The Future of Energy Codes

Dave Hewitt and Mark Frankel, New Buildings Institute
David Cohan, Northwest Energy Efficiency Alliance

ABSTRACT

In the past two years, energy codes have moved from the fringes of energy efficiency policy to center stage. Elected officials from President Obama on down tout them as key for addressing climate change and reducing utility rates; many state laws now require more stringent energy codes. At the same time, the national model residential energy code increased by 15% in stringency between 2006 and 2009 and is virtually guaranteed to increase by an equal amount in 2012. All this activity is welcome but continuing increases stringency in currently regulated areas (insulation, equipment efficiencies, lighting, etc.) yield diminishing savings and become a smaller and smaller part of a building's total energy consumption. This implies that something fundamental will need to change in the way codes are now structured to achieve the targets of extremely low or zero energy use in buildings which policy makers have set in many states.

The Northwest region recently held two meetings of a coalition formed to develop new approaches that will allow codes to continue to have a major impact on reducing building energy consumption. Recognizing the inherent limits of current code structures, the group discussed strategies such as the inclusion of performance tests, expanding regulation to operations and maintenance, building-type specific codes, consumption limits and new enforcement mechanisms. A list of guiding principles was developed which the meeting organizers hope to use to set the stage for a national discussion later this year. The Northwest organizations involved have a long track record of convening national meetings and driving national agendas.

Background

Energy codes are hot. Beyond anyone's wildest imaginings, this nerdiest of all energy efficiency disciplines has moved from the fringes of energy efficiency policy to center stage. Policy makers, energy agencies and environmental groups pursuing aggressive climate change agendas have realized that energy codes are one of the simplest, most effective tools available to reduce building energy use.

Already the result has been a much-accelerated adoption of code stringency increases driven directly, through state-level legislation, and indirectly by formal policy initiatives on the part of the U.S. Department of Energy and other major organizations. For energy code experts who have been advocating for more stringent codes for years this is all welcome news, but looking forward there is apprehension that unrealistic expectations are being set.

Currently, there is a gap between the level of code stringency and increases that can be put into place within the current structure of the codes and the capability of the market to deliver building improvements. However, new code developments and adoptions in the West Coast states, the International Energy Conservation Code ("IECC", which is used in most of the rest of the country) and ASHRAE/IESNA 90.1 updates are rapidly closing that gap. To move into the realm of extremely low or zero-net-energy buildings as envisioned by the 2030 Challenge[1] and

[1] See http://www.architecture2030.org/2030_challenge/index.html.

other policy initiatives, significant changes will need to be made in code structure and language, as well as in implementation and enforcement strategies. These changes are the focus of this paper.

Guiding Principles

In November and December 2009, the Northwest Energy Efficiency Alliance (NEEA) and New Buildings Institute (NBI) convened an ad-hoc assembly of energy code and policy experts from the four Pacific Northwest states and California[2, 3]. These states have one of the country's longest histories with energy code development and enforcement, and their jurisdictions have developed the most stringent energy codes currently in force. They also have a history of exploring new and innovative approaches and have acquired a national reputation for progressive energy code development and implementation. Nevertheless, codes in our region face the same structural limitations as all current energy codes, so the discussion of alternate strategies is very topical.

The purpose of the meetings was not to create a new code but to create a set of guiding principles that could be applied to code development around the country over the next several cycles. The principles listed below evolved from detailed discussions regarding existing and future barriers and code upgrade opportunities.

To focus the discussions we took as a given that the ultimate policy goal was to achieve a zero-net-energy building stock. By this we mean that, overall, buildings (both residential and commercial) will produce as much power as they consume though individual buildings may be net negative or net positive consumers. This reflects the reality that it is much easier to reduce energy consumption in some types of buildings than others.

Our guiding principles are listed here and then discussed in detail in the sections below.

1. Energy codes must expand in scope to account for energy consumption that is not currently regulated.

2. Equipment and systems must be tested and operate properly prior to issuance of a certificate of occupancy.

3. The code enforcement process must be modified to extend beyond initial building completion so that actual building performance comes under regulatory purview.

4. Buildings must be circuited and metered to allow collection of building energy consumption data by end use to provide guidance to owners and users on how to reduce energy use including the allocation of energy use between design and

[2] Attendees at the meetings were: John Hogan, Jayson Antonoff – City of Seattle; Chuck Murray – Washington State Department of Commerce; Martha Brook – California Energy Commission; Eric Makela, Dave Conover, Todd Taylor – Pacific Northwest National Laboratories; Vincent Martinez, Ed Mazria – Architecture 2030; Dave Hewitt, Mark Frankel, Sean Denniston – New Buildings Institute; David Cohan – Northwest Energy Efficiency Alliance.

[3] The meetings were intended for brainstorming and concept development and did not result in a formal agreement about outcomes. Therefore, while everyone who participated had a chance to review drafts of this paper, the contents represent only the perspectives of the authors.

operational parameters of building performance. For the latter, it is critical that complete end uses, rather than individual pieces of equipment, be metered.

5. Low performing systems must be eliminated from the code.

6. Existing buildings need to be effectively addressed by code improvement goals, but must be treated differently than new construction.

7. Reach codes must be adopted to provide predictability to the market on where energy codes are headed in subsequent cycles.

8. The move toward a zero-net-energy building stock will likely require a series of major shifts in the structure of the codes. As the codes evolve along this continuum, enforcement agencies must at all times have the capability of understanding and enforcing the code.

9. A metric with a fixed baseline must be established that allows progress toward a zero-net-energy building stock to be accurately measured at each new code change.

Definitions

For clarity, the following definitions of code compliance approaches are used in this paper:

Prescriptive/Component Performance. This approach describes discrete components or features required in a building. For example a prescriptive/component performance code may require that boilers have a specific minimum efficiency, that roofs are insulated to a specific minimum R-value or that a wall section meet a specified overall U-value. Prescriptive/component performance requirements can be thought of as "check box" items that either meet or do not meet the code. Most codes focus primarily on prescriptive/component performance compliance strategies, in large part because they are considered the simplest and easiest to enforce. Note that a prescriptive/component performance approach can include equipment or system operation. For example, requiring a blower door test to ensure air leakage below a certain rate is a prescriptive/component performance approach.

Energy Modeling. This compliance approach typically implies that energy modeling software is used to show that a building's predicted energy consumption or cost is equal to or lower than a baseline target that has been specified by the code. The baseline target is generally composed of a combination of component requirements from the prescriptive code and inputs from the proposed building for items that are needed for the simulation but are not covered under the code (e.g. occupancy schedules and internal gains) This approach gives maximum flexibility to designers and is particularly valuable in complex buildings. In some discussions of code improvements, performance is taken to mean actual energy use of the building. This confuses the distinction between modeled (predicted) energy use and actual energy use, which are typically very different numbers (this is discussed in a subsequent section). For purposes of this paper, energy modeling codes are defined specifically to mean predicted relative performance compared to a theoretical code baseline. (Note that the IECC and other codes refer to this as a "performance" approach. We are purposely avoiding that term as it implies a connection to the actual rather than just the predicted performance of the building.)

Outcome. We refer to the concept of regulating actual building energy use as an outcome-based code. Although no current code regulates actual energy use, there is much discussion about how this might occur and it is a critical component to achieving very low-consumption buildings.

Discussion

The following numbered items are repeated from the guiding principles list above. Under each one we discuss some of the key limitations of the current codes and opportunities for future changes.

1. Energy codes must expand in scope to account for energy consumption that is not currently regulated.

A substantial portion of the energy used in buildings is not regulated by energy codes. This energy falls broadly under the categories of process loads, which include manufacturing and food preparation equipment, and plug loads which refer to energy-using equipment that is not built-in during construction. These loads are significant (almost always >20%) in all building types as they include all computer and office equipment, entertainment systems and appliances. In some types of facilities, such as medical or industrial buildings, they can be the dominant energy use. As energy codes become more stringent, regulated loads will shrink meaning that the percentage of overall building energy use from process and plug loads will grow. As an example, if one assumes that code-regulated energy use in a building is 75% of the total then it would require a 25-30% increase in code stringency to reduce overall consumption by 20%. It is clear that long-term energy reduction goals cannot be met through codes unless their scope is increased. Encouragingly, there is already a starting point for this as ASHRAE/IESNA Standard 90.1 currently contains criteria for a number of common process loads (e.g. kitchen hoods in restaurants, fume hoods in laboratories, condenser heat recovery to pre-heat water for laundries in hospitals). To be effective, however, requirements will have to address controls for plug loads as well as the equipment itself.

As the characteristics of plug loads are highly dependent on specific tasks and use types within the building that are highly variable over time it is difficult to conceive of a process by which energy codes can directly regulate plug loads in isolation. Instead, it may be more effective to consider total energy use budgets as a mechanism to provide flexibility to the code compliance process. In general, this begins with feedback on building performance as an area of focus for moving forward with energy codes. See #4 below.

2. *Equipment and systems must be tested and operate properly.*

A fundamental assumption embedded in energy codes is that each system and piece of equipment in the building works as intended, despite a tremendous amount of research illustrating that this is not the case. This difference between assumption and reality has very real and negative, consequences in energy consumption. To use the example of the energy modeling path, the baseline code model assumes 100% effectiveness for each item in the building and the proposed building model therefore also assumes 100%. Most codes do not allow one to downgrade the energy efficiency of equipment in the code baseline to match the real-world conditions; therefore there is no incentive to adopt better design or installation strategies to fix a problem that, according to the code, doesn't exist.

This guiding principle addresses the no-man's land between the conclusion of the construction phase and the occupation of a building. It is widely understood in the building industry that large commercial buildings may not function as designed after construction is complete, yet energy codes do not account for this situation because they are focused on the physical presence of items rather than on systems and actual building performance. (Note that performance goes beyond simply functioning. Installers may ensure that things turn on and off but that is different than ensuring that they perform optimally, particularly from an energy perspective.)

The discipline that addresses actual building and systems performance is building commissioning, a process of conducting tests to verify that building systems and equipment operate as intended. While the ideal version of commissioning starts very early in the design phase and continues throughout the life of the building, abridged versions dealing with just the 'final completion' or occupancy phase of a building can be a first step in the transformation from the current completely non-performance-based code to an evolution of energy codes based on building performance.

Unfortunately, effectively codifying commissioning is difficult because of the great variation in buildings and the (ideal) need for procedures specific to each building type and system. Although some jurisdictions, notably the City of Seattle, Washington state and California, have adopted commissioning requirements, there is a great deal of work that must be to develop the most effective language and determine the appropriate scope and role of building officials in this area.

3. *The code enforcement process must be modified to extend beyond initial building completion so that actual performance comes under regulatory purview.*

This is the logical continuation of #2 and it is the most important concept on our list because, ultimately, the only energy that counts is what is used in a building after it is occupied. Our ability to predict the relationship between energy codes and actual energy use in individual buildings is not good. This is not surprising given that energy codes mainly dictate the choice of components and components are only one determinant of building energy use. (Others are siting, building/system design, construction quality, commissioning, operations and maintenance, interior design, tenant behavior and plug/process loads.) Even the energy modeling path, which takes some aspects of system interactions and occupancy into account, has problems. Recent studies have demonstrated that energy modeling is a poor predictor of actual building performance.[4]

Though post-occupancy monitoring is a radical shift from current enforcement practice, there are many well-established, non-controversial precedents for this approach. Annual or periodic inspections or review are already part of many building codes which regulate fire safety, hygiene and elevator operation. On the other hand, energy consumption data has historically been the domain of utilities so this concept would require coordination between building departments and utilities once building officials have issued a certificate of occupancy.

A major limitation in the current energy code structure is the assumption that there is a specific period of a building lifetime that must be regulated. If policy goals are to reduce energy use, codes must recognize that buildings use energy during their entire lifetimes and there is no period that is more or less important. A process by which on-going performance is managed or reviewed would address long-term operational issues. This would represent a significant expansion of the scope of energy codes.

4. *Buildings must be circuited and metered to allow collection of building energy consumption data by end use to provide guidance to owners and users on how to reduce energy use including the allocation of energy use between design and operational parameters of building performance. For the latter, it is critical that complete end uses, rather than individual pieces of equipment, be metered.*

Under current building design practices it is difficult to know how energy is being used in a building. Utility bills provide no information about this and even commercial buildings with sophisticated energy management systems cannot tell what is contributing to overall energy use if circuits are not dedicated to systems or end uses and submeters are not installed. This is the energy version of ‘You can’t manage what you can’t measure’.

A new commercial code in Washington, which will go into effect in July 2010, requires submetering of equipment that exceeds specified thresholds (e.g. Packaged AC unit systems > 240,000 Btu/h cooling capacity). A better approach is contained in the draft International Green Construction Code which is focused on entire end uses and systems[5]. Similar requirements have been adopted in the newest Seattle Energy Code.

---

[4] Frankel, Mark and Cathy Turner. *Energy Performance of LEED® for New Construction Buildings FINAL REPORT March 4, 2008*. New Buildings Institute.

[5] End uses are categories of energy use. Common ones include lighting, space heating, space cooling, ventilation and water heating but there are many others. The distinction we are making between equipment and end uses is the difference between being able to say “This is how much energy this furnace uses” versus “This is how much energy we use to heat our building.” The latter is much more powerful in terms of understanding overall energy use in a building.

This is a good first step toward providing usable information for building occupants. While a balance must be found between cost and the value of information provided, even for residential buildings it would be reasonable to require submetering of major loads. Having such information available would provide value over the lifetime of the building.

Perhaps more importantly, if outcome-based codes are the goal we must begin to differentiate building energy consumption driven by inherent design conditions from consumption driven by operational and tenant practices that are independent of design features. In this context, commissioning and end use metering become essential elements of the code.

5. *Low performing systems must be eliminated from the code.*

Energy codes do not reward more efficient design decisions. In practice, the current code approach tends to favor projects seeking the lowest common denominator in energy performance over those that might reach for higher performance goals. For example, the code has very limited regulation of HVAC system-type selection. Projects that choose the cheapest, low-end roof-top systems are given the same set of options for other building performance characteristics as those projects that opt for higher performing system types. In the energy modeling path, more efficient building design and system selection is actually punished by the code, because the rules require that they are identical in the "reference" (baseline) building and the proposed building. This is done with good intent to avoid gaming on the part of energy modelers but the effect is to sets a higher performance baseline for projects considering higher performance design and equipment options. For example, a project that considers a more energy efficient building shape or water-based chiller system must compare to a more stringent code reference building than a project that opts for a less efficient shape or an air-cooled chiller. This higher baseline makes it more difficult for the project to demonstrate savings beyond code, both for the building's shape and chiller selection, and for the other efficiency measures that might be considered (based on a more marginal energy savings rate).

6. *Existing buildings need to be effectively addressed as codes improve, but must be treated differently than new construction.*

Energy codes apply to remodels and renovations of existing buildings as well as to new construction. There have always been problems in applying the energy code to existing buildings but as code stringency dramatically increases, special care and consideration must be made to avoid the unintended consequence of slowing the pace of existing building energy upgrades.

Older chillers, for example, can be repaired almost indefinitely. An owner facing a choice of repairing an old chiller or buying a new one may choose to keep the old one if the incremental cost of a code minimum chiller (where the code is targeted mainly at new construction) is too high. A lower efficiency unit may save substantial energy relative to the existing one but if the code doesn't allow it owners will simply retain the old chiller.

A variation on this theme is an energy project which triggers requirements in other building codes. A common example is a building owner who wants to replace rooftop HVAC units but doing so would require a seismic upgrade to the entire roof. The result is that the owner keeps repairing the old, inefficient units and never replaces them.

Setting different requirements for existing buildings in some sections of the code would also allow coordination with utility incentive programs. Many utilities provide financial incentives to upgrade existing buildings but most are prohibited for paying for energy code measures since these are required by law and therefore provide no incremental savings benefit. However, if the incentive is the difference between an owner doing or not doing a project, then putting a high efficiency requirement into code (where it can't receive incentives) makes it less likely that owners will upgrade.

7. *Reach (a.k.a. stretch) codes are needed to provide predictability to the market on where energy codes are headed in subsequent cycles.*

Current code development processes provide no guidance on how the code will change beyond the version being developed. Each cycle is treated as an independent event and there is no long-term policy goal to ensure consistency of direction or magnitude of changes. This situation also exacerbates a historical tendency for codes to jump up significantly in stringency in one cycle and then be flat for several cycles rather than have consistent, moderate increases each cycle.

Predictability can be provided through the development of a reach code which is understood to be the default mandatory code for the next cycle. If known three years in advance, a reach code aligns everyone working in the market. Design and construction professionals would know what knowledge or skills to acquire help them meet the requirements of future codes. Manufacturers and distributors would be given a large incentive to compete for future market share of what they know will be required products. This works to lower prices to builders which can then be passed on to developers and owners. Another benefit is that utilities can match incentives and education and training efforts to future code requirements. Besides providing logical consistency between utility programs and codes, this would ensure higher compliance rates once the new mandatory code is adopted since a larger share of market actors would be familiar with what is required.

Reach codes are currently in the earliest stages of development and are gaining in popularity. Massachusetts developed and adopted a reach code based on the New Building Institute's Core Performance Program in 2009, Oregon has a statutory requirement to develop one in 2010 and California's new CalGreen code has optional energy performance requirements.

8. *As codes evolve toward a zero-net-energy building stock, enforcement agencies must at all times have the capability of understanding and enforcing the code.*

Jurisdictions will only enforce the energy code if they have the resources and the training to do so. Resources are usually scarce in building departments – particularly so now with the weak construction market and resulting revenue declines – and jurisdictions naturally tend to allocate them first to “fire/life/safety” codes (e.g. fire, structural, electrical) which have more direct connections to public safety which most building officials see as their mission. Exacerbating this situation is that training dollars are also allocated to other areas; without training the energy code can’t be enforced even when there is a will to do so.

The solution to this problem is largely political; elected officials must consider energy code enforcement a priority and must be willing to appropriate budgets that realistically allow building officials to enforce the codes in their jurisdiction. This would be a major change from current code enforcement practice.

A more fundamental issue that arises around enforcement is that commercial energy codes, and complex commercial buildings in particular, already require a knowledge of engineering that is unreasonable to ask of a typical building official. If this trend continues there will be a strong argument for either creating third-party certifiers or moving to outcome-based codes where only whole-building energy use is used to determine compliance. Moving more to an energy modeling path does not resolve the problem since, as noted above, there is little confidence in the predictive ability of the simulation models this path requires.

9. A metric with a fixed baseline must be established that allows progress toward a zero-net-energy building stock to be accurately measured at each new code change.

New energy codes are often described as an improvement of X% over the previous code. This is immediately confusing because, as described above, not all energy is regulated under the code so it is not clear whether X% refers only to regulated energy use or to whole-building energy use. It gets more complicated, however, when describing changes that occur over multiple code cycles. As Charles Eley noted recently, “Percent savings is confusing because the codes frequently change…. ASHRAE updated Standard 90.1 in 1999, 2001, 2004, and 2007. Early green buildings claimed savings of 40% or more relative to ASHRAE Standard 90.1-1999, but many of these buildings would fail to comply with the most recent ASHRAE and California codes….[P]ercent savings becomes confusing and unstable as policy makers set goals for zero net-energy buildings and as energy codes become more stringent.”[6]

What is needed is a fixed baseline which is nationally accepted, preferably one based on whole building energy use and in which zero is equal to zero-net-energy. References could then be made to being X% lower than the baseline and everyone would immediately understand where that puts us on the path to zero-net-energy. The U.S. Department of Energy is well positioned to create and promote such a standard.

A related topic, and the reason metrics rise to the level of a guiding principle, is that there is little understanding of how current energy codes actually perform. Recent code equivalence studies have suggested a much lower total energy use for buildings that meet code requirements than independent studies of the building stock have implied. For example, a recent study by a federal lab comparing ASHRAE 90.1-2007 with the newly released ASHRAE 189 standard suggested that 189 would deliver a 30% energy improvement over 90.1-2007. (One-third of this comes from renewable energy

[6] Eley, Charles of Architectural Energy Corporation from a Southern California Edison Work Paper “Rethinking Percent Savings”.

generation.) If you compare the predicted energy use for office projects in these two codes, the analysis suggests that energy use for projects built to code requirements are ~35 kBtu/sf/yr and ~20 kBtu/sf/yr respectively.

Comparing this to actual energy use of some office buildings in Seattle suggest that these results may not be supportable. The City of Seattle has one of the most stringent energy codes in the country – generally more stringent than 90.1-2007 – along with an aggressive enforcement policy. One of the best performing new buildings in the city, with a recent Energy Star score of 100, demonstrates metered annual energy use of 42 kBtu/sf/yr – 25% more energy than the equivalence study suggests a less stringent code will deliver.

These results imply that, from a policy standpoint, we may be significantly over-estimating the stringency of our existing codes. In addition to de-emphasizing the magnitude of the building efficiency problem, it becomes very difficult to justify on-going code stringency improvements, both from a policy and an individual project basis. Consider: if the analysis under-estimates actual building energy use by 30%, then the marginal savings from other building efficiency improvements are likewise under-predicted by 30%. For many measures, this makes the difference between a measure that is deemed to be cost effective, and one that is not. For both program-wide incentives and individual projects, this information discourages design performance improvements by underestimating their potential energy impacts.

Next Steps

The guiding principles in this paper are intended to generate discussions about future code development activities. A draft version of the principles is already being used as a starting point for US DOE's Zero Energy Commercial Building Coalition. Even more exciting is that the City of Seattle has decided to move ahead with a pilot project for outcome-based codes. Several individuals who attended our meetings are key players in developing the project.

The authors will be convening another regional meeting in July 2010 dedicated to the development of outreach strategies to national organizations and policy makers with the intent of influencing them to use the guiding principles and to think about a transition to outcome-based codes. We believe that broad application of the principles will lead to a more coherent evolution of the codes and help avoid 'dead ends' in the code development process.