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ENERGY-EFFICIENT BUILDINGS: DOES THE MARKETPLACE WORK?

by Marilyn A. Brown, Deputy Director
Energy Efficiency and Renewable Energy Program
*Oak Ridge National Laboratory

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For a variety of reasons, U.S. households, businesses, manufacturers, and government agencies all fail to take full advantage of cost-effective, energy-efficiency opportunities. Despite a growing environmental ethic among Americans and a concern for energy independence, consumers in this country are underinvesting in technologies, products, and practices that would cut their energy bills. The result is a large untapped potential for improving energy productivity, economic competitiveness, environmental quality, and energy security. The thesis of this paper is that the marketplace for energy efficiency, in general, is not operating perfectly, and the marketplace for energy-efficient buildings, in particular, is flawed.

The reasons for underinvestments in cost-effective, energy efficiency are numerous and complicated. They also vary from sector to sector: the principal causes of energy inefficiencies in agriculture, manufacturing, and transportation are not the same as the causes of inefficiencies in homes and office buildings, although there are some similarities. One of the reasons for these differences is that the structure of marketplace for delivering new technologies and products in each sector differs.

Each of the sectors is also distinct in terms of the primary societal benefits from improved energy efficiencies. Improving the efficiency of transportation is essential to improving air quality and making the economy less dependent on imported oil. Improving the efficiency of the industrial sector is essential to economic competitiveness and pollution prevention. Energy-efficiency improvements in the buildings sector is critical to reducing greenhouse gas emissions, since most of the energy consumed in buildings comes from the burning of fossil fuels.

This paper therefore begins by describing energy use and energy trends in the U.S. buildings sector. Characteristics of the marketplace for delivering energy efficiency technologies and products are then described in detail, arguing that this marketplace structure significantly inhibits rapid efficiency improvements. Next, several specific barriers to energy efficiency in the buildings sector are described. In the course of describing these barriers, a selection of government programs and policies are described, including public R&D investments and market transformation programs. These programs exemplify the types of public-private partnerships that have helped stimulate investments in efficiency improvements in buildings. The evidence presented suggests that the marketplace, in partnership with government efforts, has resulted in impressive efficiency gains, but that ongoing public-private partnerships are critical to closing the efficiency gap.

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ENERGY USE AND ENERGY TRENDS IN U.S. BUILDINGS

The gains in energy productivity achieved by the U.S. in the two decades following the 1973-74 Arab oil embargo represent one of the great economic success stories of this century. The extent that the U.S. economy improved its energy productivity can be quantified by examining the relationship between total energy consumption and gross domestic product (GDP). In 1970, 19.6 thousand Btu of energy were consumed for each (1992) dollar of GDP. By 1995, the energy intensity of the economy had dropped to 13.4 thousand Btu of energy per (1992) dollar of GDP (EIA, 1996, p. 17). DOE estimates that the country is saving $150 to $200 billion annually as a result of these improvements.

The last quarter century has also shown increases in energy efficiency in the buildings sector. In 1970, residential and commercial buildings consumed 21.7 quads of primary energy (33 percent of total U.S. energy consumption). By 1995, the buildings sector consumed 32.1 quads of primary energy (35 percent of total U.S. energy consumption) (EIA, July 1996, p. 39). Over the same 25 years, however, the number of U.S. households increased, the square footage of commercial buildings increased, and the level of energy services provided in buildings increased.

In residential buildings, improvements in energy efficiency are illustrated by examining energy consumption per household. Between 1978 and 1980 (when data were first available from EIA's Residential Energy Consumption Survey), annual energy consumption per household ranged from 114 to 138 million Btu. Between 1990 and 1993 (the most recent years of available data), annual energy consumption per household ranged from 98 to 104 million Btu (EIA, July 1996, p. 55). (Ranges of years are provided, because these energy consumption estimates are not adjusted to account for variations in weather. The high levels of consumption in 1978 and 1979 were due, in part, to severe winters.)

Similarly, in commercial buildings, energy-efficiency improvements are documented by examining energy consumption per square foot of commercial building space. Between 1979 and 1983 (when data were first available from EIA's Nonresidential Buildings Energy Consumption Survey), annual energy consumption per square foot ranged from 98 to 115 million Btu. Between 1989 and 1992 (the most recent years of available data), annual energy consumption per square foot ranged from 81 to 92 million Btu (EIA, July 1996, p. 77).

Over the same period that the energy consumed per household and per square foot has declined, the energy services provided in buildings has increased. For instance, the growth in air conditioning over the past few decades, particularly in the South, has been significant. In 1960, fewer than 2 percent of U.S. homes had central air-conditioning (Courville, 1995, p. 10); by 1993 this number had grown to 43.5 percent, and another 26.6 percent had room air-conditioning (EIA, June 1995, Table 3.16b). Similarly, commercial buildings have seen a tremendous growth in "plug loads" due to the increased use of computers. Thus, efficiency improvements in such uses as heating, lighting, and refrigeration are overshadowed, in part, by the increased energy consumed by air conditioning, computing, and other relatively new services.

It is therefore useful to examine the energy required to perform individual functions within buildings. Household refrigeration, for instance, has seen significant efficiency improvements. In 1972, the average household refrigerator in the U.S. consumed nearly 2,000 kWh per year. Today, new refrigerators consume less than 600 kWh/year, and it is anticipated that a kWh-a-day refrigerator will be available by the year 2000. Similarly, the energy used to light a square foot of commercial building space has decreased significantly, and this has resulted in secondary energy savings due to reduced cooling loads. These improvements have been enabled by DOE-supported R&D, demonstration programs, appliance labelling, and federal energy standards.

In considering the potential for future energy efficiency improvements, it is useful to examine the residential and commercial sectors independently, the energy they consume for each major end use, the life expectancy of existing structures, and the pace of new construction. It is also helpful to keep in mind the types of fuels consumed in buildings: in 1995, buildings accounted for 66 percent of the Nation's electricity consumption and 45 percent of natural gas use, but only 6 percent of petroleum (EIA, July 1996, p. 39).

In the residential sector, owner-occupied, single-family residences account for a majority (61 percent) of energy use (EIA, June 1995, Table 3.5; EIA, Oct-b 1995, Table 5.2; EIA, Oct-d 1995, Figure 3.4). In terms of energy end-uses, space heating is the most important, accounting for about 37 percent. Other end-uses include water heating (14 percent); air-conditioning (9 percent); refrigerators and freezers (10 percent); lighting (8 percent); and other appliances and purposes (the remaining 22 percent). This last miscellaneous category (which includes waterbeds, home entertainment systems, and computers) has been growing the fastest in recent years.

In the commercial sector, food and health care are the most energy-intensive establishments, accounting for 12 percent and 11 percent of sectoral energy use, respectively – even though they represent only 6.0 percent and 4.7 percent of total floorspace (Zwack and Kinsey 1995, Tables 1.2.2; EIA Oct-a 1995, Tables 3.2, 3.4). Lighting predominates commercial sector primary energy use at 26 percent; space heating is the next most dominant use at 17 percent, followed by air-conditioning and ventilation at approximately 7 percent each (Zwack and Kinsey, 1995, Table 1.3.2).

For policy purposes, it is important to distinguish new from existing buildings. Although new construction can more easily incorporate new, energy-saving technologies, new buildings amount to only 2 to 3 percent of the existing building stock in any given year (EIA, June 1995, Table 3.2a). Nearly 90 percent of the residential buildings that existed in 1990 will still exist in 2010, and approximately half of the 1990 stock will still be standing in 2030. About 80 percent of the 1985 commercial building stock is expected to still exist in 2010 (Courville, 1995, p. 37). As a result, retrofitting structures and upgrading the efficiency of their heating, ventilation, and air conditioning systems offer the opportunity for significant increases in energy efficiency.

THE EFFICIENCY GAP

The Energy Information Administration (EIA) forecasts that 36.6 quads of energy will be consumed in buildings in the year 2010 (EIA, Jan. 1996, Table A2). This is 7.7 quads higher than a "best practice" scenario, developed by Lawrence Berkeley National Laboratory. The best practice scenario indicates the energy that would be consumed by the buildings sector if the most cost-effective, energy-efficiency technologies available during this period, most of which is already currently developed, were incorporated into new construction and building retrofits (Koomey, 1995). The 7.7-quad difference would save consumers almost $50 billion annually and would result in 118 million metric tons of avoided carbon emissions in the year 2010.

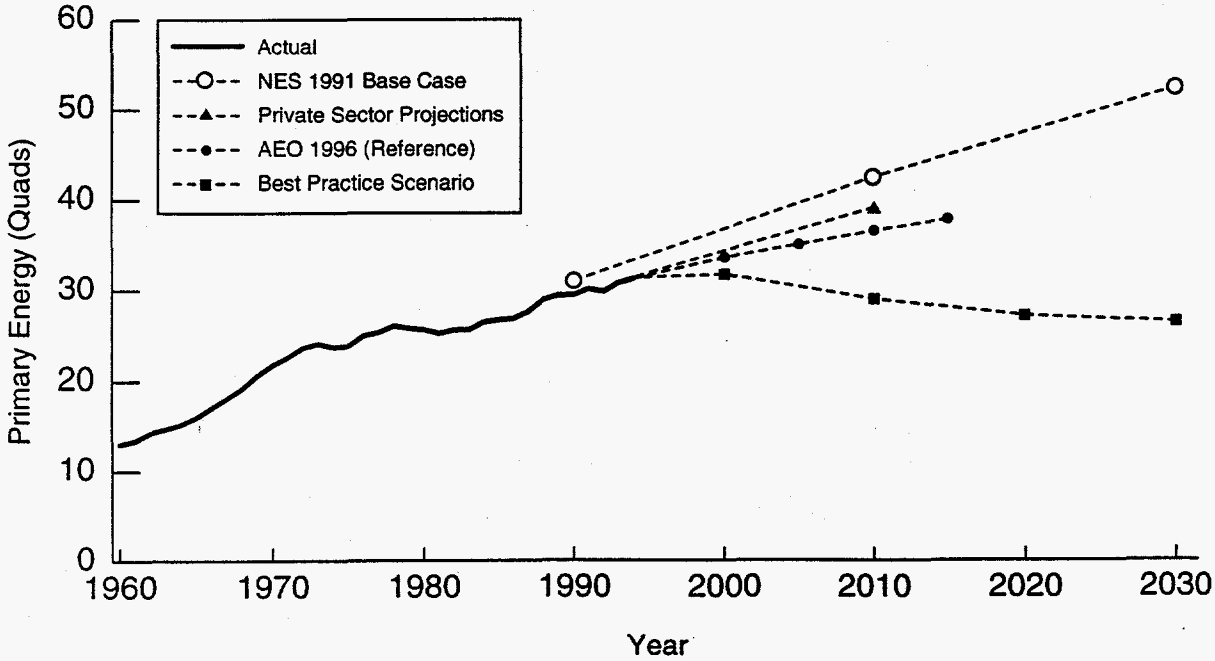

Figure 1. Energy Use in Residential and Commercial Buildings

Many of the causes of this efficiency gap are rooted in the fragmented and decentralized nature of the building sector. Figure 2 portrays the roles of the many different types of organizations that affect energy-related purchase and building operation decisions.

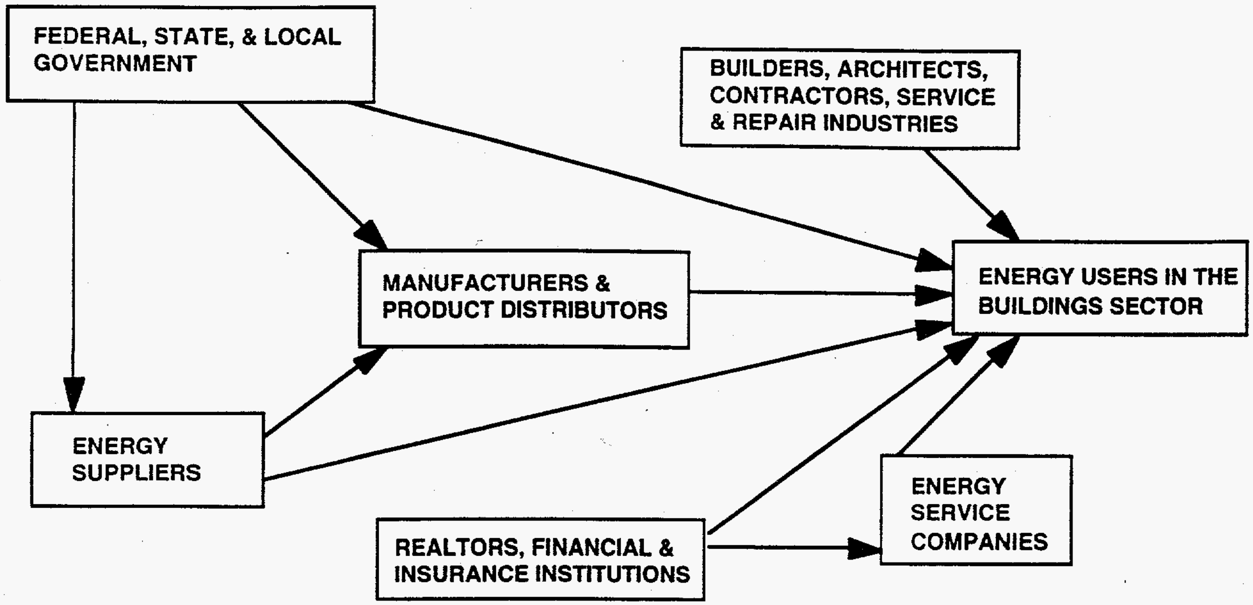

Figure 2. The Numerous Types of Organizations Influencing Energy Use in Buildings

On the consumption side, the Nation's 97 million households and the managers of nearly 5 million commercial buildings make up the largest group of energy decisionmakers in the U.S. economy. Their decisions of how to use energy to produce heat, light, and other services are typically made without information about the cost of energy for each service. In some cases, basic information about how well energy is being used by a particular piece of equipment or in a particular building is missing as well. Repetition of energy purchases aids predictability, but uncertainty about concomitant energy consumption commonly remains.

The market for energy-efficiency in buildings is further fragmented by the existence of several thousand different state and local building code specifications. These code variations fragment the demand for building materials and equipment and thereby prevent economies of scale in the production and purchase of goods and services.

On the production side, buildings are the largest handmade objects in the economy. While there has been an increase in the use of factory-assembled components, standardization and mass production remains limited, and manufactured housing represents only 7 percent of the housing stock. Regional differences in climate, energy prices, and building style traditions complicate standardization in buildings.

The building construction sector, especially the residential component, is dominated by small and medium-sized firms. The largest residential builder in the United States accounts for less than 1 percent of the market for new homes. Seventy-five percent of all residential construction firms build fewer than 25 homes per year.

Small commercial buildings (under 50,000 square feet) account for only 52 percent of commercial floorspace, but more than 95 percent of total commercial buildings (EIA April 1995, Table 3.1). Small construction companies account for a large share of small commercial building construction.

Numerous decisionmakers are involved in the construction and renovation of both residential and commercial (small and large) structures. An estimated 125,000 architects are involved in the design of buildings today, and only a small number of these are employed by large design firms. The design of many large commercial buildings typically involves an architect for the building envelope and mechanical engineers for the heating, ventilation, and air-conditioning (HVAC) system, a division of responsibilities that can result in energy-efficient approaches to envelope design that do not capitalize on opportunities for smaller HVAC equipment. The retrofit and home repair business is similarly dominated by very small firms, typically having fewer than 10 employees (OTA, 1992, pp. 76, 78).

Manufacturers and product distributors also exert profound influences on the use of energy in buildings by controlling the supply of building products and materials. Their selection of products to manufacture and their choice of geographic markets for product distribution determines the availability and ease of access to high efficiency options.

The realty, financial, and insurance industries are very much a part of the buildings sector market and can influence energy decisions. The realty industry is considerably decentralized, though recent trends in national franchising of local offices may afford the opportunity for improving information dissemination through realty channels. The Federal refinancing agencies, Fanny Mae and Freddie Mac, offer additional informational advantages by virtual of their central location in the market. Both are now supporting energy-efficient residential mortgages; realtors and the several layers of bankers must be involved for this transaction to take place. The insurance industry also may become powerful advocates of energy-efficient, environmentally-friendly buildings, in response to the increased property damage liabilities they could suffer as the result of global warming.

Finally, energy suppliers and energy service companies represent two additional players that have been instrumental in motivating and enabling energy-efficiency improvements in buildings. Demand-side management programs operated by electric and gas utility companies have offered rebates, low-interest loans, and direct installation programs that have led to the accelerated market penetration of many energy-efficient building products such as low-flow showerheads, compact fluorescent lamps, and attic insulation. However, these programs have been designed by individual utility companies, each with their own unique goals and resources, thereby further contributing to geographic variability in the supply and demand for energy-efficient building products and services. The following discussion illustrates additional ways that the fragmented nature of the buildings industry creates barriers to improved energy efficiency.

BARRIERS TO IMPROVING ENERGY EFFICIENCY

Barriers to achieving the full potential for cost-effective, energy-efficient improvements can be divided into two types: structural and behavioral (Table 1). Structural barriers result from the actions of many public- and private-sector organizations and are primarily beyond the control of the individual end-user. Behavioral barriers, on the other hand, result from characteristics of the end-user's decision-making, although they may also reflect structural constraints. As each of these seven barriers is discussed, it will become clear that there is a great deal of interdependency. The following discussions also highlight some of the public policies that have been used to address these barriers and thereby promote energy-efficiency investments in buildings. See Brown and Jones (1996) for a more thorough discussion of policy options.

Table 1. Barriers to Improving Energy Efficiency in the U.S.

Structural Barriers: Conditions that are beyond the control of the individual end-user

Distorted and uncertain fuel prices
Insufficient R&D
Limited access to capital
Supply infrastructure limitations

Behavioral Barriers: Obstacles that reflect characteristics of the individual's decision making

Attitudes toward energy efficiency
Information gaps and perceived risk
Misplaced incentives

Distorted and Uncertain Fuel Prices

The prices that consumers pay for fuels do not reflect the full environmental and social costs of fuels production, conversion, transportation, and use. For example, the cost of global warming is not now reflected in the price of fossil fuels or electricity. Similarly, the national security and foreign balance-of-payments implications of oil imports are not incorporated in fuel oil and gasoline prices. Fuel prices would rise significantly if they were to reflect their full social costs, and with higher fuel prices, investments in energy-efficient technologies would be more cost-effective.

Declining and uncertain fuel prices are a barrier to investment in both the manufacture and purchase of energy-efficient systems. Oil prices have been the most volatile: they were four times higher in 1981 than in 1972. But the price of natural gas and electricity have fluctuated, too. After decades of falling real prices, electricity prices increased by 50 percent between the early 1970s and 1982. Then the price trajectory reversed course, and electricity prices have declined steadily since then. How can consumers make rational decisions about new buildings and heating systems, when future energy prices are so uncertain?

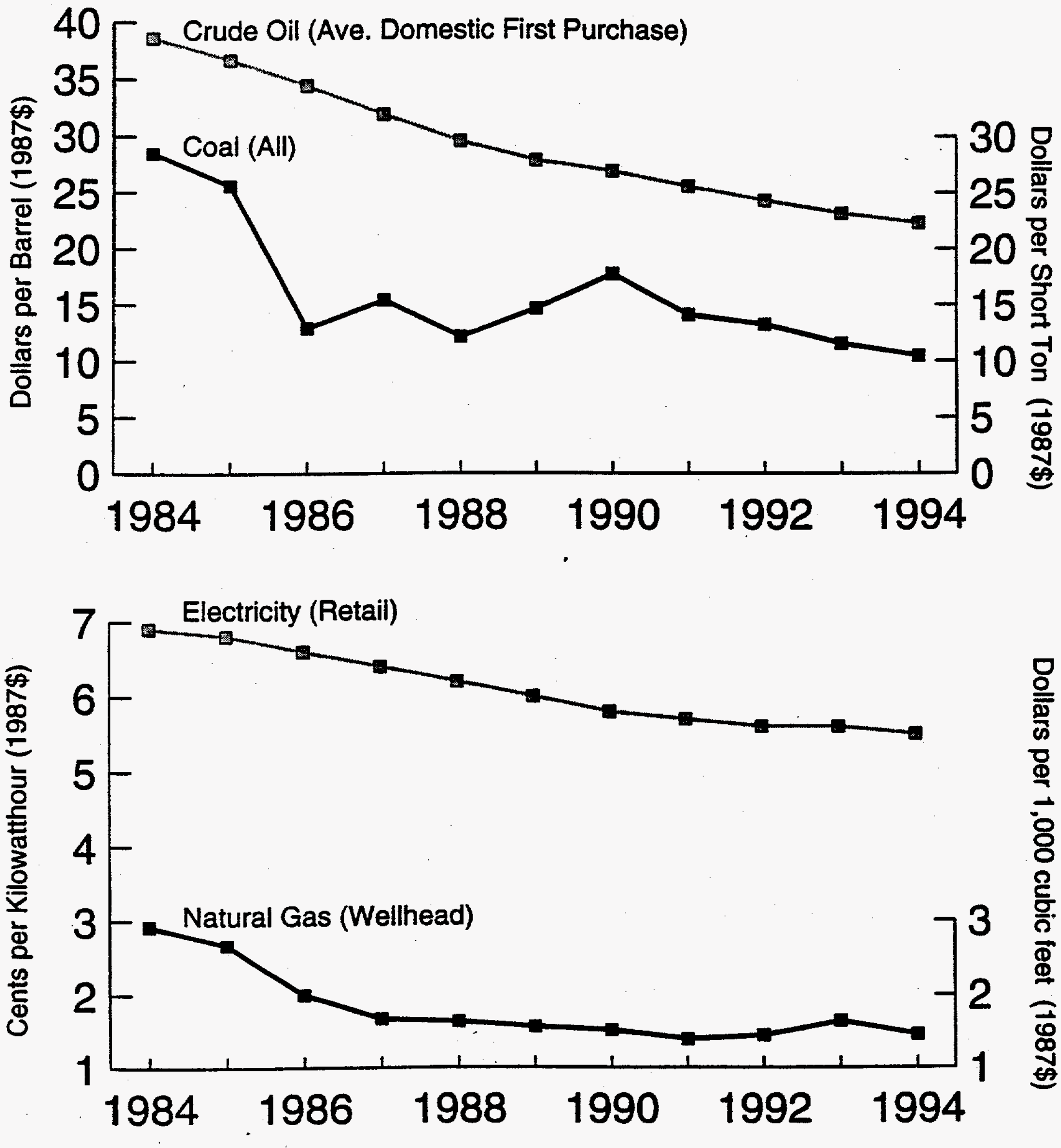

Figure 3. Declining and Uncertain Fuel Prices are a Barrier to Energy Efficiency Investments (Source: EPA, July 1996, pp. 173, 203, 225, 251)

Insufficient R&D

This market structure is highly competitive, but it discourages private R&D, on both individual components and the interactive performance of components in whole buildings. As a result, the building and construction industries spend only 1.7 percent of revenues on R&D, compared with 3.5 percent for the overall U.S. economy (*Business Week*, 1995). Some R&D on equipment is undertaken by appliance and HVAC companies and on materials by chemical companies, but their R&D generally does not extend to interactive performance with other components of the building. These characteristics also retard the market entry and penetration of new energy-efficient technologies. In addition, industry restructuring has caused a downturn in electric utility R&D.

Coordinating R&D efforts among Federal and State agencies, the private sector, academia, and the national laboratories is often cited as being vital to leveraging scarce resources, reducing duplication of effort, and dealing comprehensively with energy challenges. Reports by the Office of Technology Assessment, the Building Energy Efficiency Program Review Group, and the Secretary of Energy Advisory Board conclude that Federal RD&D programs play a critical role in financially supporting and coordinating buildings research among the various participants (OTA, 1991; OTA, 1992; BEEPR, 1992; SEAB, 1995, Annex 2, p. 143).

Some indication of the cost-effectiveness of RD&D in the buildings sector can be gleaned from the experiences to date with DOE's buildings R&D programs. From fiscal year 1975 through fiscal year 1994, DOE spent a total of about $5.7 billion on energy-efficiency R&D and related deployment programs, measured in constant 1992 dollars (Sissine, 1995). No more than $2 billion of this was spent on the buildings sector. Detailed case studies are now available that document the impacts of this research. Geller and McGaraghan (1996), for instance, have documented the benefits of low-emissivity windows, electronic ballasts, and high-efficiency supermarket refrigeration systems-three of the most successful technologies to which the DOE program contributed. In all three cases, DOE worked in partnership with private companies to develop, refine, and demonstrate innovative energy-efficiency measures. The combined DOE costs of these projects have been approximately $24 million.

The primary energy savings from use of these three technologies reached about 250 trillion Btu per year as of 1995 (including about 18 billion kWh per year of electricity saving). The value of this energy savings is about $1.5 billion per year based on current energy prices. Overall, consumers should realize net economic savings of around $10 billion over the lifetime of the low-E windows, electronic ballasts, and high-efficiency supermarket refrigeration systems produced and sold in the United States through 1995 (Geller and McGaraghan, 1996, p. 28-29).

Thus, the value of the energy saved by three technologies, alone, far exceeds the investment made by DOE in their development and also exceeds the cost to the taxpayers of the entire energy-efficiency R&D budget of DOE's Office of Building Technology, State and Community Programs (BTS) over the past two decades.

Limited Access to Capital

Research by Hausman (1979), Gately (1980), Meier and Whittier (1983), and DeCanio (1993) indicates that capital costs, or "first costs," are a barrier to energy-efficiency investments in the buildings sector. The tradeoff between larger initial outlays and lower subsequent expenditures is a typical problem in cost-benefit analysis. At high interest, or discount rates, energy savings in the future are worth less than they are with low interest rates. Market interest rates in the United States are relatively low now, ranging from 6 to 10 percent for secured loans, but many analyses have indicated that both firms and households frequently use much higher discount rates in their evaluation of energy-saving appliances and equipment.

The question of why consumers' apparent discount rates for purchase of energy-efficient building equipment is higher than might be explained by typical commercial loan rates has been a matter of some debate. Explanations most often involve additional discounts for performance and energy price risks, transactions or "hidden" costs not included in the purchase price, consumer dislike for some of the products' attributes, and the lack of specific information on performance and price described above. Awerbuch and Deehan (1995) conclude that, at least for residential fuel switching, performance and other risks are sufficient to explain situations in which apparently cost-effective choices are not undertaken.

Obtaining the incremental capital required to make energy-efficient investments can also be a problem which can lead to the choices consistent with high discount rates. Capital availability is especially problematic for low-income households, small businesses, and certain cash-constrained industries.

The result is a "payback gap" between energy efficiency and energy production investments. The cost of money for electric utilities is much less than the implicit discount rates used in making efficieny investments. This yields greater investment in power plants than in electric energy efficiency improvements.

DOE's Weatherization Assistance Program for low-income households illustrates one successful type of public-private partnership that can help overcome the problem of capital availability. Since 1976, DOE's Weatherization Assistance Program has provided financial subsidies to reduce the burden of high heating and cooling costs on low-income families by improving the energy efficiency of their homes. Local weatherization agencies provide and install conservation measures, and State agencies and DOE regional offices provide the link between the local implementers and DOE headquarters. Some 5 million dwellings have been weatherized to date with DOE funds and resources leveraged from other Federal agencies, State programs, gas and electric utilities, and nonprofit organizations.

A national evaluation of the Weatherization Assistance Program in 1989 indicated that the energy used by participants for space heating prior to weatherization was reduced by 18.2 percent as a result of their participation. Over the estimated 20-year lifetime of the installed weatherization measures, net savings from program expenditures in 1989 are projected to be 69.7 trillion Btu. At a cost of $1,550 (in 1989 dollars) per weatherized home, the value of the energy saved results in a benefit-cost ratio of 1.1 (Brown et al. 1994). Many other evaluations of low-income residential energy-efficiency programs have found them to have benefit-cost ratios between 1.0 and 2.0, depending on the range of benefits in addition to energy-savings that are included and the sophistication with which energy saving measures are selected (Pigg et al. 1995; Gunel et al. 1995).

Performance contracting can also help overcome the barrier of capital availability. Energy service companies (ESCOs) have been offering energy-efficiency improvements in the United States through energy-savings performance (ESP) contracting for roughly a decade, focusing on commercial and public buildings (Hansen 1993). Several contracting options have been developed, but the key feature of ESP contracting is that the ESCO receives part of the building energy cost savings for installing and managing new, more energy-efficient equipment.

The Housing and Community Development Act of 1987 gave Public Housing Authorities and Indian Housing Authorities greater flexibility to enter into energy performance contracts, and rules implementing these authorizations were completed by September 1991 (DOE and HUD, n.d., pp. 1–2). Federal agencies, through fiscal year 1993, awarded ESP contracts for 16 major facilities (DOE, Dec. 1995, pp. 24–26). Executive Order 12902 calls for increased Federal use of innovative financing mechanisms, including ESP contracting, for energy-efficiency improvements. Because public buildings in the United States account for 25 percent of energy use by commercial buildings and 22 percent of floorspace (EIA, 1995, April, Table 3.2), governments have an excellent opportunity to exercise some direct influence over the markets for energy-efficient and alternative energy through performance contracting.

Energy-efficient mortgages (EEMs) and loans (EELs) can also ameliorate the problem of limited access to capital. The creation of an accurate and widely accepted Home Energy Rating System (HERS) is necessary to create a market for EEMs and EELS, since they are able to convey to lenders and borrowers the information necessary to value energy-efficiency features in new and retrofitted homes, thereby providing a means for builders to "sell" energy-efficiency upgrades to a home, helping to ameliorate the pressure to minimize first costs. Collins, et al. (1994, pp. 50–51) estimate annual energy savings for each EEM would be approximately 14 percent of home energy use. In the used housing market, the HERS could assist in capitalizing the value of energy retrofits, and the EEM can allow the borrower to add the cost of energy-efficiency improvements to the mortgage, providing the longer term, lower interest rate and the tax benefits of mortgage financing.

Supply Infrastructure Limitations

The availability of new energy-conserving technologies is often restricted to particular geographic areas. For example, in the early 1990s, compact fluorescent lamps were generally available only in those areas where demand-side managament programs of electric utilities offered incentives to promote their purchase. Similarly, the purchase of heat-pump water heaters and ground-coupled heat pumps has been handicapped by limited access to equipment suppliers, installers, and repair technicians (Brown, Berry, and Goel, 1991; Technical Marketing Associates, Inc., 1988). The problem of access is exacerabated in the case of heating equipment and appliances, because they are often bought on an emergency basis, thereby limiting choices to available stock. A survey of 639 consumers who had recently replaced their gas furnaces, estimated that in one-third of the cases, the old furnace was not functioning (Cantor and Trumble 1988). Because high-efficiency furnaces represent a more costly inventory, dealers tend to prefer to sell them on special order. Thus, a potential barrier to the selection of high-efficiency furnaces by emergency buyers is the lack of available units in the stock maintained by dealers.

Another supply infrastructure constraint in the buildings industry is the shortage of adequately trained installers and O&M technicians to nurture the deployment of new energy technologies. Energy issues are not strong components of the college curricula that train architects and HVAC engineers. In addition, companies that manufacture, distribute, and service energy-efficient products provide only limited training to keep their employees abreast of the latest technological advances. For example, the reliability and performance of electric heat pumps suffered during the 1960s and 1970s because installers and technicians were not adequately trained.

Government procurement and bulk purchase programs can help to develop supply networks for energy efficiency products. These procurement activities take three forms: (1) individual purchases of currently cost-effective energy improvements; (2) coordinated purchasing to reduce costs by buying energy improvements in bulk; and (3) purchase of precommercial products to demonstrate energy savings and performance and to lower costs through large-scale production. In addition, by giving manufacturers certainty that a market exists for these products, such programs hold the promise of motivating manufacturers to produce products that surpass the energy efficiency levels that the market would have produced in the absence of collective market-pull efforts.

At the Federal level, anecdotal evidence from the personal computing industry suggests that procurement initiatives, in coordination with energy rating programs, can affect the product lines of manufacturers. The General Services Administration purchases 10 percent of all the office equipment sold in the U.S., which makes it the largest single buyer of computer equipment in the world (Dandridge et al., 1994, p. 736). Executive Order 12845 of October 1993 required the Federal Government to purchase only EPA Energy Star computing equipment in circumstances involving no cost differential or sacrifice in performance. Energy Star personal computers can reduce total PC electricity consumption by 60 to 70 percent through the use of power management capabilities. Because the Federal Government is a large consumer of computing equipment, individual manufacturers found it necessary to add these power management capabilities to maintain sales. By August 1994, more than 300 computer and monitor manufacturers representing more than 80 percent of U.S. sales, and more than 45 printer manufacturers accounting for some 90 percent of U.S. sales, were producing Energy Star PCs, monitors, and printers (EPA, 1994, p. 11).

At the State level, procurement initiatives also look promising. For example, a host of New York purchasing agencies in conjunction with local utilities are coordinating their procurement of small, energy-efficient refrigerators. This initiative involves numerous partners: the Consortium of Energy Efficiency (CEE), the New York Power Authority (NYPA), the New York Housing Authority, DOE, the Department of Housing and Urban Development (HUD), and manufacturers. It seeks to bring to the market more than 50,000 superefficient apartment-sized refrigerators. In this initiative, NYPA is acting as a purchasing agent for the large number of refrigerators that the Housing Authority buys each year. In turn, HUD has agreed to let the Housing Authority pay back the money invested by NYPA with the money saved through lower electricity bills. DOE's Technology Introduction Partnership provided support to CEE to help design the project (Tatsutani 1995). DOE directly provided technical and procurement assistance to NYPA, will monitor and validate the energy savings of the refrigerators for release of HUD performance contracting funds to NYPA, and will recruit additional buyers for the 1997 refrigerator purchase.

Coordinated building retrofits at the local scale are providing economies of scale in the dispersed retrofit market. Transaction costs—the costs of each building owner/manager searching for the best options, assessing available market information, contracting for improvements, and so forth—can be reduced through coordinated efforts. Because the costs of local building improvements depend heavily on what is regularly stocked in an area, a coordinated retrofit effort can create the level of demand necessary to introduce new products and services to local markets. DOE's Rebuild America is an example of a program designed to combine Federal energy-efficiency expertise with local buying power and government coordination to generate these new markets. Its partnerships with the U.S. Conference of Mayors, among other organizations have used Federal funds to leverage substantial investments in building retrofits (DOE, Dec. 1995, p. 6).

Attitudes Toward Energy Efficiency

Over the past 15 years, public concern about the environment has increased.

Recognizing the strong link between fossil fuel consumption and environmental degradation, increasing majorities of the public have shown a preference for energy efficiency and renewable energy over other energy alternatives. When asked in 1989 whether the country has done enough to "preserve energy," 75% called for stricter conservation. When polls give a policy trade-off between increasing energy supply and reducing demand, the public gives energy demand reduction first priority (Farhar, 1994).

At the same time, motivations for behavioral change seem weak. The public places a high premium on comfort and convenience, goals that sometimes conflict with energy efficiency. When asked "What are some of the things preventing you from making the changes leading to more efficient use of energy?", 34% responded, "I'm doing all I can" (Farhar, 1994). Thus, there is a disconnect between the positive attitudes Americans have for improving energy efficiency (i.e., their stated preferences) and ther energy-related purchase and operation decisions (i.e., their revealed preferences). Kempton (1993) argues that increased environmental concern will only translate into consistent purchase decisions when the public understands the implications of different purchase alternatives, have purchase opportunities available to them, and are not blocked by institutional barriers.

Some recent Federal and State programs may help motivate consumers to translate their supportive attitudes into concrete actions by providing a "seal of approval" for purchasing products that exceed a specified energy efficiency threshold. EPA's Green Lights Program is an example it offers acknowledgement as well as information and technical assistance to commercial building operators for lighting retrofits, which they agree to undertake with their own funding where profitable opportunities are identified. In 1993, 5 percent of all commercial floorspace in the United States was participating in the Green Lights Program (Clinton and Gore 1993, Action Descriptions, p. 2).

Information Gaps and Perceived Risks

Energy consumption and investment decisions in buildings are plagued by the difficulty of observing energy use in ways that clearly relate actions to costs and potential savings (OTA, 1992, p. 74). The problem has been likened to shopping in a supermarket with no prices for individual items, only a total bill. Wilhite (1994) concludes that consumers are not likely to choose the most effective strategies, given their general lack of knowledge about where energy goes and how it is affected by their actions.

Acceptance of advanced energy efficiency technologies is also hindered by lack of credible information on their technical and economic performance. People can easily learn what the capital cost is for an energy-efficient system, but the long-term savings in operating costs are much more uncertain. Risk aversion coupled with uncertainties about performance are strong barriers to customer participation in utility demand-side management programs and raise the implicit discount rates used by consumers in valuing alternative investments. Information gaps concerning the technical and economic performance of advanced energy technologies can also affect the decision-making of investors, manufacturers, distributors, and regulators.

Standardized methods for estimating the energy usage of building equipment and materials have been used in the U.S. since the late 1970s to provide consumers—including builders, architects, and others involved in building decisions—information about relative energy performance. Product labels and rating systems have been easiest to develop where usage patterns (that is, the demand for the energy service provided) are most similar throughout the U.S. (for refrigerators, for instance) and most difficult or controversial in cases where usage patterns vary the most (such as for overall building performance). Changes in consumer purchasing decisions ultimately depend on how well the information is presented, and whether potential cost savings are significant enough to be factored into the product decision.

Labels and rating systems are generic and do not tell consumers about their individual demands for energy services or how their own consumption patterns compare with others. Such individualized analysis are difficult for customers to conduct, but are easy and relatively inexpensive for utilities to provide. Kempton (1995) estimates that a small utility investment in enhanced billing, on the order of 2 to 25 cents per customer per year, can produce a large customer benefit.

Three pieces of information appear to be most valuable to consumers: energy usage histories (for example, month-by-month comparisons of the current year with the past year) with adjustments for weather and price fluctuations, comparisons to the usage of other customers in the same neighborhood or with similar-sized residences, and calculations of change in energy use before and after investment in a new appliance or home improvement. A study of 54 all-electric residential customers of Jersey Central Power & Light suggested that comparisons are what most customers really desire – comparisons with one's own past usage and with that of one's neighbors (Kempton, 1995). Where evaluations have been conducted, the additional information provided by enhanced bills generally has been found to be highly cost-effective (for example, with measured energy savings of up to 13 percent) (Kempton, 1995, p. 7). These positive findings are reinforced by other studies that have shown that consumers will reduce their energy consumption when provided with detailed information about their levels of energy use (Farhar, 1992). The experiences of three utilities that have provided annual reports of billing data to their customers suggest a favorable benefit-cost ratio. In general, the amount that customers indicate they are willing to pay for annual reports (an extra dollar or two per year) far exceeds the cost of providing the information (at about 30 cents per customer) (Kempton 1995, p. 17).

Sutherland (1991) argues that, if consumers really wanted energy efficiency, a market for information and expert advice would arise. In fact, elements of such a market are emerging as evidenced by the development of home energy rating systems and the enhanced billing programs described above.

Misplaced Incentives

The misalignment of incentives is a barrier to many types of energy-efficiency investments in buildings (DeCanio 1993; Howarth and Andersson 1993; Fisher and Rothkop 1989). One type of misalignment occurs when consumers must use the energy technologies selected by others. This involvement of intermediaries (e.g., builders, architects, and engineers) leads to an overemphasis on first costs rather than life-cycle costs. A second type of misalignment results when consumers are not charged specifically for the amount of energy they consume, but rather pay some standardized portion of an aggregated bill. This situation provides little motivation for the individual consumer to conserve energy.

Most residential construction is built prior to the identification of a buyer who could specify the materials and equipment to be used, so the builder is, in effect, building the house for a banker, whose criteria for selling a loan include keeping the ratio of monthly payment to monthly income of prospective buyers low enough to make the loan a reasonable risk. Thus, the builder is motivated to keep the cost of the house as low as possible. The buyer does have an interest in keeping future operating costs low, but has limited ability to identify the performance characteristics of the materials the builder used. In fact, even knowledge of, for example, the R-value of wall insulation may be insufficient to forecast its performance because the performance of the insulation depends on details of construction practices. The result is lower energy efficiency than the market would deliver if misplaced incentives could be eliminated, and if perfect information about energy efficiencies were available. Tenant-landlord relationships can also cause misplaced incentives, particularly in master-metered buildings where the rent paid by tenants does not reflect their individual levels of energy use (Fisher and Rothkop, 1989).

Commercial buildings suffer from similar misplaced incentives vis-à-vis builders versus owners, and renters versus landlords. DeCanio (1993) contends that building energy investments in large corporations also tend to suffer from inattention attributable to the same genre of incentive problem: rational actions on the parts of individual employees in the corporation frequently do not generate the same result that rational choices on the part of a single individual would produce, and cost-effective building energy investment opportunities remain unused.

Building codes have been successfully employed to address problems of misaligned incentives. Building codes in the United States principally cover new construction. In particular, they specify a minimum performance for different building components (such as walls and ceilings), but allow tradeoffs among these components, effectively placing a floor on the energy efficiency of building heating and cooling, but one that can be lower in some areas and higher in others. Rather than being required and controlled at the Federal level, building codes are imposed at the State and local levels, with enforcement entirely under the jurisdiction of the issuing government.

At the state level, the Council of American Building Officials published model energy codes (MECs) in 1992 and 1995. At present, about 10 States have adopted building codes that meet the requirements of the 1992 MEC and several are considering upgrading to the 1995 MEC. (In contrast, about an equal number of States currently use building codes that reflect technological capabilities of the early 1970s.) The Alliance to Save Energy estimates that the 10 States that have already adopted MEC standards will reduce CO_2 emissions by 556,000 tons per year (equivalent to 51,500 tons of carbon, or 0.002 percent of the residential sector's emissions in 1994).

The Bonneville Power Administration implemented a successful building code program in the Pacific Northwest in the mid 1980s that provided incentives to local jurisdictions for adopting an enhanced code; it also provided incentives to builders for constructing homes under the code. A study of houses built in Bonneville's service area suggests that those built to meet the code used an average of about 8 percent less electricity per year than did houses not built according to the new code. With a recommended ceiling on the cost of saving energy of 56 mills per kWh, Bonneville's model code was deemed cost-effective to the region, with a cost of savings estimated to be 44 mills per kWh (Brown, 1993).

Support for building codes within the buildings industry has been varied, and certainly not comprehensive. Builders worry principally about the potential for increased first costs to price new homes too far above existing homes (which are not now covered by codes in most areas). They are also concerned about the potential for codes to require technologies that prove unreliable in performance over the longer term. Cost-effectiveness is a constant issue: are standards set so high as to leave compliance costs greater than the benefits. These concerns are being addressed by various public-private partnerships, paving the way for the accelerated adoption of model energy codes in the future.

CONCLUSIONS

The data on energy use and energy trends presented at the start of this paper suggests that the marketplace, in partnership with government efforts, has resulted in impressive efficiency gains in the buildings sector. However, a large efficiency gap remains, and ongoing public-private partnerships are essential to closing it. While there are numerous barriers to improving the energy efficiency of buildings in this country, many public-private partnerships have been implemented that hold the potential for overcoming them in the future. In addition to the critical need for continuing public support for R&D, voluntary market transformation programs show great potential for stimulating further efficiency gains.

The creation of markets where none currently exists or where they are especially weak can permit consumers to signal their demands more effectively. In the buildings sector – characterized by a plethora of participants, from architects and engineers, to realtors and bankers, to owners and renters – voluntary programs can create and transform markets by providing coordination among private-sector participants, among different levels of government, and between public and private entities. These programs appear to be most effective when they combine policies and incentives to achieve the goals of multiple stakeholders. Examples discussed in this paper include the development of home energy ratings combined with incentive mortgages, the use of Energy Star labels for PCs combined with large federal purchases, and the coordination of local buying power with energy-efficiency expertise to create new markets for commercial retrofits. Other policy mechanisms for the buildings sector are discussed in a recent DOE report describing policies and measures for reducing energy-related greenhouse gas emissions (U.S. Department of Energy, 1996, chapter 3).

The marketplace has resulted in impressive efficiency gains. With further government support for R&D and with well-designed market transformation programs, the efficiency gap can be narrowed further.

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