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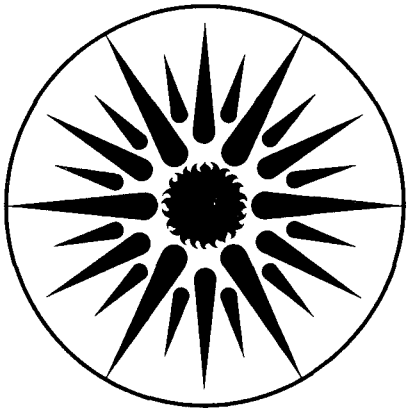

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DISCLAIMER

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BUILDING CODE COMPLIANCE AND ENFORCEMENT: THE EXPERIENCES OF SAN FRANCISCO'S RESIDENTIAL ENERGY CONSERVATION ORDINANCE AND CALIFORNIA'S BUILDING STANDARDS FOR NEW CONSTRUCTION

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ABSTRACT

As part of Lawrence Berkeley Laboratory's (LBL) technical assistance to the Sustainable City Project, compliance and enforcement activities related to local and state building codes for existing and new construction were evaluated in two case studies. The analysis of the City of San Francisco's Residential Energy Conservation Ordinance (RECO) showed that a limited, prescriptive energy conservation ordinance for existing residential construction can be enforced relatively easily with little administrative costs, and that compliance with such ordinances can be quite high. Compliance with the code was facilitated by extensive publicity, an informed public concerned with the cost of energy and knowledgeable about energy efficiency, the threat of punishment (Order of Abatement), the use of private inspectors, and training workshops for City and private inspectors.

The analysis of California's Title 24 Standards for new residential and commercial construction showed that enforcement of this type of code for many climate zones is more complex and requires extensive administrative support for education and training of inspectors, architects, engineers, and builders. Under this code, prescriptive and performance approaches for compliance are permitted, resulting in the demand for alternative methods of enforcement: technical assistance, plan review, field inspection, and computer analysis. In contrast to existing construction, building design and new materials and construction practices are of critical importance in new construction, creating a need for extensive technical assistance and extensive interaction between enforcement personnel and the building community.

Compliance problems associated with building design and installation did occur in both residential and nonresidential buildings. Because statewide codes are enforced by local officials, these problems may increase over time as energy standards change and become more complex and as other standards (e.g., health and safety codes) remain a higher priority. The California Energy Commission realizes that code enforcement by itself is insufficient and expects that additional educational and technical assistance efforts (e.g., manuals, training programs, and toll-free telephone lines) will ameliorate these problems.

INTRODUCTION

This paper was prepared for the City of San Francisco, as part of Lawrence Berkeley Laboratory's (LBL) technical assistance to the Sustainable City Project. The Sustainable City Project is a collaborative effort by the cities of Portland, San Francisco, and San Jose, assisted by LBL and the Washington State Energy Office. The Project is funded by the U.S. Department of Energy, and managed by the Energy Task Force of the Urban Consortium. The cities are developing local plans and projects that increase control over their energy future, promote long-term economic prosperity, and improve environmental quality.

In the first year of the project, each city worked with key individuals in local government and the community to identify policy options that would contribute to solving local problems in selected priority areas (e.g., economic development and transportation) while also improving overall energy efficiency. As part of its planning process, the City of San Francisco asked LBL to examine how well the City's Residential Energy Conservation Ordinance is being complied with and enforced, and to examine similar issues related to California's building standards for new construction.

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

Three different strategies are available to local governments for enforcing compliance with standards, reflecting different building code implementation strategies (Cantor and Cohn, 1989):[†] code enforcement, technical assistance, and builder-suggested. In the *code-enforcement strategy*, enforcement personnel regard themselves as inspectors (enforcers), not as builders or architects. They do not see themselves as technical advisors to the builders, nor do they engage in the iterative planning activities found in the other two strategies. Possible tradeoffs in the design are not discussed or made, and onsite inspections are made solely to judge compliance in the field. This is the traditional approach (strategy) and relies on a stable set of rules and compliance guidelines (clarification of these guidelines is important). Critical to this strategy is the ability to visually inspect practices on the building site and to judge the results on the basis of satisfying code requirements.

[†] This classification is based on Cantor and Cohn's analysis of the implementation of Model Conservation Standards in the Pacific Northwest.

The *technical-assistance strategy* uses a high level of interaction and cooperation between the enforcement personnel and builders to modify pre-adoption building practices for meeting new standards. An important feature of this strategy is coaching the builders on the available options for meeting new standards. Such coaching involves assisting the builders to choose and use new materials and construction practices (e.g., using software programs to explore with the builder the tradeoffs available for a certain construction design). Additionally, a good deal of coaching may occur at the construction site during informal inspections. But the key area is at the plan review process where it is not too late to change plans.

In the *builder-suggested approach*, builders are seen as being very innovative, and their solutions to meet building standards may be highly idiosyncratic. Accordingly, enforcement personnel must have extensive applied knowledge of building practices and a cooperative attitude towards builders. The enforcement emphasis is on field inspection and testing (e.g., blower-door testing to measure air infiltration rates), rather than on plan review or estimated compliance indications like computer simulations. This approach reveals problems that plan review and visual inspections miss, and, under this approach innovative practices in the field can be approved with as little bureaucracy as possible.

The remaining part of this paper is divided into three sections. The first section examines compliance and enforcement issues pertaining to the City of San Francisco's Residential Energy Conservation Ordinance (RECO). The second section examines compliance and enforcement issues pertaining to California's building standards (Title 24) for new residential and nonresidential construction. The enforcement of RECO and Title 24 primarily uses the code-enforcement strategy, although parts of the other two strategies are also used. The concluding section summarizes the findings from the previous discussions and briefly examines the role of nonmandatory programs in promoting energy efficiency in new and existing construction.

SAN FRANCISCO'S RESIDENTIAL ENERGY CONSERVATION ORDINANCE

In 1981, the City of San Francisco adopted its Residential Energy Conservation Ordinance (RECO) to improve the energy efficiency of its existing residential stock. This section addresses how well the ordinance is being complied with and what problems have been encountered in enforcing the ordinance. This brief evaluation is based on an interview with a key staff person responsible for enforcing the ordinance (Oliveira, 1989) and the analysis of a data base compiled by the City for tracking RECO compliance. We did not inspect housing units for compliance, measure energy consumption of the dwelling units, or interview private contractors. Thus, the following evaluation should be viewed as preliminary, as it is based on limited research.

SYNOPSIS

The City of San Francisco enacted RECO, effective Sept. 1982, to lessen the impact of rising energy costs on renters and homeowners by making existing dwellings more energy efficient (City and County of San Francisco, 1989). The existing residential sector constituted a large untapped potential for energy conservation that market forces alone were not reaching. Under this ordinance, owners of residential properties who wish to sell their property must obtain a valid energy inspection, install certain energy conservation devices or materials, and then obtain a certificate of compliance. All of this must occur prior to transfer of title of any residential building as specified in the ordinance, and the seller must provide a copy of the compliance certificate to the buyer prior to title transfer.

REQUIRED MEASURES

RECO is a prescriptive code, and the following weatherization measures are required, differentiated by type of building:

For single and two-family dwellings:

- insulate accessible attic space to a minimum value of R-19, if not already insulated to R-11;
- weatherstrip all doors leading from heated to unheated areas;
- insulate hot water heaters (R-6 insulation or greater);
- insulate the first four feet of accessible hot water line to R-4 or greater;
- install low-flow showerheads (the maximum flow permitted is 3.0 gallons per minute or less);*

* All new showerheads sold in California must now have a maximum flow of 3 gallons per minute or less.

- caulk and seal openings in the exterior of the building (closing any openings or cracks greater than 1/4 inch wide); and
- insulate (with a R-3 value or greater) accessible heating and cooling ducts.

For apartment buildings and residential hotels:

- all items required for single and two-family dwellings, plus:
- insulate steam and hot water pipes to a minimum of R-4 and tanks to a minimum of R-6 value;
- clean and tune boilers;
- repair boiler leaks; and
- install time clock controls for burners.

WHEN BUILDINGS MUST COMPLY

Prior to sale, all owners of single and two-family dwellings, apartment buildings (including each condominium unit sold), and residential hotels must comply with the ordinance. In addition, owner's compliance is also required when one of the following situations occurs:

- Metering conversions: the removal of one or more units from a master meter to an individual meter.
- Major improvements: improvements having an estimated permit application value in excess of $20,000 for single and two-family units, $6,000 per unit for 3 units and up (excluding residential hotels), and $1,000 per unit for residential hotels.
- Condominium conversion.
- Complete inspection (performed by the Bureau of Building Inspection and usually conducted when a building permit is required (e.g., adding or combining units)).

Approximately 90% of compliance certificates are issued because of property transfer. The remaining 10% of the certificates is spread among metering conversions (only for apartments and hotels), complete inspections (only for apartments and hotels), condominium conversions (only for apartments and hotels), and major improvements.

Despite initial sharp opposition to RECO by the real estate community, the ordinance has since become a routine part of title transfer: according to City staff, most owners have accepted the program as another municipal regulation (Egel et al., 1990). RECO requires little administration on the part of the City: to administer the code, the City hired one additional inspector and one half-time clerk. The fees for the inspections include the extra administrative costs, so there was no extra cost for the City for administering the ordinance. Also, instead of increasing City staff, the City relied on the private sector to conduct the additional inspections.

There have been some administrative problems that have led to increased paperwork by property owners, leading to some irritation with the ordinance. For example, inspectors and contractors sometimes make mistakes in correctly listing the block and lot number of condominiums; when mistakes are found, the property owner is responsible for correcting the mistakes. Another administrative problem occurs when buildings are remodeled: owners must comply with state standards (Title 24) as well as RECO, and the latter is sometimes not observed. This is also true for remetering (changes in service as well as changes in heating systems (from central to individual)).

THE INSPECTION PROCESS

The City's Housing Inspection Division (HID) is in charge of inspecting buildings and administering the ordinance. Under RECO, energy-efficiency measures are installed after an initial inspection. The initial inspection determines which measures are necessary; a final inspection acknowledges that the measures have been properly completed, and a certificate of compliance is issued to the owner. An energy inspection can be conducted by the Bureau of Building Inspection in HID, a certified private energy inspector, or a local utility (Pacific Gas and Electric Company) energy inspector. Each of these entities charges a fee for the inspection.

Under RECO, initial inspections have usually been conducted by HID and private inspectors. Private inspectors do not usually charge a fee for the initial inspection. Instead, the inspector usually gives an estimate of what work needs to be done, does the work (as a contractor), and then completes a compliance form. At this time, the inspector/contractor also indicates that the initial inspection was done. This occurs about one-third of the time; otherwise the two inspections (initial and final compliance) are signed off at different times. A private contractor (the person who does the work) often signs only the final compliance form. Sometimes, final compliance forms are not handed in (see below). And sometimes a third inspection is conducted to see if a violation discovered in the compliance inspection was taken care of; a fee is charged for the third inspection.

If a final compliance form is not turned in to the City, and the owner does not have the form, then the inspection has to be repeated. Noncompliance with RECO will result in the issuance of an Order of Abatement that will be attached to the title of the property. The Order will prevent a property owner from selling that property, obtaining a second mortgage, or getting a credit check until the Order is removed.

The person conducting the initial inspection and the final compliance inspection varies according to type of dwelling. For example, in 1988/89 fiscal year, HID conducted 208 initial inspections and 353 final inspections in single and two-family dwellings. In the same sector, private inspectors/contractors performed 3,056 initial inspections and 3,158 final inspections. In the apartment and hotel sector for that year, HID conducted 227 initial inspections and 404 final inspections, while private inspectors/contractors performed 369 initial inspections and 394 final inspections. The differences between the two sectors may be attributed to the fact that the City is usually the one who deals with apartments and hotels concerning city policies and ordinances; in contrast, owners in the single-family sector interact with more individuals and organizations in the private sector which are involved with city regulations.

EXEMPTIONS FROM RECO

Inspections are not required for:

- any residential building for which proof of compliance from a prior inspection has been properly recorded;
- any residential building that was granted a building permit application for its construction on or after July 1, 1978;
- any mobile home;
- any residential building or portion thereof, which is occupied as a hotel or motel unit and which has a certificate of use for tourist occupancy;
- and any portion of a residential building converted to a tourist hotel.

Transfers of title which result from an operation of law (e.g., court-ordered transfers, such as bankruptcy or probate, and transfers between spouses or co-owners) rather than by purchase are also exempt from the ordinance.

Few exemptions have been requested. When exemptions are granted, it is primarily for title transfer (probate) reasons (over 90%). Another 5% are for buildings already in compliance, and the remaining percentage are for building permits granted after July 1, 1978, or for tourist hotel/motels. Exemptions are rarely granted for mobile homes, since there are few in the city.

INSTALLATION

A private energy contractor usually installs the measures at time of sale. In general, most private contractors use high quality materials and workmanship, since they do not want to be called back for customer complaints or poor workmanship. HID has had some problems with a few private energy contractors. When this occurs, a letter is usually sent to the contractors to tell them that they have to do the work without charge to correct their mistakes. In some cases, inspectors are decertified. However, they can continue to serve as a contractor (it is very difficult to suspend someone's state license). Occasionally, homeowners perform the work themselves in the single-family sector, and their performance is mixed. While some homeowners use high quality materials and workmanship, others may not use approved materials and may have problems with installing the necessary measures.

Except for attic insulation, all of the measures are easy to explain to the property owner. There are two issues affecting attic insulation: (1) whether the attic is accessible or not, and (2) how much of the attic is accessible. If there is 18 inches of clear space at the highest point in the attic, then attic insulation must be installed. The owner/inspector must prove to HID that there is not enough space for putting in attic insulation. Also, if any space in the attic is 18 inches high or more, then the entire attic must be insulated (for smaller spaces in the attic, blown-in insulation is used).

There is no negotiation or compromise with RECO - one either complies or one does not. However, judgement calls are sometimes made by the owner: for example, (1) it may not be cost-effective to insulate a small percentage of the attic, or (2) weatherstripping of interior doors may not be necessary if the heating source for hallways in a ten-story building is located in the lobby.

Property owners comply with all of the RECO measures: compliance rate was 98% for apartments and hotels and 99% for single and two-family dwellings. Violations are often found at the time of initial inspection (see Table 1), and almost all of these are corrected at the time of final inspection. Although occurring infrequently, attic insulation violations are usually substantial and result in large costs; violations are often due to fraud or poor quality jobs. Most of the other violations are minor in detail and cost (e.g., weatherstripping and insulation of hot water heater).

No items in the ordinance are overlooked. One potential problem - verifying that showerheads are low-flow - is easily checked: all new showerheads sold on the market are low-flow, so if the showerhead is new, then it is low-flow. If the showerhead is old, then the water is tested for five seconds to see if the amount is one quart or less.

TABLE 1

RECO VIOLATIONS

AT TIME OF INITIAL INSPECTION

(July 1982 - June 1989)

	Apartments and Hotels (N=8,740)† (%)	Single-family and Duplexes (N=51,935)‡ (%)
Attic Insulation	10%	8%
Door Weatherstripping	22	20
Water Heater Tank Insulation	16	16
Water Heater Pipe Insulation	18	20
Low-flow Showerheads	18	14
Exterior Sealing	6	7
Duct Insulation	5	15
Water Heater Tank and Pipe Insulation	3	*
Boiler Certification	2	*
Boiler Repair	1	*
Time Clocks	*	*

† In this sector, 3,622 inspections were conducted, and 3,543 people complied, resulting in a 98% compliance rate. Most of the violations found at the time of initial inspection were resolved.

‡ In this sector, 21,346 inspections were conducted, and 21,048 people complied, resulting in a 99% compliance rate. Most of the violations found at the time of initial inspection were resolved.

* Less than 1%

Source: Oliveira, 1989.

APPEALS

A person may appeal the results of an energy inspection, if there is disagreement regarding the requirements as determined by the energy inspector, or if the application of an energy ordinance measure is not cost-effective. However, the appeal process is rarely used (only a few buildings). Cost-effectiveness is the basis for most of the appeals, and the burden of proof is on the owner: the owner has to show the necessary calculations indicating that the measure is not cost-effective. In those cases where someone thinks the inspector made the wrong decision, there is a complaint rather than a formal appeal, and the complaint is examined by HID staff. Only very large buildings make use of the formal appeals process, since it is not worth the trouble for owners of small buildings to hire someone to prepare a report as the basis for the appeal.

In those cases where an appeal is heard, the owner usually wins (owners often have enough supporting documentation to indicate that the measure was not cost-effective, and City staff resources are limited for extensive reviews). For example, a ten-story building was exempted from installing attic insulation because the ceiling could not support the attic insulation. The same building also was permitted not to install weatherstripping on interior doors because they were found not to be cost-effective.

Complaints with the ordinance are few: when property owners do complain, they argue that they are in the process of remodeling, or are planning to do some remodeling/renovation in the house, so they do not want to comply immediately with the code. Owners of single and two-family dwellings have the most trouble meeting the ordinance, because they are the ones usually doing the remodeling. No one has complained that the code is too confusing, vague, time consuming, or complicated.

CONCLUDING COMMENTS

The biggest problem in enforcing the code is keeping track of who has complied with the code and who hasn't. The Housing Inspection Division has a computerized tracking system to monitor residential sale transactions and uses the computerized tracking systems of the Bureau of Building Inspections and the Assessor's Office to determine if compliance with RECO occurs prior to or after the transfer of property, respectively. As discussed previously, condominium conversions, metering changes, and remodeling are the three main areas where HID's tracking system has problems. Other problem areas are: (1) verifying particular measures (e.g., attic insulation), (2) owners' reluctance to add items that increase their cost, and (3) in some cases, owners who do not believe that RECO saves energy. Accordingly, funds are needed for supporting staff to review these specific cases to ensure total compliance with the ordinance. Also, at the start of the program, there were problems with building inspectors that had not been informed about RECO. Currently, training of building inspectors occurs regularly for new personnel and private

inspectors that were formerly inactive.

Administrative problems need to be resolved. Private inspectors have difficulties in correctly completing the appropriate forms; this is less of a problem with the staff at HID. This quality control problem may be due to the diverse educational backgrounds of inspectors. Hopefully, increased training of these inspectors will alleviate the problem.

RECO is one of the most far-reaching and comprehensive efforts by a local government to achieve energy conservation in the residential sector. The compliance rate for RECO is very high, and enforcing the ordinance has been relatively simple and straightforward. Aside from correcting for specific problem areas mentioned above, it appears that the ordinance's compliance rate and enforcement are optimal. Moreover, the perceived success of RECO in retrofitting thousands of housing units helped to establish the political and administrative framework for the development of another San Francisco ordinance, the Commercial Energy Conservation Ordinance (CECO) (Egel et al., 1990). CECO is the nation's only ordinance designed to require energy conservation retrofits in commercial buildings. CECO took effect in July 1989 and is expected to save San Francisco businesses over $50 million in energy costs within 5 years.

CALIFORNIA'S BUILDING STANDARDS FOR NEW CONSTRUCTION

Established under the 1974 Warren-Alquist State Energy Resources and Development Act, the California Energy Commission (CEC) develops and implements energy conservation standards for the State of California. The CEC adopted energy conservation standards (Title 24) for new residential and nonresidential construction in 1975 and 1978. Since 1978, the standards have been enforced by local building departments through the building permit process. Since that time, the CEC has continued to develop and update energy efficiency standards, and has attempted to increase design flexibility for engineers and builders without significantly sacrificing simplicity of enforcement for local building departments.

To assist in effectively understanding and responding to the needs of designers, builders, and local enforcement agencies, the CEC has retained an outside contractor each year since 1979 to visit local building departments and determine compliance and enforcement levels of the standards. In the following pages, we highlight some of the major findings from the contractor's report for the 1987-88 fiscal year for residential and nonresidential buildings (CMJ Engineering, 1988). Before reviewing the compliance findings, we present an overview of the building standards in California.

OVERVIEW OF STANDARDS[†]

Mandatory statewide conservation standards authorized by the State Legislature for new residential buildings were adopted in 1975, became effective in 1978, and were revised in 1982, 1983, and 1987. Similarly, nonresidential building standards became effective in 1978, and at the request of the building industry, were revised in 1983 and 1985 in a joint cooperative effort. These standards were innovative, since they were the first such standards adopted anywhere in the United States.

California's **residential** building standards (1982) include mandatory measures for all new residential buildings, such as substantially increased wall and ceiling insulation, special thermostat controls, double-paned windows, window shading, limited glazing area, infiltration control and efficient equipment. They also allow credits for the use of solar water heating, and require that any appliance installed in a new residential building comply with California's appliance efficiency standards.

Energy budgets were established for each of three building types in sixteen different climate zones in the state. The three building types are single-family detached, single-family attached,

[†] This overview is based on Vine and Harris (1988b).

and multifamily. Once all of the mandatory measures have been included in the building design, there are two options for demonstrating compliance with the energy budget: the prescriptive approach and the performance approach.

The *prescriptive approach* is the most straightforward approach to compliance. Builders and design professionals following the prescriptive path select one of five lists of conservation measures, called alternative component packages, which meet the standards. All the measures from the selected list must be incorporated in the building design. The components in each list were chosen so that the computer simulation of a prototype building produced an energy budget that was less than or equal to the level set by Title 24. The major difference between the packages is which measure is emphasized for achieving the energy savings. The choice of which package to use is left up to the designer.

The *performance approach* requires more effort in demonstrating compliance but allows a wider variety of design measures and thus provides greater flexibility than the prescriptive approach. In the performance approach, the code specifies an annual custom energy budget for the building based on size, location, and other characteristics. The energy budget is calculated by the designer by modeling the building design with the measures required in an alternative component package. The designer must demonstrate that the building will use no more energy than is specified by Title 24. The performance approach permits the designer to trade off different aspects of the building design, one against the other, as long as the final design does not exceed the established energy budget. The two basic calculation methods available for demonstrating compliance with the performance approach are a point system and a computer program. The *point system* assigns positive or negative points to several common design options based upon their impact on energy consumption. By incorporating options that achieve at least the correct point total, the designer can determine if a particular building meets the energy budget. Private vendors must certify to the CEC that their *computer programs* meet the requirements for determining compliance with the building efficiency standards. There are currently three private vendor computer programs that may be used to determine compliance.

The new **nonresidential** standards (1983) are very similar to the residential standards in that: (1) the state has been divided into 16 climate zones, (2) there are mandatory features that must be met, and (3) there are two compliance approaches (prescriptive packages and performance approaches). The mandatory measures include the following: pipe insulation, appliance and equipment efficiencies, controls for lighting and space conditioning systems, ventilation system design, control of air leakage through windows and doors, and service water heating system design. For each climate zone, the CEC established *prescriptive packages* which automatically meet the new standards. These packages prescribe insulation levels, glazing percentages and shading coefficients, lighting levels, and space conditioning systems. For prescriptive methods,

compliance with the energy budget may be achieved by installing one of these alternative component packages (no computer calculations are required to demonstrate compliance if one of these packages is used). The required components in each package vary according to building occupancy type and climate zone. In more energy intensive occupancies, more energy conservation efforts are cost-effective. The prescriptive approach is appropriate for building designs that are relatively simple and can be designed satisfactorily with the components specified in the alternative component packages.

Once again, the *performance approach* provides greater flexibility in building design and choice of lighting and mechanical systems. In the performance approach, a design is modeled with an approved computer simulation program. If the design meets a specified building energy budget, it complies with the standards. The CEC has established building energy budgets for low-rise (1-3 stories) and high-rise (4+ stories) offices and for retail and wholesale stores in each climate zone.

The post-1985 nonresidential standards differ from the previous standards in the following ways: they reduce lighting and related space conditioning through improved lighting design, more efficient equipment, and daylighting; they increase the use of passive solar techniques (thermal mass and shading); they require a more efficient building envelope (more efficient window systems); they provide for ventilation, emphasizing indoor air quality by referencing ASHRAE Standard 62-1981; and they improve space conditioning system efficiency through more efficient equipment and effective use of economizers.

The new nonresidential standards will eventually cover the range of commercial and industrial building types, as well as high-rise residential buildings. The new standards first addressed the buildings most often constructed and those that are most energy-intensive. These included office buildings and retail and wholesale stores. Future updates will be developed for grocery stores, schools, restaurants, hospitals, nursing homes, hotels, motels, high-rise residential buildings, auditoriums, gymnasiums, warehouses, and miscellaneous buildings.

The revised nonresidential standards for **office buildings**, adopted in 1984, were voluntary (optional) until January 1, 1987, when they became mandatory. They were optional for two years to allow time for builders and designers to better understand and prepare for the changes. The new energy standards require few, if any, design changes to the envelope of most new office buildings. The most significant changes fall into three categories: lighting, space conditioning systems, and building department compliance documentation. The most significant changes are in lighting systems, with an emphasis on lower levels of lighting power and greater use of daylighting and tasklighting. With the lower lighting levels, construction cost may decrease since the subsequent lower cooling loads will allow the installation of smaller air-conditioning systems. And the smaller systems and loads will reduce operating costs. Even though some of these changes

are significant, compliance is expected to be easy. The new standards are also expected to help designers better understand the efficiency of their designs.

The CEC adopted revised energy standards for **retail and wholesale stores** in 1985 and new lighting standards for all occupancies (except schools) in 1987. New lighting requirements for schools became mandatory on July 1, 1988. These regulations were incorporated into the regulations already adopted for office buildings, and include both performance and prescriptive requirements.

COMPLIANCE IN RESIDENTIAL BUILDINGS

During the 1987-88 fiscal year, 102 residential buildings were monitored by an outside contractor (CMJ Engineering, 1988). The monitoring of these buildings primarily consisted of examining the methods and paperwork used for compliance with Title 24 and did not examine energy performance or whether the building was designed or operated correctly.

The most common method for energy compliance of the residential buildings sampled was the point system (47%), followed by the computer method (41%, which includes the standard certified computer programs and custom budgets), and the prescriptive packages method (6%). This is a major change in compliance: previously, the most common method was the prescriptive method. However, with the proliferation of computers, certified computer programs, and consultants, the use of computers has increased dramatically over the last ten years.

Two major types of violations were encountered: plan check violations and field check violations.

Plan Check Violations in Residential Buildings

The following groups of plan check violations were found in residential buildings (Table 2 has a more detailed list):

- *Installation of energy features in the field but not specified on the plans.* The most prominent features were weatherstripping, caulking and sealing, fireplace features, certified mechanical and plumbing equipment, intermittent ignition devices on mechanical and cooking appliances, duct construction, and certified plumbing fittings.
- *Plan omissions*: when energy calculations assumed certain energy features and these features were not noted on the plans, they were rarely installed in the field. The most frequently omitted features were outlet gaskets, dual glazing, glazing areas, shading devices, thermal mass

TABLE 2
RESIDENTIAL
PLAN CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
ENVELOPE	1. Wall Insulation	1	4
	2. Ceiling Insulation	1	4
	3. Raised Floor Insulation	1	2
	4. Slab Floor Insulation	2	0
	5. Insulation Certificate	-	0
	6. Glazing Area	1	19
	7. Glazing Type	1	4
	8. Shading Devices	2	18
	9. Labeled Windows & Doors	-	Not Required
	10. Thermal Mass	2	12
	11. Exterior Door/Window Weatherstripping	2	4
	12. Envelope Caulking	2	4
	13. Exhaust Fan Backdraft Damper	2	5
	14. Outlet Gaskets	1	7
	15. Vapor Barriers	2	2
	16. Air-to-Air Heat Exchangers	2	0
	17. Fireplace Features	2	7
MECHANICAL	18. System Type	2	1
	19. Equipment Certification	2	8
	20. IID on Equipment	2	2
	21. HVAC Sizing/Calculations	3	18
	22. HVAC Efficiency	2	31

(See Notes at end of table)

TABLE 2 (cont.)
RESIDENTIAL
PLAN CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
MECHANICAL	23. Automatic Setback Thermostat	2	5
	24. Two-Stage Thermostat	2	0
	25. Duct Insulation	1	8
	26. Duct Construction	2	6
	27. Cooking Appliances-IID	2	5
PLUMBING	28. System Type	1	6
	29. Equipment Certification	-	9
	30. Water Heater Insulation	2	6
	31. Pipe Insulation	-	0
	32. Water Heating System Insulation	2	4
	33. Certified Plumbing Fittings	2	4
METHOD	34. Component Package	-	
	35. Point System Listed in Items 54, 59, 65, 66, 74 & 75		
	36. Computer Program Listed in Items 40-53, 55-58, 60, 61, 64, 67-73		
LITE	37. Kitchen Lighting	-	12
	38. Bathroom Lighting	-	25
DOCUM	39.		
	40. Carpeted Mass in AB 163 Custom Budget	4	6
	41. Absorbed Insolation Fractions	4	8

(See Notes at end of table)

TABLE 2 (cont.)
RESIDENTIAL
PLAN CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
DOCUMENTATION	42. Framing Factors for Roof/Ceiling U-Value	4	3
	43. Use of 160 lb Concrete for Mass Materials	4	0
	44. RSURF Value for Carpeted Mass	4	2
	45. Windfactor	4	2
	46. Thermal Mass Area	4	14
	47. Building Orientation	4	8
	48. Predicted AB 163 Energy Budget for Each Model (floor area varies)	4	0
	49. Internal Gain Schedule	4	0
	50. Framing Factor for Floor U-Value	4	2
	51. Group Averaging Using AB 163	4	0
	52. Ventilation Inlet and Outlet Areas	4	5
	53. XRFLCT and TRSHTR Values for Glazing	4	0
	54. Wall Points Based on Wall Assembly	5	6
	55. AB 163 Custom Budget Assumptions for Shading Coefficient	4	2
	56. Ventilation in AB 163 Model or Proposed Model	4	0
	57. Cooling in Computer Run	4	2
	58. Cooling SEER required by AB 163	4	2
	59. Point System (AB 163) Calculations for Floor	4	0
	60. Edge Slab Loss	4	3
	61. Air Film Conductance for Carpeted Slab	4	0
	62. Compliance Documentation Could not Be Located	-	0

TABLE 2 (cont.)
RESIDENTIAL
PLAN CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
DOCUMENTATION	63. No Calculations Provided, Method Of Compliance Could Not Be Determined	-	4
	64. The Calculated Energy Consumption of the House Exceeds Allowable budget	4	0
	65. Movable Insulation Assumed in Calculations But Not Shown on Plans	2	4
	66. The Wall Areas Used in the Calculations Was Less Than the Wall Areas Shown on the Plans	1	0
	67. Framing Factor for Wall Assemblies Not Included in Calculations	4	2
	68. Setback Thermostate Modeled	4	1
	69. Vent Height	4	2
	70. Shading Coefficients	4	1
	71. Calculations Not Done For Reverse Floor Plan Orientations	3	3
	72. Air Infiltration	4	2
	73. Calculations for the Wrong Climate Zone	6	4
	74. Point System Totals	5	1
	75. Points for HVAC Efficiencies	5	1
	76. Point Credit for Pipe Insultation	5	1
	77. Water Heating System Credits Based on Standby Loss & Recovery Efficiency (July 1, 1988 Standards(	4	2
	78. Shading Factors for North Glazing (July 1, 1988 Standards)	5	1
	79. Building has Both Residential and Nonresidential Occupancies	3	1

(See Notes at end of table)

TABLE 2 (cont.)
RESIDENTIAL
PLAN CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

Notes:

1. Plans do not match calculations
2. Not noted on plans
3. Not provided in calculations
4. Calculations are in error based on Title 24 Reference Manuals
5. Calculations are in error based on point tables
6. Calculations are in error

Source: C.M.J. Engineering, 1988

types and areas, high efficiency equipment, insulation levels, and increased duct insulation.

- *Absence of calculations*: sizing calculations for HVAC equipment (especially cooling equipment) were not provided. As a result, designers were specifying oversized equipment.
- *Calculation errors*, due to incorrect input assumptions and calculation input errors. The most prominent types of input errors were errors in composite U-value calculations, absorbed insolation fractions, thermal mass areas, ventilation values, building orientation, wind factors, and equipment efficiencies.
- *Errors in HVAC and water heating system credits and shading factor credits* for the July 1, 1988 Second Generation residential buildings. Shading devices, overhangs, HVAC efficiencies, increased duct insulation, and water heating system efficiencies may be significant problem areas in the new permit submittals, in response to the July 1, 1988 Second Generation Residential Standard.

Field Check Violations in Residential Buildings

Four groups of field check violations were encountered (Table 3 has a more detailed list):

- *Installation of equipment with lower efficiencies than specified on the plans*. Building inspectors need to get the model number of the installed equipment and return to the office to call the CEC, or otherwise research the actual installed efficiency. It appears that building inspectors are unwilling to pursue this time-consuming process and are instead simply approving installed units even when they are inconsistent with plan specifications.
- *Energy features are specified on the plans but not installed in the field.* Four predominant examples were water heating insulation, pipe insulation, required fireplace features, and insulation certificates. Some of these features, however, are usually installed just prior to final inspection, so that actual number of violations could be less than that documented.

TABLE 3
RESIDENTIAL
FIELD CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
ENVELOPE	1. Wall Insulation	1	1
	2. Ceiling Insulation	-	14
	3. Raised Floor Insulation	-	3
	4. Slab Floor Insulation	-	0
	5. Insulation Certificate	2	69
	6. Glazing Area	1	22
	7. Glazing Type	1	8
	8. Shading Devices	2	5
	9. Labeled Windows & Doors	-	Not Required
	10. Thermal Mass	1	5
	11. Exterior Door/Window Weatherstripping	2	14
	12. Envelope Caulking	-	1
	13. Exhaust Fan Backdraft Damper	2	4
	14. Outlet Gaskets	1	22
	15. Vapor Barriers	1	0
	16. Air-to-Air Heat Exchangers	-	0
	17. Fireplace Features	2	11
MECHANICAL	18. System Type	1	0
	19. Equipment Certification	-	7
	20. IID on Equipment	-	0
	21. HVAC Sizing/Calculations	1	9
	22. HVAC Efficiency	1	23

(See Notes at end of table)

TABLE 3 (cont.)
RESIDENTIAL
FIELD CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
MECHANICAL	23. Automatic Setback Thermostat	2	7
	24. Two-Stage Thermostat	-	0
	25. Duct Insulation	1	4
	26. Duct Construction	-	0
	27. Cooking Appliances-IID	-	0
PLUMBING	28. System Type	1	0
	29. Equipment Certification	-	4
	30. Water Heater Insulation	2	15
	31. Pipe Insulation	-	1
	32. Water Heating System Insulation	2	39
	33. Certified Plumbing Fittings	2	9
METHOD	34. Component Package	-	-
	35. Point System	-	-
	36. Computer Program	-	-
LITE	37. Kitchen Lighting	1	9
	38. Bathroom Lighting	1	19

Notes:

1. Not installed in accordance with plans
2. Not installed at time of field check

Source: C.M.J. Engineering, 1988

- *Installed energy features are inconsistent with plan specifications.* The most prominent features were glazing types, glazing areas, shading devices, thermal mass areas, duct insulation, and outlet gaskets.
- *Installed bathroom and kitchen lighting not in compliance with energy regulations.* Homeowners have apparently complained that fluorescent fixtures are often incompatible with room decor and emit a poor quality light. As a result, many developers and builders, already concerned about the cost-effectiveness of these measures, are reluctant to install a fluorescent fixture for general lighting as required by the regulations. Many buildings officials have sided with the builders and homeowners and have not required fluorescent fixtures for general lighting.

The enforcement problems found with the residential standards during the 1987-88 fiscal year monitoring may be attributed to the following six main issues:

- The complexity of the methods of compliance, particularly with the advent of certified computer programs.
- The low priority of the standards in relation to other health and safety code regulations local enforcement agencies must enforce.
- The failure of designers to provide all energy features assumed in the calculations on the plans.
- The failure of the users of certified computer programs to follow input requirements of the Title-24 Reference Manual for the various computer programs.
- Enforcement personnels' lack of familiarity with the various certified computer programs.
- The lack of availability of Title-24 Reference Manuals.

Several steps have been taken to improve compliance and enforcement rates in the future:

- The July 1, 1988 residential certified computer programs now include many fixed input values.
- The Certificate of Compliance Form (CF-1R) should help inspectors and plan reviewers identify the required energy features used in the

design.

- Energy training is now more widely available throughout California, giving more designers and enforcement personnel the opportunity to attend.

COMPLIANCE IN NONRESIDENTIAL BUILDINGS

During the 1987-88 fiscal year, 50 nonresidential buildings were monitored by an outside contractor (CMJ Engineering, 1988): 33 were office occupancies (21 of these were designed using the Second Generation Office Standards and 12 were designed using the First Generation Standards), and the remaining 17 buildings in the sample were other occupancies which were designed using the First Generation Standards. The majority of the plan and field check violations were found in the 21 offices designed and approved under the Second Generation Office Standards; these buildings comprised only 42% of the nonresidential building sample, but accounted for approximately 60% of the violations found.

For nonresidential buildings, *plan check violations* fell into one of two groups: (1) plan omissions, where energy features were assumed on the calculations but not specified on the plans (e.g., when calculations required the installation of economizers, but none were specified on the plans), or (2) calculation and input errors, especially with the computer methods of compliance. A list of all nonresidential plan check violations cited is shown in Table 4. The two most common violations were differences between calculations and plans for insulation R-value of roof and ceiling, and the absence of shading devices on plans. In contrast, a majority of the *field check violations* cited were due to energy features being specified on the plans but not installed in the field (e.g., economizers were specified on the plans but not installed in the field). A list of all nonresidential field check violations cited is shown in Table 5. The three most common violations were (1) posted insulation certificates not posted, (2) glazing area not in accordance with the plan, (3) and uninstalled pipe insulation.

Because violations differed by type and time of compliance, we distinguish between First Generation Standards and Second Generation Office Standards, and between prescriptive and performance compliance packages. First Generation Standards have been in effect for nine years without major changes and have accounted for only 40% of the violations found. Apparently, enforcement agencies, designers and builders have a good understanding of the First Generation Standards.

TABLE 4
NONRESIDENTIAL
PLAN CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
ENVELOPE	1. U-Overall	3	3
	2. OTTV	3	2
	3. Labeled Windows and Sliding Glass Doors	-	-
	4. Weatherstripping	1	8
	5. Joint Caulking	1	7
MECHANICAL	6. Temperature Controls	1	3
	7. Automatic Interlocked Vent Dampers	1	2
	8. Fan Performance Index	2	0
	9. Pipe Insulation	1	1
	10. Duct Construction	1	3
	11. Duct Insulation	1	3
	12. Heating Load Calculation	2	3
	13. Cooling Load Calculation	2	3
	14. Maintenance Manual	1	2
	15. Ventilation Requirements	1	2
	16. Equipment Certification	1	2
	17. Model	1	1
	18. Efficiency	1	3
	19. IID	1	1
	20. Equipment Certification	1	1
	21. Model	1	1
	22. Efficiency	1	2

(See Notes at end of table)

TABLE 4 (cont.)
NONRESIDENTIAL
PLAN CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
MECH	23. Equipment Sizing/Selection	3	2
	24. HVAC Indices	3	5
	25. Economizer	1	5
H_2O HEATING	26. Equipment Certification	1	5
	27. Type	1	2
	28. Efficiency	-	2
	29. Storage Tank Insulation	-	1
	30. Pipe Insulation	-	2
	31. Temperature Controls	-	0
	32. Circulation Pump Time Clock	1	0
	33. Certified Plumbing Fittings	1	7
LIGHTING	34. Equipment Certification	-	0
	35. Fixture Wattages	1	9
	36. Double Switching	1	5
	37. Switching for Natural Light at Perimeter	-	3
	38. Automatic Switching at Skylights	1	1
DOCUMENT	39. List of Certified Manufactured Devices	-	0
	40. Insulation Certificate	-	0
	41. Construction Certificate	-	0
	42. Compliance Certificate	2	15

(See Notes at end of table)

TABLE 4 (cont.)
NONRESIDENTIAL
PLAN CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
	43. Component Package	3	1
	44. Computer Program	3	2
	45. Package "C" Used/Building Has Skylights	3	1
	46. Package "C" Used/Insulation Placed on Interior	3	1
D	47. Insulation R-Value - Roof/Ceiling	4	6
O	48. Insulation R-Values - Wall	4	4
C	49. Glazing Area	3	2
U	50. Wall Area	3	0
M	51. Conditioned Floor Area	3	3
E	52. Heating COP Input	3	1
T	53. Shading Devices	1	5
A	54. Tandem Wiring	1	4
T	55. No Lighting Calculations	-	2
I	56. No HVAC Calculations	-	2
O	57. Package "A" Used/Building Has Skylights	3	1
N	58. SCM HVAC Zoning	3	2
	59 Glazing type	4	2
	60. Second Generation Office Calculations Required	3	1

Notes:

1. Not Noted On Plans
2. Calculations Not Provided
3. Calculations Are In Error
4. Plans Do Not Match Calculations

Source: C.M.J. Engineering, 1988

TABLE 5
NONRESIDENTIAL
FIELD CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
ENVELOPE	1. U-Overall	-	0
	2. OTTV	-	0
	3. Labeled Windows and Sliding Glass Doors	-	-
	4. Weatherstripping	1	4
	5. Joint Caulking	1	0
MECHANICAL	6. Temperature Controls	2	2
	7. Automatic Interlocked Vent Dampers	2	1
	8. Fan Performance Index	-	0
	9. Pipe Insulation	1	0
	10. Duct Construction	1	0
	11. Duct Insulation	2	0
	12. Heating Load Calculation	-	0
	13. Cooling Load Calculation	-	0
	14. Maintenance Manual	3	1
	15. Ventilation Requirements	1	1
	16. Equipment Certification	2	1
	17. Model	2	1
	18. Efficiency	2	1
	19. IID	1	0
	20. Equipment Certification	2	0
	21. Model	2	1
	22. Efficiency	2	0

(See Notes at end of table)

TABLE 5 (cont.)
NONRESIDENTIAL
FIELD CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
MECH	23. Equipment Sizing/Selection	2	1
	24. HVAC Indices	-	0
	25. Economizer	2	5
H_2O HEATING	26. Equipment Certification	2	0
	27. Type	2	1
	28. Efficiency	2	0
	29. Storage Tank Insulation	1	0
	30. Pipe Insulation	1	6
	31. Temperature Controls	1	0
	32. Circulation Pump Time Clock	1	1
	33. Certified Plumbing Fittings	1	2
LIGHTING	34. Equipment Certification	-	0
	35. Fixture Wattages	2	5
	36. Double Switching	2	2
	37. Switching for Natural Light at Perimeter	-	0
	38. Automatic Switching at Skylights	-	0
DOCUMENT	39. List of Certified Manufactured Devices	3	4
	40. Insulation Certificate	3	21
	41. Construction Certificate	-	0
	42. Compliance Certificate	-	0

(See Notes at end of table)

TABLE 5 (cont.)
NONRESIDENTIAL
FIELD CHECK COMPLIANCE VIOLATIONS
1987-88 MONITORING

	Item	Note	Number Noted
	43. Component Package	-	-
	44. Computer Program	-	-
	45. Package "C" Used/Building Has Skylights	-	0
	46. Package "C" Used/Insulation Placed on Interior	-	0
D	47. Insulation R-Value - Roof/Ceiling	2	1
O	48. Insulation R-Values - Wall	2	0
C	49. Glazing Area	2	9
U	50. Wall Area	-	0
M	51. Conditioned Floor Area	-	0
E	52. Heating COP Input	-	0
T	53. Shading Devices	1	0
A	54. Tandem Wiring	1	2
T	55. No Lighting Calculations	-	0
I	56. No HVAC Calculations	-	0
O	57. Package "A" Used/Building Has Skylights	-	0
N	58. SCM HVAC Zoning	-	0
	59 Glazing type	2	0
	60. Second Generation Office Calculations Required	-	0

Notes:

1. Not Noted On Plans
2. Calculations Not Provided
3. Calculations Are In Error
4. Plans Do Not Match Calculations

Source: C.M.J. Engineering, 1988

Plan Check Violations in Second Generation Office Standards With Prescriptive Compliance Approach

- *Selection of packages was incompatible with energy features shown on the plans* (e.g., using a non-daylighting package when the building has skylights).
- *Economizers were not installed when required* (as part of a prescriptive package).
- *Actual installed HVAC power indices were inconsistent with the requirements of the prescriptive package chosen* (also, one building plan specified a gas heating system, but electric resistance heating was installed).
- *Installed insulation did not meet minimum insulation requirements in the prescriptive package chosen.*
- *Installed lighting exceeded the allowable connected lighting load for the package selected, and tandem wiring was not specified or installed where required.*

Field Check Violations in Second Generation Office Standards With Prescriptive Compliance Approach

- *Economizers were not installed on the HVAC units as required by the plans.*
- *Installed glazing types and glazing areas were inconsistent with plans.*

Plan Check Violations in Second Generation Office Standards With Performance Compliance Approach

- *Multiple zone buildings were designed as single-zone buildings*: buildings with multiple HVAC units were designed as single-zone buildings by combining the HVAC units even though the zones were not similar.
- *Allowable budgets were incorrectly calculated* (e.g., basing budgets on the conditioned cross-sectional area of the tenant improvement being designed and not on the total conditioned cross-sectional area of the story).

- *HVAC data were input incorrectly* (e.g., equipment type and efficiency of equipment).
- *Miscellaneous input errors* (e.g., errors in floor, wall and glazing areas, shading coefficients, and insulation R-values).

Field Check Violations in Second Generation Office Standards With Performance Compliance Approach: Minimal and are not discussed

Plan Check Violations in First Generation Standards With Prescriptive Compliance Approach

- *Incomplete or incorrect envelope calculations were submitted* (e.g., glazing areas and U-values).
- *Equipment sizing calculations (based on heating and cooling load calculations) were not submitted.*
- *Lighting shown on the plans exceeded allowable lighting, and switching was not specified where required* (e.g., switching for perimeter lighting, automatic switching at skylights, and double level switching).

Field Check Violations in First Generation Standards With Prescriptive Compliance Approach

- *Required pipe insulation was not installed.*
- *Installed lighting exceeded plan specifications, and switching specified on the plans was not installed in the field.*
- *Miscellaneous energy features were specified on the plans but not installed in the field.* The most prominent features were time clocks, certified plumbing fittings, and weatherstripping.

General Violations

Some violations that affected all nonresidential buildings included the following:

- Certificate of Compliance Forms (CF-1) were missing, not on the plans, incomplete, or incorrectly completed. Most enforcement personnel

believed that CF-1 forms need only be attached to the plans to satisfy the requirement that the form be on the plans.

- Insulation certificates were not posted as required. The actual number of violations may be less than that documented because some enforcement personnel stated that the insulation certificate would be posted at final inspection prior to issuance of the certificate of occupancy.
- Installation certificates for manufactured devices were not posted as required. Again, the actual number of violations may be less than that documented because some enforcement personnel stated that the installation certificate would be posted at final inspection prior to issuance of the certificate of occupancy.

Concluding Comments

Three key issues that adversely affect enforcement levels were raised by enforcement personnel:

- *The standards are too complex.* Recent changes to the standards have resulted in increased flexibility, but at a cost of increased complexity. As an example, more plan checking time was required than previously, since more of the submissions are using the performance method of compliance than was previously done.
- *Lack of a fixed time interval for changes to the standards.* Enforcement personnel were unable to keep up with the continuous influx of interpretations and changes to the Standards being issued by the CEC. Constructing some nonresidential buildings to comply with second generation standards (those adopted in 1984 for offices) while constructing others under first generation standards (those adopted in 1978 for all other buildings) complicates compliance for the building industry. The same problem existed for residential buildings in the early 1980s.
- *Inadequate time to review new standards prior to the effective date.*

The CEC is working with builders, building officials, and consumer groups to ensure consistent and effective implementation of its present standards:

- Design tools were made available as direct outputs of the standards development process to assist in building design, as well as enabling

builders to demonstrate compliance with the performance standards: public domain computer programs were developed along with a method for verifying and approving private vendor computer programs. A design compliance manual was written from a building designer's point of view, to be used as a guide at each step of the design process to ensure that the ultimate design will meet or exceed the standards. These tools provide specific information concerning energy savings of alternative measures, and the energy effects of other building variations.

- Compliance forms were provided to local building departments to simplify the plan review process.
- Educational materials were also developed to simplify compliance by the building industry.
- A monthly newsletter was prepared that contained articles about the standards, staff interpretations of the standards, and answers to questions about the standards.
- A toll-free telephone line (hotline) was established to provide immediate answers to questions about the standards.
- Training classes (seminars/workshops) are offered through professional organizations, by architects, building designers, building officials, and other industry representatives.
- Methods for lenders and appraisers to give appropriate consideration to a new home's energy-conserving features have also been developed by the CEC.

In conclusion, implementing the residential and nonresidential standards has required major ongoing educational efforts for building industry professionals and the staffs of local building departments. There is a clear need for the CEC to establish more understandable procedures and to expand and improve its technical assistance programs. Accordingly, the CEC has recently established regional training and plan check centers for building officials, is developing a computer information network for the building industry and building departments, has developed a concise custom budget procedure, and has developed a new, more accurate and simple point system. Hopefully, these activities will facilitate compliance and enforcement with California's new building standards.

SUMMARY AND CONCLUSIONS

Compliance and enforcement activities related to local and state building codes for existing and new construction were evaluated in two case studies. The analysis of the City of San Francisco's Residential Energy Conservation Ordinance (RECO) showed that a limited, prescriptive energy conservation ordinance for existing residential construction can be enforced relatively easily with little administrative costs, and that compliance with such ordinances can be quite high. Compliance with the code was facilitated by extensive publicity, an informed public concerned with the cost of energy and knowledgeable about energy efficiency, the threat of punishment (Order of Abatement), the use of private inspectors, and training workshops for City and private inspectors.

The analysis of California's Title 24 Standards for new residential and commercial construction showed that enforcement of this type of code for many climate zones is more complex and requires extensive administrative support for education and training of inspectors, architects, engineers, and builders. Under this code, prescriptive and performance approaches for compliance are permitted, resulting in the demand for alternative methods of enforcement: technical assistance, plan review, field inspection, and computer analysis. In contrast to existing construction, building design and new materials and construction practices are of critical importance in new construction, creating a need for extensive technical assistance and extensive interaction between enforcement personnel and the building community.

Compliance problems associated with building design and installation did occur in both residential and nonresidential buildings. Because statewide codes are enforced by local officials, these problems may increase over time as energy standards change and become more complex and as other standards (e.g., health and safety codes) remain a higher priority. The California Energy Commission realizes that code enforcement by itself is insufficient and expects that additional educational and technical assistance efforts (e.g., manuals, training programs, and toll-free telephone lines) will ameliorate these problems.

BUILDING ORDINANCES AND NONMANDATORY PROGRAMS

Building ordinances need to be evaluated in parallel with nonmandatory programs (Vine and Harris, 1988a). Building codes and standards provide a mechanism to establish minimum acceptable efficiency for all new buildings ("sacrificing depth for breadth"), and mandatory regulations eliminate (in principle) practices that are the "worst" in terms of energy efficiency. Because such standards are necessarily the products of compromise, however, they do relatively less to promote development or early acceptance of the best energy-efficient designs, products, and materials.

In contrast, nonregulatory programs (e.g., technology demonstrations, financial incentives, consumer information and marketing, technical information, and site and community planning) are designed to complement—or in some cases substitute for—mandatory energy efficiency requirements in local and state building codes.* Nonmandatory programs help to push efficiency beyond the minimum acceptability for program participants ("sacrificing breadth for depth"): for example, a small number of builders may build superinsulated homes. Nonmandatory programs can complement building standards by providing: (1) options for innovative approaches not covered by standards, (2) incentives for early adoption of standards, and (3) training workshops and material for educating the building community and thus enabling and enhancing compliance with standards (e.g., by reducing the cost of compliance to builders and the cost of code enforcement to government). In sum, nonmandatory programs may not only provide a receptive environment that eases the process of introducing new standards or upgrading existing ones, but also, in some cases, help to promote building practices that exceed state or local standards.

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* For more information on these kinds of programs, see Vine and Harris (1988a and 1988b).

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