6. Energy Codes + Reconstructed Buildings: 2012 and Beyond

By Marilyn E. Kaplan, RA, FAPT, and Joseph P. Hill, RA

Marilyn E. Kaplan, a Registered Architect and Fellow of the Association for Preservation Technology, is a Project Manager with NYSERDA – New York State Energy Research & Development Authority. She administers NYSERDA's programs related to the New York State Energy Conservation and Construction Code and is responsible for all code-related training and support efforts at NYSERDA.

Joseph P. Hill is a Registered Architect and Assistant Director for Energy Services with the Division of Code Enforcement and Administration of the New York State Department of State.

In the 1970s energy conservation found a ready home in the regulatory system originally intended to address issues of fire safety and public health in buildings. For the next 40 years, energy conservation has continued along a path of steady and steep advancement affecting all facets of building construction. The U.S. Department of Energy's cooperative role with professional organizations led to the development of the 1975 ASHRAE Standard 90-75, the predecessor of the Standard 90.1 series. In response to the Energy Policy Act of 1992, in 1993 DOE founded the Building Energy Codes Program.[1] Early on, DOE encouraged states to adopt ANSI/ASHRAE/IESNA Standard 90.1-1989 for commercial buildings, and through its most recent efforts associated with the American Recovery and Reinvestment Act of 2009 (ARRA), has remained active in the code development process and in encouraging states to adopt and implement energy codes.

Over the last decade, energy-related improvements, primarily associated with the thermal performance of the building envelope and the efficiency of mechanical and electrical equipment, have dominated the discussion within the communities most directly linked to building regulation, design, and construction. Table 6.1 illustrates the rise of model codes dedicated to energy conservation since ASHRAE's publication of the first energy code, in 1975.[2]

Due to increasingly rapid change in HVAC and building construction technology, in 1999 ASHRAE voted to place the standard on continuous maintenance, which allowed for its update multiple times per year, up to the current standard, ASHRAE 90.1-2010. The updates come from technologies becoming more efficient and the emerging development of newer technologies brought to market.

THE GROWING ROLE OF THE INTERNATIONAL CODE COUNCIL

Since its creation in 1994, the International Code Council has published a family of 15 codes that have superseded the long-standing dominance of unique regional and state codes. The rise of the International codes as a single set of building standards providing uniformity on a national scale deepened the opportunity to expand regulatory discussions to a common platform. The first International Energy Conservation Code (IECC), published in 1998 based on the 1995 edition of Council of American Building Officials' Model Energy Code, was updated in 2000, 2001, 2003, 2004, 2006, and 2009. The 2009 edition became the ideal vehicle for higher energy performance in buildings as encouraged by ARRA, in essence becoming the backbone of the federal government's response to global politics, energy independence, and climate change.

ARRA, THE 2009 IECC, AND STANDARD 90.1-2007

The passage of ARRA represented a significant step in improvements in required energy performance. Of the $787 billion in the ARRA budget, $3.1 billion was set aside for energy program grants to states agreeing to update their energy codes for commercial buildings (and residential ones more than three stories in height) to the performance level dictated by the 2009 IECC or ANSI/ASHRAE/IESNA Standard 90.1-2007 (Standard 90.1).

Both the 2009 IECC and Standard 90.1-2007 present several compliance paths for residential and commercial construction. Traditional prescriptive paths establish specific minimums with variations that permit the tradeoff of building envelope elements against each other. DOE-produced software programs (COMcheck for commercial buildings) provide an automated means to identify requirements of the building envelope, although additional mandatory code provisions must be met for full compliance. These software products provide the means to select among various combinations of energy-conservation measures based on climate zone, including insulation levels, glazing areas, glazing U-factors (thermal performance), and in some cases heating and cooling equipment efficiency.

In contrast, performance paths (Section 506 Total Building Performance in the IECC and Section 11 Energy Cost Budget Method in Standard 90.1) use computer models of building-specific parameters to determine compliance. Although costly, this compliance method, based on the DOE-2 platform of annual energy usage, is the most judicious in terms of energy utilization measurement. Given the specialized task and subsequent high cost of modeling, this method typically is reserved for unique buildings, large structures, and structures that are required to meet performance levels that exceed minimum code. It must be followed for highly glazed buildings with fenestration

1 Then known as the Building Energy Standards Program and later the Building Standards and Guidelines Program.

2 The original standard ASHRAE 90 was published in 1975. Several updates were made in the years between the initial publication in 1975 and 1999, and then again in 2001, 2004, 2007, and its current version of 2010.

percentages exceeding code-determined thresholds.

ARRA's goals, accepted by the states receiving ARRA funds, were to increase, by 2017, energy code compliance to 90% of the standard established by the 2009 IECC. There are different approaches to quantifying progress based on the 2006 IECC baseline. A 30% improvement in performance based on foreseen code updates has been commonly cited as the level of intended improvement between 2006 and 2017, and 5-8% improvement for commercial properties (15% for residential properties) as the intended improvement between the 2006 and 2009 IECC. Three years after passage of ARRA, required compliance evaluations from states have produced varying results on the extent of actual compliance. Heightened efforts by states can be expected over the next five years to meet these and the more aggressive performance goals described in the law.

THE INTERNATIONAL EXISTING BUILDING CODE

Energy improvements to existing buildings will have an increasing share of the marketplace, but present a myriad of different technical and administrative challenges since each building is unique based on its original construction, condition, and the owner-elected scope of intended improvements. The International Existing Building Code (IEBC) establishes code requirements according to the scope of owner-elected work, delineated as the work area. Work is classified as a Repair, an Alteration (Level 1, 2, or 3), or a Change of Occupancy. The IEBC requires energy-conservation improvements consistent with the IECC within the work area, except in the case of minor work classified as a repair, or for historic buildings (as defined in the code), providing that conditions do not exist constituting a distinct life safety hazard. Owners of historic buildings share the same goals of energy efficiency as others, although their concern for long-term durability and minimizing adverse effects on historic features and spaces permit greater latitude in selecting appropriate materials and techniques.

The philosophy of limiting required improvements to a project's work area anticipates that, over time, incremental energy improvements will create a compliant building, similar to the incremental approach to accessibility improvements long embedded in the code. However, this stepped approach does not consider the impact a single improvement can have on other building elements or systems, and further research on the interactivity of energy-conservation measures is warranted. For example, in the absence of proper consideration of building ventilation needs, the installation of code-compliant ins ulation in the building envelope must carefully follow manufacturer instructions to avoid creating conditions that might encourage mold growth or material deterioration. A deeper understanding of such aspects of integrated design by the architectural, engineering, and construction professions will come as a result of building science research and application and the broader use of models evaluating critical items such as wetting and drying of assemblies in particular climatic and use conditions.

NEXT-GENERATION CODES: IECC AND STANDARD 90.1

DOE, ASHRAE, and the ICC agreed that buildings constructed under Standard 90.1-2010 would be 30% more energy efficient than those constructed using Standard 90.1-2004, and that the 2012 IECC would follow suit and be 30% more efficient than the 2006 IECC. The goals of the 2015 IECC and Standard 90.1-2013 will likely be even more stringent, although still based on 2006 performances levels.

Voluntary programs such as LEED or the higher-performance energy codes adopted by states or municipalities are likely to also demand increased performance, with some emerging programs promoting zero-energy buildings and deep retrofits for existing buildings. ASHRAE has indicated that the target goals of Standard 90.1-2013 may be as high as 40% above 2006 performance levels, with the 2015 IECC to follow suit. In reality, although the 2012 IECC and Standard 90.1-2010 are available for adoption, without ARRA's incentives it is likely that jurisdictions will be slower to adopt next-generation codes as minimum standards, and instead will rely on voluntary programs to assist in the move toward less energy-hungry buildings.

ABOVE-MINIMUM ENERGY PERFORMANCE CONSTRUCTION STANDARDS

The IECC, the most widely adopted energy code, establishes the minimum energy performance level permitted. Authorities that adopt the IECC may establish above-minimum requirements, such as the U.S. EPA's Energy Star program, which provides buildings that perform approximately 20% higher than code-minimum buildings. Alternately, certain financial incentive programs may require above-minimum performance, as may municipal, state, or federal agencies. National or

TABLE 6.1. THE DEVELOPMENT OF MODEL ENERGY CODES

1975	ASHRAE Standard 90 - 75: Energy Conservation in New Building Design	Reissued 1980, 1989, 1999, 2001, 2004, 2007, 2010
1998	International Energy Conservation Code (1st edition)	Based on 1995 Model Energy Code (CABO); updated 2000, 2001, 2003, 2004, 2006, 2009, 2012

Sources: ASHRAE, IECC

international green rating systems such as LEED and Green Globes may require above-minimum energy performance to obtain certification.

INTERNATIONAL GREEN CONSTRUCTION CODE

The International Green Construction Code (IgCC), which was published by the ICC in March, translates the broad principles of sustainability articulated in rating systems such as LEED to a code. By providing a framework that adopting jurisdictions can customize to meet regional needs and priorities, the IgCC seeks to improve the long-term performance and safety of new and existing commercial and high-rise residential buildings.

Note: The IgCC is not applicable to single-family homes or multifamily structures of three stories or less above grade.

The IgCC includes criteria such as environmental responsibility, resource efficiency, occupant comfort, and community sensitivity. Provisions include many traditionally associated with zoning or other environmental regulations, such as greenfields, conservation areas, and the promotion of infill green building and urban redevelopment. The IgCC incorporates both *prescriptive-* and *performance-based* choices. Of particular note is the ability to self-select a compliance path option, based on performance, outcome, or energy use intensity (EUI). The IgCC also offers the option to use either the IgCC or ASHRAE/USGBC/IES Standard 189.1-2009.

The code also shifts from focusing on mechanical equipment to energy efficiency, in particular through commissioning requirements to ensure building systems operate as designed, and extensive requirements for metering and submetering. Meters must be installed for all fuel types at the whole building level, including separate (and segregated) submetering requirements for HVAC, lighting, plug, process, and building operation loads for large buildings. (In this initial edition, metering equipment is not required for buildings of less than 25,000 sf.)

Mandatory requirements (detailed in Chapters 4-11 of the IgCC) are uniquely selected from Table 302.1 by the adopting jurisdiction to meet regional goals and priorities. An additional selection by the adopting jurisdiction determines the number of project electives (1-14) from Table 302 that must be met, and whether enhanced performance or reduced flow rates for plumbing fixtures are required. The code user chooses project electives from a 60-item checklist (Table 303.1), provided that the specific elective was not pre-selected by the jurisdiction as mandatory.

Several states (Maryland, North Carolina, Oregon, and Rhode Island), municipalities (Fort Collins, Colo., the District of Columbia, and Keene, N.H.), and the Native American Kayenta Township in Arizona have voluntarily adopted early drafts of the IgCC.[3] Following upon its publication earlier this year, other jurisdictions and entities will explore adoption of the entire document or extracted sections. It is anticipated that full and rapid acceptance may be curtailed while the design and construction industry continues to adapt to the new code-minimum performance increases of the 2012 IECC and Standard 90.1-2010.

BENCHMARKING, METERING, OUTCOME-BASED CODES, AND RETRO-COMMISSIONING

One limitation of the regulatory system is its measurement of code compliance at the moment of project completion rather than having the ability to confirm ongoing compliance. Benchmarking programs, among the progressive efforts being adopted throughout the country, establish the means to quantify savings by evaluating hard and actual data on energy use. A systematic and verifiable approach to long-term savings is created by these benchmark baselines, which establish how much energy is being consumed, followed by energy audits that determine what can be done to reduce energy costs. In addition to providing owners information on the relative costs and value of upgrades (and jurisdictions and utilities data on which to predict future energy needs), benchmarking creates an informed market capable of comparing performance data and operating costs of similar properties—information that will ultimately guide purchasing and leasing decisions. For policymakers, benchmarking provides the ability to monitor progress toward efficiency targets, identify markets with the greatest needs and opportunities, and guide development of future policies and incentive programs.

In New York City, the Greener, Greater Buildings Plan—part of the greenhouse gas emissions reduction goals within PLaNYC to reduce carbon emissions citywide to 30% below 2005 levels—requires annual energy benchmarking of all city-owned buildings and commercial buildings greater than 50,000 sf, submeters in buildings larger than 50,000 sf, online disclosure of building energy ratings, and energy audits and retro-commissioning every 10 years. In Seattle, the Building Energy Benchmarking and Reporting legislation requires commercial and multifamily building owners to conduct annual energy-performance tracking. Since 2007, the states of California, Nevada, Oregon, New Mexico, and Washington and several cities (including Austin and Washington, D.C.) have also enacted energy-benchmarking or disclosure requirements.[4] Variations on rating performance and required disclosure have been adopted in more than 30 countries over the last decade, including members of the European Union, under the EU's 2002 Energy Performance of Buildings Directive (EPBD). Some cities in China have

3 The Keene, N.H., restriction applies only within with the city's Sustainable Energy Efficient Development Zone.

4 The Austin (Texas) 2011 Energy Conservation Audit and Disclosure ordinance (http://www.austinenergy.com/about%20us/environmental%20initiatives/ordinance/index.htm) requires homeowners selling their property to obtain a specialized audit evaluating heating and cooling system efficiency, air infiltration, duct performance, air sealing, weather stripping, windows, and attic insulation. As of June 1, 2012, buildings 75,000 sf or larger must report their energy ratings (using such tools at Energy Star's Portfolio Manager). That threshold drops to 30,000 sf on June 1, 2013, and to 10,000 sf on June 1, 2014.

See also the Institute for Market Transformation chart, "Comparison of U.S. Commercial Building Energy Rating and Disclosure Policies," at: http://www.imt.org/rating.html.

5 The website BuildingRating.org has a neat compilation of these programs at: http://www.buildingrating.org/content/existing-policies.

adopted similar standards, and Australia and Denmark have particularly innovative programs.[5]

Outcome-based codes, such as the initiative promoted by the New Buildings Institute, establish a building's energy use as the metric of compliance.[6] By focusing on actual energy use rather than a theoretical prediction of energy use (as is generated by traditional code application), high-quality data can be derived and used to guide future improvements and operational decisions. As in the case of metering, outcome-based codes create the opportunity to engage building owners, possibly one of the most critical steps in creating a culture that is committed to reducing energy use. Commissioning, long a component of voluntary and incentive programs, is beginning to emerge as a mandatory requirement in the next generation of codes. It is expected that retro-commissioning of existing buildings, with the goal of optimizing performance without full system replacement, will also slowly emerge as a widely adopted regulatory tool.

STRETCHING THE LIMITS OF PERFORMANCE

As mandated energy performance in buildings continues to increase over the next decade, the design and construction community will need to catch up with the aggressive goals of the current and future editions of Standard 90.1 and the IECC. Lessons learned from the real-life application of the more stringent energy codes are also likely to influence future code editions.

Integration of building science. Tighter buildings pose greater risks of condensation and associated

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AchieveGreen – Online Resource for Green Building Teams

The Vinyl Institute has launched an update to AchieveGreen (http://achievegreen.net/), an online resource where design and construction professionals can gather information and gain ideas about the benefits of using vinyl products in their building projects.

The website provides a LEED Green Building Checklist, a downloadable design management tool for projects using the Green Building Initiative's Green Globes rating system, ANSI Standard 1, and LEED for New Construction. The matrix provides links to product manufacturers' websites where data can be obtained on how PVC/vinyl products that are part of building construction systems can contribute to green rating system credits.

Another component, AchieveGreen Reference Tools, provides quick links to green building resources, including NSF Sustainable Product Standards, ASTM International, CSI GreenFormat, and Vinyl in Design.

Case studies demonstrate the proven value of PVC/vinyl products in successful building projects, among them:

- How 200,000 square feet of vinyl graphics for the 2010 Vancouver Olympics has been diverted from landfill and remanufactured into high-recycled content flooring.
- How Turner Construction and Silktown Roofing, Inc., were able to integrate a sloping reflective membrane cool roof with tubular photovoltaic modules that generate 98 kW of solar energy for an elementary school in Greenwich, Conn.
- How C&H Fire Suppression Systems used CPVC pipe to retrofit two assisted-living high-rises with fire sprinkler systems, with minimal disruption to the tenants.
- How the historic 93-year-old Fern Hill Elementary School in Tacoma, Wash., was retrofitted with 100% post-consumer vinyl-backed carpet. A buy-back program will give the school district financial incentives when it returns the carpet for recycling in the future. Students and school representatives traveled to the manufacturer's plant in Dalton, Ga., to witness firsthand how the carpet from their old building was recycled into new product.

For more on AchieveGreen, visit http://achievegreen.net/.

COURTESY MANNINGTON COMMERCIAL


Following the 2010 Vancouver Olympics, Mannington Commercial took 200,000 square feet of vinyl graphic materials by 3M Canada (as shown in photo at left), diverted it from landfill, reprocessed the waste material at its Georgia production facility (center), and recycled it into commercial flooring material that was later installed in a school (right). More such case studies can be found at http://achievegreen.net/.

damaging effects on building materials and indoor air quality, including those associated with radon. Without further study and developments that transfer, to the construction site, the results of scientific and theoretical knowledge of air infiltration materials and techniques, vapor barriers, and insulation selection and installation, significant opportunities for building failure can be created. The need to further integrate building science into the codes and construction practices is already recognized in high-performance buildings, particularly those looking to meet net-zero energy and above-code-minimum levels of performance. In existing buildings, control of moisture flow presents even greater challenges.

It is anticipated that over the next decade, as envelopes continue to tighten to meet ambitious improvement goals of governments at all levels, building science associated with energy performance will more consistently become part of the national model code framework. One example is a study being undertaken by the Preservation League of New York State, supported by the New York State Energy Research and Development Authority and Department of State. This study, using computer modeling to evaluate the wetting and drying of wall and ceiling assemblies as a function of insulation type and thickness, to be followed by installation and monitoring of selected materials, may bring forth important findings that could become the basis of future proposed code changes.

Construction quality and durability. While codes have been slow to progress in their regulation of construction quality and durability, this too has begun to change. For example, in the 2007/2009 ICC Final Action Hearings, the flexible use of permeable vapor retarders entered the International Building Code and International Residential Code. Backed by technical studies, this proposed code change recognized the importance of allowing building assemblies to dry naturally, rather than trapping bulk moisture within cavities. Because the technical understanding of the impact of vapor retarders is not universally understood, it will likely take at least a full code cycle for code users to become fully aware of the benefit of this change.

Code compliance is measured at construction start and completion, when theoretically a building will perform at its optimum. The effects of imperfect construction quality and the possible application of inappropriate or incompatible materials and details are not addressed, and an inferior or poorly applied sealant installed shortly before a blower door test, for example, can test adequately but immediately begin to deteriorate due to incompatibility with mortar or other factors associated with selection or installation. While there is no shortage of reference standards and manufacturers' recommendations to guide proper use and application, it is rare for such detailed directions to be fully transported to the construction site.

Although not explicitly stated in the code, approaches focused on enhanced construction quality have been introduced for residential buildings and are likely to be followed for commercial buildings. Chapter 4 of the IECC identifies 17 separate conditions required for proper installation of insulation and for sealing the building envelope and permits the use of ACH 50 testing as an alternate to these tabular requirements. As a result, a poorly constructed or insulated building should not be judged to be in compliance.

WHO IS RESPONSIBLE FOR ENERGY EFFICIENCY?

Energy-efficiency practices have moved from the 1970s' architects, engineers, and contractors who embraced the first generation of efficient construction, to the 171,271 LEED Accredited Professionals (as of September 2011) and those within the construction industry with certification from the Building Performance Institute. BPI, a U.S. organization involved with certifying individuals and companies associated with energy-efficient, home performance contracting, is deeply involved with energy audits and testing services associated with Energy Star and other high-performance programs. The trades involved with larger commercial construction have no counterpart that is as widely recognized.

For the great majority of new and reconstructed buildings, reaching the minimum standard prescribed by codes remains a challenge for all the actors in the design and construction industry. The newest energy codes required design professionals to explicitly state that the energy code provisions have been met. Compliance studies undertaken to establish baselines for ongoing ARRA-compliance evaluations have established that there is much to be learned by the design and construction industry to translate energy goals into practice, and to better align theoretical buildings (at time of permit) with actual performance. Involvement by design professionals during construction varies from those with minimal or no engagement during construction administration to those with a deep involvement.

Because the design professional's role is to ensure that the intent of the contract documents is met—and since code officials have a specified and minimal role in inspection—the day-to-day tasks of implementation belong to the trades, contractors, and construction managers. Except for high-performance buildings most likely to receive a high degree of oversight during the construction process, in the myriad of coordination tasks associated with large-scale construction, a focus on the important construction details related to energy efficiency is too often lost. Furthermore, the ability of facility managers to operate systems as efficiently as intended is often limited by factors such as the complexity of systems, the lack of proper commissioning, and training and staffing limitations.

Those responsible for construction and regulation also have much to learn. The adoption of more stringent codes, as encouraged by ARRA, has shone the light on code officials. These individuals have tremendous responsibility for fire and life safety, but are typically under-resourced and often lacking in high-level technical training. The combined demands of workloads and needed technical expertise, coupled with the increase in measurable performance of buildings, may move many of the code officials' traditional energy inspection functions to third-party involvement. (In New York State, this option is at the discretion of individual municipalities.) As the role of the "code expeditor" evolved in large cities such as New York to assist with the labyrinth of required permits, and as specialized sprinkler and elevator inspections became part of the overall inspection process, so too will the energy-inspecting world expand the need for those with specific energy experience.

PLACING VALUE ON DURABILITY AND LONG-TERM PERFORMANCE

Long-term performance requires fundamental improvements along the entire design and construction chain. Design professionals must be more diligent in the selection and detailing of materials, better schooled in the codes and building science, and eager to push the integration of the disciplines of architecture and engineering. Owners and construction managers must respect the criticality of technical selections, not accept substitutions of lesser value, and expect and require a consistent level of detail of field installations.

Buildings are used very differently today than in decades past. One primary reason is society's heightened expectation of comfort: How many buildings today are not air-conditioned? As energy costs have soared, in the evolution of building construction, wall and ceiling cavities, historically empty and breathable, have become fully insulated and the envelope sealed. The combination of space cooling and reduced natural breathability effectively changes a structure's moisture profile. In order to avoid long-term degradation, design professionals and code promulgators must further the integration of building science into energy and building codes.

Perhaps the largest issue returns to the value society places on durability, in particular building owners and others who typically using tax depreciation cycles and length of intended ownership to set a standard of performance. In a throwaway society, the challenge of transitioning to a long-term view, facilitated by the integration of life cycle costing applied to building construction and maintenance, cannot be understated. +