildings and residential households consume nearly 40 percent of the total primary energy used in the United States. Buildings alone consume 70 percent of our nation's electricity. In 2007, lighting, heating, cooling, cooking, refrigeration, water heating, and other building services produced 2517 metric tons of carbon dioxide emissions—39 percent of the U.S. total and 8 percent of the global total.

Given these statistics, it is now more important than ever to design and construct buildings to the most current energy codes,¹ and to seek client support for exceeding these requirements. The benefits will be felt far into the future.

¹ The term “building energy codes” includes model codes such as the IECC or IgCC, energy standards such as ASHRAE 90.1, and laws and regulations, tariffs, incentive programs, and other vehicles that require or provide incentives for the design and construction of energy efficient buildings. The term “energy codes” is used throughout this document to describe such criteria.

Because of their authority over building design and construction, states and local jurisdictions are key players in the effort to improve building energy efficiency.

There are two primary baseline documents that states and local jurisdictions can adopt to regulate the energy efficient design and construction of new buildings: **the International Energy Conservation Code (IECC), developed by the International Code Council (ICC), and Standard 90.1, developed by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and the Illuminating Engineering Society (IES).** The IECC addresses residential buildings in Chapter 4 and commercial² buildings in Chapter 5. Standard 90.1 covers only commercial buildings.

² Commercial buildings in the IECC and Standard 90.1 are considered all buildings other than one and two family dwellings, townhouses, rowhouses, and modular homes (R-3 or R-4) or multi-family residential buildings (R-2) not over 3 stories in height above grade.

“Increasing the efficiency of commercial building energy codes provides the best opportunity to bring about significant savings and helps move us along the path toward low-energy commercial buildings.”

— **Dave Hewitt**
Executive Director,
New Buildings Institute³

³ NBI and AIA Press Release – November 2, 2010
Historic changes to commercial building energy codes will drive energy efficiency, emissions reduction
<http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab086448.pdf> retrieved 5/12/11.

1.1 The Role of DOE and AIA in Building Energy Codes

The Department of Energy (DOE) Building Energy Codes Program (BECP) was formally established in 1993 in response to the Energy Policy Act of 1992, although DOE has a long history with energy codes that extends back over 30 years to its support of the Model Code for Energy Conservation in 1977. The Energy Policy Act mandated that DOE participate in the development of voluntary sector energy codes and help states and local jurisdictions adopt, implement, and support compliance with progressive energy codes.

Since then, BECP has developed and deployed many products, services, and software, and has provided considerable support for all aspects of energy codes.

The American Institute of Architects (AIA) has long advocated on behalf of the architectural profession in the codes and standards arena. Since 1975, the Institute has

published research and materials advocating a single model building code, and AIA was instrumental in forming the ICC from the three legacy model code organizations (BOCA, ICBO, and SBCCI).

AIA members have helped to shape building codes standards at the state and local level, at the national level through submission of proposed code changes and at hearings and meetings throughout the United States and participating on Boards and Commissions at the local and state levels.

1.2 What Do Codes Mean for the Architect?

Architects are required by their license to practice to comply with applicable codes.⁴

⁴ Codes in this context include building, fire, life safety, mechanical, plumbing, electrical, zoning, and all related rules and regulations applicable to buildings as adopted at the national, state, and or local level.





An energy code adds to that challenge, not only because it is an additional code, but because compliance with energy codes requires careful review to ensure continued compliance with other applicable codes.

Energy codes affect the design of all building systems separately and collectively.

Designing for energy efficiency can impact the look, feel, and function of the building.

For example, lighting and window design can impact cooling loads, window impact lighting, and so on.

To minimize the initial cost for a project and be most effective, an integrated design process is critical. The architect must ideally first employ sensible passive design strategies, then collaborate extensively with the HVAC and lighting designers, and others who will affect the performance of the building both in the design phase and after construction, to optimize the building design. For more information on passive design, see the AIA's 50to50.

Energy codes also influence the selection and placement of building materials, for example, by requiring glazing with correct thermal properties, proper insulation levels, and lighting controls that meet the intent of the code.

A benefit to the owner is a more desirable property due to increased occupant comfort and reduced utility cost. **For more information on design and the energy code, see Section 3.**

1.2.1 The Model Energy Codes

The IECC and Standard 90.1—which are considered the minimum acceptable energy efficiency criteria—address requirements for the design, specification, and application of the materials, products, systems, and equipment used in nearly all new buildings and additions and renovations to existing buildings. Their goal is to improve the overall energy efficiency of any structure and reduce the energy needed to maintain

a healthy, comfortable, and fully functioning indoor environment. Energy codes currently apply to:

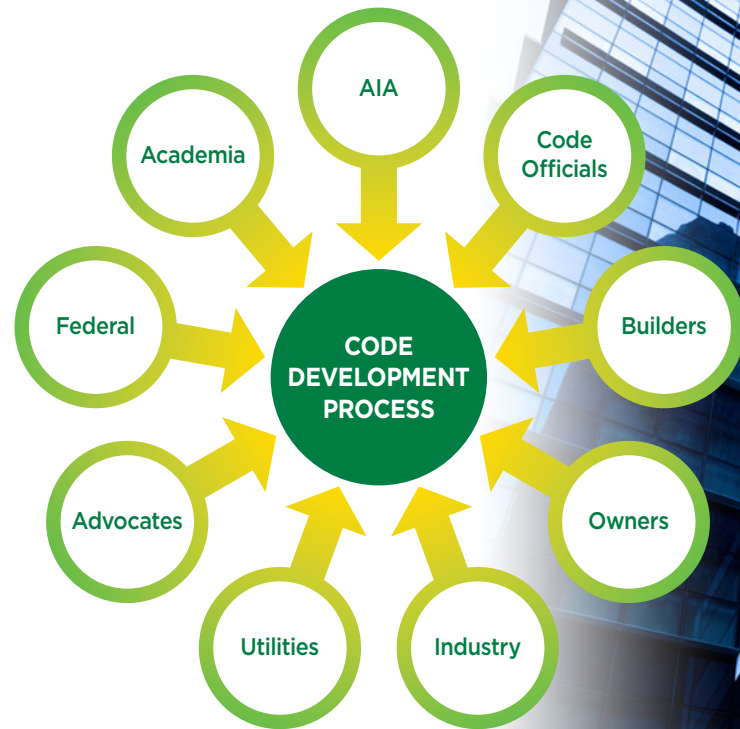
- ▶ Components associated with the building thermal envelope
- ▶ Heating, ventilating, and cooling systems and equipment
- ▶ Lighting systems and equipment
- ▶ Water-heating systems and equipment

In the future these codes will likely address plug and process loads as well, and their scope is continuing to increase beyond design and construction to include commissioning.

The IECC and Standard 90.1 provide minimum criteria to ensure that energy efficiency is considered on any building project, even without direction from the client. Without such minimum criteria, it would be commonplace to design and construct less energy efficient buildings.

1.3 Code Development

All ICC model codes and ASHRAE standards are revised every three years through open consensus processes that include stakeholders from across the building industry.⁵ The transparency of these processes is critical to widespread code acceptance, implementation, and compliance. AIA staff, chapters, and individual members have participated in the development of the model codes and standards for many years. Because these codes are typically adopted by federal, state, or local agencies, involvement at the national level through organizations such as ASHRAE and ICC helps ensure that the design community



⁵ An important distinction between the ICC and ASHRAE processes is that, while in the ICC process all proposals are published and considered at a public hearing before a balanced committee, the final decision on the acceptance of any proposal occurs at a second public hearing at which only governmental members of ICC can vote. Approvals in the ASHRAE process are always through voting members of ICC which represent enforcement jurisdictions; however, there are no public hearings and the only changes that are available for public review and comment are those approved for review by the committee assigned to the particular standard.



will support code adoption and will not be adversely affected. The alternative is to amend these documents at each federal, state, or local point of adoption.

Outcome-based codes are on the horizon. They will **provide the architect more freedom** to creatively design a code-compliant building. Current codes are referred to as prescriptive or performance. A prescriptive code can restrict freedom because of specific requirements for building components and performance. Outcome-based codes would prescribe a certain annual operational expectation, leaving the designer free to creatively design to that performance level.

⁶ Codes Task Force Report C³ Comprehensive-Coordinated-Contemporary, AIA, no date available.

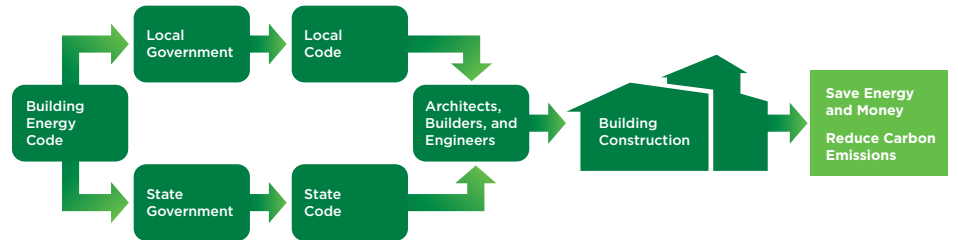
1.4 Code Adoption

Code adoption can be mandatory or voluntary. Voluntary adoption is done without any mandatory requirements and typically occurs through an incentive program, a corporate decision to follow certain provisions in a code, or a personal decision. Mandatory adoption can also include voluntary adoption of provisions beyond the minimum, for example, a corporate decision to adopt the IgCC over a state-mandated minimum code based on

the IECC. Mandatory adoption is typically driven by federal, state or local legislation or regulation, but can also occur within a contract for services, utility tariff or lender or insurance carrier.⁶

1.4.1 The Adoption Process

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



RESOURCES



Energy Codes 101

www.energycodes.gov/becu

Provides contractors, architects, and trainers with building code related training and certification opportunities.



Policy Maker Resource Guide

www.energycodes.gov/publications/resourceguides/policymaker.stm

- ▶ **Directly through legislative action**—When codes are adopted through legislation, a committee may be appointed to provide recommendations and/or draft the legislation.
- ▶ **By regulatory action**—When codes are adopted through a regulatory process, states and local governments often appoint an advisory body of representatives of the design, building construction, and enforcement communities. This advisory panel recommends codes for adoption and revision. In basing their recommendations on model codes, the advisory panel considers modifications to the model codes to account for local preferences and construction practices. The panel also may provide information during the adoption process. Their recommendations then enter a public review process.

Adoption processes vary depending on whether the energy code is adopted by legislation or regulation and at a statewide or local level.

Once adopted, codes apply to the design and construction of buildings as covered in the scope of the adopting laws, rules, or regulations. That scope of adoption can range from only new state-owned buildings, to all new buildings in certain localities within a state, to all new and existing buildings in a state.



CODES: Which One Applies and Why It Matters

2.1 Know the Local Codes

Code adoption can occur at all levels of government and through different agencies. The architect is responsible for knowing which minimum codes apply to the project, whether federal, state, local, or those adopted by others such as utilities. A project may have federal, state, and local requirements that must be satisfied and, at each of those levels, requirements from different agencies. The adoption of national model codes and standards is intended to minimize the potential for multiple, duplicative, or conflicting provisions, but it can still occur.



Visit BECP's Status of State Energy Codes web page for more information on code adoption.

www.energycodes.gov/states/index.stm

2.2 Green Building Codes and Beyond Code Programs, and High Performance Buildings

Beyond the minimum energy codes are green building codes and building certification programs. By definition, codes are mandatory, and rating systems are voluntary. However, in recent years, both have been adopted on a mandatory and voluntary basis. They may have been adopted on a voluntary or mandatory basis by the local jurisdiction, state, or federal agency- or they may be the desire of the client. Building energy is an important feature of these codes and programs and may include design elements such as:

- ▶ Green roofs
- ▶ Orientation
- ▶ Siting
- ▶ Hardscape features

RESOURCES



AIA forms and contracts can be downloaded from the AIA website:
www.aia.org/contractdocs/index.htm



Green Building and Beyond Code Adoption. A Nationwide database of local adoption
www.energycodes.gov/GreenBuildings



An additional useful resource is the **BECP 2009 IECC and ASHRAE 90.1-07 comparison**, which can be found at:
www.energycodes.gov/publications/research.stm



United States Green Building Council:
www.usgbc.org/DisplayPage.aspx?CMSPageID=1779

Use of a green building code or building certification program is an opportunity for architects to demonstrate their knowledge of high performance buildings and act as a resource to both their clients and their jurisdiction.

The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) building certification program is widely used in both the public and the private sector. The codes and LEED address comprehensive sustainability issues such as site use, water, indoor environments, and materials.

New on the horizon are the ANSI/ASHRAE/IES/USGBC⁷ 189.1-10 and the ICC International green Construction Code (IgCC) (to be published Spring, 2012), developed in collaboration with AIA and

American Society for Testing and Materials (ASTM). Both codes cover the design and construction of high-performance green commercial buildings, with provisions that are 10 to 15 percent more energy efficient than the IECC and Standard 90.1.

Architects can learn about energy code compliance through training provided and sponsored by the AIA. The AIA and AIA continuing education providers also provide education resources on going above code to promote integration of energy efficient and sustainable design into new buildings.

Owners and developers make many decisions that determine the potential for success on their projects-selecting a design process, assembling a team, and deciding which contract to use and when. Each decision has implications for improved

⁷ American National Standards Institute (ANSI), Illuminating Engineering Society (IES), U.S. Green Building Council (USGBC)





collaboration, and ultimately, integrated project delivery (IPD).



For more on IPD, see the AIA's Center for Integrated Practice.

www.aia.org/CIP

2.2.1 High Performance Buildings

Verifying that a building complies with an energy code is one of the final steps in the building process. Efforts to verify compliance are generally termed “enforcement activities” when compliance is mandated by law, rule, or regulation and compliance is verified by an independent third party. Like the other steps on the path—energy code development, code adoption, and code implementation through compliant design and construction—enforcement is key to verifying compliance

and to realizing energy efficient buildings as intended by the code. The owner or property developer and their agents (architects, engineers, contractors, suppliers, etc.) are responsible for energy code compliance, while code enforcement is the responsibility of the states or jurisdictions who have adopted the code or the utilities, lenders, insurers, or even corporate offices who have adopted the code and tie compliance to a penalty or an incentive.

Education and communication are vital to the ensuring compliance with an adopted energy code.

Traditional enforcement strategies at the state or local level vary according to the state or local government’s regulatory authority, resources, and manpower, and may include all or some of the activities listed below. These activities may also be undertaken by third parties interested in ensuring code compliance or even first parties who will internally document their rate of compliance so they can continue to

“*Architects have an opportunity to take charge and determine what they want the future to look like and then memorialize that in the codes.*”

— **Dave Conover**
Pacific Northwest
National Laboratory⁸

⁸ AIA Podcast 7/12/2010 **What Every Architect Should Know** with Jessyca Henderson (AIA) and Dave Conover.

self-certify that their buildings are designed and constructed to code.⁹

- ▶ Review of plans
- ▶ Review of product, material, and equipment specifications
- ▶ 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

⁹ *Integrated Project Delivery For Public and Private Owners*, a Joint Effort of the National Association of State Facilities Administrators (NASFA); Construction Owners Association of America (COAA); APPA: The Association of Higher Education Facilities Officers; Associated General Contractors of America (AGC); and American Institute of Architects (AIA), published in 2010. Website is <http://www.aia.org/aiacmp/groups/aia/documents/pdf/aiab085586.pdf>.

Building performance is becoming increasingly valuable to clients and end users, regardless of codes or other program requirements.

Progressive states and local jurisdictions that focus on energy efficiency and/or sustainability are increasingly building on the baseline energy codes and adopting green, sustainable, or more stringent codes, either as minimum codes or as a component of a program that provides incentives for compliance. These codes all have energy efficiency in common; although they may have more rigorous requirements than minimum energy codes or address additional issues not covered in the energy codes.

Designers still need to thoroughly understand the underlying baseline energy code when working with criteria that go beyond the minimum energy code.

Most of the states and local jurisdictions that go beyond the minimum codes use the IECC and/or Standard 90.1 as a baseline, with





additional requirements. Adopting entities are both mandating these programs and offering incentives to those who voluntarily comply. They vary widely in scope—from a simple requirement to comply 10 percent above the current IECC to comprehensive programs such as LEED or Green Globes (a product of the Green Building Initiative).

Initially a proving ground for new provisions, more stringent provisions, and new formats for provisions, documents that go beyond minimum codes are used to improve efficiency. Over time these provisions become more widely supported and are often submitted for consideration in minimum energy codes and standards.

For example, high-efficacy lighting systems for residential homes have been included in incentive programs for some time and are now required in the IECC. A second example is the New Building Institute's Core Performance Guide, which has also been codified and was approved for the



To achieve high-performance buildings, design teams must use integrated systems design, including architectural system efficiencies (such as siting, massing, landscape, and the building envelope).

RESOURCES



Federal Energy Management Program
www1.eere.energy.gov/femp/program/sustainable_requirements.html

2012 IECC to improve the commercial building efficiency.

For federal buildings, leadership in this area is provided by FEMP. FEMP sponsors a federal portal to the High-Performance Buildings Database, which contributes to the exchange of information about federal agency sustainable design activities as demonstrated in high-performance federal building projects. The High-Performance Buildings Database, research sponsored by DOE, seeks to improve building performance measuring methods by collecting data on factors that affect building performance, such as energy, materials, and land use.

The database includes information from buildings around the world, ranging from homes and selected commercial building loads to large buildings and even whole campuses and neighborhoods. Architectural and engineering firms can use this tool to assist with design features and can contribute completed energy efficient projects to the database.

As development cycles for building energy codes evolve, today's beyond-code programs become tomorrow's baseline. Ultimately, the minimum energy codes will begin to converge with the goal of buildings with zero energy use. AIA has worked closely with industry partners to codify building energy efficiency requirements to support the Institute's goal of carbon neutrality in the built environment by 2030.

2.3 Federal 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. While each agency generally adopts specific model codes and standards (e.g., ICC, NFPA, Institute of American Plumbing and Mechanical Officials (IAPMO), ASTM, American Society of Mechanical Engineers (ASME), ASHRAE), they may amend those codes. Then the application of those codes at each facility (e.g., federal prison, naval





facility, presidential library, post office) is addressed by the national agency headquarters and each facility manager in different ways. With respect to energy codes, federal agencies are subject to several statutory requirements, executive orders, and other policies surrounding sustainable buildings and campuses.

Some federal projects are owned in the private sector but leased to the federal agency or licensed to qualify for certain federal programs such as Medicare and Medicaid. This can become complicated, as these projects are not only subject to the federal requirements but also the applicable state and local codes. When the federal requirements don't neatly overlay the state and local codes and simply provide more stringent provisions or criteria, it may be challenging to determine and apply the criteria to a design. When the federal provisions and the state or local code directly conflict, it can pose a significant problem for architects and their

clients. One such conflict occurs in health care facilities, where the local government may require a variance to the state code that allows the federal requirements to be satisfied and “authorizes” a conflict with the state code.

2.4 Contracts

Well drafted contracts, subcontracts, and consultant agreements will help project participants clearly define the roles and responsibilities necessary for code compliance and successful project completion. The 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.

The AIA also publishes AIA Document D503-2011 *Guide for Sustainable Projects, including Agreement Amendments and Supplementary Conditions* to assist the participants in sustainable

design and construction projects in better understanding the unique roles, responsibilities, and risks encountered on sustainable projects.



AIA Document D503-2011 is available for free download at:

<http://www.aia.org/sustainableprojectsguide>



Additional information regarding AIA Contract Documents can be found at:

<http://www.aia.org/contractdocs>

AIA Public Policies on Codes and Standards

Building Codes and Standards

The AIA supports regulation by a single set of comprehensive, coordinated, and contemporary codes and standards, which establish sound threshold values of health, safety, and the protection of the public welfare throughout the United States. To that end, the AIA espouses the development and adoption of model building codes that:

- ▶ Include participation by architects and the public in a consensus process;
- ▶ Are the product of informed education and research;
- ▶ Are without favoritism or bias to any special interest;
- ▶ Include provisions for a prompt appeals procedure for all that might be aggrieved;
- ▶ Are cost-effective in relation to public benefit; and
- ▶ Promote building code provisions that set performance rather than prescriptive criteria.

Accessible Environment

The AIA supports governmental policies, programs, and incentives that ensure a built environment that meets the reasonable needs of people with disabilities through accessibility rules and guidances that are clear, certain, and consistent. Physically disabled individuals should be afforded the means to participate in society to the extent that they are able, through the elimination of physical barriers in a manner that balances the interests of the physically disabled, the public good, and cost effectiveness.



DESIGN: Design/Energy Code Interface

Architects blend their creative talents and technical knowledge to design buildings that satisfy the needs of their clients. In doing so, they must work within the federal, state, or local rules and regulations for buildings as well as any additional criteria from utilities, lenders, insurance carriers, and their client. These criteria cover all aspects of the building, from siting and height to the number of required accessible lavatories, and include requirements for energy efficient design and construction (and possibly commissioning).



Traditional design and construction processes that occur in a series of events, each controlled by a separate “trade,” are giving way to new approaches that foster collaboration and better utilize information technology.

3.1 Energy Codes Impact Design

Building design encompasses multiple system designs, including:

- ▶ Thermal envelope assembly, form, materials, and methods for construction
- ▶ Lighting system design, installation, control, and integration with daylighting opportunities as well as the efficacy of the installed lighting sources

- ▶ HVAC system design, installation, control and sealing, equipment efficiency, and size in relation to loads and use of renewable or waste heat sources
- ▶ Water heating system design, installation and control, equipment efficiency, and size in relation to loads and use of renewable or waste heat sources
- ▶ Electrical system design, installation, control, and efficiency of delivery of electric power throughout the building

The following discusses each of these system designs in terms of what the energy codes cover, how they affect the design of the building, and how they reduce the energy use of a building while maintaining

Vestibules can be an important design feature, and may be required by code depending on your climate zone.

a comfortable and functional indoor environment for the building occupants.

BUILDING THERMAL ENVELOPE

Local climate influences the energy code requirements for the materials and techniques used to construct a building's thermal



The energy efficiency levels of fenestration (doors, windows, skylights) vary according to thermal and light transmittance properties, while opaque assembly insulation levels depend on local climate. Orientation and exterior shading play critical roles in ensuring glazing does not increase cooling loads.

envelope.¹⁰ Energy code requirements specify the insulation levels in the opaque portions of the floor, ceiling, and walls, and require sealing to limit air leakage through the envelope. Some air leakage requirements prescribe the methods and materials to be used, while others specify a maximum allowable air leakage rate that is verified by testing.

All current model codes include a provision for installing materials and products per the manufacturer's 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

¹⁰ "Building thermal envelope" refers to the assemblies that separate the conditioned space of a building from the exterior of the building or unconditioned or semi-conditioned spaces in the building. This is different from "building envelope," which is generally thought of as the assemblies that comprise the exterior of the building and are subjected directly to all outdoor weather conditions.





client retain them during construction to verify that their design and specifications are properly implemented.

LIGHTING

The building lighting system provides adequate light levels for occupants, provides for safety and security, and enhances the building's interior and exterior aesthetics.



Codes regulate lighting based on watts per square foot, giving the designer the flexibility to select the light source based on design goals. Lighting efficacy and surface reflectivity are tools for increasing lighting levels while remaining within the lighting budget.

Because lighting is often the predominant energy load on a typical commercial building, good lighting design can save a lot of energy.

Good lighting design first employs daylighting where possible to minimize loads, and makes best use of available lighting technology. The selection of light sources that meet the needs of the space takes into considerations of both minimum footcandle requirements and lighting efficiency. Good lighting design also makes best use of lighting controls to either turn off lights when not needed or automatically dim lights when the lighting system is coupled with daylighting design for the building envelope. Automatic lighting controls can save significant energy in spaces such as private offices, conference rooms, and lunch rooms. Controls on exterior lighting can save energy by turning off lights during the daylight hours.

For example, lighting designers can select higher efficacy T-8 lamps fluorescent lamps over less efficient products to provide higher lighting levels in office spaces. Traditional

RESOURCES



For more information regarding BIM and other building technologies, visit the following **AIA Technology in Architectural Practice** website:

<http://aia.org/about/initiatives/AIAS078440>

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high bay lighting in large warehouse-type stores can be replaced with T-5 fluorescent lights that can provide more footcandles at the work surface while meeting the maximum watts per square foot for the space. Codes also provide additional allowances for display lighting in retail spaces where higher levels of



Lighting design should also consider vertical glazing and skylights to use of daylighting within the space. It is important to coordinate lighting design with the design of the building envelope and the HVAC system to reduce the overall building energy use while providing a suitable space for occupants.

lighting are required to showcase products. These lighting allowances are based on the type of product to be displayed (e.g., jewelry, fine china, kitchen appliances).

Codes regulate lighting power on the building exterior by providing lighting budgets for areas such as walkways, parking lots, and building entrances, and additional lighting for features like automated teller machines where safety and security are an issue. Codes place requirements on the types of lighting controls installed in the building with the goal of shutting lights off when not needed. The designer has the flexibility to select a combination of both manual and automatic controls to meet lighting needs. Controls for daylight areas are accounted for to make best use of the lights installed next to vertical glazing or skylights.

Because lighting systems can drive the cooling loads for a building, directly affecting HVAC sizing, it is important for designers to focus on system efficiency, considering both lighting source efficacy and lighting controls.



HEATING, VENTILATING, AND AIR CONDITIONING

HVAC systems maintain comfortable temperature and humidity and bring healthy levels of outside air into buildings. HVAC systems use electricity to move air through ducts (fans) and liquids through pipes (pumps), convert electricity to heat (electric resistance heaters), move heat from inside a building to outside (air conditioners and chillers), and move heat from outside a building to inside (heat pumps). HVAC systems also use energy from fossil fuels to release heat in furnaces and boilers through the process of combustion.

Codes regulate the use of energy by HVAC systems in several ways. They reduce the energy used by fans and pumps by requiring efficient motors and reduced flow of air and liquids during off peak operation (using variable frequency drives), and by minimizing the resistance to flow in ducts and pipes.

Codes reduce energy used by air conditioners, furnaces, and HVAC equipment by setting minimum efficiency levels. Finally, codes require controls such as programmable thermostats, temperature dead bands between heating and cooling set points, and the automatic use of outside air to provide “free” cooling when available (economizers).

Codes also regulate the size of HVAC systems relative to the demand of the spaces they serve based on the principle that systems running nearer to full capacity are typically more efficient than systems that are grossly oversized.

HVAC design is highly dependent on the design of other building systems. For example, changes to the lighting system or the building thermal envelope affect HVAC loads.

WATER HEATING

Water heating energy efficiency depends on equipment, delivery, and operational controls. Energy codes provide minimum criteria to effectively heat and deliver hot water.

It is very important that the professionals designing the building envelope, lighting and HVAC work together to consider these interactions and optimize overall building energy use.

3.2 Daylighting

Daylighting is the use of strategically placed fenestration to bring sunlight into buildings, eliminating or minimizing the use of artificial light. In commercial buildings, daylighting can provide higher quality light, support



Daylighting combines the type and thermal properties of fenestration installed, placement, shading of the fenestration during the year and the interior design of the building to control the amount of sunlight that enters the space.

productivity and health, and bring substantial energy savings. The availability of highly energy efficient fenestration coupled with advances in lighting design have allowed designers to efficiently use fenestration to reduce the need for artificial lighting during daylight hours without causing heating or cooling problems.

A light color ceiling will reflect and enhance the daylight so it fills the room. In the United States, south-facing windows are best because they let in the most light in the winter, but little direct sun in the summer. North-facing windows are also good for daylighting because they let in even, natural light with little glare and little summer heat. East- and west-facing windows aren't as good for daylighting. They provide lots of light in the morning and afternoon, but it often comes with lots of glare and excess heat during the summer.

The most recent editions of energy codes include daylighting control requirements





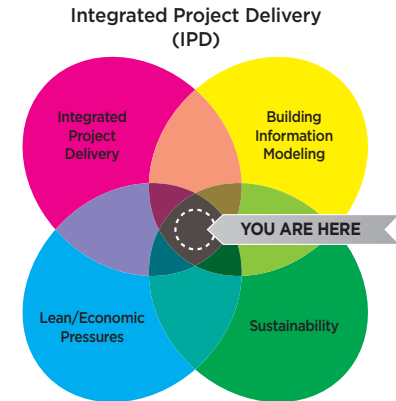
Windows manufactured today are extremely energy efficient and can actually insulate the space while still letting the light in. And some special electrochromic windows change color with the brightness of the sunlight like polarized sunglasses do.

that are now (or soon are likely to be) required for commercial building projects. For example, ASHRAE Standard 90.1-2010 includes detailed requirements for daylighting control and skylights to achieve recommended lighting levels

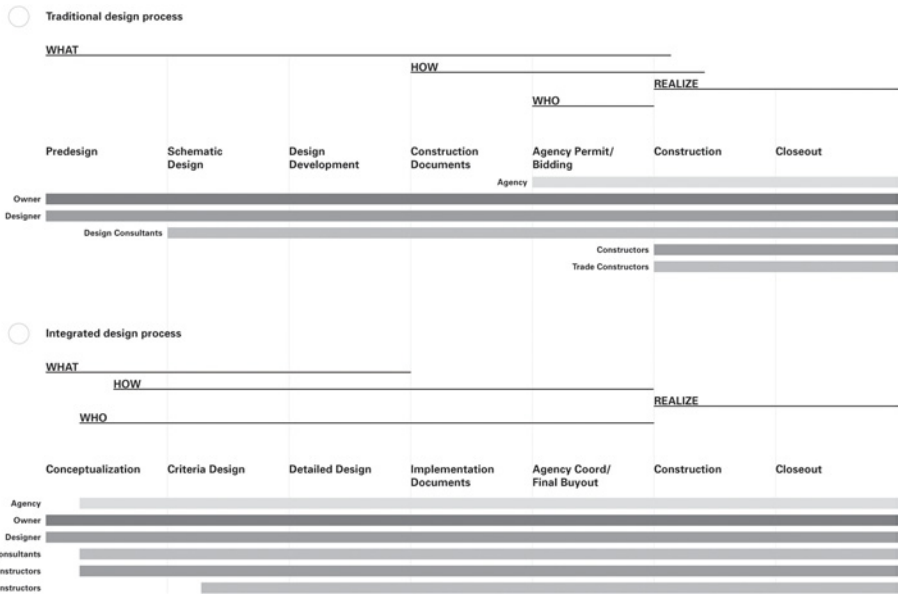
in commercial buildings. Daylighting additions to the code require control of general lighting over two types of spaces: 1) daylight areas under skylights or roof monitors that exceed 900 ft², and 2) sidelighted areas next to windows exceeding 250 ft². Control must be multi-level photo with at least two output levels (0-35 percent and 50-70 percent) or continuous dimming. There are some exceptions where daylight spaces will be very small or sunlight will be blocked. Functional testing (calibrated, adjusted, programmed) of lighting controls is required within 90 days of occupancy of the building. This testing must be performed by individuals not involved in design, manufacture, or installation of the lighting systems. This testing includes verification that all performance criteria are met and confirmation that photosensor controls effectively control electric lighting in response to daylight.

3.3 Integrated Design and Delivery

The terms “integration” and “collaboration” are broadly used, often interchangeably. With the emergence of the term “integrated project delivery,” or IPD, the term “integrated” has become even more broadly applied.



NOTES



From *Integrated Project Delivery: A Guide*, 2007, AIA/AIACC.
<http://network.aia.org/centerforintegratedpractice/home/>.





Encouraged by the design community, most owners are determining, on a project-by-project basis, the potential benefits and tradeoffs of a higher level of integration.

Integration of project teams is improving results. Though practices that are now labeled as “integrated” have been used before, many are now taking a fresh look at how owners can use contract incentives to encourage teams to collaborate and focus on the project’s best interest. Whether with a multi-party contract or under alternative project delivery methods, both new practices and updated approaches are helping owners increase the value of their investments in capital assets. AIA assists with IPD through their Center for Integrated Practice, established in 2009, which provides resources related to project delivery, technology, architectural practice, and stakeholder relationships.

AIA supports collaboration, collects and conducts project delivery outcomes and

research, and develops resources and tools for members, the profession, and the public.

Another technology that facilitates IPD is building information modeling (BIM). 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.

3.4 Design Tools

There are several tools architects can use to design buildings that meet energy codes and to document that the design complies with the code.

RESOURCES



The U.S. Department of Energy’s **Building Energy Software Tools Directory** provides summaries of many energy modeling tools that are currently available:

http://apps1.eere.energy.gov/buildings/tools_directory/

These include design guides, energy modeling software, and compliance tools that help designers and builders understand and implement energy codes, which positions them to go beyond the minimum code requirements.

3.4.1 Design Guides

ASHRAE has created a series of advanced energy design guides that recommend ways to achieve 30 percent energy savings over the minimum requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999. This is the first step toward achieving a net-zero energy building (i.e., a building that annually provides as much energy as it consumes from outside sources by using on-site, renewable energy sources). The guides were developed in collaboration with AIA, BECP, IES, and the USGBC.

The following free guides can be downloaded from www.ashrae.org/aedg:

- ▶ Advanced Energy Design Guide for Small Office Buildings
- ▶ Advanced Energy Design Guide for Small Retail Buildings
- ▶ Advanced Energy Design Guide for K-12 School Buildings
- ▶ Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings
- ▶ Advanced Energy Design Guide for Highway Lodging
- ▶ Advanced Energy Design Guide for Small Hospitals and Healthcare Facilities





ASHRAE and its collaborators are also working on another series of design guides for 50 percent energy savings compared to buildings that meet the minimum requirements of Standard 90.1-2004. One of these guides—the ASHRAE 50% Advanced Energy Design Guide for Small to Medium Office Buildings—is complete and can be downloaded for free from the ASHRAE website.

3.4.2 Energy Modeling

Architects are in a unique position to help clients make design and construction decisions that will produce energy efficient buildings that cost less to operate and are thus perceived as worth more in the market. Building energy modeling is a key tool in this effort. Energy modeling is most often used to 1) comply with mandatory requirements, such as the equivalent performance paths in the IECC, IgCC, 90.1, or 189.1; and 2) comply with program requirements for desired outcomes (e.g., LEED certification, qualification for tax incentives, 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.

Energy modeling predicts building energy use based on assumptions about building operations, not actual energy use. Actual energy use depends on factors like building use patterns, maintenance, occupant behavior, and the weather, making it as hard to predict as the actual fuel efficiency of a car on a specific trip.

Three types of energy models are currently used:

REGULATORY (OR COMPLIANCE) ENERGY MODELING

is the most commonly used. This modeling requires the development of a whole-building energy model of the proposed design, which is then used to compare the energy use of the building as designed to that of a “baseline” building model. The baseline model is built according to strict rules set by a regulatory

agency or a professional standards organization (e.g., ASHRAE) such that the comparison demonstrates that the building as designed will use no more energy than if it were designed to just meet the minimum code requirements. Whole-building models take a substantial amount of time to create and require the design to be mature enough to provide the detail of building systems, controls, and so forth; therefore, compliance energy modeling is typically done once, toward the end of design.

DESIGN-PERFORMANCE ENERGY MODELING uses available information during the design process to create multiple model options of partial building areas, systems, or components of a potential building design. These alternatives can then be used as a tool throughout design development, providing useful predictions of energy use as components and systems are further developed and detailed, and keeping the design on track to meet energy compliance targets. Because these models consist of

simpler, partial building areas, systems, or components, they are much easier and quicker to develop, making them useful during the early stages of design (when a less complicated approach and comparison of multiple alternatives is needed).

CALIBRATED ENERGY MODELING

is currently used primarily in building commissioning for measurement and verification. These models are completed after a building is occupied and are calibrated using measured data. Calibrated energy models should closely predict actual building energy use; however, minor modeling inaccuracies are inherent in the process. Presently, this type of modeling is used infrequently because it requires substantial resources and time; however, it will become increasingly important and prevalent as we move toward outcome-based design.

Note: An additional type of modeling, PROJECT RESOURCE MODELING, may sometimes be proposed or encountered. This type of modeling includes energy modeling

(as one of the precious resources modeled) but also includes estimates of other resources the building project might affect such as water, waste, land-development, and so on.

Energy models are built differently to answer specific questions at different stages of design, and must be adapted to the information needed and available, much like sketches and drawings. Energy modeling requires modeling skills and a knowledge of both building and building-system design and performance. Modeling tools are improving and becoming easier to use, and the process is becoming increasingly seamless.

While energy modeling for code compliance may be required during building commissioning, achieving high-performance buildings requires design-performance energy modeling to inform design decisions throughout the process. To get a client to agree to the additional effort needed for design-performance modeling, the architect must be able to articulate the value of this type of energy modeling.





The major benefit of design-performance modeling is that it can enable the design team and client to make strategic and best value decisions about designs based on factors such as cost and energy use.

Energy modeling requires modeling skills and a knowledge of both building and building-system design and performance. Modeling tools are improving and becoming easier to use, and the process is becoming increasingly seamless.

While specifics of each jurisdiction are likely to vary, in general, code officials look for documentation that demonstrates how the proposed building's energy use performance compares to a standard or baseline building. (As most architects will attest, it is always useful to start an early dialogue with the project's code official about what type of modeling and compliance forms will be required.) Additionally, it is in the architect's best interest to form and document a clear understanding of the many modeling

assumptions most likely to differ significantly from the actual building's operation and use.

To avoid surprises (for both the code official and the architect) that might result in rework (and additional costs) for the energy modeler, the architect should:

- ▶ Ask the code official what documentation is required at permitting to demonstrate energy efficiency compliance and get agreement **before** starting the modeling process.
- ▶ Include the modeling assumptions in all documentation. If the actual project's energy use doesn't meet the predicted energy use, differences between actual and assumed values (including building use schedules) may be the problem.
- ▶ Discuss whether the code official will accept building energy use or percent savings results as a range rather than a single number.

RESOURCES



COMcheck is available as a no-cost download from:
www.energycodes.gov/software.stm



Or it can be directly accessed for web-based use at:
<https://energycode.pnl.gov/COMcheckWeb>



Additional resources for designers are available on the **BECP website**. The Solutions and Help Center provides links for assistance requests, software and tools, and resources:
www.energycodes.gov/help



BECP Publications
www.energycodes.gov/publications

3.4.3 Energy Code Format and Impact on Design

An energy code's format can significantly influence design, sometimes more than the actual requirements. A prescriptive code clearly states what does and does not apply, 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 buildings with singular HVAC, service hot water, and lighting systems are more likely to be designed using a prescriptive approach. Larger buildings that have multiple systems or varied uses and loads provide more opportunities to follow a performance-based code. The following is a summary of how criteria are presented in current or past energy codes.

Prescriptive provisions are simple, singular metrics that individual components of the building must satisfy (e.g., minimum insulation R- value, maximum fenestration U-factor or SHGC).

Component performance relates to the performance of a particular component, system, or sub-system of a building (e.g., the total wall U_o shall not exceed X or the lighting system is limited to X watts per square foot connected load).

Equivalent performance relates to the expected performance of the whole building as designed compared to how the same building would perform if it complied with all provisions of the code (e.g., Section 506 of the IECC or Section 11 of 90.1).

Outcome-based performance is similar to equivalent performance, but rather than evaluating compliance during design based on equivalency, the energy code establishes a performance goal in the





form of a singular energy use intensity for all buildings of a particular type, and compliance is determined after occupancy based on actual metered energy use (e.g., 55,000 Btu/ft²/yr).

Peak energy capacity provides for a maximum ability to use energy via installed systems, but does not necessarily regulate the time or period of use (e.g., public assembly buildings shall have a peak connected load for all purposes of 5.1 watts per square foot of gross floor area).

3.5 Compliance Tools

BECP provides several tools for assessing and documenting code compliance. Some are simple pencil and paper documents and others involve software.

Compliance Checklists

BECP developed checklists for Standard 90.1 and the IECC. Each checklist summarizes

the requirements in each document and provides a way to verify or document compliance at each stage of construction, from plan submittal to final inspection. These checklists are available at no cost and can be adapted by any architectural firm to guide design compliance or document compliance for state or local officials.

COMcheck™

BECP's easy-to-use code compliance software, *COMcheck*, allows architects to demonstrate compliance with energy codes for commercial buildings, such as Chapter 5 of the IECC and Standard 90.1. Using information about the building design and specifications, the software verifies compliance and generates a compliance report that can be submitted with the plans and specifications. The software facilitates the consideration of designs that do not necessarily meet all the provisions of the code but overall are code compliant. This allows for flexibility and trade-offs between

RESOURCES



Tax Deduction Rewards Architects for Sustainable Public Sector Work, AIA website, Practicing Architecture, Zach Mortice, retrieved on 6/21/11 from: <http://aia.org/practicing/AIAB083035?dvid=&recspec=AIAB083035>

components. For example, a designer may compensate for a larger glass area on a wall in a view corridor by increasing insulation levels elsewhere.

A companion application to COMcheck that enables performance-based code compliance using DOE's EnergyPlus modeling software is scheduled for initial release in late 2011. This application will accept an externally generated building model, collect code information about that model, create a code equivalent model, and provide compliance results and reports.

3.6 Tax Incentives

179D Tax Deduction

The Energy Efficient Commercial Building Tax Deduction, or "179D," is a little-known tax deduction that encourages commercial building owners to strive for high performance buildings. In cases where

the owner of the building is a public entity, the deduction may be allocated to the person primarily responsible for the design of the energy efficient property. This allocation allows the designer to claim up to \$1.80 per square foot as a deduction for qualified property that is at least 50 percent more energy efficient than ASHRAE Standard 90.1-2001. Many of these projects can include schools, military facilities, and other local, state, and federal buildings. At a time when architecture firms are feeling the effects of a depressed design and construction economy, many architects have relied on this deduction to boost their bottom line.



CONSTRUCTION: Building Construction and Commissioning

4.1 Building Construction

Each stage of the design and construction process is important to ensure a successful new building or renovation project.

Typically, an architect's responsibility extends from the design phase through the end of the construction phase, including the installation of some or all of the building's systems.

For some projects, the architect's responsibility ends at design. For others, where the architect is retained during construction, the architect may oversee the construction and installation of some or all building systems. In still others, the architect's role may actually extend into the operations phase of the facility.

Wisconsin and other states require the architect or engineer of record to confirm that the building meets the adopted code, in which case the architect or engineer may be involved in oversight of construction.

Future formats of energy codes, such as outcome-based codes, also provide an opportunity for the architect to be involved in construction and beyond to verify compliance.

This section highlights the importance of proper construction and installation of technologies to ensure that energy efficiency is maximized and indicates resources available from BECP that relate to proper construction.

Building energy codes focus only on energy efficiency and, therefore, differ from traditional building, fire, mechanical, plumbing, and electrical codes that are adopted and enforced to protect public safety. But, building energy codes still apply to the building and building systems and components, in many cases concurrently with those other codes.

Building and fire codes govern the construction of the building assemblies such as a wall, for instance, with respect to

RESOURCES



AGC Resource Page

www.energycodes.gov/publications/resourceguides/documents/contractor_landing.pdf

The AGC Resource Page provides building code resources for every stage of the building process, from building code basics to complying with the building codes.

fire resistance of the materials in the wall. Energy codes, on the other hand, govern the thermal performance requirements for the same assemblies and materials. As another example, plumbing codes govern piping system size, location, and design, while energy codes require a certain level of insulation on some piping.

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.

This activity, coupled with building commissioning, will ensure that the building achieves its energy efficiency potential.

4.2 Building Commissioning

Commissioning is the systematic process of ensuring that all building systems perform individually and collectively according to the contract, the design intent, and the building's operational needs once it has all been installed on site. An industry consensus is evolving as to the nature and scope of building commissioning services.

Since 1993, the National Conference on Building Commissioning has served as a forum for experts from private industry, utilities, and government to discuss the most recent trends and developments in the commissioning, operation, and





maintenance of buildings. In addition, guidelines and standards on commissioning have been developed by ASHRAE and others. The advent of these documents and the increased recognition that building performance may not be guaranteed through a code focused on design and construction. However new code language, building certification programs and green building codes requiring buildings be commissioned as a caveat for building approval and an occupancy permit.

In the past, it was relatively easy to determine whether a building was operating correctly. If no visible problems were observed and the plumbing, lighting, electrical, and HVAC systems seemed to work as expected, then the building was considered to be finished. But these days it is much more difficult to ensure that all systems are installed, programmed, and operating correctly until the occupants observe system operations during daily use.

Commissioning is becoming a part of all construction projects, and it is a mandatory requirement of the LEED programs as well as the 2012 IECC.

Energy costs are a key component of a building's operating expenses, and energy-saving features and equipment can decrease these expenses. Decreasing energy costs by increasing energy efficiency is good for the environment and for the building owner's bottom line. Studies have shown that building commissioning can significantly reduce energy costs.

Energy-saving measures are often inexpensive to implement, and funding may be available from local utilities and/or government agencies. In addition, energy savings from commissioning continue to save money for years after the process is completed.

For design/build contracts, the architect may oversee the commissioning of some or all building systems. The proper operation

of each system is crucial to maximize building energy efficiency. The building commissioning process assures the owner that the systems are installed and operating correctly. After all, it makes no sense to install energy-saving equipment in a building unless it works as intended.

NOTES



- ▶ AIA online documents/links
 - AIA's Codes Advocacy home page
 - AIA's IGCC toolkit
 - AIA's energy codes home page
 - AIA Codes & Standards LinkedIn Group
 - AIA public policies on codes and standards
 - Paper outlining AIA "one-code policy"
 - Follow AIA on Twitter: @AIACodes
 - Like AIA on Facebook
- ▶ AIA Conference Publications
- ▶ AIA Pod Casts
- ▶ BECP *Setting the Standard* Newsletter
- ▶ BECP Code Notes
- ▶ FEMP Source:
 - <http://femp.buildinggreen.com>

Acronyms

- ANSI — American National Standards Institute
- ASHRAE — American Society of Heating, Refrigerating and Air-Conditioning Engineers
- IESNA — Illuminating Engineering Society of North America
- ICC — International Code Council
- IECC — International Energy Conservation Code

BUILDING TECHNOLOGIES PROGRAM

Building Energy Codes Resource Guide: COMMERCIAL BUILDINGS for Architects

PNNL-SA-82940