TRANSFORMING CHINESE BUILDINGS

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ABOUT NRDC

The Natural Resources Defense Council is a national nonprofit environmental organization with more than 550,000 members. Since 1970, our lawyers, scientists, and other environmental specialists have been working to protect the world's natural resources and improve the quality of the human environment. NRDC has offices in New York City, Washington, D.C., Santa Monica, and San Francisco. Visit us on the World Wide Web at www.nrdc.org.

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INTRODUCTION

NRDC AND CHINA

NRDC's Energy Program has over 25 years of experience in the development of building and equipment energy standards and in their implementation and enforcement. We have also developed significant expertise in a wide variety of energy efficiency incentive and market transformation programs.

Since 1997, NRDC has collaborated intensively with Chinese experts and officials on improving energy efficiency in buildings. NRDC has a comprehensive memorandum of understanding with the Chinese Ministry of Construction's Research Institute for Standards and Norms to improve the energy efficiency and environmental performance of Chinese buildings. NRDC was an active participant in the development of residential energy efficiency codes for the "hot in summer/cold in winter" (transition zone) standard recently promulgated by the Ministry of Construction. NRDC is also working with other U.S. participants in assisting provinces within the transition zone in implementing the national code, and in developing residential and commercial building codes for other regions in China. NRDC is spearheading commercial green building demonstration projects in Beijing, Shanghai, Chongqing, and Shenzhen.

CHAPTER 1

WHY BUILDING ENVIRONMENTAL IMPACTS ARE IMPORTANT IN CHINA

On average, people spend 70 to 90 percent of their time indoors; therefore, it is vital that interior conditions be maintained in a comfortable and healthy level, at a reasonable cost, and with minimal impact on the natural environment.

Buildings represent 20 to 25 percent of China's total energy consumption. Industrial energy for the manufacture of building products, principally concrete and steel, represents another 15 to 20 percent. In terms of total energy consumption, this places China's building sector on a par with developed countries, where buildings consume approximately 40 percent, with another 5 percent or so represented by the embodied energy of materials.

The environmental impact of this energy consumption is severe. Direct combustion of coal for cooking and heating produces severe indoor and ambient environmental quality problems. Consumption of electricity for a variety of end-uses in urban areas requires predominantly fossil-fueled power plants to produce the electricity, with its attendant local air quality and global environmental impacts.

While a number of policies are suitable for limiting local air pollution and greenhouse gas emissions, one of the most effective, and certainly the most economically attractive, is improving energy efficiency. Energy efficiency reduces emissions by reducing the need to burn fossil fuels in buildings or industrial sites or transportation vehicles, or by reducing electricity consumption, which cuts the usage of fossil fuels in electric power plants.

CHAPTER 2

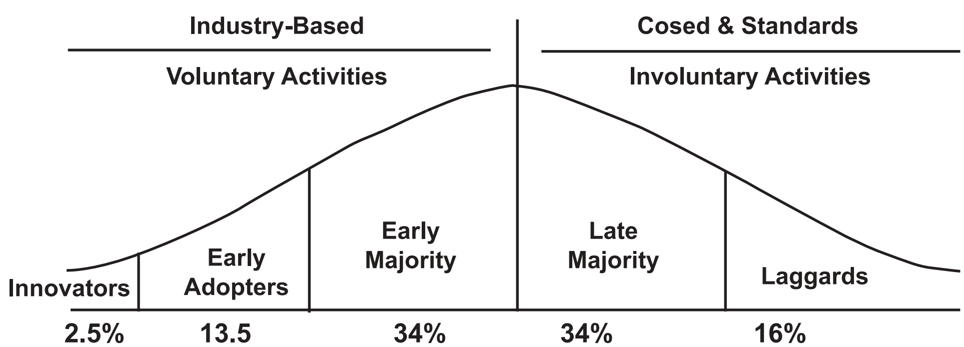
WHAT IS MARKET TRANSFORMATION?

Market transformation encompasses the totality of programs and policies that fundamentally alter practices within an industry, in this case, the buildings sector. We will describe below a broad array of policy and programmatic tools that will help improve the quality and comfort of Chinese buildings, while at the same time lower operating costs and reduce energy consumption.

Before we discuss the various tools of market transformation, it is useful to examine the market that is being transformed. In general, as shown in Figure 1, a typical market can be broken down into five segments: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. We will use these terms below when discussing which market transformation tools are most effective at engaging each particular segment of the building market.

As Figure 1 shows, both mandatory standards and voluntary market-based activities are needed to transform the market. Standards are essential for setting performance benchmarks for voluntary policies and addressing the portions of the market that are not responsive to voluntary measures. Market-based programs on the other hand push an industry to go beyond minimally acceptable performance and incentivize innovations that can eventually be incorporated into common practice.

Figure 1. General Market Composition



The terms "Early Adopters" and "Laggards" in Figure 1 suggest that there is an inevitable progression from less energy-efficient to more energy-efficient in the building sector. This is not necessarily the case without the stimulus of policy. In some cases, such as U.S. water heaters and refrigerators between 1950 and 1972, U.S. automobiles following 1986, and "torchiere" style lighting fixtures worldwide in recent years, efficiency has actually declined over time. In other cases, such as lighting systems globally from about 1950 to 1980, efficiencies were stagnant.

Market transformation policies, including codes and standards, are essential to creating forward progress in markets affecting energy efficiency.

Figure 1 could also lead the viewer to the mistaken belief that it is problems or mistakes on the consumer side of the equation that are impeding the progress of energy efficiency. But the problems are more complex than that: They are the consequence of market structures, rather than "mistaken" behaviors by any one sector of the market.

Table 1 shows the four basic markets[1] that market transformation policies would address in the building sector. Each of these markets is composed of different decision makers from the policy and investment perspective. Within these decision makers there are Innovators, Early Adopters, Early Majority, Late Majority, and Laggards who would be targeted by different policy and programmatic options.

Table 1: Market Segments for Buildings

New Commercial[2]	New Residential[3]
Existing Commercial	Existing Residential

THE TOOLS OF MARKET TRANSFORMATION

A number of mandatory and voluntary policies and programs aimed at the building industry have been implemented successfully in the United States. Table 2 provides a brief definition of the major categories of market transformation policy options. These elements will be described more fully below.

Table 2: Summary of Market Transformation Policies and Programs

Market Transformation Tool	**Description**
Mandatory	Has the force of law. Requirements must be fulfilled prior to building occupancy.
Building and Equipment Energy Codes	Minimal legally acceptable practice for building construction and equipment performance.
Building and Equipment Energy Standards	Generally provide structured recommendations for implementing minimally required or best practice.
Voluntary	Optional. Building may be occupied whether project participates or not.
Incentives	Provide something of value to a project. Can be monetary or non-monetary.
Labeling Programs	Buildings that meet certain criteria are given a performance label to distinguish them in the market.
Education/Training/Information (ETI)	Provide market with tools and skills to make the energy efficient and ecological choice.
Industry Collaboratives	Can pool intellectual and financial resources to achieve higher levels of performance.
Procurement Programs	Large users set internal energy efficiency goals for purchased items.

The four principal policy options to improve the energy efficiency of buildings are: (1) do nothing—"the market" will take care of it; (2) pursue a purely command and control strategy that relies exclusively on mandatory codes; (3) pursue a purely voluntary strategy where optional, market-based programs are the primary driver; (4) adopt an integrated approach of mandatory measures coupled with voluntary programs benchmarked on required minimum performance levels. We believe option 4 is the most effective path for policy makers.

CHAPTER 3

BUILDING AND EQUIPMENT CODES: THE FOUNDATION OF MARKET TRANSFORMATION

The impacts of energy efficiency standards in the United States have been significant, particularly for jurisdictions that have pursued a policy of continuous improvement.

In the United States, since the mid-1970s, most state and many local building codes[4] have imposed significant energy efficiency requirements on new homes and commercial buildings. However, despite considerable development efforts of standards by professional organizations, national building code organizations, and federal agencies, a considerable gap remains between what is considered to be economically desirable building construction and actual practice.

The Energy Policy Act of 1992 (EPAct) requires states to ensure that new nonresidential buildings meet or exceed the efficiency standards recommended by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).[5] EPAct also requires states to consider requiring new homes to meet or exceed the Model Energy Code of the Council of American Building Officials (CABO), now called the International Energy Conservation Code (IECC).[6]

THE ECONOMICS OF ENERGY CODES

Energy codes have been one of the most cost-effective ways of meeting regional and national energy needs. Discounted fuel-cost savings over the lifetime of a residential building are typically at least twice the cost of the projected cost of efficiency. That is, a code that adds $1,000 to the cost of a new house will produce $2,000 of present value in energy savings. For nonresidential buildings, the results generally are even better: Benefit-cost ratios of 3 or 4:1 are common.

Generally, estimates of economic benefits from energy codes are likely to be understated. The economics of energy efficiency are considered prospectively: The costs of complying with the code are estimated using the cost in the marketplace for the technologies predicted most likely to be used for compliance. But actual costs generally are lower for two separate reasons.

- 1. The increased availability of technologies, equipment, and services used to comply with the energy code causes increased competition, which drives the cost down. For newer technologies, the "learning curve effect," where the real cost of technology declines at least 15 percent for each cumulative doubling of production, leads to significant cost savings.

- 2. The energy efficiency measures and strategies used by the construction industry to comply are often less expensive than the ones assumed by government officials in developing the codes. This is a nearly inevitable outcome of reliance on performance-based standards, and one of the primary arguments for relying on them, as we discuss below.

CALIFORNIA'S STATE BUILDING CODE: PERHAPS THE MOST EFFECTIVE BUILDING ENERGY CODE IN THE WORLD

California first set its energy efficiency standards for buildings and appliances in the mid-1970s. Savings from buildings and appliance standards in California to date exceed 5,400 megawatts, more than 10 percent of total electricity demand for all purposes (which is about 45,000 megawatts). These savings are projected by the California Energy Commission to grow to 10,000 megawatts in the year 2010. As the volume of new construction increases over time, these savings should grow.[7]

California had virtually no requirements for energy efficiency in new buildings before 1975 when a new agency, the California Energy Commission (CEC), was established by state law to plan comprehensively for energy supply and energy efficiency. The CEC was explicitly mandated to develop energy efficiency standards for buildings.[8]

In 1976 and 1977, the CEC's new standards mandated significantly increased levels of energy efficiency, restricted the use of electric resistance heating, and also embodied several innovations. First, rather than requiring all houses to contain the same levels of conservation measures, a basic passive solar building with prescribed efficiency levels was used to define a baseline level of energy consumption.[9] Several additional prescriptive packages, or alternative combinations of conservation features, were provided explicitly in the building standard and certified as achieving equivalent energy consumption.

Second, the CEC developed a simple "point system" for comparing the energy performance of buildings with higher efficiency in some components and reduced efficiency in others. The point system allowed the designer to make trade-offs between alternative energy efficiency technologies.

Third, computerized energy calculations could be used to show that a proposed design met the intended level of energy performance. The CEC's proposed standard spawned conflict with the building industry. The resulting compromise created "prescriptive packages"[10] that were established as the primary basis of the standards. It required the builder to model the energy consumption of his proposed building and compare it to that of an identical building that employed the new "prescriptive package." This was referred to as the "custom budget" procedure for computer calculations.

In 1987, the CEC established new prescriptive packages of conservation measures more energy-efficient than the previous packages. For commercial buildings, it adopted stringent lighting power limits and restricted the common practice of providing heating and cooling simultaneously. More important, the CEC eliminated the "fixed budget" approach for commercial buildings as well as residential buildings, and defined carefully the rules for computer simulation to eliminate loopholes in the computer process, which had begun to undercut efficiency goals significantly. While the "custom budget" procedures appeared to be a way to appease and weaken the standard when they were first adopted, subsequent field experience showed that they created more fairness and did not compromise energy efficiency significantly.

Following these revised rules, reports from the field suggested improved builder acceptance of, and compliance with, the standards, as well as the decreased paperwork and simplified compliance. They also demonstrated a continued and even growing builder interest in using the performance-based approach. Many observers believe that the increased level of educational materials provided along with the standards and the effort to train building code officials can be credited with this result.[11]

The California Energy Commission undertook another significant upgrade of the Title 24 standards in 1992. It supervised a comprehensive study of the costs and savings of energy efficiency measures available for residential buildings and required that the prescriptive packages and the performance approach be based on a building that included all cost-effective efficiency measures.

Additional important upgrades were made in 1998. For the commercial sector, the results of utility DSM programs were used to guide the commission to reduce significantly the lighting power budgets. Lighting is the single largest energy user in commercial buildings. For residential buildings, low-solar-heat-gain glass was required, and implementation rules that allowed builders to take credit for movable shading devices, such as window shades, that were not really used in practice were eliminated. The code began to incorporate new research and testing standards on leakage from air distribution ducts, which was found to account for more than 20 percent of energy use. Credit was given for leak-free ducts, tested by a fan and pressure gauge, as a voluntary compliance option. The building industry was put on notice that these leak-free duct systems would be required in the prescriptive case during the next three-year code revision cycle.

The code revision process was accelerated due to California's electric power crisis of 2000. In response to legislation intended to avert blackouts, the energy commission rapidly adopted improvements in both residential and commercial building codes, adding significant requirements for solar-reflective windows in nonresidential buildings and requiring upgraded air conditioning systems and reflective roofs in the cooling climates, along with accelerating the date that leak-free ducts were required in the residential standards.

During the 1990s, several utility evaluation studies looked at the extent of compliance with the code and with the extent to which buildings exceeded it as a result of utility-sponsored incentive programs. The studies show that code enforcement was generally quite good, with average energy performance of buildings consistent with that which would be predicted from the text of the code. One study showed that by 2000, more than 90 percent of residential buildings were demonstrating compliance using the performance method.[12]

CHAPTER 4

DESIGNING EFFECTIVE BUILDING ENERGY CODES

Designing a technically sound building standard is an important first step toward creating an effective energy code that saves energy in practice, not just in theory. However, many such standards have failed to save any real energy as codes because of insufficient market acceptance and inadequate administrative and enforcement infrastructure. Below, we discuss key components of a successful implementation program and how the technical content of the standard can be designed to facilitate implementation.

A FOCUS ON IMPLEMENTATION

A well-designed code will have the goal of successful implementation at its core. In order to be effectively implemented, energy codes must be fully understood by the entire building market. Some studies have shown that simple codes are more likely to result in high levels of compliance. For example, Oregon's relatively simple mechanical system codes resulted in 96 percent compliance, while Washington state's more complex codes averaged only about 72 percent compliance.[13] Generally, the people implementing an energy code will have less education and technical experience than those designing the code.[14] If a code is more complex, better training and more carefully administered implementation approaches are needed.

An effective code must be one that enforcement officials and designers are capable of implementing and are motivated to implement. It must be one that can be met in the field by available technologies and professional services. An agency that plans on enforcing an effective energy code should plan on the following activities:

- 1. *The development of guidebooks for design assistance and training.* These materials explain what is meant by the legal requirements in the code, and illustrate typical ways that designers can achieve and document compliance. Guidebooks for the designer may also be accompanied by training manuals that explain how this information can be conveyed to code officials. The best guidebooks explain the benefits of code compliance to the building owner or tenant, and encourage designers to go beyond the code. Examples of beyond-the-code measures and their additional benefits are provided.
- 2. *Provision of training for code officials.* Training is essential. Building officials are, at best, most accustomed to enforcing code provisions whose consequences are more visible when there is failure, such as structural or electrical or fire safety requirements. If they cannot understand energy efficiency requirements, they are not likely to enforce them. On the other hand, if they

realize that these standards protect the financial well-being of the consumer, reduce pollution, and maintain comfort, they will do a more effective job.

> Numerous studies in the United States show that training is necessary at regular intervals. In the United States, personnel in building inspection departments may change jobs frequently. Thus, a good training program in 2001, when a new code is introduced, may still mean most officials in the department have not been trained by 2004, when a new code revision takes place.

- 3. *Compilation of interpretations.* No matter how comprehensive the code and the design assistance materials, questions of interpretation are certain to arise. The code agency should make it easy for designers to look up interpretations, and to obtain new ones if necessary. This requires compiling the most commonly used interpretations as they are developed and making them easily available. It is helpful to have a toll-free telephone number or a Web Site that a designer may access to get on-the-spot expert interpretation of how to enforce a particular element of the code. At the California Energy Commission, the staff that developed energy codes are required to answer these telephone lines because it gives them a new perspective on what elements of the code are poorly written or inconsistent with field practice.
- 4. *Outreach and training for building designers.* Users of the code must be trained as well. The submission of incomplete or incorrect designs can cause significant disruption in the smooth working of the enforcing agency. Ideally, these training programs will familiarize users with complementary programs, incentives, and information resources, to the extent they are available.
- 5. *Encourage public participation.* No matter how effective or well prepared the adopting authority is, field situations will arise that create difficulties for complying with the standards. Solutions to these problems can be found if there is a process for public participation during the implementation of the code as well as in its development. Local officials, builders, building supply industries, and other stakeholders should have regular opportunities to speak with the authorities responsible for developing the code to point out problems, thereby encouraging revisions that can most effectively achieve the same result.

  Energy codes often attract considerable controversy among advocates or opponents of particular technologies or levels of energy efficiency. In the United States, many building supply industries use code revisions to improve the market for their products. These attempts can be in the public interest when the product offers new ways to save energy and is effective to the building user. There is also general opposition from the construction industry to any sort of change. These concerns do not always go away by ignoring them or overriding them: They often show up as enforcement problems. A public process in which all stakeholders can comment on the proposed code and revisions and in which the code developers are required to respond substantively to requests for changes are generally valuable to all parties, even if they can be frustrating to the participants. In many cases controversies over elements of the code can be resolved in a win-win fashion.
- 6. *Regular (three- or five-year) revisions.* Technology and design strategies improve over time; what was considered a very energy-efficient building when a code was initially adopted falls far short of the economically justified target a few years later. Therefore, code officials should plan on a regular cycle of revisions to the energy code. Having a regular cycle is highly preferable to

only conducting irregular revisions. A regular revision cycle prepares the construction industry and the enforcement apparatus to adapt to change and reinforces the need for regular retraining.

With a regular cycle—typically three years in the United States, but perhaps longer periods for other regions new to mandatory codes—the market can build in expectations of not only expanded sales of new energy efficiency technologies but also forecast the level of sales for existing technologies. Moreover, the engineering, design, and construction industries also can plan for modifications to their current practices.

The ability to revise a code on regular intervals allows for some of the more advanced energy efficiency measures to be phased in over time.[15] In addition, new technologies can be included in the prescriptive requirements for the energy code, resulting in additional energy savings. As discussed below, this automatically advances the stringency of the performance target as well.

TIERED ENERGY STANDARDS

One way of automatically integrating a revision in a building code is to adopt tiered standards. Tiered standards codify two or more increasing levels of efficiency, incorporating a later implementation date for the more stringent requirements.

As noted above, California adopted its requirements for solar-reflective fenestration systems in homes and for leak-free ducts in tiers. Since the mid 1980s, residential windows standards had required low solar heat gain but had effectively allowed clear-glass windows to be used because more credit was given for cheap (and uninspectable) white roller shades than for low-e coated solar reflective glass. The commission decided in the 1998 code revision to reduce the credit for roller shades by about half, effective immediately, and to eliminate it in the subsequent code revision.

The leak-free duct requirement was also established in phases, as described above. In the first phase, credit was given for tested leak-free ducts, but they were not required. In the second phase, it was understood by builders that the standards would require this measure in the reference house—that is, that builders would either have to install leak-free ducts or increase the stringency of other energy efficiency measures to compensate.

DESIGN OF ENERGY CODES

Prescriptive and Performance Options

NRDC is very encouraged by the progress that has been made by the Ministry of Construction in developing new national codes in China. We have supported their development, and will continue to support their aggressive implementation, because they will save substantial amounts of energy cost and pollution in China, and globally.

But China's standards fall far short of current technological potential. Their development was constrained in several different ways. Perhaps the most significant constraint is the recognition that design and construction practices, as well as the availability of building supplies, cannot change radically overnight.

Thus, for example, the use of insulating materials in load-bearing concrete walls, while undoubtedly a cost-effective technology, could not be required in the current generation of codes because of the limited availability of appropriate materials and finishing techniques, as well as the limited familiarity of the building crafts and trades with their installation. Similarly, the lack of developed rating systems for energy components, such as windows, impedes the introduction of highly cost-effective technologies into the code, such as solar reflective windows.

Virtually all of the most successful energy codes around the world offer two paths for compliance: a “prescriptive approach” and a “performance approach.” The prescriptive approach dictates the performance of particular components of the building, such as the U-value for wall systems and shading coefficiencies for windows. The performance path sets an energy consumption or energy cost target for the entire building and allows designers to meet it through a variety of acceptable energy efficiency measures and design changes. Although these can be considered competing options, experience has demonstrated that the existence of both paths actually provides mutual reinforcement.

The Prescriptive Approach. The prescriptive approach demonstrates to compliance officials and designers, in concrete terms, what the standard requires.

Most building code officials prefer a prescriptive approach because it is simple to understand and enforce. Many builders also prefer it because they can simply know that if a wall is constructed in a certain way, or a window is labeled for a certain attribute, it complies. Others do not favor this approach because it limits options for how to build their buildings.

With a prescriptive code, there are generally fewer compliance problems. Fewer measurements are required, and fewer types of calculations are needed. Generally, a prescriptive code is the best first step in getting a building industry to accept the concept of regulating energy efficiency measures in a building. It allows the compliance and enforcement infrastructure to be put in place and, because it is simple and clear, will result in the fewest conflicts in the field.

A prescriptive code, however, is not a very effective means of promoting continuous improvement in the overall energy performance of buildings.

The Performance Approach. A performance standard requires that a given energy target be met without specifying the means for achieving it. Thus, it provides a market opportunity for new efficiency technologies to replace old ones.

In a well-functioning market that minimizes construction costs, which is typical of most economically successful regions in the world, builders will constantly be looking for new ways to achieve code compliance at lower cost than their competitors. While this is moderately beneficial to the economy in that it leads to lower construction costs, it does not encourage further energy savings.

Although the performance approach is in many ways an alternative to the prescriptive approach, it is difficult to enforce or even understand the performance method without reference to a prescriptive method. This is because neither the designer nor the enforcement official has any intuitive idea as to what a complying building should look like. But, if the code is structured such that the performance standard achieves the same energy performance as required by the prescriptive standard, then the intuitive leap is possible.[16]

Because there are thousands of ways for calculating compliance and thousands of ways of calculating energy consumption for a given building, the performance path only works when simple and fixed rules and forms for calculating compliance are provided. Even the most expert individuals at modeling building energy performance can come up with significantly different results if they use slightly different methodologies. Thus, the question of what complies or does not comply with the performance approach can become ambiguous. The way to avoid ambiguity is to provide firm rules and algorithms for doing the calculations.

These complex calculations are best done by computer. Computers not only provide more accurate simulation of energy performance, but also assure automatically that all calculational rules are followed, and that the designer is not able to adjust, either accidentally or intentionally, parameters that are not part of the building design in order to make compliance easier.

Most performance-based methods in America are hardly, if ever, used. But this is because they are complex and often produce irreproducible results. This complexity causes some building officials to reject performance-based applications altogether.

But the two states, California and Florida, where the performance method has been automated and simplified—simplified to the point where any building code official can understand the output and inspect the building to see whether it conforms—the performance method is used by 90 percent of the applicants for energy permits in new homes.

DESIGN INTENT VS. FIELD PERFORMANCE

Energy codes regulate the design intent of a building, but do not necessarily regulate the actual use of energy in a real building.

It also has been demonstrated by measurements that identically designed buildings can have substantially different energy performance depending on the operation and maintenance of the equipment and the preferences and behaviors of the occupants. For example, for residential buildings in the United States, there can be a difference of as much as 10:1 in the heating energy consumption of homes with identical designs.[17]

Many buildings use more energy than predicted, particularly larger buildings. Most of this divergence is due to poor installation of equipment and poor operation and maintenance procedures. Problems of improper installation or insufficient testing can be ameliorated through properly commissioning buildings once they are complete. Commissioning protocols are currently under development in the United States by the New Buildings Institute, the U.S. Green Building Council, and other organizations.

From an energy planning perspective, proper implementation of energy codes is very important. Even though the energy use of a code-compliant building can still vary significantly depending upon occupant behavior, the variance in energy consumption is substantially smaller compared to a building constructed without an energy code.

ENERGY STANDARDS FOR APPLIANCES AND EQUIPMENT

Basic energy savings not realized by improved design through the building code can be captured by equipment standards.[18] Unlike buildings, energy efficiency in equipment and appliances has been regulated principally (but not exclusively) at the national level.

These performance standards for appliances and equipment have been the other cornerstone of regional and national energy efficiency policies in the United States to reduce energy consumption. In the United States as a whole, appliance and equipment standards are already saving 2.8 percent of total peak electricity use, or 21 GW; this will rise to 12.6 percent savings, or 120 GW, by 2020 due to standards that have already been adopted but are not yet in force.

Equipment standards have an advantage over building codes in that they apply to equipment going into existing buildings as well as new buildings. But, as with building codes, appliance and equipment standards will not save energy if they are not enforced.

Outside of space conditioning, other building energy end-uses in the United States have grown significantly. By 1975, refrigerators had become the largest user of electricity in U.S. households, with other appliances such as air conditioners, water heaters, clothes washers, and lighting systems also consuming large amounts of energy. Recently, small transformers used to power electronic equipment have also become significant energy users.

Prescription or Performance Standards

The issue of whether to use prescriptive or performance standards for equipment arose in the United States in the early 1970s. The appliance industry expressed a general preference for performance-based standards.

As with buildings, performance standards require the development of a test protocol—analogous to the computer-based calculation method for buildings—and then the establishment of a maximum energy use based on the test procedure. In all major countries, the appliance testing protocols have become the basis for ratings that are available to consumers and energy officials throughout the country or region. These ratings, typically in kilowatt-hours per year, or kilowatt-hours per year per unit of output, can be the basis for incentive programs and other market-based programs to encourage energy efficiency.

Household Appliances. Minimum efficiency standards were first adopted for household appliances and certain commercial equipment in California in the mid-1970s.[19] California strengthened its standards in 1983, and several other states passed different sets of requirements. This diversity of standards encouraged the appliance manufacturing industry to seek a national standard that would preempt the state standards.[20] The National Appliance Energy Conservation Act (NAECA) was adopted into federal law in 1987 and amended in 1988.[21] The law prohibited the manufacture and sale of products that fail to meet the minimum efficiency requirements. NAECA required Department of Energy to review prevailing standards periodically and strengthen them if technically and economically feasible. The 1992 EPAct added a number of other energy- and water-using products and established minimum regulations and a process for strengthening them.

Since these laws were passed, the Department of Energy has promulgated approximately 10 amended standards requiring higher levels of efficiency. While this falls significantly short of the number of revisions required by the law (with deadlines that have already passed) it nevertheless has prompted noteworthy increases in appliance efficiency, as shown in Table 3.

Table 3: Examples of Efficiency Changes

Appliance	1970-1975 Energy Use		2000-2001 Energy Use	
	Average	**Best**	**Average**	**Best**
Refrigerator	1,725 kWh/yr	1,325 kWh/yr	2001 Standard = 475 kWh/yr	~400 kWh/yr
Clothes Washer	3.81 kWh/cycle		~2 kWh/cycle	0.7 kWh/cycle 2007 Standard is at this level
Central Air Conditioners	7 EER*	9.5 EER*	9.8 EER*	13 EER* 2006 Standard requires ~11.3 EER*
Dishwashers	4.2 kWh/cycle		~2 kWh/cycle	~1 kWh/cycle

*An energy efficiency ratio (EER) measures the amount of electricity required by an air conditioning unit to provide the desired cooling level in BTUs. The higher an EER, the more energy efficient a unit is.

The largest number of standards have been established for refrigerators, which also have been subject to a number of other policies that are discussed in this paper. This example is so important that it is discussed separately in the section on appliances and equipment below.

Lighting

In the United States, lighting accounts for approximately 25 percent of annual energy costs, almost $37 billion.[22] Approximately 60 percent of lighting energy use is from fluorescent lamps, which require a ballast to provide a suitable starting voltage and then limit current flow during operation of the lamp. Ordinary ballasts dissipate about 20 percent of the total power entering a fixture. More efficient magnetic ballasts, introduced in the mid-1970s, make use of better materials, including copper windings and high-grade steel, to reduce ballast losses by 50 percent to 60 percent. Solid-state electronic ballasts, first introduced during the early 1980s, cut lamp/ballast system losses 15 percent to 20 percent further than efficient magnetic ballasts and increase lamp efficacy due to high-frequency operation.

By 1987, about one-third of ballast sales were energy-efficient magnetic ballasts. In 1988, federal ballast efficiency standards were adopted. As a result, inefficient magnetic ballasts could no longer be sold or imported into the United States. In 1994, the DOE proposed new efficiency standards for fluorescent ballasts that require use of electronic ballasts. The standards were to be finalized by 2000 and take effect in 2005.[23] The department estimated that these standards will save 57 TWh per year by 2015. The consumer will realize economic benefits of nearly $14 billion over a 35-year period.[24]

Incandescent lamps account for approximately 30 percent of electricity used for lighting in the United States.[25] The use of compact fluorescent lamps (CFLs) will result in energy savings of approximately 66 percent to 78 percent with equivalent light output.[26] CFLs also have approximately 10 times longer lives than typical incandescent products. For commercial buildings, this also results in labor cost savings since they need to be changed less frequently.

CHAPTER 5

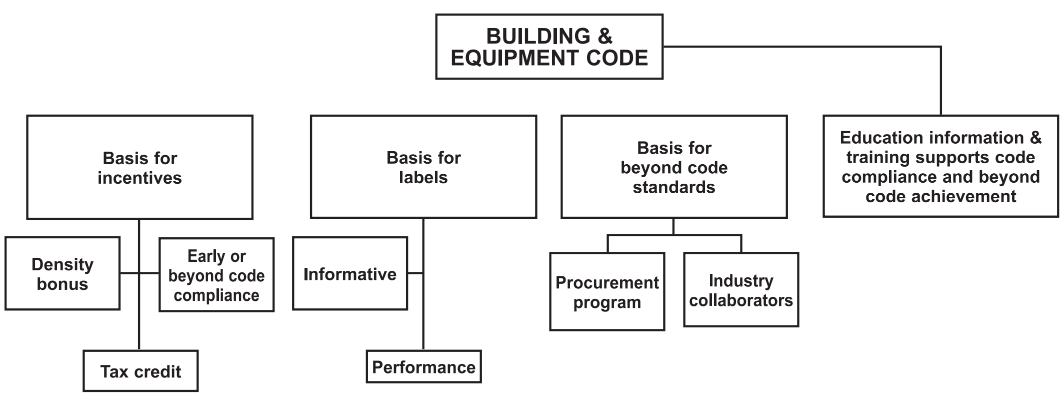
BEYOND ENERGY CODES

In addition to the regulatory push to rid the market of the worst performing technologies and practices, an incentive pull is necessary to encourage continuous improvement in energy efficiency. First, we will discuss how codes can be integrated into a broader market transformation strategy, then we will describe the limitations of energy codes and advances in building research that have revealed the different ways buildings use energy that are not captured by typical energy-only standards. Finally, we will describe a number of successful market transformation tools that have been used to comprehensively improve energy efficiency beyond the mandatory requirements of codes.

INTEGRATING ENERGY CODES INTO A BROADER STRATEGY

Energy efficiency codes work best when they are undertaken as part of a more comprehensive strategy that includes incentives, both short-term, actively managed incentives and longer-term, fixed incentives, along with both informative and normative labeling policies that establish the value of energy efficiency in the marketplace, and, more broadly, education and outreach programs and research and development for new technologies and designs. As shown in Figure 2, all of these policies interact in multiple directions.

Figure 2: Energy Codes as the Basis for Beyond Code Activities



Although no jurisdiction has yet fully adopted a comprehensive approach, experience in regions that have adopted several of the pieces shows that each piece reinforces and strengthens all of the others. Standards generally constitute the basis from which these other programs can be designed. A well-designed, comprehensive program will intentionally build into standards the types of policy features that can be useful in designing incentive or educational programs.

LIMITATIONS OF CODES

Energy codes are a necessary, but not sufficient, element of a market transformation strategy. While codes have been the primary policy force causing improved energy efficiency in buildings, they also have severe limitations if they are the only policy tools available.

First, prescriptive codes usually can only require technologies already widespread in the market because they apply to all new construction without exception. If the code were to require a technology that is only minimally available in the market, builders may be unable to comply. If this is the case, compliance officials may have a tendency to look the other way if the code requires "impractical improvements." This will hinder enforcement and undermine the credibility of future code improvement efforts.

This problem can be partially mitigated by the performance approach, since no particular technology is required. However, if the code places reliance on one technology with very large energy savings, it could be very difficult or expensive to make up these energy savings using other technologies.[27] Therefore, it often is not good policy to develop building codes that require technologies that are not currently widespread in the market.

A second weakness of codes as the sole energy efficiency policy is that codes seldom include all cost-effective measures. This is more a political problem than a policy problem; there is no reason in theory why all cost-effective measures could not be included, and, indeed, there are a few examples where they were.[28] But in general, the building industry has trouble accepting changes in many different components in the building at once.

A third limitation of energy codes is that they have trouble addressing complex systems. The best example is the heating ventilation and air conditioning (HVAC) systems of large high-rise buildings. Much of the energy performance of HVAC systems is determined by operational characteristics such as equipment settings and programming of equipment. These are difficult, if not impossible, for building inspectors to identify, and the inspected settings are a moot point once the building is certified for occupancy.

Complex systems have so many different options that prescriptive requirements tend to get very complicated. For each option, a different prescriptive requirement is needed. In practice, this can lead to a different "reference case" in the performance standard for each variation in system design.

The problem with respect to energy savings is that either the standard is set based on some relatively simple prototype and could become difficult or impossible to meet in all cases, or else the standard is adjusted upward in energy consumption for certain hard-to-design systems and then ceases to encourage much efficiency.

Finally, building codes only address new construction. Energy efficiency in existing buildings must be addressed by equipment standards, incentives, and education programs.

OPERATIONS ARE NOT THE ONLY WAY BUILDINGS CONSUME ENERGY

As energy codes have improved over time, other aspects of energy consumption related to buildings can actually exceed the energy used to operate them. These aspects include a building's location, its site plan and landscaping, and its construction materials.

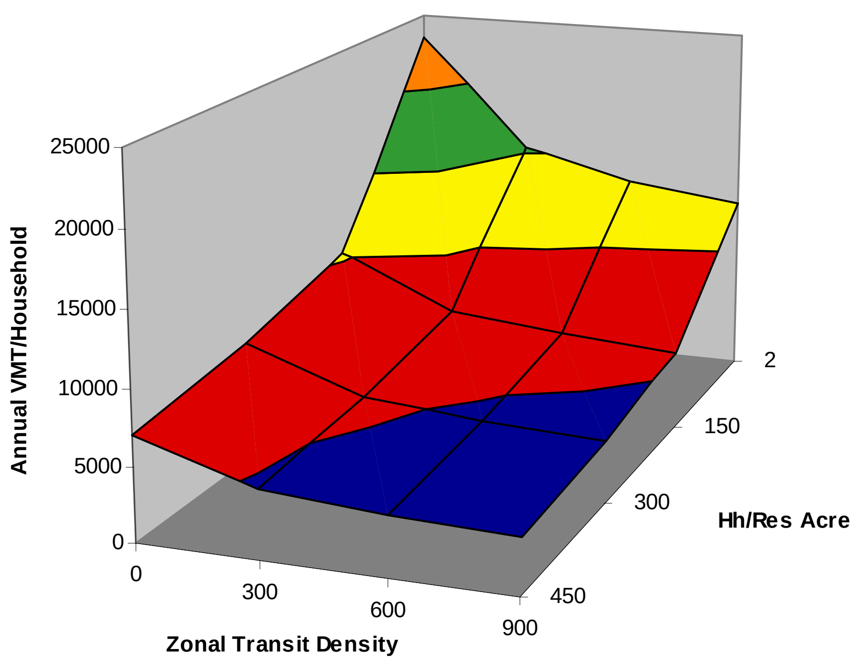
Location is perhaps the most significant of these in the United States. An efficient building in a remote location will result in more energy being used by the occupants commuting to and from the building than the building consumes itself. Even more remarkably, the total cost of driving cars to and from the remotely located building in the United States can exceed the entire cost of purchasing the house.

It is possible to quantify the extent of driving and its related cost (energy use) in air pollution emissions, for a given location, at least in the United States. The extent to which these are lower than a worst-case location of "suburban sprawl" can be expressed as the "location efficiency" of the house and its neighborhood.

It has been found that differences in neighborhood characteristics, primarily the residential density, or number of housing units per hectare of residential land, and the level of provision of transit service (number of buses or rail vehicles per hour passing within walking distance of the residence) have the largest effects on location efficiency. Reasonable variations in these two variables alone can reduce the amount of driving by almost two-thirds, based on typical conditions in the United States, holding income and family size constant. The results are displayed below in Figure 3.[29]

While these results are based on U.S. data only, they are consistent with findings whose database is global.[30]

Figure 3. Vehicles per Household vs. Households per Residential Acre—San Francisco



Proper site planning and landscaping can reduce urban heat islands and the water required for irrigation. Heat islands can increase ambient temperatures by 6 to 80 F (4–50 C), significantly increasing air conditioning levels. Water purification and pumping are among the largest municipal energy consumers in the arid western United States.

Finally, the embodied energy of a building can be significant, particularly where energy intensive cement and steel are the dominant building materials. As noted above, industrial energy consumption to manufacture building materials in China is nearly equal to the energy used in the buildings themselves. This seems a particularly ripe area for intervention, either in the building sector or in the industrial sector.

MODEL OR VOLUNTARY STANDARDS

In the United States, relatively few jurisdictions have the budget or the technical expertise to develop their own energy standards for buildings. In most instances, they incorporate other organizations' standards into their building codes instead. A number of these model energy standards have been developed since the 1970s.

Association Standards

The ASHRAE/IESNA 90.1 Standard (Standard 90.01) is the predominant national standard for commercial buildings.[31] Although Standard 90.1 is a national standard, it is not a federal standard. Ongoing upgrades of Standard 90.1 have resulted in commercial buildings that save as much as 50 percent of energy consumption compared to noncomplying buildings before the first standard was adopted in 1975.[32] The standards also have reduced construction costs by cutting excessive lighting and window area.[33] ASHRAE has developed a standard that also applies to residential buildings, Standard 90.2, although it has yet to be adopted by any code-enforcing jurisdiction. ASHRAE standards have also been instrumental in the model federal building efficiency standards and guidelines developed by the DOE. However, in the area that accounts for the largest fraction of energy use in commercial buildings—lighting—the DOE adopted requirements around 1990 that went significantly beyond those in the ASHRAE standard. Implementation of ASHRAE commercial standards is expected to reduce energy bills by $2.1 billion annually by 2010.[34]

The International Codes Council (ICC) is the sponsor of the International Energy Conservation Code (IECC). The IECC is a voluntary code principally used for low-rise residential construction, although it covers all commercial buildings as well. About 40 states have adopted some version of the IECC, or used it as a basis for their state code, while a couple of states have adopted the commercial building version. Several studies have found that the IECC energy requirements are highly cost-effective. An analysis by the Alliance to Save Energy, for example, suggests that if the 34 states with codes less stringent than the 1995 version of the IECC adopted the model code, the resulting changes in new homes would achieve paybacks of less than two years. Furthermore, the alliance found that in some regions of the country codes stricter than the IECC would provide a four-year payback.[36]

Federal Model Standards

Two federal agencies, the DOE and the Department of Housing and Urban Development (HUD) have been active in the development of model or actual building energy codes and standards. Although the number of buildings constructed annually for the federal government is limited, the government directly finances about 27 percent of new home mortgages through the Federal Housing Administration, the Veterans Administration, and the Farmers Home Administration. Eligibility requirements for federal financing can directly influence building design and construction.

Through a variety of legislation, Congress directed HUD to issue an energy standard for housing programs within the agency and for manufacturing homes. The federal government first issued the Minimum Property Standards (MPS) in the 1950s to establish energy criteria for homes using federally financed mortgages. The standard limited the level of household utility expenses and reduced the rate of default on home mortgage loans. The 1990 version required that "all detached one and two family dwellings and one family townhouses not more than three stories in height shall comply with the model energy code (MEC)." [37]

RATING AND LABELING SYSTEMS

Market-based rating and labeling systems are a bridge between mandatory codes and information systems. These systems can convey a signal to the market that a building delivers superior performance. These ratings or labels are often based on standards or specific performance criteria. In addition, these programs can convey information of comprehensive environmental performance in addition to energy efficiency.

Building labels could be a key component of a comprehensive energy efficiency program. As discussed below, a variety of incentive and purchase programs to encourage energy efficiency could also encourage widespread use of labels. If rating and labeling systems are designed properly, they could serve as effective tools to building owners and managers and to the property sales and lending marketplace in encouraging better buildings as well as greater energy efficiency.

LEED Rating System

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is the next wave of beyond-code programs in the United States. Developed by the U.S. Green Building Council,[38] LEED has 64 requirements in five categories including site, water, Energy, materials and indoor environmental quality.[39] Buildings receive LEED ratings ranging from Certified to Platinum.[40]

After two years, LEED is in use by more than 6 million square meters of commercial and high-rise multifamily buildings, approximately 3 percent of the new construction market. LEED is anticipated to penetrate approximately 5 percent of the new construction market this year. Although small relative to the entire market, this represents almost 25 percent of the target market of Innovators, Early Adopters, and a portion of the Early Majority that comprose the top 25 percent of the building market. This market proportion is very similar to the segment targeted by the EPA's Energy Star program as discussed below. LEED's market share should grow as new products are being developed to address the specific market concerns of speculative developers, existing building owners and operators, and subtenant spaces that only do interior renovations.

Operationally, LEED certified buildings are approximately 75 percent more energy efficient than average new commercial buildings, not including secondary energy savings.[41] About 40 percent of LEED buildings are in full development in urban areas and 60 percent of them are located within walking distance of mass transit. About 60 percent have taken landscaping measures to reduce heat islands[42] and have eliminated irrigation systems, while nearly every project has reduced landscape water use by at least 50 percent.[43]

Energy Star Label

The U.S. Energy Star system created by the U.S. Environmental Protection Agency (EPA) is another example of a normative label—one that establishes a recommended or "good" level of energy efficiency.[44] The Energy Star program encompasses appliances, office equipment, and new and existing buildings.[45]

The use of a widely recognized logo such as Energy Star can provide market differentiation that will encourage both manufacturers and consumers to move toward higher levels of energy efficiency. For this to work, the label must be credible in terms of technical accuracy and in terms of distinguishing significantly better energy performance from merely average performance.

Informative Energy Labels: Theory vs. Practice

Informative labels are intended to provide objective estimates of energy consumption, often measured in cost to the consumer.

Residential Buildings. In theory, the presence of energy ratings will be incorporated into the marketplace for buildings, raising the valuation of energy-efficient buildings and reducing the valuation of energy-inefficient buildings.

Economic theory says that widespread availability of ratings should cause the market to solve all the problems of energy efficiency. There has yet to be any practical validation of this hypothesis. Indeed, it remains the case that in most of America, energy efficiency measures that could cut building energy use by 50 percent or more are almost universally ignored in the marketplace, except where required by code or encouraged by economic incentives.

Policy makers in the United States have been trying to develop home energy ratings for over 20 years, with very limited success. These efforts have focused primarily on the residential sector, despite analysis suggesting that the commercial sector might be able to use the ratings more effectively.

As a result of these years of effort, ratings for residential buildings finally are now available in the United States. There is a national standard, adopted by the National Association of State Energy Officials, covering both the engineering calculations that lead to a uniform energy rating and the procedures for certifying individuals who are qualified to do energy ratings, assuring that they are well-trained and financially independent of the builder.[46] Energy Star also rates new homes and LEED is developing a national residential green building system. As shown in Table 4, about two dozen local homebuilder associations have developed or are developing green building rating systems.

Table 4: Local Homebuilder Association Green Building Programs

Program Name	Program Administrator	Date of Inception	Contact Information
Austin Green Building	City of Austin	1991	www.ci.austin.tx.us/greenbuilder
Built Green	HBA of Metro Denver	1995	www.builtgreen.org
Innovative Building Review Program	County of Santa Barbara	1995	805-568-2507
Green Points	City of Boulder (CO)	1996	www.ci.boulder.co.us/environmentalaffairs/green_points/gp_overview.html
Build a Better Kitsap	Kitsap County HBA	1997	www.kitsaphba.com
Green Builder	HBA of Central New Mexico	1997	www.hbacnm.com/green_builder/index.html
Green Building	MD National Capital Building Industry Assoc.	1998	301-445-5400
Build a Better Clark	Clark County (WA) HBA	1998	www.cchba.com/green.asp
Scottsdale's Green Building	City of Scottsdale (AZ)	1998	www.ci.scottsdale.az.us/greenbuilding
Earth Craft House	Greater Atlanta HBA	1999	www.atlantahomebuilders.com
Green Built Home	WI Environmental Initiative	1999	www.wi-ei.org/GBH/index.htm
Green Building	City of San Jose (CA)	2000	www.ci.san-jose.ca.us/esd/gb-home.htm
Built Green Colorado	HBA of Colorado	2000	303-421-4889
Built Green	Master Builders Association of King & Snohomish Counties	2000	www.builtgreen.net
Earth Advantage Homes	Portland General Electric (OR)	2001	www.earthadvantage.com
Vermont Built Green	Building for Social Responsibility	2001	802-658-6060 ext. 1016
The Heart of America Green Builder	Metropolitan Energy Center (Kansas City)	2001	816-531-7283 www.kcgreen.org
Program under development	Western North Carolina Green Building Council	N/A	828-251-5888 www.main.nc.us/wncgbc
Program under development	Southern Arizona Green Building Alliance	N/A	520-624-6628
Program under development	Florida Green Building Coalition	N/A	floridagreenbuilding.org
Program under development	Alameda County (CA)	N/A	510-614-1699
Program under development	City of Chula (CA)	N/A	619-409-5870
Program under development	HBAs of Hudson Valley and Schenectady (NY)	N/A	518-355-0055 (Schenectady) 914-562-002 (Hudson Valley)

Despite the number of programs, these ratings have been negligibly used to date. More than one million new homes are constructed annually in the United States, but fewer than 100,000 ratings of any type are performed in the year for all these programs combined. One of the barriers to wider use of ratings is the cost of ratings and the availability of raters. This can be a vicious circle: If ratings are expensive or hard to get, no one will request them; but if almost no one requests ratings, then there is no business opportunity in becoming a rater, and raters will be unavailable.

Ratings are required as part of the newly adopted regional energy codes in the Russian federation. But there is a lack of standards to assure uniformity in the ratings and to provide recommended procedures for doing them, so compliance with this aspect of the code is lagging.

Commercial Buildings. Energy ratings for commercial buildings should, in theory, become important in the marketplace. This is because estimates of property value, which are used for informing banks about loan amounts, as well as helping to establish selling prices for buildings, are often based on energy costs.

For example, more than half of buildings are appraised by the "net operating income" method, in which the value of a building is obtained by projecting the net operating income—that is, the rental income for the building minus the cost of operation—and multiplying it by a capital recovery factor, which typically has a value of over 10 years. Energy is considered explicitly (in theory) in evaluating operating costs. Thus, a building that saves $10.00/square meter in energy costs compared to an alternative building is valued at more than $100/square meter higher than the inefficient building.

But this theory does not work out in the real world because of a lack of detailed energy consumption figures. Instead of filling in an energy cost estimate specific to the building, appraisers use regional averages in calculating that aspect of operating income. All buildings are treated as if they had the same energy efficiency. To correct some of these deficiencies, The Institute for Market Transformation, a U.S.-based NGO, is working with appraisers to establish procedures for using building-specific figures for energy costs.[47]

Improving Building Labeling Systems. The most effective labels would provide two different types of calculations, following the model used in the Russian regional codes as described next.

First, the label would provide an estimate of annual energy use, measured in units of costs and based on energy calculations using the design of the building. This would provide a uniform scale for rating efficiency without regard to the behavioral variations between buildings. Thus, two buildings with a given rating would provide a prospective owner with the same level of energy performance, whether that individual would prefer to heat their home to 15°C in the winter or 25°C. The cost target provides both a way of comparing one building to another and a way to verify that energy is really being saved in a single building – or to diagnose why energy is being wasted and figure out what to do about it.

As is in the case in the Russian document, a list of the energy efficiency measures used to meet the calculated energy level of efficiency should also be provided. This list is essentially part of the input used to calculate the design-based energy consumption. It is an important part of the document because it can complement code enforcement efforts by providing a permanent record of the types of measures that supposedly were installed to make the building energy efficient. If subsequent owners find that the performance of a given component falls short of the level in this document, they can hold the builder responsible for the variance between claimed and actual energy efficiency. The risk of such litigation provides a powerful backstop to keep the code compliance process honest.

Second, the labels should provide an estimate of actual consumption. This actual value can be compared with the predicted value, which will provide several useful inputs for the building owner or operator. The Energy Star program relies on estimates of actual energy consumption over the course of a year. This requirement is obviously a barrier to the participation of new buildings in a labeling system. This impediment is particularly severe because for large buildings, the full occupancy may not be achieved until several years after construction.

The Russian Energy Passport also requires estimates of actual energy consumption. But, perhaps due to the newness of the program, such estimates are not available yet. So there is no evidence to date as to whether the requirement for adding estimates of actual energy consumption to compare with the projections is implementable.

Actual energy consumption provides the best added value in making markets work for energy efficiency by allowing comparisons, not just on an annual average basis but monthly, between projected energy use and actual energy use. For example, if the actual energy use is higher than the predicted energy use for a given level of intensity of usage and weather conditions, then it is a sign that something is not working correctly in the building. Perhaps an examination of installed equipment compared to specified equipment will show that the original design intent was not followed. Perhaps an evaluation will show that a piece of equipment is adjusted improperly or is malfunctioning or is worn out. Perhaps controls were installed improperly or not programmed correctly.

Indeed, examinations of month-by-month comparisons of projected and actual energy use can often provide “signatures” for specific types of malfunctions. Many of these malfunctions can be identified simply by the pattern of deviation between predicted and actual by month.

In some cases, the equipment needed to measure energy use can be integrated by the building’s energy management system to provide a very detailed comparison of projected and actual energy use, which can determine whether the installed equipment and the program-controlled strategies are working in the field the way they were intended, and provide instant feedback on how to correct them if they are not.

It also could be the case that actual energy use is lower than predicted. In some cases, this is because thermal comfort or other elements of indoor environmental quality are not being maintained at a sufficient level in the building. For example, reduced energy consumption might be due to inadequate ventilation or lighting, or due to uncomfortable thermal conditions in the summer or the winter.

Appliance and Equipment Labels. In the United States and the European Union, energy performance labels are also required for major appliances. In the United States, this requirement has been in existence since 1978. Labels are present on almost all major energy-using equipment, but are mostly ignored by consumers. Some studies have suggested that the U.S. labels are hard to understand by the consumer, who often is confronting the label only once in 10 or 20 years when their appliance breaks down and they need to purchase a new one.

Despite their relative ineffectiveness in influencing consumer markets, utilities operate incentive programs for energy-rated equipment and rely heavily on these ratings and labels to administer their programs.

Equipment labels appear to be more effective in the European Union. The labels are easier to understand, rating products by letters of the alphabet from “A” to “C” in terms of relative efficiency. Perhaps the European market is more sympathetic to environmental claims than the American market.

CHAPTER 6

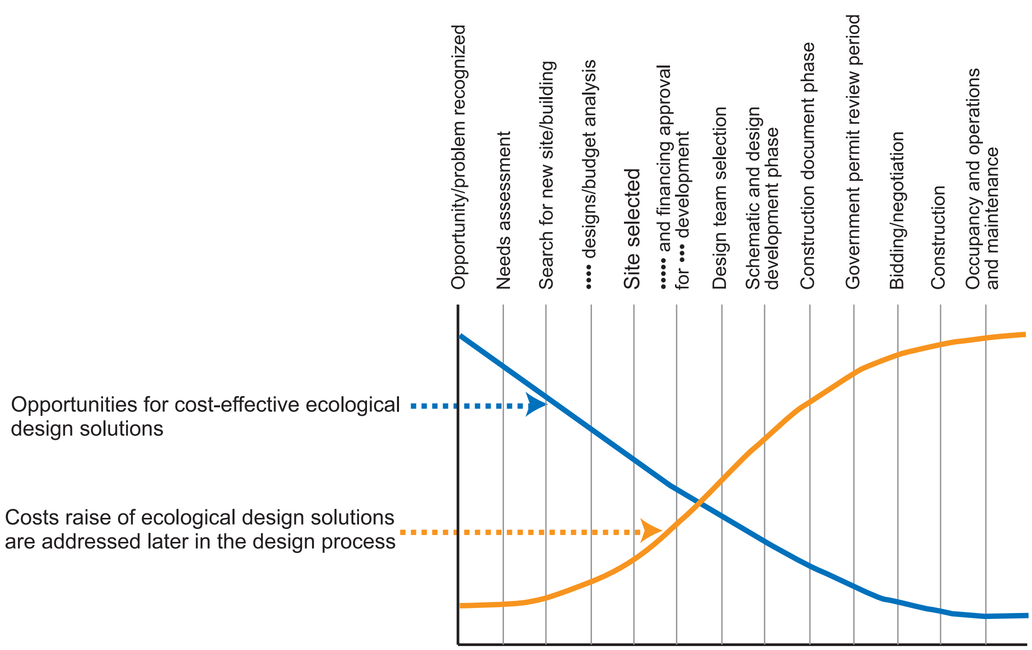
INCENTIVES

Energy efficiency markets are not generally well understood, and when they are understood, this comprehension tends to be on a theoretical level rather than on a practical level. Thus, it is hard to write an advance plan for "how to encourage energy efficiency" in a particular city in a particular type of building.

However, as a complement to energy codes, one of the most effective policies in the United States for encouraging increased efficiency in buildings is the use of financial incentives. In incentive-based systems, projects that achieve defined levels of increased energy efficiency are rewarded in some fashion. These rewards can be very broad in nature and provided over a long period of time, or they can be very targeted and be in effect for only a short while.

The necessary level of efficiency can be defined prescriptively, such as the required use of certain technologies, on a performance basis—for a subsystem, such as the watts per square meter used for lighting in commercial buildings; or on a building-wide basis, such as a percentage reduction from an energy code. Incentives can also be based on achieving the performance set out in building and equipment labeling and rating systems.

Figure 4: Opportunities to Influence Design



Design and construction of a building can take several years. Thus, a key question involves when to target incentives. As shown in Figure 4, the opportunities to influence the energy efficiency and green attributes of a building decrease further along in the project timeline.

Incentives targeted early in the process can result in large changes for relatively small cost, but it has been extremely difficult to identify and reach projects at this stage of development. Conversely, it has been much easier to find projects that have already begun construction, but it is much more difficult and expensive to alter their choices.

In addition, there are some trade-offs involved with how incentives are targeted. In general, program evaluation has shown that targeting incentives to producers of energy-efficient products or designers of energy-efficient buildings is more effective—more efficiency *and* lower cost. However, producer-targeted programs are much less visible and less popular programs than incentive programs that target consumers. If policy makers want to make a big splash and public gesture that they are saving energy, then they could offer a consumer-oriented program that is supplemented or complemented by a behind-the-scenes, producer-oriented program. Producer-oriented programs tend to be longer-term, while consumer-oriented programs tend to be shorter-term, in part because of the cost of maintaining the short-term programs.

LONG-TERM INCENTIVES

Many of the important decisions affecting energy efficiency, such as the orientation in massing of the building, its ability to use solar energy for natural daylighting or for passive solar heating, its ability to shade itself from excessive solar heat gains, the integrated design of heating, ventilation and air conditioning HVAC systems, and the insulation used in the building envelope, are made early in the design process. The actual energy savings of these choices will not be realized until the building is finished, which is often several years later.

Unless incentives are assured to be available in the future, structural efficiency measures will not be encouraged by economic incentives. In order to affect these long-term design processes, and in particular to allow better integration of the architectural design processes of the building and the various engineering design processes, long-term incentives are needed. In the United States, at least, about the only way to provide such long-term assuredness for incentives is through the tax system.

For example, if a building is being designed in 2002 with expected occupancy in 2005, an architect that is designing a system for greatly reduced heating and cooling loads would need to spend extra money, time, and effort on the design. They would not likely be able to do so unless they had some assurance that an incentive would be available in 2005 when the building is completed.[48]

The method that currently is being discussed in the U.S. Congress is to provide incentives at a fixed level of money (per dwelling unit or per square meter of occupied floor area) for a midterm length of time, such as six years. In S.207, a bill that has been used as basis for both Republican and Democratic energy legislation (H.R. 4 and S. 517), the amount of incentive provided is approximately 25 percent to 35 percent of the estimated costs of energy efficiency measures, based on conservatively high cost projections.

Several states are considering using the LEED rating system as the basis for providing tax incentives.[49] The proposals would offer an incentive equal to 4 percent of the building's construction cost as an incentive for achieving the LEED Certified level and up to a 7 percent credit for a Platinum achievement. New York state has an interesting way of incentivizing broader participation in green construction. Its tax law offers a 5 percent credit for the main structure of the building, but 7 percent if the tenants all participate.

If incentives are going to be frozen for a modestly long period of time, they should demand very high levels of performance that are uncommon or unknown in construction. If the incentives are based on levels that are currently being achieved by even a modest number of buildings, then the cost of the incentives will be relatively high due to "free ridership." In addition, it is quite possible that nearly 100 percent of the market will jump to the incentivized level of efficiency, which could become quite costly.[50] In this case, it may be more cost effective to incorporate this level of efficiency into the building code.

But if the levels of efficiency demanded are high enough, then even a 100 percent participation rate in the incentive will be good public policy because it will cause such a large change in the markets for energy-efficient designs and equipment that maintaining these levels should be sustainable after the tax incentive is phased out.

While it is important to establish incentives that will be fixed for a moderately long period of time, the incentives should not go on in perpetuity. Periodic evaluation of the successes and failures of the program is needed to offer possible midterm corrections. Perhaps the tax incentive program encourages the use of labels or ratings to such an extent that the market will continue to provide high levels of energy efficiency, even without the economic incentives. Perhaps the market will provide these results up to a certain level of efficiency, but further incentives will be needed for even higher levels in the future. Perhaps unforeseen problems or advantages will arise that should be considered in developing energy efficiency policy in the future.

Another key characteristic necessary for long-term incentives is that procedures for demonstrating compliance must be simple, but accurate. They can be based on the procedures used for demonstrating performance-based compliance with energy codes, with slight modifications to account for energy efficiency measures that policy makers might want to credit in terms of achieving additional energy savings but not credit in terms of making trade-offs against other minimum measures with the code.[51]

Tax incentives or long-term incentive programs should automatically generate labels and ratings that are designed to be useful in the marketplace. The types of documentation needed to establish compliance with the tax or administration authorities should also be useable, with minor adaptation, to meet the needs of the marketplace in crediting energy efficiency.

Nonmonetary long-term incentives can also be put in place. Examples of such incentives currently used in the United States allow increased development density for projects incorporating the LEED rating system. Other incentives used to spur early code compliance provided expedited construction permitting and project review.

SHORT-TERM MANAGED INCENTIVE PROGRAMS

Short-term, actively managed programs can have a number of advantages where the ability to adjust to unforeseen conditions is particularly important, such as in markets where incentives or efficiency codes have not been widely used.

Generally, electric utility companies or state energy conservation offices have been the principal sponsors of short-term managed incentive programs in the United States. Often these programs are offshoots of a policy that emphasizes energy conservation as a means to meet society's growing energy needs at a lower cost than the development of new energy supplies. With proper regulatory incentives, energy efficiency programs can be more profitable for utilities than purchasing power or building new generating facilities.

Utility incentive programs are considered "short term" when they are created with one-year budgets and renewal for the succeeding year is not assured. These programs are actively managed by the utility and can be changed to adapt to the observed conditions if the market is responding to the program differently than expected. These programs are most effective when they are administered in a flexible manner: operate the program based on an initial design, observe the results, and make changes as appropriate, given the market response.

Sometimes experience will determine that additional technical information or assistance is needed. Perhaps the incentive levels are too high or too low. This can be determined by market research and other analysis provided by the utility, the program administrator, state officials, or universities, as appropriate. The resulting adjustments to the program can be relatively simple or profound. If a program is found to be failing because of the lack of supplies, the utility can attempt to contact suppliers and provide encouragement for them to offer the product locally. To the extent that the regional market may be too small to interest suppliers, programs can be coordinated across regional boundaries to provide sufficient market power that is of interest to manufacturers.[52]

The higher success rate of the flexible approach has been the experience of U.S. utility-sponsored programs. They have been extremely effective at encouraging changes in the "last-to-be-built" components of the building, such as lighting systems, and can produce some relatively modest improvements in the HVAC system. Again, this is illustrated by the right-hand side of Figure 4. But they have been less successful in encouraging innovative HVAC system designs for the total system, and they will have very little impact at all in encouraging architectural changes unless specifically targeted in the context of going beyond code requirements—the processes of the left side of Figure 4.

Technology-Based Incentives

Technology-based programs are simpler to administer and evaluate than integrated, whole building programs. They can also produce very large energy savings quickly if comprehensively implemented. They are applicable to new construction and existing buildings in both the residential and commercial sectors. These programs risk failure through "cream-skimming" because by targeting the easiest energy savings, they can foreclose the option of installing the even larger, though more difficult to capture, energy savings that result from a more comprehensive approach.

Compact Fluorescent Lamps

The success of compact fluorescent lamps (CFLs) in penetrating the U.S. market is attributed to several factors, including utility incentives, especially among residential consumers. According to the Electric Power Research Institute, utility incentives were estimated to be involved in half of integral CFL sales in 1991. However, in the commercial sector, utility incentives are less pervasive, since there is a greater economic incentive to purchase CFLs because of the high usage levels and the maintenance cost savings from having to change the bulbs much less often.

Windows

In California, utilities intervened to speed the introduction of low U-value windows. They did this not only by providing incentives for the thermally improved windows, but also by funding the creation of a window-testing infrastructure. The test procedures for labeling windows required computer simulation and then physical testing of a sample of windows. But when the program was being developed, there were no laboratories in California certified as being qualified to do the testing. The utilities helped create this testing infrastructure, which in turn led to the availability of labeled windows that could be used for code compliance.

Lighting

For nonresidential buildings, utilities achieved dramatic successes in the mid-1990s in incentivizing the use of new lighting technologies that allowed lower power densities in non-residential buildings. The 1992 code in California required less than 17 watts per square meter of connected lighted power. But, due to utility incentives, a large number of buildings were constructed with power densities in the range of 10 to 12 watts per square meter. This allowed the California Energy Commission in 1998 to adopt a reduction in the maximum power standard to 13 watts per square meter with no opposition from the lighting or building industries.[53]

Whole-Building Incentive Programs

Many of the most successful utility programs in the United States have achieved their success through active management. One of the best examples is the California new construction program operated by Pacific Gas & Electric Company, which modified its program design sufficiently that by the mid-1990s it was achieving well over 50 percent market share of participation in its new construction program.

Super Good Cents (SGC) was a voluntary regional program initiated by the Bonneville Power Administration (BPA) to encourage early adoption of the ambitious new Model Conservation Standards (MCS) in the Pacific Northwest of the United States. At first, this program encouraged builder familiarity with higher levels of efficiency and created markets for new building supplies. Later, utilities agreed to pay for compliance with the codes even after it was required for a period of 18 months. This offer to ease the pain of transition for builders was instrumental in achieving credibility and widespread compliance with the codes.

In 1992, Seattle City Light implemented the SGC conservation program in the multifamily sector because of very high construction rates. Seattle then used its experience with the SGC program to develop new specifications and terms for a replacement program. The Built Smart program for energy and resource efficiency in multifamily new construction projects began operation in spring 1997.

Seattle's evaluation of SGC found that the program provided significant benefits: tenant energy savings of more than 17 kWh/m2 and annual energy savings to the owner from common-area lighting of 16 kWh/m2. Energy bill savings for program participants with buildings completed in 1993 to 1994 amounted to $75 per unit for tenants and $50 per unit for building owners.[54]

Despite this success, the evaluation recommended that SGC could be improved by developing ways to underscore the value of improved energy efficiency in participating building through follow-on services.[55]

INDUSTRY COLLABORATIVES

The Super Efficient Refrigerator Program (SERP), also known as the Golden Carrot Program, was the result of a broad-based partnership between NRDC and other NGOs, the federal government, and electric utility companies. The Golden Carrot Program coordinated utility incentives to stimulate the development and commercialization of advanced technologies and superior efficiency levels. The first Golden Carrot Program was a competition among manufacturers of refrigerators that resulted in the design and production of refrigerators that were 30 percent to 40 percent more efficient than the 1992 standard for comparable-sized conventional units.

The SERP product became the design basis for the 2001 DOE national refrigerator standard, which is now in effect. Interestingly, for the first time in history, U.S. manufacturers agreed to accept a standard at the 2001 level. Previously, they had opposed all proposed energy efficiency standards. The result was a fourfold improvement in energy efficiency between the mid-1970s and 2001, which came in the face of continually increasing size and features and declining price (in inflation-adjusted dollars).

Similar approaches are being used for products such as high-efficiency gas and geothermal heat pumps in the DOE's Technology Introduction Partnerships.[56] The success of the Golden Carrot Program strengthened efficiency standards and the existence of promising advance technologies. This program rewarded manufacturers in producing refrigerators with higher efficiency standard than required.

The Consortium for Energy Efficiency (CEE), is a national nonprofit public benefits corporation that promotes the manufacture and purchase of energy-efficient products and services. The CEE's goal is to induce lasting structural and behavioral changes in the marketplace, resulting in the increased adoption of energy-efficient technologies.[57]

CEE members include utilities, statewide and regional market transformation administrators, environmental groups, research organizations, and state energy offices. Also contributing to the collaborative process are CEE partners—manufacturers, retailers, and government agencies. The U.S. Department of Energy and the U.S. Environmental Protection Agency both provide major support through active participation as well as funding.

PROCUREMENT PROGRAMS

Procurement programs involve large purchasers setting internal standards for the goods and services they obtain in the market. These standards can be based on a label or rating system, such as LEED or Energy Star, or they can be based on a certain benchmark, such as percentage of recycled content or renewable energy purchased or exceeding miles per gallon regulations by a certain amount. Government entities, large corporations, and even electric utility companies tend to be the major participants in procurement programs.

In addition to the market transformation role government plays in setting standards, government can also help transform the market as a major consumer of goods and services. For example, Presidential Executive Orders 12873 and 13101 almost single-handedly established the market for recycled paper by requiring that all paper used by the government contain a minimum of 20 percent then 30 percent recycled fiber.[58]

Similarly, at least six federal Executive Orders[59] govern energy efficiency in federal buildings, transportation fleets, and other energy and environmental aspects of government operations. State and local governments likewise are significant market drivers. About 30 percent of the LEED projects are some type of government building. The architects, engineers, construction companies, and product manufacturers involved with these projects all carry the experience of working on an energy- and environmentally efficient building into other projects, thus producing a significant "free driver" effect.[60] While procurement has not been used as heavily as direct consumer or manufacturer incentives in the United States, it has played a significant role in a few market transformation programs.

One of the earliest and most noteworthy of such programs is ENERGY STAR computers. In one of the first uses of the normative label "ENERGY STAR," the U.S. Environmental Protection Agency established a specification for energy efficiency computers in the early 1990s. A key step towards making this program successful was a U.S. government procurement decision to exclusively buy computers that met the ENERGY STAR level shortly after it was introduced. This encouraged manufacturers to design to the ENERGY STAR specification. Once they had done so, it was easier to sell all of their products at the complying level than to maintain separate product lines for a trivial difference in cost. This program was quite successful, with the overwhelming majority of computers complying with the specification.

SERP could also be considered a procurement program. SERP was a consortium of utilities that offered a $30 million competition for manufacturers to produce the most energy-efficient and environmentally clean refrigerator that they could; based on program designs put together by the U.S. EPA, the Washington State Energy Office, and NRDC, with strong participation from the American Council for an Energy Efficient Economy, the utilities designed the equivalent of a competitive procurement of some 200,000 refrigerators. The entire contract would go to the single refrigerator manufacturer that offered to sell the most cost-effective "green" refrigerators—the ones that saved the most energy for the least amount of payment per unit. SERP received 14 bids, selected two finalists, and offered the contract to one winning refrigerator company. This program led the way to the 2001 DOE energy efficiency standard and to the existence of ENERGY STAR–rated models that save 10 percent to 15 percent more than required by that standard in the year 2001.

There are limits to the effectiveness of procurement programs in the absence of broader market-based and regulatory tools, especially if present alternatives are perceived as preferable. The purchase of alternative-fueled vehicles in government fleets, for example, had little impact on overall market penetration of this technology beyond the vehicles purchased by the government. There can be many reasons for this failure: lack of market acceptance, inferior performance, inconvenience, noncompetitive price, etc. For this reason, it tends to be preferable to specify a certain level of performance and allow the interplay of consumers and producers to find the best solution.

EDUCATION/INFORMATION/TRAINING PROGRAMS

Education/Information/Training (EIT) programs are necessary, but not sufficient components to any market transformation strategy. Education programs are distinguished from training programs in that they are focused on students preparing to become practitioners, while the training tends to focus on professional development. Information programs have two principal targets: (1) information and analysis about energy trends in consumption, production, and price are targeted to policy makers and advocates; (2) consumers, either as individuals or procurement agents for larger entities, are provided information about energy in general and specific to certain technologies. Too often the expectations of EIT programs are set either too high or too low.

When the expectations are set too high, EIT is used as a lower cost substitute for more substantial programs that put actual technology in the hands of users. The assumption is that with a certain kind of knowledge, market participants will act a certain way. This assumption flies in the face of reality, which is that the lack of EIT is only one of the barriers to increased penetration of ideas or technology.

When expectations are set too low, EIT is avoided altogether and people misapply good technology or ideas or pursue unrealistic or ineffectual policies. Then because they don't work properly, otherwise good building design ideas or technologies are abandoned or underused.

Energy Efficiency Demonstration Centers

One particular kind of targeted education, the efficiency demonstration center, appears to be quite effective at influencing the markets toward greater energy efficiency. Such centers target commercial sector users. Some examples include:

- The Seattle Lighting Design Laboratory
- The Pacific Gas and Electric (PG&E) Energy Center
- The Southern California Edison Customer Technology Application Center
- The Southern California Gas Company's Energy Resource Center

These centers provide hands-on educational and demonstration materials concerning equipment and design practices for increased energy efficiency, provide lectures and reading materials to promote efficiency, and conduct user-oriented demonstrations of energy efficiency, including in some cases mock-ups of user lighting designs. In some cases, they provide direct consulting services (although not explicitly building design) and a library of materials.

Two evaluation studies have recently been issued concerning these centers, both of which find significant positive market response:

- The PG&E Energy Center Market Effects Study[61] concluded "the [Energy Center] is responsible for significant changes in relevant market-related behaviors. Substantial portions of relative decision makers responded to surveys that they were specifying more efficient equipment and that this change was due entirely or in part to the Energy Center's influence. Eighty percent of respondents said that the changes [in their behaviors] had influenced at least one commercial building. More than 20 percent said that the changes in behavior had influenced 21 or more buildings. An even higher percentage (32 percent) said they felt the change would influence 21 or more buildings over the next two years."

- The CTAC study[62] concluded, "CTAC's market intervention strategies appear to be linked to a reduction in barriers to market effects [originally hypothesized.]" This study places a relatively greater emphasis on identifying market barriers and evaluating the extent to which these barriers were overcome.[63] Based on customer interviews, the study concluded that "nearly all [respondents] agreed that awareness had significantly increased and...[m]any felt strongly that increases in demand have been observed for energy efficient lighting equipment…[and that] some HVAC manufacturers...report that sales of energy efficient HVAC equipment have been positively influenced by utility programs."

Education Program Examples

Most state energy offices have energy extension programs that provide consumer information for distribution to retailers, schools, libraries, and other information outlets. For many years, these programs were supported by special government funds established when it was found that oil producers had been price-gouging consumers. Currently, these programs are co-funded between the federal and state government budgets.

Texas Energy Education Development (TEED). TEED, a nonprofit organization, is the Texas affiliate of the National Energy Education Development (NEED) program. TEED is unique among curriculum-related programs because it combines a "hands-on," out-of-classroom series of activities and projects with a comprehensive classroom curriculum suited for use in science, math, social studies, language arts, and special education. Utilizing a "Kids Teaching Kids" philosophy, schools (K-12) teach themselves, their fellow students, and the community about energy resource issues and energy conservation. The school projects are submitted annually to the Texas Association of Student Council and are eligible for state and national awards.

Highlights of the TEED program:

- An Energy Kit of resource material for energy conservation projects and activities
- Community Weatherization Project for Low-Income Housing
- Awards program in conjunction with the Texas Association of Student Council
- Annual Summer Energy Camp for high school students
- READ with TEED Curriculum Book aligning energy materials with all disciplines in the classroom
- Governor's Proclamation/visit to the Capitol to declare March as "Texas Energy Education Development" Month
- TEED Scholarship Program

Policy Information Program Examples. As noted above, information programs can have two primary focuses: decision makers and consumers. For example, the New York State Energy

Research and Development Authority[64] (NYSERDA) provides general energy statistics and data on energy consumption, supply sources, and price and expenditure information for New York state and a comprehensive set of New York state–specific energy statistics. In addition, the Energy Analysis Program focuses on using energy, regulatory, and environmental policies to help New York state businesses grow and to meet the needs of New York state's energy consumers. Energy Analysis Program staff analyze important energy issues, publish comprehensive statistics and data, and respond to energy supply disruptions or shortfalls. Staff are viewed as a source of objective information about all aspects of New York's energy picture.

In addition to providing timely and relevant analytical information, NYSERDA Energy Analysis Program staff study current energy issues to assess energy requirements and available supplies to determine their effect on the state's economic and environmental well-being. For example, Energy Analysis staff participated in a national policy dialogue in cooperation with the Center for Clean Air Policy, utilities, state agencies, and public interest groups from across the United States to determine the effects that restructuring the electric industry could have on air quality, electric system operations, and consumer costs.

Energy Audit Information Programs. Energy audits are another kind of information that can be provided by government entities to consumers; in this case, building owners. Generally, audits are conducted on a cost-share or free-of-charge basis. This analysis provides insight to the most cost-effective and feasible ways to save energy. The results of this kind of analysis can also be very useful to policy makers.

For example, when evaluating the impact of energy efficiency measures on a commercial building in Beijing, the analysis showed that energy consumption for heating was extremely small, while energy consumption for lighting and cooling was extremely large. Up to this point, it was believed that heating was the dominant energy factor in commercial buildings, and early attempts to develop a commercial building energy code had focused on measures to reduce heating energy consumption. In the absence of this new information, a significant public policy opportunity could have been missed.

The California Bright Schools (CBS) Program helps schools with upgrading to energy-efficient equipment. CBS provides information and evaluates the work needed. The California Energy Commission, California Conservation Corps, the local utility company, and other qualified energy service companies (ESCOs) have teamed up to guide schools through the steps of an energy upgrade project:

- Identifying and determining a project’s feasibility
- Securing financing for the project
- Purchasing and installing the new energy-efficient equipment.

The schools receive the following benefits from the program:

- Improved classroom comfort for a better learning environment
- Energy cost savings accrue year after year to use for other school needs
- Free energy audits and energy usage consultation
- Integrated package of project planning and management services

- Assistance in securing best financing options
- New school design review assistance
- Bulk pricing on energy-efficient lighting equipment purchases through the state's Office of Procurement
- Procurement assistance on selected equipment purchases
- Low cost installation by trained professionals

School districts through this program received more than $150,000 in utility energy efficiency rebates and more than $115,000 through energy-efficient projects each year.

CHAPTER 7

APPLYING THE TOOLS OF MARKET TRANSFORMATION TO SPECIFIC MARKETS

To transform the Chinese building market for energy efficiency, policy makers will need to apply the various tools discussed above to the various markets described in Table 1. Although China's construction industry is much more centralized than that of the United States, Chinese building markets are still essentially local in nature as is the case in the United States. These measures will need to be adapted locally to achieve full penetration of the market.

Table 5 lists the most successful tools that have been used to improve energy efficiency in the different building markets. This table distinguishes appliance and equipment markets from the buildings markets because the policy and programmatic measures used to improve efficiency can be applied independently, although greater results can be obtained through the synergy of a combined approach.

Below we will evaluate each of the tools as they apply to (1) New Commercial, (2) New Residential, (3) Existing Commercial, (4) Existing Residential, and (5) Appliances and Equipment.

Table 5: Tools of Market Transformation Applied to the Building Sector

Buildings	**Commercial**	**Residential**
New	Building Codes Incentives Labeling ETI	Building Codes Incentives Labeling ETI
Existing	Standards Incentives Labeling ETI	Standards Incentives ETI
Appliances & Equipment	Standards (mandatory within codes; voluntary) Incentives Industry Collaboratives Labeling Procurement Programs	

NEW RESIDENTIAL BUILDINGS

Residential buildings account for 21percent of U.S. energy consumption.[65] In China, this sector consumes approximately 13 percent of the nation's total energy.[66] Nearly 400 million square meters of residential construction are on going in China at any one time.[67]

Figure 5: Super Good Cents: Standards and Label Incentives and EIT=Code

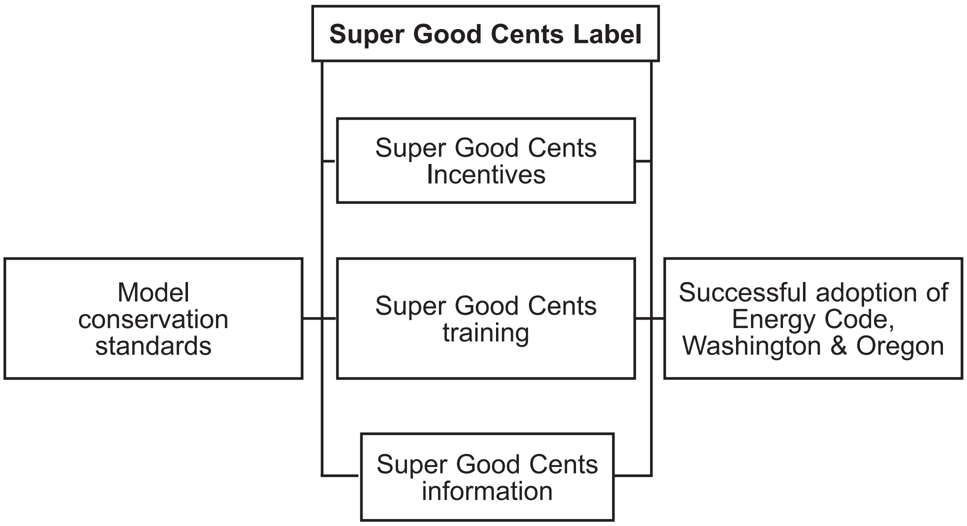
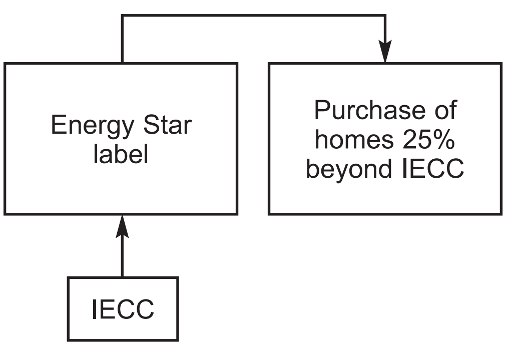


Figure 5 illustrates how the Super Good Cents program successfully used incentives and training to ensure rapid adoption and widespread compliance with a new energy code. The Energy Star label identifies homes that are 30 percent more efficient than the IECC. The Energy Star program has rated approximately 40,000 homes since its inception in 2000.[68] The interplay between the different market transformation tools is shown in Figures 6 and 7.

Figure 6: Energy Star Homes: Code and Label = Beyond Energy Savings



NEW COMMERCIAL BUILDINGS

Commercial buildings account for approximately 17 percent of U.S. energy consumption.[69] In China, this figure is approximately 9 percent of total consumption, but is forecast to grow rapidly with China's accession to the WTO.

For the commercial sector in the United States, the New Buildings Institute estimates that savings this year exceed $775 million per year, or 1 percent of the commercial sector's entire utility bill. This is all the more remarkable of an achievement because the typical codes in use in the United States are not very stringent in their energy efficiency requirements.

Figure 7: Existing Residential

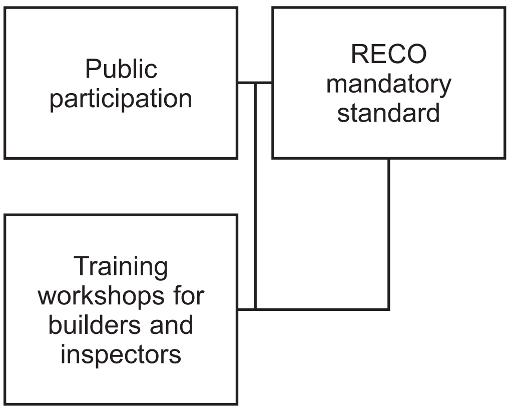
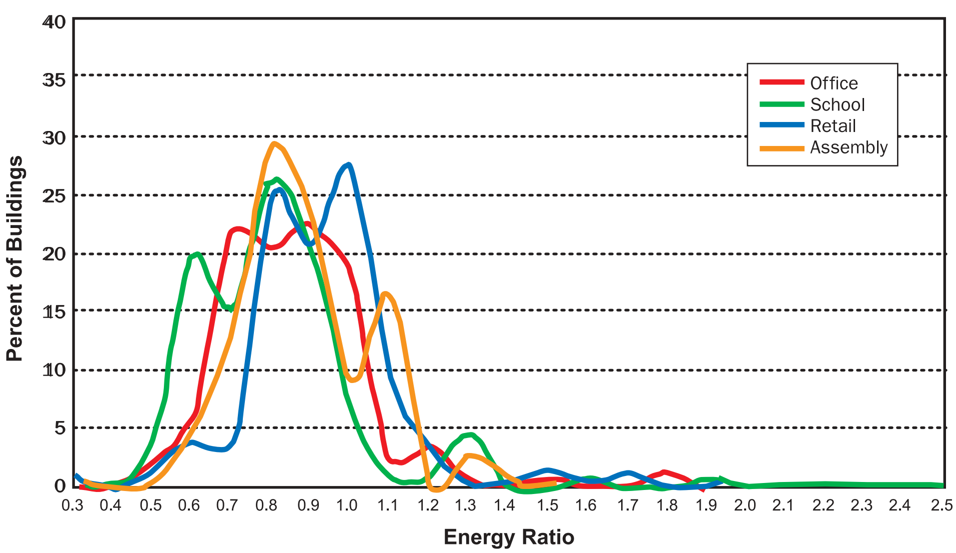


Figure 7 is a frequency distribution of building energy use compared to the energy code in California in the mid-1990s.[70] It illustrates, for four different building types, what percentage of buildings consumed a given level of energy compared to the energy code. The scale on the "X–axis" of 1.0 indicates a code-compliant building. Energy ratios of, for example, 1.3, indicate 30 percent more energy consumption than would be allowed by code; an energy ratio of 0.7 indicates 30 percent savings.

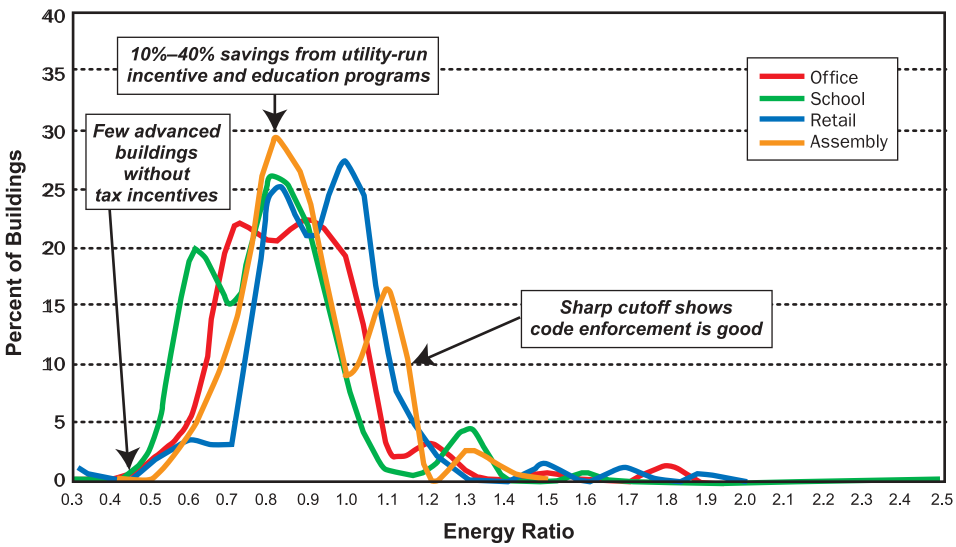
Figure 8: Distribution of Building Energy Use Compared to Code: California 1990s



This graph was prepared from data collected in California in the mid-1990s, when there was an active program of energy code outreach and enforcement along with utility-based incentives. As shown in Figure 8, the result is entirely consistent with the theories discussed in this paper.

The first noteworthy result observed from the graph is the sharp cutoff of buildings with energy ratios above 1.0. With the slight exception of schools, where enforcement of the energy code is not fully mandatory, we can see that the overwhelming majority of buildings comply with the code. Even those that fail to comply are typically only a few percent out of compliance. This shows good code enforcement. Good enforcement has been complemented by extensive training and education programs promoted by the California Energy Commission.

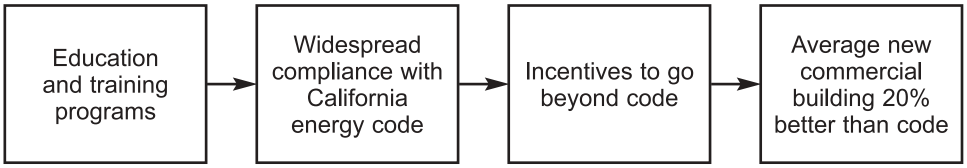
Figure 9: Interplay of California Building Code with Market Mechanisms



The second noteworthy observation from the graph is the broad plateau between code compliance (an energy ratio of 1.0) and 40 percent savings (an energy ratio of 0.6). Most buildings do not merely comply minimally with the code, but save 10 percent or 20 percent or 30 percent, or even 40 percent beyond the code. This is consistent with the widespread use of short-term incentives and education and outreach programs during the mid-1990s by California utilities.

A third observation from the graph is the sharp drop-off of buildings at energy ratios of .5 or lower (equivalent to 50 percent or better energy savings). This is not unexpected given the absence of long-term incentives. Indeed, the regulatory environment for utilities was so volatile at this point in history that the utilities were not in a position to make even informal commitments about the availability of the incentives two or three years in the future.

Figure 10: Code and EIT and Incentives = Beyond Code Energy Savings



The paucity of buildings saving 50 percent or more is not an indication of the technical limits on energy efficiency, however. NRDC designed new buildings for our own occupancy in the late 1980s and mid-1990s, relying only on technologies and designs that were available in the marketplace and had a financial rate of return higher than NRDC's cost of borrowing money for construction. Our buildings saved between 70 percent and 80 percent compared to the code, clearly demonstrating that the limiting factor on large energy savings is not technological or economic.

EXISTING RESIDENTIAL BUILDINGS

This is one of the toughest markets to penetrate comprehensively because they are very diffuse, essentially comprised of millions of households. Major architectural elements are difficult and expensive to retrofit, particularly in a multifamily market. The largest and most easily captured potential to reduce residential energy consumption resides in new appliance and equipment mandatory standards, as described below. Incentive programs do work for existing households but are expensive and complex to administer.

The U.S. Department of Energy's Rebuild America Program facilitates voluntary community partnerships in improving their buildings through energy efficiency. When communities, businesses, and housing agencies form Rebuild America partnerships, they tailor their programs to local needs and choose which buildings to renovate, how much energy to save, and the best technologies to use. Rebuild America lets partnerships select the best ways to improve their communities. Rebuild America supports partnerships with technical and business experts, resource materials, and a national network of peers who are working on the same issues and developing innovative solutions.[71]

Rebuild America focuses on six different market sectors: colleges and universities, kindergarten through twelfth-grade schools, state governments, local governments, commercial buildings, and housing. Each of these sectors represents a particular customer group that has similar or related characteristics, common needs, and responds to the same motivation.

An example of a Rebuild America Program implementation is the Knox Housing Partnership, Inc. (KHP), a private, charitable corporation facilitating affordable housing for low-income residents of Knoxville and Knox County, Tennessee. KHP teamed with Knoxville's Housing Development Corporation (KHDC) to undertake a joint housing revitalization project involving 146 single-family detached homes that will revitalize two inner-city neighborhoods. The goal of the $6.8 million project is to bring renters into home ownership by providing a pool of quality, affordable housing and assisting families in obtaining below-market rate financing. More than two-thirds of the revitalized homes are being sold to the existing renters or other low-income buyers. The remainder of the houses are being made available for continued rental to current clients to avoid displacing those who cannot afford to or do not wish to move into home ownership. The results of this program are shown in Table 6, below.[72]

Table 6: Monthly Housing Costs Before and After KHP Rehabilitations

	Before rehabilitation	After rehabilitation
Rent/mortgage	$260–$325	$270–$430
Energy costs	$100	$66
Total housing costs	$360–$425	$336–$496

Some communities have developed mandatory programs for improving the energy efficiency of existing residential buildings. In 1981, the California city of San Francisco adopted the Residential Energy Conservation Program (RECO), a prescriptive code designed to improve the energy efficiency of existing housing. RECO has reduced the amount of energy the average home uses in San Francisco by more than 15 percent, without any cost to the city treasury.[73]

RECO has proven to be simple to understand and easy and inexpensive to enforce. RECO requires such energy-saving measures as adding insulation; caulking and weather-stripping doors, windows, and other openings in the building shell; insulating hot water heaters and pipes; installing low-flow faucets and shower heads; installing low-flush toilets or flush reducers on existing toilets; and insulating heating ducts. Once RECO is triggered, homeowners or landlords must hire a private contractor to install the prescribed energy efficiency measures or do it themselves. A compliance inspection is then required to assure the work was completed.

Several events can trigger the need for compliance with RECO, including the sale of a building; metering conversions (changing from a master to individual meters, for example); improvements greater than $20,000 for single and two-family homes, $6,000 per unit for buildings with three or more units, or $1,000 per unit for residential hotels; condominium conversion; or a complete building inspection (for adding or combining units, for instance). To give the ordinance teeth, an Order of Abatement can prevent the transfer of property unless the owner complies with RECO.

In spite of initial sharp opposition from the real estate community, the ordinance is now a routine part of doing business in San Francisco. Acceptance was helped along by extensive publicity, an informed public, involvement of the private sector from the beginning and training workshops for both city and private inspectors. The simplicity and cost-effectiveness of the measures required for compliance also play a part in RECO's success.[74]

EXISTING COMMERCIAL BUILDINGS

RECO has a commercial building counterpart, the commercial conservation ordinance, aptly named CECO. RECO established the political and administrative basis for CECO, which took effect in July 1989. The story of San Francisco's Commercial Conservation Ordinance illustrates the complexities of designing energy standards for use in a competitive commercial real estate market.

California mandates energy efficiency standards for all new buildings, but does little to improve the performance of buildings already built. Support to find ways to conserve energy was strong in San Francisco, but translating energy efficiency policy into a workable ordinance presented some challenges. Commercial codes are more complicated than residential ones, and the city is examining the commercial ordinance to simplify its requirements and streamline its enforcement.

Presently, the events that can trigger CECO review and enforcement include the transfer of a building's title, an addition to a building that increases the heated space by more than 10 percent, and renovation and improvements valued at more than $50,000. After a trigger event, CECO review is required. A private inspector conducts an inspection for a fee and identifies the areas of the building that do not comply with the ordinance. The building owner must then implement prescribed energy efficiency measures up to a simple payback of four years.

Small Business Standard Performance Contract Program (SBSPC). The SBSPC is a statewide incentive program in which third-party (*i.e.*, non-end user) project sponsors are paid for measured, verified savings, based on a fixed schedule. End users cannot self-sponsor projects. A minimum savings of 20,000 kWh per year is required for an application. Aggregation of like customers is allowed and encouraged. A standard contract between the program administrator (utilities) and third-party sponsor specifies incentives, simplified performance measurement and verification (M&V) options and protocols, payment terms, and other operating rules. Sponsors are responsible for M&V. Incentives (specified amounts per kWh saved) are paid to project sponsors, with 40 percent after installation and 60 percent after one year, based on verified savings. The project sponsor incentive includes a fixed "participation incentive" of $1,000 for lighting projects, $2,500 for HVAC projects, and $1,500 for motors/other.[75]

Table 7: Basic Program Data Summary for 1999 California SBSPC Program*

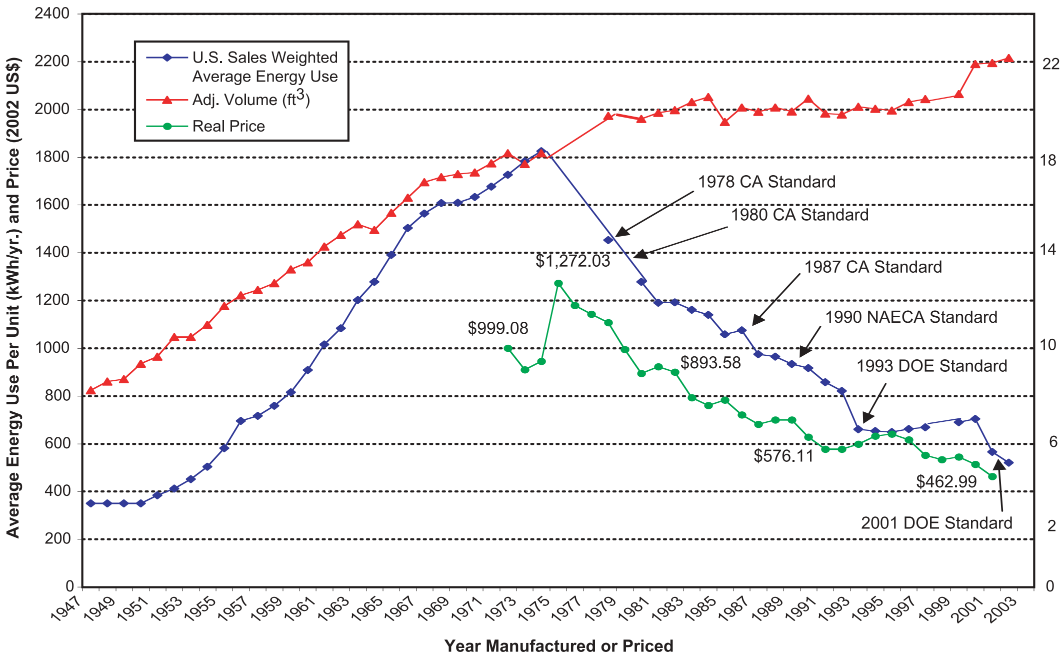
Utility	Applications	Total Incentives	Customers
SCE	91	$768,510	56
SDG&E	20	$234,834	21
PG&E	70	$698,919	62
Total	181	$1,702,263	139

*Notes: These figures are based on data received by the authors from the utilities in early 2000 and are not official figures. Final official participation figures for 1999 will likely differ slightly from those reported here.[76]

APPLIANCES AND EQUIPMENT

Figure 11 shows the evolution of refrigerator energy use in the United States over the past 60 years. Up until the mid-1970s, refrigerator energy consumption was increasing at an annual rate of more than 6% compounded. This increase was due to a growth in size and in features, as well as an absolute decline in energy efficiency. Had this growth trend continued until today, refrigerators would be consuming more than 150 GW of electricity in the United States, well above the output of the entire U.S. nuclear energy program.

Figure 11: Trends in Refrigerator Energy Consumption



This trajectory changed dramatically with the adoption of energy efficiency standards by California in a proceeding that took place in 1975 and 1976. These standards influenced the market for refrigerators nationwide, as manufacturers quickly realized that it was cheaper to comply with the California standards nationwide than to produce separate products for different states.

The California standard was based on the most efficient products at the time. Ironically, they were introduced by a manufacturer who marketed their advantages in terms of greater energy efficiency, but was unsuccessful in the marketplace; it eventually went out of business.

Following 1980, the shallow slope towards more efficiency was likely encouraged by utility-based incentives for products that were 10 percent or so better than the standards. Utilities in California, several states in the Pacific Northwest, and New York set new standards in 1984 with effectiveness dates of 1987 and 1992. These were nationalized with a three-year lag time for the first tier, and contributed to the observed drop in energy consumption at these dates.

CHAPTER 8

FUNDING MARKET TRANSFORMATION ACTIVITIES IN CHINA

Funding sources for market transformation tools can be as diverse as the tools themselves. Funding for standards development can come from the government at the national or province level. The macroeconomic benefit-cost ratio to governments for establishing energy efficiency standards is on the order of 100:1. It is also possible that a professional engineering or design association may wish to use its funds and donation of in-kind expertise to develop an energy standard, if there were some reasonable expectation that it would be received well at the Ministry of Construction.

Government can also be a source of incentives. Indirect monetary incentives, such as tax credits, or reduced tax rates reduce government revenues but do not require additional budget to achieve. Similarly, local governments can use nonmonetary, but still valuable, incentives, such as increased density allowances and expedited permitting and review. In the United States, the largest source of building market transformation incentives has been the electric utility industry, which was putting up to $2 billion per year into this area at the peak of activity. These funds were supported by very modest increases in electricity tariffs of less than 3 percent. NRDC coauthored an extensive discussion of utility funded programs in the Chinese context.[77]

Energy and environmental labels or ratings for buildings and equipment can be funded in similar ways to the development of standards. A government-sponsored label, such as Energy Star, would be funded out of the government budget, while a privately sponsored rating system, such as LEED, would be developed using the resources of an organization like the U.S. Green Building Council. For example, if a group of enterprises and government agencies wanted to form an independent China Green Building Council, they could fund the development or adaptation of a green building rating system similar to LEED.

Procurement programs require little to no additional funding beyond normal budgets for materials and equipment, the only difference being the emphasis on certain levels of energy and environmental performance in the purchased materials.

Industry collaboratives would be funded through voluntary in-kind contributions from participating entities that could be covered within existing staffing levels or the creation of new positions, depending upon the level of commitment of the participant.

CHAPTER 9

CONCLUSION AND RECOMMENDATIONS: A COMPREHENSIVE POLICY FOR ENCOURAGING ENERGY EFFICIENCY IN BUILDINGS

China is already engaged in several of the market transformation activities mentioned in this paper, although in an uncoordinated fashion. A comprehensive policy to improve energy efficiency in buildings should be based on the following elements that have been shown to be effective instruments for promoting improved comfort and building performance, as well as ever-increasing levels of energy efficiency. China could be the first nation to fully implement such a comprehensive program.

1. The first step is to develop standards that encourage performance-based compliance and achieve 30 percent-50 percent energy savings compared to prevailing practice. China has already completed or is actively pursuing the development of standards for residential buildings in the heating, cooling, and transition zones. Plans also exist to begin development of a commercial building standard. In addition, China also has developed voluntary energy efficiency performance standards for air conditioning equipment, refrigerators, and certain lighting products. China should identify emerging trends in equipment energy use and develop standards to reduce energy consumption of these devices.
2. The next step is to develop mandatory codes based on these standards. This will require moving energy standards into the same legal category as health, life, safety, and structural standards. Compliance with the performance standards should be universally required as a prerequisite to building occupancy or to the sale of equipment or appliances in the market.
   - Agencies in authority should plan now for regular revisions to the standards to achieve higher levels of efficiency in the future.
   - Standards should include criteria for energy ratings through associated labeling, rating, and incentive programs as part of the performance approach.
3. Through government agencies or by encouraging professional associations, China should develop its own simple normative labels to distinguish the most efficient buildings and equipment. As a complement to normative labels, informative labels that can be used to establish the entire range of energy values in the marketplace should be developed.

4. The Chinese government should establish procurement programs based on normative and informative labels that require the purchase of the most efficient equipment or appliances and design of the most efficient buildings for use by government agencies. Incentives could be developed for large enterprises to participate individually or collaboratively.
5. Short-term, managed incentive programs should be developed through government agencies or the electric and natural gas utility industries that promote modest improvements (about 15 percent to about 30 percent beyond the standards) based on labels or voluntary beyond-code standards.
6. Tax incentives or other long-term, fixed incentives for achieving 50 percent to 75 percent savings beyond the code, possibly based on labels or rating systems, should be approved by the government.
7. China should continue its efforts in research and development of new technologies and the implementation of innovative design principles.
8. In conjunction with the development of energy codes and standards, education, outreach, and training of designers, engineers, builders, and code officials should be budgeted for and staffed as an integral part of the code development process. These programs could possibly be funded through multilateral development bank loans or grants from the World Bank, in conjunction with its municipal heating system reform project or as a separate proposal to the Asian Development Bank.

ENDNOTES

[1] These basic markets could also be subdivided a number of ways, but this is unlikely to add much to the discussion.

[2] These are called "public buildings" in China.

[3] From an energy perspective, high-rise multifamily dwellings tend to behave more like commercial buildings, so they are generally included in programs and policies directed at commercial buildings in the United States. For the purpose of this paper, we will address multifamily high-rise buildings in the residential sector because developers of multifamily high-rises are also the primary builders of low-rise housing, which has much different energy use and characteristics.

[4] Construction requirements are set at the state and local level in the United States Energy efficiency standards for new buildings are employed at the state and local level in virtually all of the 50 states. Model standards developed by the federal government and professional associations do exist, but first must be adopted into local or state regulations before becoming mandatory. The U.S. Department of Energy (DOE) assists states and local code jurisdictions in upgrading their building standards and improving their implementation and enforcement.

[5] Energy Policy Act of 1992, Pub. L. No. 102-486, 106 Stat. 2776 (codified as amended in various sections of 15, 16, & 42 U.S.C.). [Hereinafter EPAct].

[6] Although called "international," in practice, the code only serves the United States and Canada.

[7] These estimates of energy savings from California's codes are conservative because they assume that the energy code remains fixed at the level most recently adopted. It is common practice for codes to be revised every three to five years to include higher levels of energy efficiency. Because the savings from these future revisions are hard to predict, they are not included in projections of energy savings.

[8] Warren Alquist Act of 1975 (Public Resources Code Section 25001 *et. seq.*).

[9] Passive solar houses with an exception to the glazing area restrictions because with proper orientation and thermal mass, more glass leads to reduced rather than increased energy consumption.

[10] See section VI.C.1 and 2 on pp.15 and 16 for a discussion of prescriptive and performance-based energy standards.

[11] Department of Energy, "Tomorrow's Energy Today for Cities and Counties: Commercial Energy Codes Lay Foundation for Saving Money 3" (February 1995). [Hereinafter Commercial Codes].

[12] "Residential New Construction Study,." prepared by Regional Economic Research, Inc., San Diego, CA, for Pacific Gas & Electric, September 10, 2001.

[13] Commercial codes, note 14, above at 4.

[14] Personal communication with Robert Kelly, technical director, National Conference of States on Building Codes and Standards.

[15] For example, the requirement that hot and cold air distribution ducts in homes in California be tested for elimination of air leakage was phased in over a six-year time period. During the first three years, the method was optional and could be used to trade off against other energy efficiency measures. During the second three-year period, it was required.

[16] A building, for example, that fails to meet the prescriptive requirements for most of its components, and fails by a significant margin, is unlikely to gain compliance through the performance method if it does better than the code in only one attribute. A building that purports to do this should be subject to much more careful scrutiny to determine whether it really complies.

[17] However, improvements in calculated energy performance consistently lead to improvements in actual energy performance. That is, while any individual energy-efficient building may use more heat than any individual nonenergy-efficient building, a sample of 100 energy efficiency buildings will perform better than a sample of 100 inefficient homes, and the ratio of energy use will be about what is expected by the calculations.

[18] In California, savings from appliances and equipment standards augment the savings from building standards by about 50 percent.

[19] California's standards regulated refrigerators, freezers, stoves, residential central air conditioners, room air conditioners, water heaters, furnaces, fluorescent lamp ballasts, and showerheads.

[20] The energy crises spurred by the Middle East oil embargo made the adoption of energy efficiency policies critical for states heavily dependent on oil, such as California and New York. The difficulty for manufacturers, which produced and sold to a national market, was that nonuniform requirements in different states made it extremely difficult to produce and ship the correct equipment.

[21] NAECA regulated energy in the appliances covered by the California legislation, as well as dishwashers and clothes washers, cooking ranges, fluorescent and incandescent lamp ballasts, and low-flow toilets.

[22] U.S. Department of Energy, Energy Efficiency and Renewable Energy network. See http://www.eren.doe.gov/erec/factsheets/eelight.html.

[23] Howard Geller and Steven Nadel, "Market Transformation Strategies to Promote End-use Efficiency," 19 Annual Review of Energy and the Environment, at 308 (1994).

[24] *Id.*

[25] *Id.* at 311.

[26] *Id.*

[27] In the few cases where advanced technologies were relied on in prescriptive code development, all but one of them had already included a widely used or widely projected to be used performance option.

[28] The other problem that arises is that the definition of "cost-effective" for code purposes is defined based on a very short time horizon, often as a result of political pressure from stakeholders wishing quick profitability.

[29] See D. B. Goldstein, "Research Ideas for Transportation," presented to the U.S. National Research Council Surface Transportation Environmental Cooperative Research Program advising board's Research Priorities Workshop, Washington, DC, September 26, 2000.

[30] P. Newman & J. Kenworthy, Cities and Automobile Dependence: An International Sourcebook, GoverPublishing, 1989.

[31] The American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) and Illuminating Engineering Society of North America (IESNA) are national and international professional engineering associations. More than 40 of the 50 states enforce energy efficiency standards derived in whole or in part from ASHRAE Standard 90.

[32] D. B. Goldstein, "The American Experience with Establishing Energy Efficiency Standards for New Buildings: Case Studies of California and National Energy Studies," presented at the Third Soviet American Symposium on Energy Conservation, October 2–15, 1988, at 1.

[33] *Id.*

[34] "Sustainable Energy Strategy: Clean and Secure Energy for a Competitive Economy, " National Energy Policy Plan Pursuant to Section 801 of the DOE Organization Act, 30 (July 1995). [Hereinafter National Plan], at 30.

[35] Earlier versions of the IECC were released in 1983, with updates in 1986, 1989, 1992, 1993, and 1995.

[36] T. Jones and D. Norland, The Alliance to Save Energy, "The 1993-95 Model Energy Code:

Energy and Environmental Savings, Costs, and Benefits by State," 1996 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, DC, ACEEE, 1996.

37 U.S. Congress, Office of Technology Assessment, Building Energy Efficiency, OTA-E-518 (Washington, DC: U.S. Government Printing Office, May 1992). [Hereinafter Building Efficiency], at 108.

38 The USGBC is a voluntary non-profit organization of more than 1,100 major stakeholders in the building industry. For more information, visit http://www.usgbc.org.

39 Although IEQ is not directly related to energy consumption, negative impacts on indoor air quality from improperly implemented energy efficiency measures have been used by opponents of energy standards to relax requirements or even to forestall adoption of efficiency measures.

40 Certified buildings achieve 40 percent to 50 percent of the available points; Silver, 50 percent to 60 percent; Gold 60 percent to 80 percent; and Platinum, 80 percent +.

41 Based on the U.S. Environmental Protection Agency's Energy Star benchmarking system, an average new building scores a 50, while an average LEED building scores an 87. LEED currently references the ASHRAE 90.1 Standard and requires that buildings exceed it by 20 percent to 60 percent depending upon what level of rating the building desires to certify.

42 Reducing urban heat islands in the United States could reduce annual energy bills by more than $1 billion, according to Lawrence Berkeley National Laboratory.

43 Water treatment and distribution can consume up to 2.5 kWh per thousand gallons.

44 Normative labels are used to provide simple and easy-to-use access to the marketplace. While economic theory says that consumers will optimize for energy efficiency, in practice, energy efficiency most often is totally ignored. The first step of improvement beyond ignoring energy efficiency is to make a simple "yes/no" distinction between energy-efficient buildings or equipment and inefficient ones.

45 The Energy Star program covers: New homes and commercial buildings, Furnaces, Heat pumps (Air-source, Geothermal, and Gas-fired), Central air conditioners, Boilers, Programmable thermostats, Insulation, TVs, VCRs, Light fixtures, Office equipment (Computers, Printers, Fax machines, Scanners, Multifunction devices, and Copiers) Refrigerators, Dishwashers, Room air conditioners, Clothes washers, and Windows. See http://www.energystar.gov.

46 See http://natresnet.org/standards/default.htm.

47 See M. Chao, "Energy Costs and Valuation of Commercial Properties by Appraisers and Lenders," 1998 ACEEE Summer Study on Every Efficiency in Buildings, Washington, DC, ACEEE, 1998.

48 Paying an incentive for the architectural aspect in 2002 would not work because the actual energy savings will not be known until the rest of the building systems are designed and specified. For example, an envelope designed for daylighting would waste energy rather than saving it if the electric lighting system is later designed to be the same as it would have been for a non-daylit space.

49 This structure is being proposed in legislation under development in Maryland, Massachusetts, and Pennsylvania.

50 A 100 percent market share for only modest efficiency gains suggests a second problem: Perhaps the cost of building in the extra efficiency is much less than expected. If the incentive level exceeds the incremental cost of efficiency, it could actually hold back further gains in efficiency by reducing cost competition between different technologies.

51 An example is: Indirect evaporative cooling as a replacement for vapor compression cycle air conditioning to provide credit for indirect evaporative cooling in a code compliance program would be self-defeating. The energy saved by the more efficient cooling system would be used to justify the larger cooling loads—perhaps so large that the evaporative cooling system would no longer work effectively. But, if the cooling loads are already minimized to comply with the basic code, indirect evaporative cooling systems ought to be available for incentives for going beyond the code.

52 On the West Coast of America, changes in window requirements encouraged a changeover from aluminum-framed windows, which waste energy because of aluminum's high thermal conductivity, to vinyl-framed and wood-framed windows. But these changes were facilitated by the availability of incentives. In both California and the Pacific Northwest, active utility intervention in building markets that was explicitly aimed at facilitating code changes achieved its desired result.

53 J.A. Johnson, "Transforming Markets in California: Ratepayer Funded Codes and Standards Successes," by New Buildings Institute for PG&E, October 2001.

54 M. Schuldt et al., *A Tale of Two Cities: Boosting Energy Efficiency in Multifamily New Construction*, presented at 1997 Energy Evaluation Conference, Chicago, IL, August 27–29, 1997, at 550.

55 *Id.* Follow-on service would provide building owners and tenants with ongoing information about energy bills and saving. Assistance with operations and maintenance could ensure that the proper lams are replaced in high-efficiency lighting fixtures. Follow-on services also serve the utility by supporting the persistence of impacts and reinforcing consumer demand, along with the opportunity to provide nonenergy customer services.

56 "Sustainable Energy Strategy: Clean and Secure Energy for a Competitive Economy," National Energy Policy Plan pursuant to Section 801 of the DOE Organization Act, 30 (July 1995). [Hereinafter National Plan].

57 In the United States' restructured utility market, some states are continuing with utility administration of energy efficiency programs; other states are designating public agencies for this work. CEE serves the needs of both, providing a forum for the exchange of information and ideas. See http://www.cee1.org.

58 See http://www.epa.gov/cpg/paprman.htm.

59 Executive Order 13150; Executive Order 13149; Executive Order 13148; Executive Order 13134; Executive Order 13123; Executive Order 13101. The text of these rules may be found at http://www.ofee.gov/greening/greening.htm.

60 The free driver effect refers to the impact of a program or project beyond its immediate scope.

61 J. H. Reed and N. P. Hall, PG&E Energy Center Market Effects Study, Arlington, VA: TecMRKT Works, May 1998, at vii.

62 CTAC Market Effects Study, Volume 1 Final Report, prepared by Hagler Bailly, Inc., San Francisco, for Southern California Edison.

63 The key barriers it analyzed were: Information Costs; Performance Uncertainty; Information Asymmetry; and Bounded Rationality.

64 NYSERDA, a public benefit corporation, provides energy-related technical and financial packaging assistance to businesses and institutions to promote energy efficiency and economic development. NYSERDA sponsors energy research and development programs that promote safe and economical energy production and efficiency technologies in New York state, issues tax-exempt bonds and notes for energy-related projects, and analyzes the effect of New York's energy, regulatory, and environmental policies on the

state's business, institutional, and residential energy consumers.

[65] Energy Information Administration, Annual Energy Review 2000, at 38. [Hereinafter AER2000].

[66] Lawrence Berkeley National Laboratory, China Energy Data Book v.5.0, May 2001.

[67] See http://www.chinavista.com/business/cnedc.

[68] See http://yosemite1.epa.gov/estar/homebuyers.nsf/content/NEWSWhatsNewSnapshot.htm.

[69] AER2000 at 38.

[70] Eley & Associates, Architectural Energy Corp., California 2001 vs. ASHRAE 1999: *Comparison of ASHRAE/IESNA Standard 90.1-1999 and the 2001 California Nonresidential Energy Efficiency Standard*, prepared for the California Energy Commissions, August 2, 2001.

[71] M. P. Ternes, Oak Ridge National Laboratory; J. Cavaio, Argonne National Laboratory; C. Applegate, D&R International, LTD; "Successes from Rebuild America's Housing Partnerships," 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, DC, ACEEE, 2000, at 2.299.

[72] *Id.* At 2.307.

[73] Department of Energy, Tomorrow's Energy Today for Cities and Counties: Commercial Energy Codes, Lay Foundation for Saving Money 3 (February 1995). [Hereinafter, Commercial Codes].

[74] *Id.*

[75] Market Assessment and Evaluation of California's 1999 Small and Medium Nonresidential Energy Efficiency Programs, M. Rufo, XENERGY, Inc.; M. O'Drain, Pacific Gas & Electric Company, A. Lee, XENERGY, Inc., J. Cavalli, Quantum Consulting Inc.; J. Larkin, XENERGY, Inc.; 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, DC, ACEEE, 2000.

[76] *Id.*

[77] B. Finamore, Dr. H. Zhaoguang, Dr. Z. Fuqiu, Professor Y. Zhirong, L. Weizheng, L. Jing, *Utility demand-Side Management in China Opportunities and Policy Options*, February 2002.