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AN EVALUATION OF ENERGY CONSERVATION PROGRAMS FOR NEW RESIDENTIAL BUILDINGS

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An Evaluation of Energy Conservation Programs for New Residential Buildings

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DISCLAIMER

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AN EVALUATION OF ENERGY CONSERVATION PROGRAMS FOR NEW RESIDENTIAL BUILDINGS†

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ABSTRACT

This paper evaluates the implementation of programs promoting energy efficiency in new residential construction. This paper is one of a series of program experience papers that seeks to synthesize current information from both published and unpublished sources to help utilities, state regulatory commissions, and others to identify, design, manage, and evaluate demand-side programs.

We focused our investigation on nonmandatory programs that are designed to complement—or in some cases substitute for—mandatory energy efficiency requirements in local and state building codes. We evaluated the following types of nonmandatory programs: technology demonstrations, pilot demonstration programs, financial incentive programs (including rebates, conservation rates, reduced hookup fees, reduced loan interest rates and loan-qualifying criteria, guaranteed savings, and tax credits), consumer information and marketing programs (including energy rating systems and energy awards), technical information programs (including professional guidelines, design tools, design assistance, and standards-related training, compliance, and quality control), and site and community planning.

In addition to presenting findings for each program category, we summarize general program conclusions, applicable to most of the energy conservation programs reviewed in this paper:

- Many different types of nonmandatory programs appeared to be successful in (a) overcoming barriers to promoting energy efficiency in new buildings, (b) complementing and facilitating the adoption of future energy conservation building standards, and (c) promoting compliance with existing standards.
- Few program evaluation studies exist, resulting in a paucity of quantitative data on program effectiveness, especially beyond the pilot or demonstration stages.
- No program strategy was clearly dominant.
- Only a few programs were designed as part of a long-term strategy to promote energy-efficient construction.
- Successful programs were often characterized by intervention early in the building design and planning process in order to minimize delays in the project design, approval, financing, and construction process.
- Education, training, and design assistance activities were especially important.
- Nonmandatory programs can reinforce and pave the way for codes.
- Most programs focused on the early design stages of a building without addressing issues normally arising later (e.g., details of construction, quality control, building commissioning, and operations and maintenance).
- Utility rate designs were typically not used as conscious reinforcement for promoting energy-efficient construction.
- Many programs considered successful were judged to be so on the basis of both energy and nonenergy reasons (e.g., improved thermal comfort, creation of new markets, and improved customer relations).
- Most of these programs can be easily implemented in other areas around the country and in other countries.

For designing and implementing energy conservation programs for new residential buildings, the evidence suggests that a comprehensive and long-term perspective is needed to design and choose programs. Long-term goals and objectives of programs need to be made explicit in order to provide program guidance. The following program strategies should be considered as part of a well-integrated package of programs: design assistance, financial incentives, quality control, training and education of design professionals and the building community, simple and easy-to-use design tools, rating and labeling of buildings, effective marketing and promotion, energy awards for buildings and for design and building professionals, operations and maintenance activities, building commissioning, process and impact evaluation, monitoring, and feedback activities. As program objectives and priorities change, these strategies may occur at different stages in the implementation of a given program.

INTRODUCTION

For over ten years, energy conservation programs for new residential buildings have been implemented by local, state, and federal government agencies, utility companies, and private organizations in the U.S. and in other countries. Most of these programs have been designed and implemented in isolation from one another and have emphasized different technical and marketing designs. Because of the renewed interest in these programs (in part related to utility demand-side planning efforts in the U.S.[1]), it is important to understand how effective they have been in penetrating the new construction market, in saving energy, and in influencing the design and construction of energy-efficient buildings. In addition, we need to know what issues remain unresolved and what kinds of programs should be implemented in the future.

This paper is one of a series of program experience papers that seek to synthesize current information from both published and unpublished sources to help utilities, state regulatory commissions, and others to identify, design, and manage demand-side programs. This paper evaluates the experience with implementing nonmandatory programs promoting energy efficiency in new residential buildings.[2] We investigated this topic for several reasons. First, many areas of the country are experiencing increasing demand for electricity, due in large part to all-electric new construction. Constructing energy-efficient buildings (including those with lower demand during utility system peak periods) will reduce the need for, or forestall, new power generating plants. Second, even in areas where there is now a surplus of electric generation capacity, new buildings should be considered a "durable good" that will last for 3 to 5 decades or more; any delay in constructing energy-efficient buildings represents a "lost opportunity" to save energy (Northwest Power Planning Council, 1986). Third, it is often easier and less expensive to construct an energy-efficient building from the beginning than to retrofit an existing building later. Fourth, in those areas where building codes have been in place for a number of years, there is a general reluctance to further tighten the energy-efficiency requirements until other, nonregulatory approaches have been explored. Finally, the implementation of the programs demonstrates that utilities can become active participants in promoting energy-efficient buildings without being linked by their customers with the stigma often connected to mandatory building standards.

The programs examined in this paper illustrate the range of approaches taken in promoting energy-efficient buildings. We were interested in both successful and less successful programs, since both can help guide future program design. A successful program is one in which, at a minimum, energy conservation features have been incorporated into the design of buildings and, at a maximum, energy savings

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[1] Demand-side planning includes both conservation and load-shifting programs.

[2] A more extensive report on both residential and nonresidential programs is available from the authors (Vine and Harris, 1988a).

(especially, electricity savings, the most costly form of energy) have been significant and cost-effective, and/or market penetration has been extensive. Other indicators (e.g., occupant satisfaction and indoor air quality) are also sometimes included in defining a successful program. In conclusion, we feel that our sample of programs represents many of the most important programs encouraging energy-efficient construction in new residential buildings in the United States and in other countries, and that their collective experience can be helpful as a guide to future program and policy choices.[3]

CONCEPTUAL FRAMEWORK

This investigation was guided by our perspective on how programs address the barriers to widespread adoption of energy-efficient design and better end-use technologies in new buildings. Different frameworks have been used in the investigation of barriers in residential buildings; our categorization reflects these earlier perspectives (e.g., Blumstein *et al.*, 1980). We considered four types of barriers: lack of information, high initial costs, degree of technological development, and perceived risk. These barriers are not mutually exclusive and often interact.

Information

Designers, architects and engineers, builders and developers, and the lending community need information on energy-efficient design and product availability, as well as data on their costs and energy performance. In addition, there is a widespread need for better energy design tools and improved methods for evaluating new technologies as they relate to a specific building. The lack of this information and the perception of problems regarding new technologies may prevent even highly motivated individuals from investing in cost-effective, energy-efficient buildings, or inhibit design professionals from recommending such measures.

Initial Costs

Most of the actors involved in the design, construction, and ownership of energy-efficient buildings are sensitive to initial costs and are less concerned with long-term operating costs. Similarly, any time delays in designing and constructing a building represent increased costs that someone must bear. This is of special concern to small developer/builder firms, to prospective home buyers with strained budgets, and even to many governmental agencies. Frequently, an increase in initial costs is passed through to the buyer (possibly affecting the buyer's ability to qualify for a loan) and to business or residential tenants. Accordingly, market demand for more efficient buildings may be lessened if the initial costs are perceived as too high, even if the corresponding savings in energy operating costs represent an attractive return on the added first-cost.

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[3] Detailed descriptions of the programs are contained in Vine and Harris (1988b).

Technology

The availability of some new energy-efficient technologies may be limited (e.g., electronic ballasts and point-of-use water heaters), especially in those areas where there is no established market. Also, a large number of manufacturers continue to introduce new products into the marketplace at a fast rate. As a result, problems arise related to the quality, performance, and reliability of these products, and to concerns over possible adverse impacts on occupant health and comfort. The lack of a support infrastructure that is willing and ready to install and/or service new products may compound the problem. Furthermore, new technologies may not be readily accepted without the availability of measured, long-term performance data from a credible source, or some sort of quality assurance from an established institution.

Perceived Risk

For some individuals, the perceived risks associated with constructing (or owning) an energy-efficient building may be considered too high, compared to a more familiar "current practice" building. In the absence of adequate financial incentives, individuals may prefer to wait until new energy-efficiency standards are required, until the advantages of these new technologies have been demonstrated beyond any doubt, or until they are more familiar with the performance of the new designs and products. This delay among consumers and builders, in turn, represents some of the marketing risks confronting program managers and energy forecasters.

Each of these barriers suggests, in turn, possible strategies to overcome barriers to energy-efficient construction in new residential buildings. In organizing the information on the wide range of programs examined, we developed a typology (Table 1) that reflects different approaches to overcome these barriers to energy-efficient construction. Several of the programs we examined have multiple objectives and may overlap the program categories described in Table 1. Moreover, at different stages in the implementation of a given program, the objectives and emphasis may change, thereby changing the nature of the program. For example, demonstration efforts tend to evolve toward technical information programs. Similarly, financial incentives may be phased out once they achieve a certain amount of visibility and market acceptance, to be replaced by information, marketing, and design assistance activities.

Table 1. Types of nonmandatory programs.

Programs	Barriers Addressed			
	Information	Cost	Technology	Risk
Technology Demonstrations and Demonstration Programs	Yes	[Yes]*	Yes	Yes
Financial Incentives				
Direct Incentives	[Yes]	Yes	No	[Yes]
Reduced Utility Rates and Hookup Fees	[Yes]	Yes	No	[Yes]
Reduced Rates on Loans and Loan Qualifications	[Yes]	Yes	No	[Yes]
Guaranteed Savings	[Yes]	Yes	No	Yes
Tax Credits	[Yes]	Yes	No	[Yes]
Consumer Information and Marketing				
Energy Rating and Labeling	Yes	[Yes]	[Yes]	Yes
Energy Awards	Yes	No	No	[Yes]
Technical Information				
Professional Guidelines	Yes	No	[Yes]	Yes
Design Tools	Yes	No	[Yes]	Yes
Design Assistance	Yes	[Yes]	[Yes]	Yes
Standards-related Training, Compliance, and Quality Control	Yes	[Yes]	[Yes]	Yes
Site and Community Planning	Yes	No	[Yes]	Yes

* A [Yes] response indicates that the barrier addressed is not the primary focus of the program.

We focused our investigation on nonregulatory programs that are designed to complement—or in some cases substitute for—mandatory energy-efficiency requirements in local and state building codes. We did not examine implementation issues or impacts of the codes themselves. Building codes and standards, however, do serve an important purpose that is missing in nonmandatory programs. Codes and standards provide a mechanism to establish minimum acceptable efficiency for all new buildings ("sacrificing depth for breadth"). Thus, the role of mandatory regulations is to eliminate (in principle) practices that are the "worst" in terms of energy efficiency. Because such standards are necessarily the products of compromise, they do relatively less to promote development or early acceptance of the best energy-efficient designs, products, and materials. In contrast, nonmandatory programs help 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:

- options for innovative approaches not covered by standards,
- incentives for early adoption of standards, and

- 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, these 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 promote building practices that exceed state or local standards.

METHODOLOGY

In selecting programs for new residential buildings for this review[4], we conducted extensive literature searches and contacted key organizations and knowledgeable individuals in the field. We also sought program descriptions from state energy offices through an announcement in *Conservation Update*, a monthly newsletter published by the U.S. Department of Energy. Our interests included programs that were completed (or otherwise terminated), are presently being conducted, and, in some cases, those about to be initiated. Some of the programs were considered successful by their sponsors, while others were not. The common strand linking these programs was that valuable lessons could be learned from their implementation.

We focused on programs that promote the design and construction of energy-efficient buildings, with a particular emphasis on the building shell or envelope. Although lost opportunities occur if energy-efficient appliances are not installed at the time of construction, programs that simply promote the purchase of energy-efficient appliances, without addressing the building envelope, were not included in this study (e.g., rebates for installing efficient lighting equipment, heat pumps, and other space conditioning equipment). However, we did include programs that address both shell and equipment efficiencies. Similarly, conservation-oriented rate design, such as time-of-use rates and demand charges, were not included in this paper. These rate design strategies are often targeted primarily at existing buildings, although designers of new buildings may take them into account when designing for energy-efficiency.

Using these criteria, we selected for review a total of 48 programs: 37 programs for new residences, and 11 that apply to both residential and commercial buildings. We reviewed each program based on a telephone interview with at least one individual knowledgeable about the program (usually a representative of the program sponsor) and on written materials, when available. The interviews lasted from 10 to 30 minutes and were based on a structured questionnaire. The principal topics addressed during the interview were: program objectives, key participants, date(s) of implementation and current status, marketing methods, type of monitoring and evaluation, key results (in terms of market penetration, savings, costs,

[4] These programs included single-family houses, multifamily units, and manufactured houses (mobile homes and factory-made buildings) for residential uses.

and cost-effectiveness), related programs, and the interviewee's overall assessment of the program. After the program descriptions were written, they were sent to the interviewees who corrected any inaccuracies in the descriptions, updated the status of the program, and provided new information on specific questions raised during our own review of the program writeups. We found the feedback from this iterative process worthwhile, and we recommend this procedure for future program evaluations.

PROGRAM DESCRIPTIONS AND FINDINGS

In this section, we briefly discuss the different approaches used in promoting new energy-efficient construction in the residential sector. After each program category description, we present key findings based on our evaluation of the programs in that category. Table 2 lists the programs reviewed in this paper. The columns in this table are based on the conceptual framework described earlier. Several programs make use of multiple strategies and could be listed under more than one category. In these cases, we assigned a "primary category" and cross-referenced the program's other features.

TECHNOLOGY DEMONSTRATIONS AND DEMONSTRATION PROGRAMS

The building industry is characterized by a large number of specialized regional or local homebuilding firms (U.S. Department of Energy, 1988). As with other sectors that are highly fragmented, the industry is often slow to adopt new technologies, including energy-efficient design features, equipment, or controls. Demonstration programs often play an important role in field-testing new technologies -- or simply in proving the "buildability," performance, economics and marketability of energy-efficiency features. Sometimes these demonstrations are targeted as much to the staff of the sponsoring agency as to the local building or lending communities, especially when the agency is implementing a conservation program for the first time and wants to become more familiar with new technologies.

Demonstration programs often select a small number of sites to test the performance of new technologies in occupied buildings and to prove that the *technology* works. Such technology demonstration sites differ from a second type of demonstration program that is aimed at testing a new *program* approach on a small-scale, pilot basis: if successful, the program is then expanded to a larger scale. Many of the demonstration programs included in this category have incorporated both objectives: to test new technologies and new delivery systems. In Table 2, we distinguish between demonstration programs emphasizing "technology testing" and those focusing on "program testing."

Table 2. Energy conservation programs for new buildings.

Name of Program	Sponsor (see key at end of table)	Program Features (√ = Primary Feature)										
		TD	DP	DI	UR	LL	RL	EA	DT	DA	TC	SP
TECHNOLOGY DEMONSTRATIONS AND DEMONSTRATION PROGRAMS												
Technology Demonstrations												
Energy-Efficient Home Proj. of Oregon	BPA	√	•			•	•		•			
Residential Stds. Demo. Pgm.	BPA	√	•	•						•	•	
Residential Constr. Demo. Pgm.	BPA	√	•	•						•	•	
Energy Efficient Housing Demo.	Minn. HFA	√				•			•	•	•	
Superinsulated Housing Demo.	St. Louis	√	•	•						•		
Energy Efficient Housing Demo.	Baltimore DHCD	√	•							•	•	
Resid. Constr. Demo. Manuf. Housing Prj.	BPA	√	•	•			•	•		•	•	
Class B Passive Solar Perf. Eval. Pgm.	DOE	√	•									
Demonstration Programs												
Denver Metro Home Bldrs.' Pgm.	SERI	•	√	•						•	•	
Affordable Comfort in Manuf. Housing	NCAEC		√	•								
SolarSave Program	Maine OER		√	•								
Passive Solar Manufactured Bldgs.	DOE/SERI	•	√	•						•		
Code Adoption Demonstration, Early Adopter & Northwest Energy Code Pgms.	BPA	•	√	•							•	
Tacoma's Early Adopter Pgm.	Tacoma	•	√	•			•			•	•	
FINANCIAL INCENTIVES												
Utility Rates and Hookup Fees												
Conservation Rate Discount	Carolina P&L				√						•	
Residential Conservation Rate	Duke Power				√							
Residential Service Conserv. Rate	So. Carolina E&G				√						•	
Proposed Hookup Charge	Maine PUC				√							

Key to Features:

TD = Technology Demonstration Site(s)
DP = Demonstration Program
DI = Direct Incentives
UR = Utility Rates & Hookup Fees
LL = Low-interest Loans
RL = Rating & Labeling
EA = Energy Awards
DT = Design Tools
DA = Design Assistance
TC = Training, Compliance & Quality Control
SP=Site & Community Planning

Table 2 Continued. Energy conservation programs for new buildings.

Name of Program	Sponsor (see key at end of table)	Program Features (√ = Primary Feature)										
		TD	DP	DI	UR	LL	RL	EA	DT	DA	TC	SP
Reduced Loans and Loan Qualifications												
Energy-Efficient Mortgage Pilot Pgm.	ASE		•			√	•					
Cut Home Energy Costs Loan Pgm.	Manitoba E&M					√						
Energy-Efficient Construction	So. Dakota HA	•	•			√				•	•	
CONSUMER INFORMATION AND MARKETING												
Energy Rating and Labeling												
Energy Value Home	NE Utilities				•		√					
Energy Saver Home	TVA			•			√			•	•	
Super Energy-Efficient (R-2000) Home	EM&R (Canada)						√		•	•	•	
Energy Efficient Home	Salt River Project						√					
Thermal Crafted Home	Owens-Corning						√		•	•		
Super Good Cents	BPA			•			√		•	•	•	
Energy Conservation Home	PG&E			•			√				•	
Super Saver Award	Florida Power			•	•		√					
Energy Efficient Home Award	Nevada Power						√					
Energy Saver Manufactured Home Award	Arkansas P&L			•			√					
Energy-Qualified (EQ) Home	Owens-Corning			•			√		•			
Energy Award Programs												
Energy Efficient Bldg. Design Competition	EEBA							√				
Energy Conservation Awards	Owens-Corning							√				
TECHNICAL INFORMATION												
Professional Guidelines												
Whole Bldg. Performance Stds.	DOE								•			

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Name of Program	Sponsor (see key at end of table)	Program Features (√ = Primary Feature)										
		TD	DP	DI	UR	LL	RL	EA	DT	DA	TC	SP
Design Tool Programs												
Energy Efficient Home	New England Electric	•						•	√	•		
Design Assistance Programs												
Resid. New Construction	SMUD			•			•		•	√		
Passive Solar Home	SMUD						•			√		
Design Assistance	Va. Dept. Energy			•						√		
Alaska Craftsman Home	Alaska DCRA									√	•	
Bldg. Industries Short Course	Arizona Energy Dept.									√		
Design Assistance for New Bldgs.	San Antonio								•	√		
Solar Design Strategies	PSIC								•	√		
Training, Compliance, and Quality Control												
Calif.'s Conservation Stds. (Title 24)	Calif. Energy Comm.								•	•	√	
Fla. Energy Code and Mktng. Pgm.	Fla. Energy Office						•		•		√	
SITE AND COMMUNITY PLANNING												
Landscaping and Solar Access Protection												
Resid. Solar Access Protection	Nampa (Idaho)			•					•	•	•	√
Community Planning												
Milton Keynes Energy Park Demo.	Milton Keynes (England)	•					•				•	√
Saint Paul Energy Park	Saint Paul											√

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SP=Site & Community Planning

Table 2 Continued. Energy conservation programs for new buildings.

Key to Sponsors	
ASE	Alliance to Save Energy
BPA	Bonneville Power Administration
DCRA	Department of Community and Regional Affairs
DHCD	Department of Housing and Community Development
DOE	U.S. Department of Energy
E&G	Electric and Gas
E&M	Energy and Mines
EEBA	Energy Efficient Building Association
EM&R	Energy, Mines and Resources
HA	Housing Agency
HFA	Housing Finance Agency
NCAEC	North Carolina Alternative Energy Corporation
OER	Office of Energy Resources
PG&E	Pacific Gas and Electric Company
PSIC	Passive Solar Industries Council
PUC	Public Utilities Commission
SERI	Solar Energy Research Institute
SMUD	Sacramento Municipal Utility District
TVA	Tennessee Valley Authority

The key evaluation findings for technology demonstrations and pilot demonstration programs were the following:

- Demonstration programs were often well-funded and helped create the infrastructure and capability to deliver large-scale energy conservation programs.
- Measured electricity space-heating savings, based on utility bills, averaged 45% compared to new buildings not built under these programs.
- In many cases, the design and construction of energy-efficient buildings did not require significant construction cost increases or significant changes in building practices.
- The education and training of building professionals and quality control procedures were essential for program success.
- The focus of many demonstration programs was on "market-leaders" and not on high market penetration rates.
- The impacts of some demonstration programs continued after the program ended.

FINANCIAL INCENTIVE PROGRAMS

Financial incentives play an important role as marketing tools in the implementation of programs and often complement technical assistance, training, and education activities. Financial incentives are used to obtain the target audience's attention and participation, especially by helping overcome actual or perceived costs and risks. Financial incentives have also legitimized and emphasized the public policy pronouncements and goals regarding the need for energy conservation investments. A utility's willingness to contribute a portion of the cost of the investments acts as a "seal of approval" that encourages energy-efficiency investments. The types of financial incentives evaluated in this paper are: rebates, conservation rates, reduced hookup fees, reduced loan interest rates and loan-qualifying criteria, guaranteed savings, and tax credits.

Direct Incentives

Direct incentives are used to reduce the up-front purchase price, long-run mortgage payments, and risk of energy-efficient technologies to the target audience (e.g., the consumer or builder). Reduction of initial costs is often seen as financially and psychologically more important than an equivalent slight reduction in long-term mortgage payments for building owners. Direct incentives are usually rebates and direct cash payments, often benefiting building owners, and are considered a one-time payment. Sometimes constraints are placed by the program sponsor on how the money is used: in one program, dealers of energy-efficient manufactured houses could only use the money in advertising the program.

Reduced Utility Rates and Hookup Fees

Utility companies have used a variety of rate structures designed, in part, to encourage efficient energy use, as well as reliable cost recovery for the utility and equitable cost allocation among customers. Examples of specialized rate structures, to achieve one or more of these objectives, include: demand charges, time-of-use rates, off-peak rates, seasonal rates, inverted rates, variable levels of service, and promotional rates. These rates, however, are usually not designed to reinforce demand-side management programs. While these rates apply to all customers in a given class, new construction can often take advantage of these rates if they are designed and built correctly. We focused on those programs using conservation rates, the principal type of rate promoting energy-efficient new construction. In these programs, customers meeting the utility's criteria for efficiency are placed in a separate (lower) rate category.

Two important features differentiate rate reductions from rebates and other direct incentives: their duration and the target audience. The percentage reduction in rates typically last for the lifetime of the house (or the homeowner); on the other hand, rebates are typically paid only once, after a building has been completed or piece of equipment installed. Reduced rates typically benefit homeowners. Builders indirectly benefit from these rates by the increased demand for energy-efficient housing by consumers favoring lower rates, as experienced in some home energy rating programs (see below). In contrast, rebates have a mixed target audience and are often of greatest benefit to builders. Consumers indirectly benefit from rebates by the increased supply of energy-efficient housing and equipment. Programs often consider both rebates and rate-oriented (continuing) incentives for promoting energy-efficient buildings, depending on where the greatest leverage per dollar exists.

Another rate-oriented incentive available to utility companies is a reduced hookup (connect) charge. For example, a utility might promote energy conservation and reduce peak loads by allowing owners of new energy-efficient buildings and equipment to pay reduced connect charges. In many cases, this approach would reverse the established system of reduced hookup fees for new users with higher connected loads and of increased "free-footage allowances" for new service connections.

Reduced Loan Interest Rates and Loan-Qualifying Criteria

A homeowner's ability to purchase an energy-efficient house is often contingent on his or her ability to qualify for a mortgage loan, and that qualification is a function of current income, total debt and monthly obligations, and equity in the house. Traditionally, lending institutions have implicitly penalized energy efficiency by not including reduced energy costs in their loan calculations. One reason for this was that the lending industry had no accurate, widely accepted way to ascertain the energy efficiency of a particular structure, and to determine the impact of this on loan-qualifying ratios.

In the last seven years, there has been some change in this situation. This has been largely due to the development of home energy rating systems (see below) which provide the means for ascertaining energy efficiency and energy costs. With a relatively accurate and reliable estimation of energy costs, a lending institution has a basis for altering the expected debt-to-income and payment-to-income ratios (the debt-to-income ratio compares total debt to total household income, while the payment-to-income ratio compares monthly housing payments to monthly income). The lower energy expense anticipated from an energy-efficient structure changes the payment ratio, so that a borrower can afford to pay for a larger loan than would otherwise have been the case. Where utility bill savings offset any increases in first-cost on a lifecycle basis, the loan-qualifying process is less restrictive, and more marginal buyers may actually qualify for a loan. Thus, households of all income levels, previously considered to be on the borderline of qualification, can qualify more easily (Schuck and Millhone, 1982).

In contrast to lowering loan qualifications, reduced rates on mortgage loans (interest rate buy-downs or write-downs) for buildings complying with energy efficiency standards are another strategy attempted in a few demonstration programs. Very few programs have used this strategy, and evaluation data are sparse.

Guaranteed Savings

Another financial incentive used by some institutions and builders to promote energy-efficient buildings is guaranteed savings: a builder or utility markets the energy-efficient building with a guaranteed maximum utility bill for the first few years of ownership. For example, the homeowner pays no more than $100 on a given bill, and the utility pays the balance. Supporters of this strategy argue that guaranteed savings benefit developers by facilitating the rapid sale of new buildings, ensuring greater profitability and market share. By guaranteeing savings, these incentives have other noneconomic benefits: they increase the trustworthiness of the sponsor providing the incentives and, where available, increase the value of home energy rating systems (Vine *et al.*, 1987). However, while these guarantees entail little risk for the homeowner, they may result in greater risk to the providers: utility companies may have to increase rates, or builders increase selling prices, to recover their costs if savings do not occur. And these risks are small compared to lost credibility and lawsuits. However, none of these problems have occurred so far.

Tax Credits

During the 1970s, federal and state governments adopted conservation tax credits and solar tax credits as incentives to help reduce the first-cost of energy efficiency and renewable energy investments. Many of the incentives offset the installation costs of energy equipment (e.g., solar water heaters) rather than improvements to the building shell. In addition to increasing the cost-effectiveness (to the consumer) of energy-saving measures, the tax credits often had other goals, such as: develop new jobs and businesses, achieve environmental benefits, accelerate technological development, increase security and reliability of energy supplies, and counter-balance subsidies to conventional energy sources.

The key evaluation findings for financial incentive programs were the following:

- The size of an incentive has not been shown to be positively correlated with program participation; above some "threshold value," the presence of an incentive may be more important than its magnitude.
- Financial incentives varied by target sector (e.g., builder versus homeowner), duration of impact (occurring at one time versus over the lifetime of the building), breadth of impact (e.g., all homeowners versus high-income homeowners), and program sponsor (e.g., state government versus utility).
- The impact of direct incentives on program participation is greater when offered in conjunction with technical assistance, training, and education.
- The largest direct incentives were targeted at developers participating in demonstration programs.
- Reduced utility rates were well-received by residential customers and utilities, were easy to implement, often resulted in peak demand savings, but were seldom tried.
- Although potentially of great impact, hookup (connect) fees tied to a building's energy efficiency have not been tested in the U.S..
- Few programs had promoted guaranteed savings.
- Reduced mortgage rates and lending policies incorporating energy efficiency guidelines have thus far had limited impact in creating market demand for energy-efficient housing.
- Tax credits were useful for promoting energy efficiency investments, but the credits typically benefited high-income households, and their near-term future impact will be limited since few states offer tax credits.

CONSUMER INFORMATION AND MARKETING

Information/marketing programs can be used to publicize energy conservation programs (program marketing) as well as to help expand and intensify the market for energy-efficient products (market enhancement). Many programs include both objectives by increasing the target audience's (e.g., consumers, builders, and developers) awareness, acceptance, and support of particular energy conservation programs. Several types of marketing methods are used, often in combination with one another: *education* through bill inserts, brochures, information packets, displays, and direct mailings; *direct contact* through face-to-face communication in workshops and seminars; *trade ally cooperation* through cooperative advertising and marketing and certification; and *advertising and promotion* through mass media (radio, television, and newspaper) and point-of-purchase advertising.

Two types of consumer information and marketing programs are considered in the following discussion: home energy rating systems and energy awards. The former is an excellent example of how different marketing strategies can be used in an integrated fashion to successfully promote conservation programs to several target audiences. In contrast, the latter is directed mainly to designer/builder professionals, and, by itself, has a more limited impact. However, when combined with other features, such as building energy ratings, the impact of energy awards becomes more significant.

Energy Rating and Labeling

Home energy rating systems (HERS) typically certify that a home meets a specified level of energy efficiency or that it contains specific energy efficiency features. In addition to the technical rating of the program, support activities (such as program marketing and financing) are often included as part of the HERS. Home energy rating systems are often targeted to many groups: consumers, builders, the real estate community, appraisers, and lenders. The experience with implementing HERS is extensive and well-documented (Hendrickson, 1986; Vine *et al*, 1987).

Energy Awards

Energy awards are sometimes presented in recognition of those design professionals whose work demonstrates energy efficiency in new construction (i.e., "the best" energy-efficient buildings). The primary objective of design competitions and awards is to generate interest in energy-efficient buildings within the design community. In some cases, the design competition may be part of a demonstration program, and the winning designs may become the models for buildings built in the program.

The key evaluation findings for consumer information and marketing programs were the following:

- Home energy rating systems were more successful, in terms of penetration rates and improved energy efficiency, when they:
    - were actively marketed,
    - had a comprehensive appreciation of the market,
    - were adaptive to the needs of particular users, and
    - included user participation in the operation and revision of the program.
- Where a HERS was offered, the percentage of new residential construction participating ranged from 2-100%; the average market penetration rate was 40%.
- Measured annual electricity space-heating savings of new homes participating in HERS ranged from 30-50% (compared to current building stock or state standards).

- Other features important to the success of HERS were: the credibility/trustworthiness of the HERS sponsor; cooperation with building associations; and cooperative advertising between sponsors and the building and financing communities.
- Low-income homebuyers rarely participated in HERS; this was particularly true in manufactured housing.
- Energy awards were effective in promoting energy-efficient construction when they were featured as part of comprehensive energy efficiency programs.

TECHNICAL INFORMATION

Professional Guidelines

The provision of technical information for design practitioners and building professionals is often one of the first resources to be developed in the promotion of energy-efficient construction. One source of technical information is guidelines on designing and constructing energy-efficient buildings issued by professional organizations, often in conjunction with a code adoption process. While guidelines are also offered in many programs, as part of the interactive discussions between program sponsors and target groups, the guidelines considered here are those that are generic to all building types, without reference to specific building sites or geographic locations.

Design Tools

As part of most design assistance programs (see below) and as part of information transfer activities, special design tools for evaluating energy-efficiency features have been developed and made available to the design community. The available design tools are varied, including workbooks, guidebooks, calculator programs, daylighting models, and microcomputer or mainframe computer software. The same tools can be used both for complying with local or state energy codes and for improved design that goes beyond standards.

Design Assistance

In contrast to the broad and generic approach characteristic of professional guidelines and most design tools, design assistance programs are typically identified with a customized approach that is building specific. Moreover, aside from programs providing direct rebates for appliances and equipment, the provision of technical assistance in designing energy-efficient buildings is one of the most common types of energy-efficiency programs offered by utilities and governmental agencies to new residential customers. As part of the design process, these design assistance programs often include consulting services and site-specific design review between energy experts and the architect and engineering team and their client.

Standards-related Training, Compliance, and Quality Control

Technical workshops and seminars are sometimes conducted, as part of energy conservation programs, to provide technical information and training to architects, engineers, building owners and managers, builders, developers, building code officials, appraisers, real estate professionals, and staff of financial institutions. These training activities are especially important to encourage conformance with mandatory standards or voluntary guidelines. In addition to ongoing education and training activities, quality control inspections are sometimes made during the construction process and/or after the building has been completed to ensure that the building has been constructed properly and that the equipment is working as designed.

The key evaluation findings for technical information programs were the following:

- Design guidelines issued by professional organizations were important, over the long term, in establishing new norms of professional practice, new design guidelines, and new local and state building codes; however, more immediate, personal, and interactive design assistance was often needed for promoting energy-efficient construction.
- Design tools were effective in promoting energy-efficient construction when they were featured as part of comprehensive energy efficiency programs.
- Simple, low-cost and readily available analysis tools that provide reliable, useful information on energy performance of proposed design measures were considered important for the success of design assistance programs.
- Design assistance programs demonstrated that the initial reluctance of some designers to have their plans reviewed can be overcome when both the design firm and the client were clearly shown the benefits of designing energy-efficient buildings.
- Design assistance programs were most successful when energy efficiency options were introduced as early as possible in the design stage, and when they did not add delays to the project design, approval, financing, or construction process.
- Design assistance programs demonstrated that, in many cases, substantial gains could be made in energy efficiency without requiring significant cost increases or significant changes in building practices.
- The focus of design assistance programs was on "market-leaders" and not on high market penetration rates.
- Significant indirect effects of design assistance programs were: a more receptive environment to innovative methods, materials, and technologies; a new private service industry in designing and constructing energy-efficient buildings; and the development of prototypes for future buildings.

- Technical workshops and seminars were important for encouraging conformance with mandatory standards or voluntary guidelines.
- Quality control inspections were key features of many programs.

SITE AND COMMUNITY PLANNING

Site planning refers to those measures taken outside of the building that influence the amount of energy used inside the building. The most common methods revolve around landscaping and protecting solar access, while more extensive means relate to community planning and development. The latter requires a large amount of resources that public agencies do not normally have or are willing to commit. Consequently, the private sector, with some public assistance, has been the principal planner and developer of new communities. There are few examples of programs that combine site planning *and* building-level strategies, nor of linking utilities with community planning. Moreover, many utilities are presently encouraging commercial and industrial economic development projects without offering energy-efficiency design assistance. The potential impact of site and community planning activities is significant and requires further demonstration.

The key evaluation findings for site and community planning programs were the following:

- Solar access protection regulations helped promote energy-efficient construction.
- Increased dwelling density in planned unit developments was a powerful incentive for promoting energy-efficient construction.
- New communities offer the potential for widespread construction of energy-efficient buildings.

CONCLUSIONS

General program conclusions, applicable to most of the energy conservation programs reviewed in this paper, were the following:

- Many different types of nonmandatory programs appeared to be successful in:
    - overcoming barriers to promoting energy efficiency in new buildings,
    - complementing and facilitating the adoption of future energy conservation building standards, and
    - promoting compliance with existing standards.
- However, few program evaluation studies exist, resulting in a paucity of quantitative data on program effectiveness, especially beyond the pilot or demonstration stages.

- No program strategy was clearly dominant.
- Only a few programs were designed as part of a long-term strategy to promote energy-efficient construction.
- Successful programs were often characterized by intervention early in the design and planning process in order to minimize delays in the project design, approval, financing, and construction process.
- Education, training, and design assistance activities were especially important.
- Nonmandatory programs can reinforce and pave the way for codes.
- Most programs focused on the early design stages of a building without addressing issues normally arising later (e.g., details of construction, quality control, building commissioning, and operations and maintenance).
- Utility rate designs were typically not used as conscious reinforcement for promoting energy-efficient construction.
- Many programs considered successful were judged to be so on the basis of both energy and nonenergy reasons (e.g., improved thermal comfort, creation of new markets, and improved customer relations).
- Most of these programs can be easily implemented in other areas around the country and in other countries.

STRATEGIC INTERVENTION

Most programs do not have a long-term, explicit strategy for promoting energy-efficient construction. Many programs have not set long-term goals or targets, nor do they know how close they are to achieving the goals. Because programs are typically designed in response to short-term goals and objectives, the lack of a long-term strategy may result in vague and unworkable program design and program implementation. As a result, programs may be terminated before they reach full maturity.

Accordingly, programs should be strategically introduced at certain stages to accomplish long-term goals. For example, in areas where there is already a minimum energy conservation building standard that would not be tightened until nonmandatory approaches are considered, demonstrations are often the first type of program introduced by an organization to promote energy-efficient construction. These programs typically emphasize "technology testing" and "program testing" and are targeted at a narrow audience. Once the program has proven that the technology and program work, the organization considers other strategies for obtaining broader participation: the development of a technology transfer plan to disseminate demonstration results, technical and financial assistance programs for the design and construction community (e.g., rebates, training seminars, and workshops), and educational and financial programs for consumers (e.g., reduced utility rates for homeowners). Energy rating systems may be effective at this stage. After the program has been implemented for some time, the program targets hard-to-reach groups: for example, developers of multifamily units, low-income households, speculative builders, and landlords with short-term leases. After these programs have been in effect for a number of years, more stringent building codes and standards may be introduced to make sure that nonparticipants are constructing more energy-efficient housing. At this stage, standards-related training, compliance, and quality control programs are important.

An exemplary set of programs that demonstrate the exception to this trend and demonstrate "strategic intervention" are the programs currently being conducted by the Bonneville Power Administration (BPA) (Northwest Power Planning Council, 1987). BPA is committed to promoting the voluntary adoption of energy-efficient building codes in the Pacific Northwest, pursuant to the 1986 Power Plan of the Northwest Power Planning Council. This commitment is demonstrated through market-based incentives and nonmandatory programs with prescribed goals and target dates. Moreover, many different types of organizations are cooperating in this effort: for example, utility companies and state and local governments. Recently, state utility commissions have been requiring utilities in other states to develop long-term programs for promoting energy-efficient construction as part of "least-cost utility plans." We believe the programs in the Pacific Northwest are one model for utilities in other regions to consider in their development of demand-side utility plans and programs for new construction (Northwest Power Planning Council, 1987).

PROGRAM DESIGN AND IMPLEMENTATION RECOMMENDATIONS

For designing and implementing energy conservation programs for new residential buildings, the evidence suggests that a comprehensive and long-term perspective is needed to design and choose programs. Long-term program goals and objectives need to be made explicit in order to provide program guidance. The following program strategies should be considered as part of a well-integrated package of programs: design assistance, financial incentives, quality control, training and education of design professionals and the building community, simple and easy-to-use design tools, rating and labeling of buildings, effective marketing and promotion, energy awards for buildings and for design and building professionals, operations and maintenance activities, building commissioning, process and impact evaluation, monitoring, and feedback and technology transfer activities. This undertaking is necessary for the serious promotion of energy-efficient construction in the residential sector. If one organization is unable to provide both incentives and support activities, then two or more organizations may be able to coordinate these activities (e.g., utilities provide financial incentives and local governments provide support activities).

Most of these programs can be easily implemented in other areas around the country. We do not see geographical and climatic differences as barriers to the implementation of these programs. As a word of caution, we do not want to imply that programs can be easily transferred from one region to another.

Programs can be used as models, but they must be adapted to fit local circumstances. Program managers need to find out about the details of other programs before adopting them, including any mid-course corrections made during the implementation of the program. Implementation of energy conservation programs is not an easy task, and there have been lots of failures at various stages in the implementation process. The challenge is to design and implement a program that meets the needs of the target audiences as well as promoting energy-efficient construction.

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