ENERGY CODE COMPLIANCE

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EXECUTIVE SUMMARY

Energy code compliance is an often overlooked issue for code officials and energy efficiency advocates. Energy codes are generally adopted through legislation or regulation, with most states adopting national standards with local modifications. Although 46 states have some building energy code, research indicates that compliance rates are often low. It is common for builders and designers to be unfamiliar with the energy code or to treat energy codes as unimportant. Similarly, code enforcement officials often have little knowledge of the energy aspects of the building code and, even if they know about code requirements, they usually have little time to enforce energy codes.

This paper addresses the variety of issues surrounding energy code compliance in an attempt to suggest methods for improving compliance and enforcement. It begins with a discussion of code adoption processes, with particular emphasis placed upon the effect of the adoption process on usability and understandability of the code in the building community. There is also a brief discussion of the common definitions of "compliance" and "enforcement" in both the building and code community as well as among researchers of the topic.

A review of code compliance studies performed by state or local jurisdictions, as well as by electric utilities, is also included. These studies are the basis for the subsequent discussion of the technical, financial, and procedural issues surrounding energy code adoption, compliance, and enforcement.

The paper concludes with recommendations for improving energy code compliance. Adopting simplified codes and better educating designers, builders, and homeowners about energy codes will help improve code compliance. Another critical step in improving compliance is coordinating with Home Energy Rating System (HERS), utility new construction, and creative finance programs. The development of better compliance and enforcement tools is essential to increase awareness and compliance. Finally, improved methods for analyzing compliance and enforcement and for understanding individual jurisdiction's problems more thoroughly are also strongly recommended.

INTRODUCTION

Energy code compliance is of concern to consumers, state and local governments, and utilities for a variety of reasons. Energy codes, like health and safety codes, set minimum standards for construction and design practices. While fire and safety codes eliminate unnecessary risks for building occupants' health and well-being, energy codes similarly prohibit building design practices that lead to unnecessarily high building energy use and associated costs while ensuring occupant comfort. Energy savings resulting from energy code compliance benefit building owners and occupants directly, while indirectly reducing our nation's reliance on non-renewable energy sources, cutting utilities' peak supply demands, and reducing pollution associated with energy use.

Energy codes have other indirect effects on energy use and the building economy. As codes set standards for building energy performance, they in turn influence manufacturers of insulation, windows, and other building equipment. Energy codes are often used as thresholds by utilities in determining rebates to builders/owners who incorporate more efficient designs into their new facilities, or as part of energy-efficiency promotion programs targeted to new construction.

However, energy codes have been traditionally considered less important as compared to health, safety, and fire codes. The range of knowledge needed by officials to enforce fire, health and safety, mechanical, electrical, and/or energy codes adequately is, obviously, vast. Since most enforcement agencies have limited budgets for salaries and training, departments are usually filled by people with backgrounds in the construction trades who get little additional job training. Given their backgrounds and the relative importance of life-safety issues as compared with energy, enforcement emphasis is naturally placed much more heavily on health, safety, and fire code compliance. In some cases, code officials are not even familiar with the energy code.

Definitions of Compliance and Enforcement

Vine (1990) offers the following definitions of compliance and enforcement as related to energy codes:

> Compliance is a measure of how effectively the building standards are being implemented: has a given building been built in accordance with particular requirements? Enforcement is the manner in which compliance is assured and includes such activities as plan reviews, field inspections, computer analysis, and general technical assistance.

The way in which researchers and code officials define compliance greatly affects perceptions of the effectiveness of a standard. Most analyses of code compliance at state or local levels define a "compliant building" as one that meets all aspects of the code, as Vine's definition suggests. This, however, leads to some confusing conclusions; a building that does not meet the code because of one minor deviation would be classified "noncompliant" along with another building that failed to meet any portion of the code. The former case may have equivalent or lower actual energy consumption as compared to other "complying" buildings and thus meet the general intent of the code, while the latter would be truly inefficient and violate the letter *and* spirit of the code.

This "pass or fail" definition leads to difficulties in estimating potential energy benefits from improved compliance. For example, Baylon, Frankel & Clark (1992) found that only approximately 50% of new commercial buildings in Washington and Oregon met each state's respective energy code requirements for thermal envelope, HVAC, and lighting. However, when considering compliance for each of these three building components, they found compliance rates between 75 and 95%. This suggests that many buildings met two of the three component requirements without meeting the third. Thus, studies that cite low compliance rates and recommend increased funding for enforcement, for example, may have difficulty in quantifying the energy savings possible with improved compliance.

Vine's broad definition of enforcement suggests a scenario wherein code officials cooperatively work with well-intentioned builders and designers to "assure" compliance. While a cooperative relationship exists between code officials and builders in some jurisdictions, code enforcement activities in practice in many localities range from confrontational (between officials and builders/designers) to nonexistent. Inadequate enforcement agency staffing and budgets, builders and designers' lack of awareness of the benefits of code compliance, and many other factors influence the manner in which enforcement is practiced. While the majority of builders and designers would consider it highly unethical to subvert health and safety code requirements intentionally (whether or not enforcement activities would "catch them"), some ignore energy code requirements, mostly because they do not expect to "get caught" by officials who pay little or no attention to energy code enforcement. Researchers in Oregon stated that the energy portion of the state code was viewed by some enforcement officials as more of a guideline than an absolute standard (like life and safety requirements), and therefore it was acceptable to exercise leniency. One code official there stated,

> In my mind it boils down to conservation of money or conservation of energy. As long as energy is plentiful and commercial interests can pass on the cost to someone else, it [thorough administration of the code] won't happen. It takes so

much time to "call" someone on conservation and they will just get their architect to sign it off anyway" (Portland Energy Conservation, Inc. & Ross Econometrics 1988).

OVERVIEW OF CURRENT CODE PROCESSES

The code adoption process, as currently practiced in the U.S., is described by Conover, Jarnagin & Shankle (1992). We provide a brief discussion of the process here for background purposes.

There are three common methods of energy code adoption:

- states adopt code through legislation;
- states adopt code through regulation; and
- local jurisdictions adopt code through ordinance.

Currently, 36 states have statewide energy codes, while 10 others have codes only for state-owned and/or -funded buildings. Only four states — Alaska, South Dakota, Colorado, and Louisiana — have no energy code.

States and local jurisdictions most frequently adopt a model standard as their code. The most common of these are:

- Council of American Building Officials (CABO) Model Energy Code (MEC) *(most recently updated in 1995, with 1983, 1986, 1989, 1992, and 1993 versions also in use),*
- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) standard 90.1 (commercial) or standard 90.2 (residential), and
- Building Officials and Code Administrators International (BOCA) National Energy Code *(most recently updated in 1993, with 1981, 1984, 1987, and 1990 editions also in use).*

The Energy Policy Act of 1992 (EPAct) requires that by October, 1994 each state should have "reviewed the provisions of its residential building code regarding energy efficiency and made a determination as to whether it is appropriate for such State to revise such residential building code provisions to meet or exceed CABO Model Energy Code 1992. States are also required to review commercial building energy codes and update to "meet or exceed the requirements of ASHRAE Standard 90.1-1989" (EPAct 1992, Subtitle A, Section 304). As of June, 1994, a comparison of state residential energy codes with the 1992 MEC revealed that:

- Twenty-six (26) states did not meet or exceed 1992 MEC;
- Two (2) states marginally did not meet or exceed 1992 MEC[1];
- Seventeen (17) states met or exceeded 1992 MEC; and
- Two (2) state codes marginally met or exceeded 1992 MEC (Klevgard, Taylor and Lucas 1994).

A handful of jurisdictions, including the states of North Carolina, Alabama, California, and New York, have created their own energy standard. This process of developing and adopting a unique standard can be much more time-consuming and costly than revising a national standard in whole or with minor state-specific modifications or simplifications. Code updates are also much more cumbersome for jurisdictions with their own standards. The national standards organizations (ASHRAE, CABO, and BOCA) update their standards regularly (typically with minor updates annually and major updates every three years), and most jurisdictions that adopt these model standards also adopt their codes following action by the national standards organizations.

Responsibility for enforcement also varies throughout the country. Frequently, the mandating entity (either the state or local jurisdiction) is directly responsible for enforcement. With many statewide codes, however, local jurisdictions are charged with enforcement. In this arrangement, local governments sometimes receive some financial and/or technical assistance from the state. Less frequently, other government agencies are responsible for enforcement, in whole or in part. For example, some jurisdictions in Minnesota require electrical safety inspectors to enforce energy code requirements that relate to electric equipment (Sachi, Hewett, & Vavricka 1993). In some areas of the Pacific Northwest, the Bonneville Power Administration (BPA) funds energy code enforcement activities undertaken by local governments to ensure that new homes within its service territory are being constructed in an energy-efficient manner (Nadel 1992).

[1]State codes labelled as "marginally" passing or failing had U_o values close to (i.e., $\pm$ 5%) those implied by the 1992 MEC.

The process of enforcement differs from jurisdiction to jurisdiction. For many commercial buildings, enforcement authorities perform reviews of building plans and specifications; one or more field inspections during construction are also common. However, some authorities accept an architect or engineers' stamp in lieu of inspections or reviews. For residential structures, which tend not to require detailed plans or specifications, field inspections are often the most common form of enforcement.

Methods of enforcement also vary greatly. Code officials, for example, may withhold construction or occupancy permits for noncompliant buildings until designers/builders can demonstrate compliance with the code. In extreme cases, architect, engineer, and contractor licenses can be revoked for noncompliance.

Utilities involved with enforcement may have policies under which service is withheld for noncomplying properties. Alternately, some utilities offer incentives for the incremental cost (or some portion thereof) of new construction that exceeds required standards as part of their demand-side management (DSM) program activities. For example, in the cities of Tacoma, Washington and Burlington, Vermont, the local municipally-owned utility works closely with other local government agencies to enforce the local energy code (Nadel 1992). New construction DSM programs may therefore serve as an indirect enforcement mechanism. Baylon, Frankel & Clark (1992) found that 76% of buildings participating in new construction DSM programs in the Pacific Northwest complied with all aspects of the code, as compared to approximately 50% for buildings sampled at large. However, builders/designers who are likely to participate in utility incentive programs may be more interested in energy conservation, and, therefore, may meet code with or without a utility program in place.

REVIEW OF CODE COMPLIANCE STUDIES

As stated above, energy codes have taken a back seat relative to the importance of health and safety codes. This is also true in terms of funding for and interest in studying energy code compliance. According to Conover, Jarnagin & Shankle (1992), only the states of California, Florida, New York, Oregon, and Washington have completed some form of thorough energy code compliance, implementation, and/or enforcement studies. However, utility studies on typical construction practices are becoming more common. Electric utilities throughout the U.S. have become involved with energy code compliance and enforcement through either their new construction DSM programs or simply as a means of informally ensuring that efficient buildings are being constructed in their service territories. These studies indirectly have expanded the body of knowledge available on code compliance.

California

Johnson (1992) outlined the evolution of building efficiency regarding the development of state and local city codes in California since the late 1970s. He stated that the first statewide standards, passed in 1978, were "so simple and clear" that the building community accepted them easily, while the second generation standards of 1987-88 "were sufficiently complex that enforcement has been a major problem." This conclusion is affirmed by the findings of CMJ Engineering's studies for the California Energy Commission. CMJ monitored 107 residential and 44 non-residential buildings constructed in California in 1988 and found a high incidence of code violations, ranging from 20-over 50% (depending upon the building system analyzed for compliance). Code officials surveyed cited time and budget constraints, and complexity of the standard as the primary barriers to compliance and enforcement (CMJ Engineering 1989).

Vine's 1990 study of California's building standards analyzed the reasons for relatively poor compliance. He cited the existence of 16 different climate zones (all with corresponding different standards for construction) as an example of the overwhelming complexity of the code. He stated that the complexity of the code is the primary reason for noncompliance, followed by the confusion among builders and enforcement officials due to the frequent, irregular update process and short time span between new standards adoption and effective date.

A study for Pacific Gas & Electric (PG&E), evaluating the impact of their non-residential new construction program, showed the dramatic effect of such programs on energy code compliance. Efficiency thresholds for program participation were set at Title 24 levels. They found that 98% of program participants were familiar with Title 24 requirements as compared to 63% of non-participants surveyed, thus indicating a strong influence of the utility program on code awareness and compliance (ADM Associates, Inc. and Regional Economic Research 1993). However, econometric analysis of billing data for PG&E program participants revealed that approximately 24% of savings were naturally occurring — that is, they would have occurred even without the utility incentive program. Similar results were found in a study of Southern California Edison's residential new construction program, where approximately 21% of savings in participant buildings were "free-riding." Thus, the influence of these utility programs on code compliance is difficult to quantify (Mahone et al. 1994). In contrast, a study of PG&E's residential new construction program revealed that current construction practices for non-program participants was 3-5% below Title 24 levels for the equipment targeted by the PG&E program — cooling, insulation, and windows. This data indicates that the program had a small but significant impact on construction practices and code compliance (Caulfield & Lee 1994).

Florida

The Florida Legislature first passed laws in 1977 requiring local governments to adopt energy efficient building standards; this was amended in 1980 when the legislature passed the Florida Model Energy Efficiency Code for Building Construction. The original Florida code was primarily based upon ASHRAE 90-75, but has since been regularly updated by the Florida Department of Community Affairs to reflect up-to-date ASHRAE standards. Furthermore, the code is uniform statewide, and may not be made more stringent or lenient by local governments. Code enforcement, however, is the responsibility of local governments (municipalities or counties, depending upon the region) (Rose et al. 1992).

In 1992, the Florida Energy Office commissioned a study of electricity conservation and energy efficiency in Florida. This study included an analysis of the Florida code as compared to other state codes, as well as an analysis of code compliance and enforcement procedures throughout the state. The compliance and enforcement analysis was performed through interviews with building code enforcement personnel in Florida and, for comparison purposes, similar interviews were performed in California and Washington.

The code compliance and enforcement analysis revealed that the majority of code officials spent "very little time" reviewing the energy code applications, and that code forms were rarely cross-checked against building plans. In fact, commercial code compliance applications that were fully completed and signed by an architect or engineer were generally approved without any review whatsoever. Code officials stated that, on average, they spent 15-20 minutes on energy code considerations during residential building inspections, with more time spent on commercial buildings depending upon their size and complexity. Code officials stated that their primary limitations in properly enforcing the code included lack of manpower and clear understanding or interpretation of the code. They cited the complexity of the code, and frequent code changes, as significant barriers to improving their knowledge and understanding of the code. Finally, code officials indicated that they generally enforce "good building practice," which they felt fairly accurately reflected the intent and spirit of the code, rather than strictly enforcing precise code provisions. Interestingly, the interviewers found similar results from their interviews with code officials in California and Washington. The study recommended that energy code compliance and enforcement in Florida could be improved through the following means:

- simplifying the code (i.e., eliminating or consolidating compliance options) and making revisions less frequent;

- providing checklists or software to both building professionals and code officials; and

- providing education on the code to building professionals and code officials (Rose et al. 1992).

Oregon and Washington

Oregon and Washington have been pioneers in the area of energy codes. Both states adopted energy codes in 1980. In response to rising electricity rates in the region in the 1970s, the Northwest Power Planning Council developed a set of Model Conservation Standards (MCS) in 1983 that served as a template for many jurisdictions in the Northwest and elsewhere. The MCS were finally incorporated into statewide residential codes in Oregon and Washington in 1990 and 1991, respectively (Nadel 1992).

Evaluation of compliance and enforcement in these states began as early as 1985. Church/Davis Architects (1985) found that approximately one-half of new commercial buildings complied with all of the Oregon energy code. They found that larger buildings complied more often than small buildings, and that large jurisdictions had better enforcement than smaller jurisdictions. Informal surveys of the architect and engineering communities revealed that many professionals were largely unfamiliar with specifics of the code and thus did not incorporate the standards into their designs. Enforcement officials surveyed cited limited time and money, complexity of the code, and the relative lower priority of the energy code as compared to other parts of the building code as the primary barriers to better enforcement. The researchers recommended:

- simplifying the code;

- requiring manufacturers of HVAC equipment to certify that equipment comply as-built;

- providing training to architects, engineers, and code officials; and

- requiring reporting on code enforcement problems by local jurisdictions to the state.

Portland Energy Conservation, Inc. and Ross Econometrics (1988) performed an evaluation of commercial building energy code enforcement costs and practices in Oregon. They found that compliance varied from building system to system, with insulation requirements met more than 90% of the time while lighting provisions were met less than 50% of the time. Their interviews with code officials shed light upon the reasons for this varied compliance. They found that training sessions for builders and designers were attended mostly by code officials, and that those builders and designers who were well-informed about the code often viewed it more as a guideline rather than an absolute requirement.

O'Neill & Company, Inc. (1989) found that the commercial energy code in Washington was not being well enforced except for the insulation and glazing portions, which were the easiest portions of the code to understand and where it was relatively easy to identify noncompliance in the field. They found that about 5% of most jurisdictions' code enforcement budgets were spent on energy code enforcement, with an average enforcement cost of $543 per commercial building.

Their analysis also included a survey of commercial energy code enforcement officials in Washington. While the majority of the code officials' professional backgrounds were in the building trades, most felt that their educational background was inadequate to do their job properly; most had some college education and approximately one-half had a degree. They also felt that their on-the-job training was inadequate. O'Neill & Company recommended targeting large jurisdictions for commercial energy code enforcement training, as these jurisdictions represented the overwhelming majority of the new commercial construction. They emphasized the need for one-on-one training in the field, with easy-to-use checklists and other tools for enforcement officials. Furthermore, they recommended establishing a state central plan review service as a resource for commercial code officials, and training for architects and engineers on the energy code provisions to increase voluntary compliance (O'Neill & Company, Inc. 1989).

Baylon, Frankel & Clark (1992) conducted a study of a random sample of 141 new commercial buildings in Washington and Oregon permitted during 1990. Similar to the Church/Davis study, they found that approximately 50% of buildings complied with all aspects of the code. However, this analysis broke down compliance into three categories: building envelope, HVAC, and lighting. Within these subcategories, Baylon, Frankel & Clark found compliance rates of 80, 95, and 74%, respectively. The sample was also stratified for participation in an electric utility new construction DSM program; of the buildings analyzed, 12% participated in such a program, and, of these, 76% met all aspects of the code.

Baylon, Frankel & Clark also conducted interviews with code enforcement officials, whose comments echoed those cited in the Church/Davis and O'Neill studies. They expressed the need for simplifying the code, more time and money for reviews, and more training and tools to aid in enforcement. Baylon, Frankel & Clark also conducted interviews with architects, mechanical engineers, lighting engineers, and builders in the two states. They found that about one-half of the architects had no involvement with code compliance, leaving this aspect of the building design to the mechanical engineers. The lighting engineers were for the most part knowledgeable regarding the code and stated that they incorporated it into their designs. They indicated that the majority of noncompliance in the lighting aspects of the code probably came from changes in the field (substitution of fixtures or lighting components to lower costs, etc.). Only 6% of the design/build professionals surveyed had ever received any response from enforcement officials on energy code compliance.

A follow-up report on residential energy code compliance in Oregon was also performed in 1994 (Frankel & Baylon 1994). This analysis of 283 residences indicated that compliance with prescriptive requirements for the building envelope was approximately 56%. Compliance as measured by overall envelope heat loss rate, calculated based on the prescriptive requirements, however, was found to exceed 80%. They found that homes that failed on one aspect of the code (for example, wall insulation) often exceeded code requirements in other areas (for example, windows). Thus, noncompliance did not appear to have a significant impact on actual total home energy use; when comparing typical noncomplying homes with complying homes, they found no increase in heating energy usage in gas-heated residences, and only a 1/2-1% increase in electrically-heated homes. The authors theorize that the widespread acceptance of the code by builders has resulted in typical construction practices being very close to code requirements, and thus typical noncompliance is insignificant (Frankel & Baylon 1994).

This study also included interviews with code officials and builders. While both groups voiced specific criticisms of the code itself and enforcement procedures, there was widespread acceptance and approval of the code. Code officials cited the need for more consistent window and door labelling requirements, as well as greater clarity in below-grade and slab insulation requirements. Builders' primary concerns were the confusion arising from ongoing code revisions and the costs of compliance (Frankel & Baylon 1994).

Minnesota

A recent study of Minnesota lighting code compliance (Sachi, Hewett & Vavricka 1993) was performed for small commercial buildings in the Minneapolis/St. Paul metropolitan area. The study revealed that 64% of buildings in the sample complied with 1989 standards (which applied at the time of permitting these buildings) while only 32% would comply with 1993 standards that were about to take effect. They found a significant (14.6%) increase in *installed* lighting wattage over the *design* lighting wattage, indicating that field inspection is a key component in ensuring compliance.

The second phase of the study (Czeschin et al. 1994) analyzed small commercial construction begun after September 1992, at which time the ASHRAE/IES 90.1-1993 standard was in effect in the state. The buildings selected were in two categories: those with designers/builders who participated in state-sponsored lighting code training before the building design was begun, and those with designers/builders who had received no formal lighting code training. This phase of the study revealed that compliance in the buildings with trained design staff and those without trained design staff was similar (both with about 50% fail rate), raising questions about the effectiveness of the training itself, or this type of training in general.

Their informal interviews with architects, design-build contractors, and code officials revealed a variety of levels of understanding and acceptance of the code. All architects surveyed said they had a thorough knowledge of the code and applied it to their work, as their license could be revoked through noncompliance. However, most design-build contractors had no knowledge of the code, and both they and the architects stated that they had never been asked for compliance forms by code officials. Code officials stated that they rarely enforced the energy code, as the limited time available for each review is focused on health and safety code review.

Georgia

Southface Energy Institute (1993) performed an analysis of compliance with the residential energy code in Georgia for the Governor's Office of Consumer Affairs. They found that none of the 100 homes surveyed complied fully with the code, although there was a significant range in the severity of noncompliance. Building shell and HVAC system violations were most common. They estimated that it would cost an average of $325 extra to build a home to code, yielding a 2.5 year payback to the homeowner.

Massachusetts

In 1992, a group of Massachusetts utilities commissioned a study that examined current commercial construction practices (Xenergy 1991). Results of this study can be compared to Massachusetts code requirements to help estimate code compliance rates. The main focus of the study was on connected lighting power. For example, the study found that the average office had a connected lighting load of 1.75 Watts per square foot, as compared to the 1.5-1.9 Watts per square foot allowed under the most commonly used lighting requirements in the Massachusetts code, implying that the majority of buildings are in compliance with the code's lighting requirement. Of the 62 offices examined, 19 had a connected lighting load of more than 1.7, implying that approximately 69% of offices were in compliance. On average, the noncomplying buildings used 2.15 Watts per square foot and thus used approximately 21% more lighting power than allowed by code. For retail buildings, a similar analysis also implies that the majority of buildings are in compliance, that approximately 37% of the buildings are not, and that these noncomplying buildings uses 32% more power than the average code allowance. While these code compliance rates seem fairly high, these high rates are due in part to the fact that even before the lighting code took effect, the prevailing construction practice was nearly at the level of the code requirement (Nadel & Davis 1989).

New England Electric Systems conducted focus groups with home builders in the early 1990s to see what current residential construction practices were and to determine a baseline for their new construction program. While focus groups are not considered a rigorous method of evaluation, the results indicated that current design and construction practices were in line with code provisions. In evaluating the program after a short implementation period, builders indicated that the utility incentives for meeting its program requirements were not sufficient to cover incremental efficiency improvement costs. These statements indicate several possible shortcomings of such a baseline evaluation and/or incentive program implementation, including the possibility that the energy efficiency of baseline construction practices was overstated by builders (Fryer 1993).

Northeast Utilities performed an analysis of standard commercial building construction practices for their service territory in Connecticut and Massachusetts in 1987, comparing standard practices to energy code requirements. Their analysis indicated that typical construction practices in Connecticut exceeded their many-year-old code requirements, while those in Massachusetts (with a more progressive code) were at or slightly below code requirements (depending upon type of building and building system). These findings were used to set thresholds for rebates under the utility's new construction program at or above code, thus serving as an indirect enforcement mechanism (Dethman & Associates 1991).

COMPLIANCE AND ENFORCEMENT ISSUES

The studies discussed above indicate several general findings regarding energy code compliance today. First, compliance rates are typically on the order of 50-80%, with substantial variation from jurisdiction to jurisdiction; the reasons for the wide variation in compliance rates and existence of low compliance rates in some jurisdictions are complex and varied. Second, there is a general lack of understanding of both the technical components in current standards and the multi-varied benefits of energy codes.

This applies to all players in the building industry, i.e., architects, engineers, designers, builders, owners, and code officials. Third, there is significant potential for improving code compliance through a variety of means. These options include:

- adoption of simpler codes in a more expeditious manner;
- continuing education of members of the building community and code officials;
- development of improved compliance and enforcement tools; and
- coordination of energy code enforcement with other building activities, i.e., mortgages, HERS programs, utility DSM programs, etc.

Since most available research has reached these conclusions, why haven't these recommendations been adopted? What remaining barriers to improving code compliance exist? In order to understand these questions, there needs to be a thorough examination of the technical, financial, and procedural issues surrounding energy code compliance and enforcement. This section details these issues, with particular emphasis placed upon eliminating barriers to better compliance and easier enforcement.

Technical Issues

In the introduction, we discussed definitions of compliance and enforcement and the methodological problems associated with the commonly-accepted definitions. The "pass or fail" concept of a compliant versus noncompliant building does not provide researchers with much insight into the commonly violated components of energy standards and into the amount of expected energy savings that is "lost." A handful of studies have attempted to disaggregate compliance data by building component and found varied levels of compliance. These variations were due mainly to two factors: ease of meeting requirement with current accepted building practices and likelihood of code officials to check compliance for the specific component.

Baylon, Frankel & Clark (1992) found that while overall commercial code compliance in Washington and Oregon was around 50%, 80% of the buildings surveyed complied with the envelope requirements, 74% complied with lighting requirements, and over 90% complied with the HVAC requirements. Another evaluation of Washington state compliance found that commercial building insulation and glazing systems were regularly inspected and generally found compliant, but that other building systems were not adequately inspected and generally had lower compliance rates (O'Neill & Company, Inc. 1989).

An evaluation of compliance and enforcement problems in California stated that the residential lighting components of the energy code (which require use of fluorescent lighting in certain rooms) were the most difficult to enforce, as homeowners were generally very demanding about what type of lighting they wanted for aesthetic reasons. Also, they found that "easy to inspect" residential components, like water heater and attic insulation, were generally inspected and that standard building practices generally met code. However, more complex items (such as shading devices) and more "difficult to inspect" items (such as wall insulation) were frequently not inspected and/or were not installed to meet code. On the commercial side, they found that lighting systems were again a common area of violation that was ignored by inspectors, particularly in retail applications, and that complex systems (economizers, for example) were not understood by code officials and thus were ignored.

HVAC system compliance for both residential and commercial buildings is likely higher than other building system components because efficiencies for many classes of HVAC equipment are mandated by federal regulations, so contractors can only install equipment that meet code requirements. The majority of violations thus probably arise with duct insulation or other non-federally regulated components. The relative low levels of lighting system compliance occur for the reason implied above, namely that owners/occupants are very concerned about lighting for aesthetic reasons and many design and construction professionals are not aware of state-of-the-art efficient fixtures and systems that are as appealing as traditional incandescent fixtures. Beyond this, many builders stated that lighting, particularly in commercial buildings, is often not installed as designed. This is an area where changes in the field are often made to reduce construction costs, which generally result in a compromise in energy efficiency (i.e., it is not that extra fixtures go in, but lower quality fixtures with inefficient lamps, ballasts, etc., are installed in place of those specified on the plans).

Lack of understanding of energy codes is a major barrier to implementation. Research in this area, as discussed above, is mostly based on informal interviews with code officials, architects, engineers, and contractors. All parties have overwhelmingly stated that they have little or no understanding of prevailing energy codes for a variety of reasons.

Most architects and engineers view energy code requirements as a low priority and note that they seldom have time or budgets to address energy issues in the design process. A possible exception to this may be in jurisdictions in which license retention is tied to code compliance. In Minnesota, for example, architects indicated that they had a thorough knowledge of the lighting code and applied it to their work, as failing to do so could result in license revocation. However, in jurisdictions where an architect and/or engineer's stamp is accepted as proof of code compliance, researchers found that some design professionals had little or no knowledge of the energy portion of the code and signed off on buildings without paying any attention to code (Portland Energy Conservation, Inc. & Ross Econometrics 1988).

Where they are familiar with energy codes, architects and engineers generally found the energy code understandable but cumbersome to use. In commercial building design, there is often confusion among architects and engineers as to which party is responsible for seeing that a building complies, and thus this low-priority item is neglected in the design process. Even when designers do consciously comply with the code, field changes made by builders concerned with price and/or ignorant of energy code requirements undermine code-compliance efforts. For residential buildings, there is often no architect or engineer involved, and design-build contractors generally have less knowledge and/or understanding of energy codes than design professionals and thus often do not comply with energy code requirements (Sachi, Hewett & Vavricka 1993). In both commercial and residential construction, design and construction professionals surveyed in a number of studies stated that code officials rarely checked for energy code provisions or asked for "required" energy code compliance forms, thus reinforcing the relative unimportance of this portion of the code.

Several surveys of code officials indicated that they had insufficient educational and technical backgrounds for understanding all code provisions. As the majority of code officials were formerly in the building trades and thus have similar backgrounds to builders (who are typically ignorant of energy codes), they had no familiarity with energy codes coming into their jobs and most stated that they have had little energy-related training since becoming involved in code enforcement. None of the jurisdictions surveyed by Shankle, Lesperance & Fowler (1992) had requirements for ongoing energy code enforcement training, but some had training as part of obtaining inspector certification or had training when there was an energy code update.

The lack of training and attention to energy issues reinforces the common treatment of the energy portions of the building code as "optional" or as a "guideline" rather than a minimum standard, while the health and safety portions are taken very seriously. At best, the more sophisticated system components (i.e., economizers, shading devices, etc.) that are unfamiliar to officials, at worst, all energy provisions of the code are ignored during building inspection. Shankle, Lesperance & Fowler (1992) surveyed over 100 building code agencies throughout the U.S., and found that 20% spent no time on energy codes and another 10% spent only "minimal" time on energy aspects of the code. As one Oregon code enforcement official stated:

> The [energy code] needs to be oversimplified at our level. A lot of inspectors don't understand the technical aspects of the code. We don't have the ability or

desire to get into [the energy code] at anything other than a superficial level. This part of the code is very different from the rest of our work (Portland Energy Conservation, Inc. & Ross Econometrics 1988).

Code officials also frequently cite the need for better tools, ranging from computer software to simple checklists. The range of requests for tools varied generally by the size of the jurisdiction — larger jurisdictions with better educated officials inspecting more complex commercial buildings cited the need for sophisticated computer analysis tools while smaller jurisdictions' officials wanted simple checklists to enable them to do better residential inspections. A California inspector criticized the development of computer-based component compliance options for prescriptive standards, stating that the standards have "increased in flexibility for the designer but have increased in complexity for enforcement personnel" (CMJ Engineering 1989).

Code officials also cite the lack of resources available to their agencies as a primary barrier to improved compliance and enforcement. Inadequate enforcement tools, little initial and ongoing job training, and staff with insufficient educational and technical backgrounds follow from this lack of resources. Code enforcement departments are chronically understaffed and underfunded.

Another technical problem that results in low compliance rates and inadequate energy code enforcement stems from the enforcement process itself. There are several stages of the building process where code officials may intervene, including: plan reviews (after design but before construction is begun), calculations (typically submitted along with plans), and field inspection (performed either during late stages of construction or after construction is completed but before the Certificate of Occupancy is issued). Between these stages, many changes can occur so that, for example, a building found compliant according to the plan design will not be compliant as-built due to changes made by the builder. Conversely, in residential design, there may be no site-specific plans to follow and thus the inspector must rely upon site inspection. If this occurs past a certain stage of construction, it may be extremely difficult to verify compliance of some building components (wall insulation, for example). Also, site visits may be required at different stages in the construction process (e.g., inspecting for foundation insulation versus inspecting for wall or attic insulation) but may be impractical. In customized commercial buildings, designers may follow system component compliance methods and submit calculations to show conformity to the code. Often, however, neither the designer nor the inspector understands the calculations or performs/reviews them correctly.

As stated throughout, another factor affecting compliance and enforcement is the supreme importance of health, fire, and safety aspects of building codes and the relative unimportance of the energy code by comparison. Baylon, Frankel & Clark stated that the energy code should not be considered similar to health and safety codes that set minimum standards and limits of liability, but should serve as a "design standard seeking to codify energy efficient design practices" (Baylon, Frankel & Clark 1992).

Manufacturers and wholesalers also play an important role in code compliance. As stated above, national equipment standards have resulted in mandatory compliance with many HVAC equipment portions of energy codes; builders simply cannot buy equipment that does not meet code requirements. For other types of equipment, however, procuring more efficient models is often significantly more expensive or requires a longer ordering period. Efforts currently underway by utilities, government agencies, and other organizations to promote "market transformation" seek to make efficient equipment procurement less burdensome and, ultimately, the norm for all classes of consumers. These market transformation efforts aid in increasing the availability and promoting the sale of more efficient equipment (Nadel & Geller 1994).

Financial Issues

On both the compliance and enforcement ends, financial constraints are often cited as the key reason that the energy code isn't met. In jurisdictions where standard building practice does not meet energy code, designers, builders, developers, and owners typically cite construction budget constraints, while code enforcement agencies cite budget constraints that result in inadequate staffing and training for staff and thus the inability to properly enforce energy codes.

While numerous analyses have shown that the incremental cost of energy conservation practices mandated by most national energy standards are cost-effective over the lifetime of the equipment/home, life-cycle cost analyses do not necessarily match financial criteria used by homeowners, mortgage companies, and real estate developers. On the residential side, builders and purchasers are often influenced by first cost and aesthetic considerations more than by energy costs. Also, energy-conserving features in existing homes are typically undervalued in appraisals, so home builders planning to sell within a short period of time have little incentive to make the up-front investment (Curtis 1993). On the commercial side, there are also a number of barriers. First, there are many players — architects, engineers, contractors, developers, lenders, leasing agents, building managers, and owners/occupants — responsible for considering a building's energy performance in the design and construction phase, all of whom have a strong incentive to control costs. Developers and owners of rental properties tend to focus on occupant comfort as a selling point for potential clients over energy conservation. Tenants, who generally pay their own utility bills, may not demand efficient construction because energy costs are typically a small fraction of total business operating expenses. Finally, as a result of limited capital availability, developers rarely install equipment that does not payback within one to three years (much shorter than the life of the equipment) (Sachi, Hewett & Vavricka 1993).

Several strategies are being used in some jurisdictions to remove cost barriers (real and perceived) to residential and commercial energy code compliance. Sliding permit fee scales, utility new construction DSM programs, and energy efficient mortgages are among these mechanisms.

In the previous section, we discussed the implications of limited operating budgets for code enforcement agencies. Budget constraints result in several problems: hiring of lower-salaried, less-qualified personnel; lack of adequate initial and ongoing training; shortages in staff resulting in insufficient time available for individual building reviews and inspections; and inability to develop and/or procure necessary enforcement tools.

As most agencies are charged with enforcement of all aspects of the building code for both residential and commercial buildings, code officials need a very broad, in-depth understanding of construction practices and building systems. However, with most code officials coming from building trades, their knowledge of the code relating to their former trade is likely quite good while their knowledge and understanding of other aspects of the code may be lacking. For example, a former electrician may be quite knowledgeable and understand the electrical code but may not understand and therefore not properly enforce the building shell requirements of the energy code. Officials surveyed by Shankle, Lesperance & Fowler (1992) stated that their technical backgrounds were "inadequate" to perform all aspects of their job.

A nationwide survey of enforcement agencies found that 80% of officials in large cities felt that their training budgets were "insufficient," as compared to 40% in medium-size jurisdictions and 20% in small jurisdictions (Shankle, Lesperance & Fowler 1992). Most enforcement personnel state that budget constraints limit spending on training.

Financial constraints also affect designers in jurisdictions where adequate training for all building personnel is available; one code official in the Northwest stated that even when they held code training sessions for builders and designers, only enforcement personnel attended because "architects and engineers don't come during good times because they are too busy. They don't come during bad times because they can't afford it" (Portland Energy Conservation, Inc. & Ross Econometrics 1988).

Code officials also universally state that they have insufficient time to perform plan reviews and inspections and thus have to concentrate on critical issues, like health and safety requirements, at the expense of less important aspects of the code. Officials in Washington and Oregon estimated that they spend eight to ten hours per building, and less than one hour of this is typically spent on energy-related issues (Baylon, Frankel & Clark 1992). This was confirmed by another survey of officials in these states in which they indicated that 5% of their time per building was spent on energy-related aspects of the code (O'Neill & Company, Inc. 1989). Shankle, Lesperance & Fowler's national survey (1992) indicated that average time spent on energy issues in plan reviews ranged from 15 minutes in large cities to 20 minutes in medium to small cities; average times for energy issues during field inspections ranged from 20 minutes in large cities to 30 minutes in small cities.

Alternative enforcement funding mechanisms, such as utility financing of enforcement efforts, are being implemented in a handful of jurisdictions in an attempt to overcome these problems. In the Pacific Northwest, for example, BPA encouraged local jurisdictions to adopt the Model Conservation Standards before they were adopted statewide by offering financial incentives and technical assistance. To garner homebuilder support for the MCS, BPA provided builders with incentive payments to cover the extra costs of a MCS home (Nadel 1992). BPA also helps to reduce the cost of enforcement by reviewing plans for highly complex commercial buildings through its central commercial building plan review service, which focuses the work of highly paid, experienced code officials on these sites, freeing up local building code staff to work on more typical projects.

Procedural Issues

Beyond the significant technical and financial barriers, there are also procedural issues related to permitting requirements, enforcement responsibilities within states/jurisdictions, and enforcement activity schedules that also serve to block effective implementation of energy codes.

In most jurisdictions, code enforcement officials are made aware of new construction projects when a construction permit application is filed. In most cases, permits are issued by code enforcement personnel. Sometimes, however, permits are issued by another department besides code enforcement and communication between permitting and code enforcement personnel may not be clear or as expeditious as needed to involve code officials in the review process at an early stage. This is particularly problematic when permitting and enforcement offices are located within different levels of authority, i.e., when a special permit is issued by state government and the code enforcement authority is part of the county or local government.

Further complications arise when the code is enacted at a different level of government than where the enforcement agency resides. A local/municipal code enforcement office, for example, may not be aware of a state-enacted code update process in advance of its adoption; thus, enforcement officials are being asked to immediately start enforcing a code of which they have no knowledge. Also, certain code provisions may be difficult to enforce if the code enactment and enforcement agencies are not working together closely. In some states, there are statewide assistance programs to aid local jurisdictions with information on code provisions and code updates, and even provide plan review services for complex commercial building designs. In Pennsylvania, for example, the state is responsible for enforcement of the energy code for large buildings while smaller buildings are still under the jurisdiction of municipalities (Conover 1994).

The code review process itself often leads to shortfalls. As previously discussed, most enforcement officials review plans before construction and then also perform on-site inspections during or after construction. Between these two steps, field changes can occur that may reduce the energy efficiency of building systems to levels below code compliance but which may be difficult to note at the field inspection. However, compliance forms may have been filled out indicating that the installation was performed per design (and therefore code-complying) either because of a lack of communication between the designers and contractors or in an attempt to subvert the energy code requirements.

OVERCOMING BARRIERS

Utility Programs

Utilities are becoming increasingly involved in energy code compliance and enforcement, as mentioned throughout this paper. This involvement has taken several forms, ranging from indirect involvement through new construction DSM programs to direct involvement in inspections, training, etc. A thorough review of code-related utility efforts is provided by Nadel (1992).

Utilities recognize that incorporating efficiency measures during initial construction tends to be much less expensive than retrofitting an inefficient building later. Thus, despite overall cut-backs in DSM spending, utility new construction programs are a common component of utility energy service strategies. Under these programs, utilities offer incentives to cover incremental costs (or a portion thereof) measures installed in new buildings that meet a level of efficiency specified by the utility (and generally, that also meet certain cost-effectiveness criteria). Utilities often set the threshold — or level beyond which improvements in energy efficiency are paid for under the program — at the existing energy code levels. This level may be adopted because utilities assume that current standard building practices meet code (just as health and safety standards indicate minimum levels for these building systems), or because analysis of building practices indicates that they are at code levels.

For example, the administrators of Northeast Utilities' Energy Conscious Construction program performed an analysis of standard construction practices for their service territory in Connecticut and Massachusetts at the program's inception in 1987. Based upon this analysis, the threshold for projects in Massachusetts was set at code levels while the threshold for Connecticut projects was set above the existing code; their analysis indicated that typical construction practices in Connecticut exceeded their many-year-old code requirements. However, Northeast Utilities changed their thresholds to meet ASHRAE 90.1-1989 standards as of July, 1991 in anticipation of the Connecticut code upgrade to 90.1 taking effect in January, 1992 (Dethman & Assoc. 1991). The utility program indirectly laid the groundwork for acceptance of the new code.

Similarly, Pacific Gas and Electric's New Construction Rebate program in 1985-1986 used incoming California code requirements as the standard for incentive payment, thus encouraging builders to begin incorporating construction practices that would meet the forthcoming code before its application was mandatory. BPA provided a similar service through their Early Adopter Program, which encouraged local jurisdictions to adopt the Model Conservation Standards before they were adopted statewide and offered monetary incentives to do so. Thus BPA ensured that some new homes were being built to energy-efficient standards and the local jurisdictions got needed money for enforcement activities. Numerous analyses have shown that participants in utility new construction programs have much higher levels of code compliance than new buildings on average. The very existence of these programs also educates designers and builders about the code (both its existence and content). Thus, matching code and utility program requirements, either for threshold or incentive levels, can improve compliance rates and increase utility program participation rates.

Some utilities have experimented with penalties or prohibitions for buildings that are "below code." Tacoma City Light requires MCS compliance for all new electrically heated homes in their service territory, and withholds service if a home is found noncompliant. (They also provide incentives to exceed the standard.) Mason County (Washington) Public Utility District #3 established a $2000 service fee for electrically heated mobile homes that do not meet the MCS (Nadel 1992).

Other utility efforts aim to assist enforcement agencies with training and enforcement tools. For example, the California Energy Commission and a group of California utilities jointly funded development of a public-domain code compliance computer program. They also founded the Utility New Construction Advisory Professionals group, which assists with the development of training materials for designers/builders, utility staff, and enforcement officials (Mahone et al. 1994). BPA offers training sessions at local enforcement offices through their Code Official Circuit Rider program; code officials have stated that this on-site, individual training saves them valuable budget resources and more directly addresses their individual needs. BPA has also developed training materials and begun a hotline for code officials in the Northwest through the International Congress of Building Officials (ICBO) (Madison, Usibelli & Harris 1994); New York has a similar hotline service provided through the State Energy Office. Furthermore, BPA offers a free commercial building plan review service through ICBO; this service reduces the burden on local inspectors by providing assistance in reviewing complex commercial building plans (Nadel 1992).

State Programs

Since the widespread adoption of state energy building codes began, there has been a general recognition of the need to create more effective code adoption procedures. The recent code update procedures employed in Washington state provide a good example of steps which may be taken to ease this process and in turn improve code compliance and enforcement.

In response to the Energy Policy Act of 1992, Washington evaluated its commercial energy code for compliance with ASHRAE/IES 90.1-1989. Finding that the code did not meet this standard, the state sought to update their existing code to comply with EPAct. The State Building Code Council (SBCC) appointed a Technical Advisory Group (TAG) to draft the new state code. Concerns raised about the length and complexity of the draft code prompted the formation of two additional committees by the SBCC: one to focus on simplifying the code language without compromising the efficiency criteria and another to formulate a plan to implement the code.

The second draft code was approximately 50% smaller than the first version and was adopted in September, 1993 with an effective date of April 1, 1994. Several themes had emerged during the comments received from public hearings held regarding the code update and were all taken into consideration in preparing the draft code:

- the existing code was too long, complex, and generally foreboding;

- requirements that applied either to only residential or non-residential buildings were difficult to determine;

- prescriptive paths needed to be more comprehensive to accommodate current construction practices;

- many requirements added immense complexity with little, if any, energy savings; and

- some requirements were not within the scope of enforcement activities and could not be documented on plans nor verified in the field (Madison, Usibelli & Harris 1994).

Another commonly voiced solution to code complexity problems is to move towards a single national model standard. The EPAct directives requiring states to evaluate their residential and commercial building codes for conformity with the 1992 MEC and ASHRAE/IES 90.1-1989 has effectively acted to establish these standards as model national standards. Additionally, the collaborative MEC process, in which ICBO, Southern Building Code Council International (SBCCI), and BOCA participate, also serves to coordinate the efforts of these major code organizations around a single standard. Finally, there are many code advocates who cite the need to simplify national consensus codes, such as MEC and ASHRAE 90.1, and in fact simplification is a major goal of the 90.1 committee working on the next version.

While simplifying code adoption procedures and codes themselves can aid in improving compliance, education for designers and builders, building owners, and code officials, preparation of improved code compliance and enforcement tools, and coordination with other building conservation efforts are also essential in maximizing building energy code compliance. Picking up again on the Washington state example, the SBCC formulated a three-pronged plan for code implementation: (1) training and education, (2) enforcement support, and (3) quality assurance and evaluation. The training and education component targets comprehensive education for all parties involved in the building and code evaluation process. Enforcement support was provided by local utilities through the Special Plans Examiner/Inspector (SPEI) program. This program is set up to train inspectors who are then tested and certified. A jurisdiction can then choose to "farm out" code work (either for complex building reviews or for all reviews in a small jurisdiction) to a SPEI. The SPEI is paid by the property owner, who may in turn bill the Utility Code Group for reimbursement if the property is shown to be in compliance with the commercial code (Madison, Usibelli & Harris 1994).

CONCLUSION

Energy codes afford an opportunity for cost-effective energy savings in all types of buildings. However, much needs to be done to improve energy code compliance and enforcement procedures. Careful thought and effort on the part of all players in the building community is required to overcome the barriers inherent in the construction, permitting, and inspection processes. Several good models of successful code implementation exist and provide a base of experience from which communities, states, and utilities can glean insights about methods for improving energy code compliance.

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