Chapter 3

If Energy Efficiency Is Such a Good Idea, Why Haven't We Done More of It?

Box 3-A-Chapter Summary

If energy efficiency is technically and economically feasible, why doesn't it happen on its own? Interviews with consumers, builders, and others are used to explore the reasons behind this apparent paradox.

The methods used by consumers to make energy-related decisions often work against energy efficiency. Goals of minimizing first cost, time to make a decision, and risk are often pursued; minimizing life-cycle costs is rarely mentioned. When future savings do enter a decision, they are heavily discounted. There are few incentives for efficiency; for example, repair contracts are often awarded based largely on first cost, which leads to the use of low first-cost, inefficient equipment. Energy costs are about 1 percent of labor costs in a typicaI office building, so management attention and capital are directed elsewhere. Many attributes, such as first cost, familiarity, and convenience, often overshadow energy efficiency. Efficiency is a relatively intangible feature with benefits that are seen as uncertain, and therefore loses out to more tangible, visible attributes. Builders and manufacturers often believe that consumers are relatively unwilling to invest in efficiency, and therefore often offer and emphasize other features.

The net result of these market characteristics is that energy efficiency investments are often neglected.

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INTRODUCTION

Many energy efficient technologies offer financial rates of return exceeding those available from other financial investments. Therefore one would expect consumers to take advantage of these efficiency investments. However there are numerous untapped opportunities for cost-effective efficiency improvements, as discussed in chapter 2, suggesting that the issue is more complex than a simple financial analysis would indicate. If energy efficiency is such a good idea, why haven't we done more of it?[1]

This chapter explores why energy efficiency has not been implemented to the level that appears economically justified. Energy use in buildings is determined by decisions about equipment selection and operation, and these decisions are made to satisfy a number of needs and constraints. Implementing greater energy efficiency in buildings will require policies that influence these decisions; these policies will be most effective if they are based on a clear understanding of how and why decisions about equipment selection and operation are made. This chapter provides such an understanding through the use of interviews (box 3-B) and other evidence. The focus is on how these decisions are made, as distinct from how they should be made.

Box 3-B—Interview Methodology

The results presented in this chapter are based in part on a series of interviews conducted by OTA in the spring of 1991. These interviews were conducted with building owners, architects, homeowners, engineers, equipment manufacturers, and others whose decisions influence building energy use. The interviews made use of ethnographic interviewing techniques, in which the respondent is allowed to guide much of the discussion. This technique has been used by several researchers to explore perceptions of energy use and energy efficiency.[1] Our intent was to explore the respondent's beliefs and concerns related to energy use; to do so in an unbiased manner we encouraged respondents to raise issues they felt important. For example, rather than asking "do your tenants care about energy costs," we asked "what factors do your tenants seem most concerned with?" Although the number of interviews was relatively small, we believe they captured many of the key issues affecting energy-related decisions.

[1] See, e.g., W. Kempton and L. Montgomery, "Folk Quantification of Energy,' *Energy,* vol. 7, No. 10, 1982; R. Wilk and H. Wilhite, "Why Don't People Weather-h Their Homes? An Ethnographic Solution," *Energy,* vol. 10, No. 5, 1985; P. Komor and R. Katzev, "Behavioral Determinants of Energy Use in Small Commercial Buildings: Implications for Energy Efficiency,'' *Energy Systems and Policy,* vol. 12, 1988.

RESIDENTIAL BUILDINGS

Decisions affecting the energy use of residential buildings occur throughout the lifetime of the buildings. Perhaps the most important decisions are made in the initial design and construction, but appliance replacement, shell retrofits, and equipment operation can affect residential energy use as well. This section describes how decisions affecting energy use are made, including those related to design and construction, those made by equipment manufacturers, those related to retrofit and repair, and those of owners and occupants.

The Design and Construction of New Residential Buildings

The energy efficiency of new residences plays a critical role in determining overall residential sector efficiency. It is generally much less expensive to build an energy efficient residence than to retrofit an inefficient one; and some energy saving technologies, such as passive solar design, cannot easily be retrofitted to an existing residence. By 2010 a significant fraction of the total housing stock will

[1] From D. Morell, "Energy Conservation and Public Policy: If It's Such a Good Idea, Why Don't We Do More of It?" *Journal of Social Issues,* vol. 37, No. 2, 1981, p. 8.

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Table 3-l-Construction of New Residential Housing, 1990

Type	Number of units started (thousands)	Percent
Single unit	895	64
2 to 4 units	37	3
5+ units	261	18
Mobile homes	205	15
Total	1,398	100

NOTE: Privately owned units only. Mobile home data are 'placed for use' in 1989.

SOURCE: U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States: 1997* (Washington, DC: 1991), pp. 720, 722.

Table 3-2—The Residential Construction Industry, 1989

Type of firm	Percent of firms	Percent of new units built
Small (1 to 24 units per year)	74	13
Medium (25 to 99 units per year)	16	20
Large (100+ units per year)	9	67
Total	100	100

NOTE: Includes high-rise and multifamily residences. Totals may not add to 100 due to rounding.

SOURCE: National Association of Home Builders (NAHB), *Housing Economics,* June 1990, p. 6.

have been built in the period 1990 to 2010,[2] highlighting the importance of new construction in overall efficiency.

In 1990 the residential construction industry built 1.4 million new residences (table 3-l), at a value of $187 billion.[3] Almost two-thirds of these were single unit residences, the remainder were in multiunit buildings and manufactured (mobile) homes. This industry is usually perceived as a very decentralized business consisting of thousands of very small firms, each building only a few houses each year. This is only partially true: there are about 100,000 residential building firms in the United States, with an average size of about five employees each.[4] These small firms, however, build only 13 percent of new housing units. Larger firms (defined as firms building over 100 units per year) build over two-thirds of new housing units (table 3-2). Larger building firms tend to make greater use of preassembled components and structures (table 3-3), which can reduce construction costs by allowing for standardization of design and economies of scale in assembly.

Large Builders and Developers

Decisions affecting the relative energy efficiency of homes built by large builder/developer companies are driven by several factors. One of the most important factors is the company's perception of what will satisfy the consumer—both to sell the home initially, and to keep the consumer satisfied after moving in. Those in the builder/developer business often believe that consumers are relatively unwilling to invest in energy efficiency. For example, if a builder invests $1,000 in insulation, then most of this investment will be invisible to the prospective purchaser-but the additional cost of the insulation will be extremely visible, in the form of a higher priced house. From the builder's perspective, it may make more sense not to invest the $1,000 and thereby reduce the house price, or alternately to invest the $1,000 in a feature that is more visible to the prospective buyer (e.g., landscaping or more expensive doors).

Photo credit: Paul Komor

Single-family houses account for over two-thirds of new home sales.

[2] For comparison, in 198940 percent of the total existing housing stock had been built in the preceding 19 years (i.e., in the period 1970 to 1989). U.S. Department of Commerce, Bureau of the Census, *American Housing Survey for the United States in 1989*, H150/89 (Washington DC: U.S. Government Printing Office, July 1991), p. 1.

[3] U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States.' 1991* (Washington, DC: 1991), p. 716.

[4] Ibid., p. 715.

[5] This discussion excludes larger high-rise multistory buildings, because the institutions and decisions affecting energy use in these buildings are similar to those in commercial buildings, which are discussed below.

Table 3-3-New Residential Building Construction in the United States: Definitions and Market Shares

Type	Definition
High-rise	Two or more stories, has an elevator.
Manufactured (mobile) home	Also called a 'HUD-code' home, assembled entirely at the factory and installed on a semi-permanent foundation.
Modular	Approximately 95 percent of assembly occurs at the factory, usually shipped as several pieces and installed on a permanent foundation.
Panelized	Major components, including walls, floors, and ceilings are preassembled at factory; final assembly and finish work done on-site.
Production	Usually uses preassembled roof and floor trusses; remainder of unit built on-site.
Stick-built	Built entirely on-site; no major preassembled components used.

Type	Market share (percent) 1980	1989	Unit sales (thousands) 1989
Manufactured (mobile) home	19	15	202
Modular	5	6	79
Panelized	29	36	487
Production [a]	48	43	573
Total	100	100	1 ,341

[a] Includes Stick-built, which is estimated at less than 5 percent of total *(Automated Builder,* January 1991, P. 15). Percents may not add to 100 due to rounding.

NOTE: Market share and unit sales data apply only to one to four family housing starts.

SOURCE: R. Berg, G. Brown, and R. Kellett, "An Analysis of U.S. Industrialized Housing," Center for Housing Innovation, University of Oregon, October 1990, p. 24. Sales and market share are uncertain, and varying estimates can be found (see NAHB, *Housing Economics,* October 1989 for a discussion).

Builders often market homes as a ''base' home, and then offer a series of upgrades. An upgrade might consist of more expensive bathroom fixtures, wood floors, or a finished basement. Energy efficiency upgrades, however, are rarely offered, as some builders fear that offering such an upgrade will give consumers the impression that their base house is not energy efficient. The energy efficiency of a building can vary widely, but some argue that consumers see energy efficiency as an all or nothing attribute, and that offering an energy efficiency upgrade will lead consumers to think that, without it, the house is not energy efficient.[6]

When selecting space conditioning appliances for new houses, builders often select those brands and models that they have found reliable and easy to work with in the past. There is always competitive pressure to keep first costs low, and investments in energy efficient units, although perhaps cost-effective on a life-cycle basis, may increase the first cost of the house and thereby put the residence at a competitive disadvantage relative to other, lower-priced residences.

Interviews and discussions with larger home-building firms revealed a considerable knowledge and understanding of energy efficient technologies and construction methods. The decisions of these firms to adopt or not adopt innovative energy efficient technologies were not based on ignorance or lack of information but on their perceptions of the economic interests of their company. The director of architecture at one large home building firm, for example, had previously taught passive solar design at an architecture school. However he did not consider solar orientation when designing a new subdivision, because to do so would apparently reduce by 15 percent the number of homes he could fit into the subdivision, which would in turn reduce the firm's revenues.

[6] A director of marketing for a large home building firm interviewed by OTA indicated that many home-buyers think of energy efficiency as ayes/no feature, similar to a garage or central air conditioning, i.e., the home either has it or doesn't have it.

Small Builders

Most residential construction firms are quite small; about three-fourths of all residential construction firms build less than 25 units per year (table 3-2). Smaller firms typically build more expensive custom homes, while the larger firms typically build less expensive, tract-style homes.

Residential construction is largely a trade learned from experience, rather than through schooling or other formal training, so adoption of new technologies and construction techniques can be quite slow due to a preference for using past practice. The risk associated with innovation is also a barrier, as small firms often cannot carry the financial burden of a house that may not sell due to an innovative characteristic that may prove unpopular.

Moreover, even builders well-versed in energy technologies may not use them. Reported one interviewee, ' 'I'd like to build more energy-efficient homes, I know how to do it, but I can't afford to. " From his perspective, potential home-buyers are often unwilling to pay more for a feature that is largely invisible and whose benefits may be seen as uncertain. Building an efficient home costs more upfront, which puts him at a competitive disadvantage relative to builders offering a home that looks the same but costs less.[7]

Slightly more than one-third of new single-family homes are built for a specific owner, rather than on speculation.[8] The design of these homes is influenced by both the builder and the owner. According to owners and builders interviewed by OTA, owners' interest and concern regarding energy varies. Some owners are interested in payback of energy-related investments such as increased insulation, for example; but many decisions are motivated by other factors. For example, natural gas heat is seen by some as more comfortable than electric heat pumps due to the higher register outlet temperature, and in the opinion of one builder those consumers committed to gas are not interested in paybacks of other technologies, Capital constraints are also an issue; even if an investment offers an attractive payback the owner may not have sufficient capital for the investment (or the source of the capital, typically a bank, may be unwilling to supply it).[9]

Photo credit: Paul Komor

Manufactured (mobile) homes account for about 15 percent of new home sales.

Manufactured Homes

The manufactured home (also called mobile home or HUD-code home, for Department of Housing and Urban Development) industry sold about 202,000 units in 1989 (table 3-3). These units are entirely assembled at the factory and then shipped to retail dealers, who then sell them to consumers. Manufactured homes are typically the least expensive type of new housing. The construction of these units is regulated by the HUD Manufactured Home Construction and Safety Standards (MHCSS), which include energy-related requirements.

Industry decisions as to the energy efficiency level of their new units are bounded at the minimum level set by the HUD code but can exceed the HUD code if there is a demand for greater efficiency. For example, one large manufacturer reported that its basic unit for one climate area has R-14 insulation in the ceiling, but that a utility-sponsored incentive program has resulted in dealer requests for units with R-28 in the ceiling instead.

[7] It should be recognized that other attributes often accompany efficiency. For example, a well-insulated house may be more comfortable due to smaller temperature fluctuations, as well as more efficient. These attributes, however, suffer from the same problems as efficiency; they are invisible, occur in the future, and are somewhat intangible.

[8] In 1990, about 36 percent of single-family homes were built for a specific owner, 61 percent on speculation and the remaining 3 percent for rental. U.S. Department of Commerce, Bureau of the Census, *Characteristics of New Housing: 1990*, C25-9013 (Washington, DC: June 1991), p. 3.

[9] One policy response t. this problem, the use of mortgages as a source of funds for energy efficiency improvements, is discussed in ch. 5.

Table 3-4—Shipments of Selected New Appliances, 1989

Appliance	Units shipped, 1989 (thousands)
Microwave	10,600
Washer	6,250
Refrigerator	7,100
Room air conditioner	5,090
Dryer	4,570
Dishwasher	3,670
Electric range	3,050
Gas range	2,170
Freezer	1,220
Other	5,010
Total	48,730

SOURCE: Association of Home Appliance Manufacturers (AHAM), *Major Home Appliance Industry* Fact *Book 1990/91* (Chicago, IL), p. 11,

The manufactured home industry markets its units somewhat like the automobile industry. with a basic unit offered at lowest first cost and a number of additional cost packages, which may include energy efficiency features, offered at additional cost. According to a manufacturer, consumers buying the more expensive units are often willing to invest in energy efficient packages, but those looking for less expensive units often cannot afford to upgrade and want the unit with the lowest first cost.

Residential Equipment Manufacturers

Residential equipment manufacturers can be divided into two general types: 1) home appliance manufacturers, who make refrigerators, freezers, clothes washers and dryers, room air conditioners, and other appliances; and 2) heating and cooling equipment manufacturers, who make furnaces, heat pumps, boilers, and central air conditioning systems. Since the manufacturers and market distribution systems differ for these two types, they are discussed separately below. Space heating and cooling equipment is discussed under the Commercial Buildings section.

In 1989 the home appliance industry shipped about 49 million new appliances (table 3-4), worth about $12.4 billion.[10]" Relatively few of these appliances are exported or imported. The industry exported only 6 percent of its production in 1989, and only 16 percent of the appliances bought in the United States in 1989 were imported, two-thirds of which were microwave ovens.[11]

As discussed in the preceding chapter, the energy efficiency of home appliances increased dramatically from about 1970 to the present (see, for example, chapter 2, figure 2-7). The technologies used to achieve these gains were discussed previously as well. It is useful to consider the factors that motivated the manufacturers to make these changes. Several are relevant:

- Technology changes made for reasons other than energy efficiency, such as lower cost, improved reliability, or a simpler manufacturing process, sometimes had the incidental benefit of reduced energy use. For example, the switch from fiberglass to polyurethane foam insulation in refrigerators was done mainly for manufacturing process reasons, but also had the benefit of improved energy efficiency.
- In 1976 California adopted energy efficiency standards for refrigerators and air conditioners, and as California was a significant fraction of the total United States market, these standards influenced national average efficiency levels for these products. Other States followed California's lead, contributing further to the increase.
- Although consumer awareness of energy issues in the 1970s may have motivated manufacturers, OTA interviews with appliance manufacturers suggest that energy efficiency is not seen as a primary consumer product cue; in other words efficiency is not thought to be a primary determinant of consumer purchase decisions. Therefore consumer preference may not have contributed significantly to the historical increase in home appliance energy efficiency.

At present, the requirements of the National Appliance Energy Conservation Act (NAECA, Public Law 100-12, discussed in ch. 4) are driving appliance manufacturers' decisions as to the energy efficiency of their products.

10 Products included here are kitchen ranges and cooktops, microwave Ovens, clothes washers and dryers, dishwashers, refrigerators, freezers, room air conditioners, dehumidifiers, disposers, and trash compactors. Association of Home Appliance Manufacturers (AHAM), *Major Home Appliance Industry Fact Book 1990191* (Chicago, IL), pp. 8, 11.

11 Ibid., pp. 11,15,17. This excludes home entertainment equipment, such as televisions and radios. Imports of major home appliances increased from 1970 to 1987 but have dropped since 1987.

Retrofit and Repair

Approximately $57 billion was spent in 1989 to improve, repair, or retrofit existing residences.[12] It is not clear how much of this was spent on energy-related changes, but by one estimate about one-third of all single-family households perform an energy-related retrofit or repair each year.[13] Energy-related retrofits and repairs to many residences are performed by general contractors or specialized tradespeople such as heating and cooling specialists, plumbers, and remodelers. This field is dominated by small businesses, typically with less than 10 employees.[14] These firms are either hired directly by a building owner/manager or as subcontractors.

The contractor typically selects the specific type and model of energy-using equipment to install. Many contractor jobs are awarded based on cost estimates, and therefore there is always pressure to reduce first cost. In the view of many contractors, most homeowners do not want to pay extra for energy efficiency.[15] Contractors also reported other reasons for avoiding the use of new, energy-efficient technologies, including:

- New technologies often require new installation procedures, increasing both the time required for installation and the risk of incorrect installation;
- Their dependability/reliability is unproven;
- There is perceived risk of consumer dissatisfaction due to poor performance and/or mechanical breakdowns;
- Current building standards may make innovation difficult (i.e., changes in equipment may require other design changes, further increasing project cost and complexity);
- The insurance industry often requires that the same materials be used when rebuilding a damaged structure; and
- There is suspicion and distrust of the energy savings claims of new technologies.[16]

Contractors and other home-repair professionals select and install energy-using equipment in existing residences, and these decisions strongly influence the subsequent energy use of these residences. These decisionmakers weigh heavily attributes of first cost, reliability, and familiarity y, and have few incentives to consider energy efficiency.

Owners and Occupants

Building occupants can directly improve the energy use of buildings in several ways: by operating equipment efficiently, by replacing failed equipment with more efficient equipment, and by retrofitting existing buildings with energy efficient technologies and features. In addition, occupants can indirectly influence energy use of new residences by expressing a desire, through purchase behavior, for more efficient technologies and features.

Equipment Operation

Opportunities for building occupants to reduce energy use by improving equipment operation include reducing thermostat settings, turning off lights, taking shorter showers, and other behavioral changes. Although these actions can save significant amounts of energy, they can also reduce comfort and/or convenience. The perception that energy efficiency requires sacrifice is very persistent and acts as a significant barrier to wider use of energy efficient technologies. Survey and interview research has found that a majority of people, when asked what they could do to reduce energy use, typically mentioned turning off lights, reducing thermostat settings, and other behavioral changes involving reduced comfort; improved technology (e.g., a more efficient energy-using device) was rarely mentioned.[17]

Some behavioral changes can save significant amounts of energy with little or no discomfort, such as night setback of thermostats. According to

12 U.S. Department of Commerce, Bureau of the census, *Statistical Abstract of the United States: 1991* (Washington, DC: 1991), p. 717.

13 U.S. Department of Energy, Energy Information Administration, *Housing Characteristics* 1987, DOE/EIA-0314(87) (Washington, DC: May 1989), p. 118.

14 Employees per establishment for relevant industries. U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States: 1991* (Washington DC: 1991), p. 715.

15 Participants in a workshop of retrofit contractors estimated that "90 percent of homeowners do not want to pay extra for energy efficiency." P. Mihlmester, J. Gonos, L. Freeman, M. Brown, *Technology Adoption Strategy for the Existing Buildings Efficiency Research Program, Oak* Ridge National Laboratory, ORNL/CON-286 (Springfield, VA: National Technical Information Service, June 1989), p. 34.

16 Based on a workshop of contractors. Adapted from ibid., pp. 39-41.

17 W. Kempton et al., "Do Consumers Know 'What Works' in Energy Conservation?" *Marriage and Family Review, vol. 9, No.* 1/2, fall 1985.

surveys based on self-reports of behavior, 48 percent of U.S. households turn down their heat at night.[18] The energy savings from reducing thermostat settings at night typically range from 6 to 16 percent.[19] Similarly, the use of cold rather than warm rinse in clothes washing machines reduces heated water consumption about 23 percent per wash cycle and is generally agreed to have no adverse effects on washer performance, yet consumers still use warm rinse about 25 percent of the time.[20]

Equipment Selection and Purchase

Consumers can affect energy use through the energy efficiency of new appliances they purchase. Understanding how consumers make appliance selection decisions, and how these decisions are influenced by labels, rebates, and other factors, is needed to design effective programs and policies for encouraging energy efficiency.

Consumer equipment selection decisions can be divided into two types: 1) smaller home appliances (refrigerators, room air conditioners, washing machines, and lights), for which consumers typically make product selection decisions themselves, and 2) larger equipment (furnaces, heat pumps, central air conditioning systems, and water heaters), for which product selection decisions are typically shared with or made by a contractor or other outside agent.

When purchasing a home appliance, consumers try to satisfy many goals. These goals may include spending the least amount of money, spending the least amount of time to make the purchase decision, or buying whatever will fit in the available space. Reducing energy consumption may or may not be a goal, but there is some evidence that energy efficiency must be extremely financially attractive for consumers to invest in it. This can be measured with an ''implied discount rate, '' calculated by comparing the first cost increment to the annual energy savings (table 3-5). The very high implied discount rates shown in table 3-5 suggest that consumers will invest in energy efficiency only if the annual energy savings exceed the additional frost cost within just a few years.

Table 3-5-implied Consumer Discount Rate Estimates for Energy Efficiency Investments

Appliance/action	Discount rate estimate (percent)
Refrigerator	45 to 300
Room air conditioner	5 to 89
Water heater blanket	67
Clock thermostat	310
Replacement furnace	70

SOURCES: Refrigerator: D. Gately, "Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables: Comment," *The Bell Journal of Economics, vol.* 11, 1980, p. 374. Room air conditioners: J. Hausman, "Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables," *The Bell Journal of Economics, vol.* 10,1979, p. 53. Water heater blanket: P. Komor and L. Wiggins, "Predicting Conservation Choice: Beyond the Cost-Minimization Assumption," *Energy, vol.* 13, No. 8, 1988, p. 641. Clock thermostat and replacement furnace: Cambridge Systematic, Inc., *Implicit Discount Rates in* Residential *Customer Choices,* vol. 1, EPRI EM-5587 (Palo Alto, CA: Electric Power Research Institute, February 1988), p. 4-11.

There are many potential reasons why consumers do not invest in energy efficiency. Consumers often pursue other attributes, such as comfort, convenience, or simplicity, which may take precedence over energy efficiency. They may be unaware of the energy features of an appliance, or unfamiliar with the concept of trading off initial cost and operating cost. They may intend to own the appliance for only a short period of time, making an energy efficiency investment financially unattractive. There may be other undesirable attributes associated with energy efficiency; for example, an energy efficient model of an appliance may be available only with other expensive features that the consumer does not want to purchase.[21] Whatever the reason, the outcome is clear. Consumers often do not invest in energy efficiency unless it offers a fairly short payback—typically less than 2 years for home appliances.

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[18] U.S. Department of Energy, Energy Information Administration, *Housing Characteristics 1987, DOE/EIA-0314(87)* (Washington, DC: May 1989), p. 122. There is evidence, however, that self reports of thermostat settings are often lower than actual settings, suggesting that somewhat less than 48 percent of households actually turn down their heat at night. See W. Kempton and S. Krabacher, ''Thermostat Management: Intensive Interviewing Used To Interpret Instrumentation Data,'' in W. Kempton and M. Nieman (eds.), *Energy Efficiency: Perspectives on Individual Behavior* (Washington, DC: American Council for an Energy-Efficient Economy, 1986), p. 261.

[19] Units are heating fuel savings per household. T. Wilson, ''Good News on the Setback Front, '' *Home Energy, vol. 8, No.* 1, Jan./Feb. 1991, p. 12, table 1.

[20] U.S. Department of Energy, *Technical Support Document: Energy Conservation Standards for Consumer Products: Dishwashers, Clothes Washers, and Clothes Dryers,* DOE/CE-0299P (Washington, DC: December 1990), pp. 3-11, 3-12.

[21] For example, as described inch. 2, some very efficient water heaters come with a special finish and a lifetime warranty, and a consumer may not want to pay for these other features.

Investments in larger equipment (furnaces, water heaters, heat pumps, and central air conditioners) are made somewhat differently. Most of these investment decisions are not made solely by the consumer, but by a contractor or other individual hired to fix or replace the equipment. As this equipment supplies essential services (heat, hot water), there is usually a high cost to delaying the purchase; contractors will often install the unit that is easiest to obtain, rather than the most efficient. Consumers may be unaware that they can choose a more efficient unit, or they may want the contractor to put in the cheapest unit that will deliver the needed service. For example, in an OTA interview a homeowner replacing a central air conditioner unit in summer reported that, ''I had three contractors come and give estimates, and then I chose the contractor who gave the lowest estimate. Here again, it is quite easy to see why energy efficient equipment that may be less expensive on a life-cycle cost basis is often not used: consumers usually do not consider life-cycle costs when selecting equipment.

Rental housing is an especially challenging sector for energy efficiency. About 35 percent of U.S. households are rented. In slightly over half of these rented households the tenants pay the energy bill directly, while the remainder pay energy bills through the rent.[22] In Situations where the tenant pays the bills the owners have little incentive to put in energy efficient equipment, because they receive no direct financial benefit from doing so. Conversely, tenants paying for energy through the rent often do not pay for their actual consumption, and therefore have no direct financial incentive for operating equipment efficiently.

Retrofits

The third means for consumers to influence energy use is by retrofitting their homes with energy efficient features. These improvements can range from very simple, low-cost measures (e.g., caulking) to more involved retrofits such as adding wall insulation.

As with other aspects of residential energy use, there is some evidence that retrofits are not made primarily to save money. Survey data have shown that other factors, such as hassle avoidance, frost cost, and perceived effects on comfort, are more important than perceived savings.[23] It has also been argued that the simplified methods of analysis used by consumers in making energy conservation decisions result in lower energy efficiency than would result from the use of economically "rational' methods.[24] For example, using payback as an efficiency investment criterion ignores savings accruing after the payback period regardless of their value. Similarly, high discount rates discourage investment in any option for which the returns accrue in the future, such as energy efficiency. These simplified methods are also used by those with technical energy training,[25] suggesting that information alone is not sufficient to correct these biases.

Extensive market research on how consumers make energy-related decisions has suggested that residential consumers can be divided into distinct groups, based on their values and concerns (table 3-6). For example, ''hassle avoiders' try to limit the time required to make energy-related decisions and are less concerned about cost and other attributes. Utilities use these market segmentation techniques to improve the marketing of their conservation programs. For example, in communities with a large number of 'pleasure seekers' a utility might stress the improved comfort and convenience resulting from a clock thermostat, rather than the energy savings. According to the scheme shown in table 3-6, only 13 percent of the U.S. population is concerned primarily with value when making energy-related decisions. Therefore it is quite clear why cost-effective measures are often not pursued: because much of the population makes decisions based on attributes other than operating cost.

22 U.S. Department of Energy, Energy Information Administration, *Housing Characteristics 1987*, DOE/EIA-0314(87) (Washington, DC: May 1989), p. 18.

23 P. Komor and L. Wiggins, "Predicting Conservation Choice: Beyond the Cost-Minimization Assumption,'' *Energy*, vol. 13, No. 8, 1988, pp. 633-645.

24 Consumer methods ''are Systematically biased in ways that cause less energy conservation than would be expected by economically rational response to price. " From W. Kempton and L. Montgomery, "Folk Quantification of Energy," *Energy*, vol. 7, No. 10, 1982, p. 826. Specifically, consumers focus on end-uses that are perceptually salient (e.g., electric mixers) but that are not necessarily large energy users, use peak dollars rather than actual energy consumption to measure savings, and do not account for price and weather effects.

25 Ibid., p. 817.

Table 3-6—Market Segmentation of Residential Energy Users

Type	Description	Percent of market
Pleasure seekers	Interested in comfort, convenience, and personal control.	21.5
Appearance conscious	Most concerned with appearance.	18.4
Lifestyle simplifiers	Less concerned with comfort; pursue simplicity, often rent or low income.	16.9
Resource conserves	Concerned with environment, will pursue conservation for its own sake.	16.7
Hassle avoiders	Minimize hassle (time and effort) in making energy-related purchases, less concerned with cost.	13.4
Value seekers	Most concerned with value, will invest time and effort in making decisions.	13.1

SOURCE: National Analysts, Synergic Resources Corp., QEI, Inc., *Residential/ Customer Preference and Behavior: Market Segmentation Using CIA SSIFY*, EPRI EM-5908 (Palo Alto, CA: Electric Power Research Institute, March 1989), p. 10,

COMMERCIAL BUILDINGS

The energy use of a commercial building is largely determined by the design of the building and the efficiency of the equipment within it, However, occupant decisions in areas such as lighting and thermostat operation also influence energy use. This section describes energy-related decisions as they occur in the lifetime of a typical commercial building-starting with owners/developers, followed by architects/designers and builders, equipment manufacturers, managers/operators, and concluding with tenants/occupants.

Owners and Developers

Commercial building owners include both speculative owners, who lease or sell buildings after construction, and owner-occupants who occupy buildings after construction.[26] Speculative owners' decisions as to energy efficiency are determined in part by first cost and perceived "leasability." Energy efficient designs may require more capable (and therefore more expensive) building designers, more time to construct if builders are unfamiliar with a technology, and more time to work with building inspectors to demonstrate that a design meets health and safety requirements. From the speculative owners' perspective, these are costs that must be compared to the potential benefits. The leasability, or market appeal, of a building is determined by location, appearance, access to transport, lease costs, and other factors. A typical rent (including energy) for a large office or retail building is about $19.70 per square foot per year, while energy costs are only about $1.70 (table 3-7). Therefore a 25 percent drop in energy costs would yield only a 2 percent drop in rent costs—probably not enough to influence significantly a prospective tenant's decision.[27] From the perspective of a speculative owner, the costs of energy efficiency in terms of time and effort are very visible, but there may be little or no financial return.[28]

Many commercial buildings are master-metered, meaning that one meter measures energy consumption for the entire building. This prevents determination of actual energy consumption for an individual tenant occupying part of the building. Many have argued that submetering would reduce consumption by allowing for the billing of actual consumption, thereby providing a financial reward for efficient behavior. This may be difficult in large commercial buildings, however, because much of the energy use is associated with the central heating, ventilating, and air-conditioning (HVAC) unit; furthermore, submetering might also lead to a rate increase as utility rates are often discounted for large users.

26 In 1989 about 26 percent of nongovernment-owned commercial space was leased or rented. U.S. Department of Energy, Energy Information Administration, *Commercial Building Characteristics 1989*, DOE/EIA-0246(89) (Washington, DC: June 1991), p. 83.

27 Some property managers note, however, that in a competitive market a small advantage in operating costs can be enough to influence a prospective tenant. See ' 'Citicorp Managers Call Efficiency Key to Tenant Draw, " *Energy User News*, June 1991, p. 18.

28 "The goal of the developer is to build a quality building in the least amount of time at the lowest first cost, " reported one interviewee.

Table 3-7—Breakdown of Rental Costs for an Average Large Office/Retail Building in the United States, 1989

Type of expense	Dollars per square foot per year
Energy	1.70
Repair/maintenance	1.30
Cleaning	1.10
Administration/other	0.90
Roads/grounds/security	0.50
Fixed expenses, loan amortization, profit, etc.[a]	14.20
Total	19.70

[a]Calculated as the difference between average rent and variable operating costs shown.

NOTE: Excludes nonbuilding expenses, such as salaries and office equipment.

SOURCE: Adapted from Building Owners and Managers Association International (BOMA), "1990 BOMA Experience Exchange Report," Washington, DC, p. 27.

According to a large building owner/manager interviewed by OTA, tenants prefer fill-service leases that include everything from energy to security to cleaning. This reduces hassle for the tenant as there is only one monthly bill for the space, and simplifies budgeting as this kind of monthly bill does not fluctuate.

Owner-occupied buildings are somewhat more amenable to energy efficient technologies. Owner-occupants are typically more concerned with operating costs, as they are clearly the ones paying these costs. They often work more closely with the building designers, and they may be more willing to invest the time and effort needed to understand and even promote the use of innovative technologies. In fact, many highly energy efficient new buildings are built for clients interested in their high-tech appeal and as a demonstration of environmental awareness—not for their reduced operating costs .29 Reported one architectural/engineering (A/E) firm interviewed by OTA, ''our clients who want energy efficiency seem to be motivated by an ecological ethic or concern, and not by dollar savings.

Commercial Building Architects, Designers, and Builders

About 1.1 billion square feet of commercial buildings were built in 1989 (table 3-8), with a value of about $84 billion.[30] The process by which commercial buildings are planned, designed, and built varies, but typically the owner or developer will hire an architectural/engineering (A/E) firm to design the building and a general contractor to oversee the actual construction. The A/E firm designs and specifies the building design, the building shell, and the energy-using equipment to be installed, and therefore plays perhaps the most important role in determiningg building energy use.

Commercial building architects and engineers interviewed by OTA felt that opportunities for energy efficiency in new commercial buildings are considerable, and that some of these opportunities may *not* require an increase in construction (first) cost (see chapter 2, box 2-D). Building designers interviewed by OTA were confident that energy efficient designs would operate well, and in many cases would have important nonenergy benefits as well. Well-designed lighting, (e.g., making use of daylighting where appropriate) is thought to enhance productivity as well as energy efficiency. Using a cooling system with a larger temperature differential means smaller pumps and smaller pipes-which means lower frost cost, lower energy consumption, and a smaller portion of valuable interior space taken up by the space cooling system.

The implementation of such features, however, is often difficult for several reasons. The lack of incentives for energy efficient design is probably the single most important barrier to greater use of innovative energy technologies by A/E firms. Using a different design, even if it has many advantages, entails some risk. It may not perform as intended, the builders may be unfamiliar with it and install it

Table 3-8—New Commercial Building Construction in the United States, 1989

Type/purpose	Million square feet	Percent of total
Retail and offices	782	*69*
Educational	138	*12*
Hospital	71	*6*
Social/recreational	45	*4*
Public buildings	36	*3*
Religious	27	*2*
Miscellaneous	34	*3*
Total	*1,133*	100

NOTE: Percents may not add to 100 due to rounding.

SOURCE: U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States: 1991* (Washington, DC: 1991), p. 718.

29 This is similar to the "conservation ethic" often raised as an important motivation for homeowners to invest in energy efficiency.

30 U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract* @the *United States: 1991* (Washington, DC: 1991), p. 718.

incorrectly, or it may require changes in other building components. The rewards for energy efficient design are usually small. Clients are typically concerned with appearance, comfort, leasability, and other factors and are rarely willing to pay more for energy efficiency, The traditional business relationship between risk and return-that a higher risk choice has a higher return as well-does not appear to hold for energy innovations. It is usually easier for the designer to follow accepted, standard practice, especially if the designer's fee is the same in either case. As one interviewee said, "The path of least resistance does not include energy innovative design.

Commercial Building Equipment Manufacturers

Equipment in commercial buildings consumes energy to provide space conditioning (heating, cooling, and ventilation), lighting, and various other needs, depending on the building. The manufacturers of this equipment vary widely in size. For example, there are about 10 major manufacturers of large air-conditioning systems, while there are many small manufacturers of fluorescent light fixtures. The diversity of the business makes it difficult to generalize about how these firms incorporate energy efficiency into their production and marketing decisions. There are, however, several issues that apply to most of the industry.

The building equipment business is very competitive. Even in the relatively concentrated businesses, such as air conditioning equipment, companies typically compete for contracts. First cost is probably the most important, but certainly not the only, criterion on which manufacturers compete. Other factors raised as important by manufacturers include reliability, performance, features, and energy efficiency.[31]

Equipment manufacturers see energy efficiency as one of several important attributes that could differentiate their product from their competitors and thereby increase their market share. It is not clear how these attributes (first cost, reliability, performance, etc.) are valued or traded off by consumers, but from the manufacturers perspective, energy efficiency is typically of only moderate importance to most consumers. Features that add new functions (e.g., computerized control of an HVAC system to allow free-tuning of temperature in individual offices) are seen as having more marketing appeal than a less visible improvement such as energy efficiency.

The channels through which equipment manufacturers market and distribute their equipment vary. For very large building equipment, such as a large air handling unit, the A/E firm or the mechanical engineering firm subcontracting the HVAC work specifies the equipment, which is then built to order and delivered to the job site. Standardized equipment (such as lighting ballasts) is distributed through a private wholesaler or through a manufacturer-owned distribution system.

Building Managers and Operators

Large commercial buildings and commercial complexes typically have building operators or managers who operate, maintain, and repair the energy-using equipment. Their chief responsibility is to maintain occupant comfort and to respond to complaints. Very large complexes sometimes have energy managers, whose sole responsibility is energy management.

Building managers and operators are often hesitant to use innovative energy efficient equipment and practices, as from their perspective the costs are high and the benefits minimal. As discussed above, an innovation often carries with it an increased risk of poor performance,[32] and typically a change in building operation must go through a period of adjustment and free-tuning. The costs to the operator are in the form of increased complaints, as he or she is expected to fix the problem. The chief benefit, reduced energy costs, typically flows to the institution or owner and not to the operator. In addition, complex systems such as computer-controlled energy management systems are sometimes installed without adequate operator training. Reports a facilities manager for a large commercial building complex, "We simple folk who operate and maintain

[31] In our interviews wc typically asked "what do your customers look for when selecting equipment?' rather than "how important is energy efficiency to your customers?' as the former would allow us to see how energy efficiency compares with other attributes.

[32] A survey of commercial customers found "performance of the conservation equipment' ranked as the highest concern when considering efficiency improvements. "Total amount of money saved" and ' 'payback' ranked somewhat lower. Temple, Barker, & Sloane, Inc., Xenergy, Inc., *Market Research on Demand-.Side Management Programs,* EPRI EM-5252 (Palo Alto, CA: Electric Power Research Institute, June 1987), p. 3-4.

systems are given state of the art equipment to operate, and when things don't go well we are frequently told we don't know what we are doing. ' '[33]

Bad experiences with energy efficient equipment, in which the equipment failed prematurely, performed poorly, or was otherwise inadequate, have made operators and managers wary. For example, variable-air-volume (VAV) systems for large commercial buildings are a popular retrofit and are common practice in new construction, due in part to their large efficiency advantage over traditional constant volume systems. One interviewee reported that VAV systems are quite popular with tenants—not for their energy savings, but for their reduced noise. However VAV systems are very design sensitive, and reports one facilities manager, ''I have never seen or known of a fully functional variable air volume system. '[34]

Tenants and Occupants

About one-quarter of commercial building space is leased or rented, rather than owner-occupied. This fraction varies by building use—for example, less than 10 percent of commercial building floor space used for assembly or health services is leased or rented, while 30 percent of office space is leased or rented.[35] In most commercial buildings, opportunities for tenants to influence building energy use are somewhat limited. Control of drapes and blinds, proper use of space heaters, and turning off equipment (e.g., computers and printers) when not needed can all contribute to reducing consumption. However, indoor temperature often cannot be adjusted and lights often are centrally switched, limiting occupant control over energy use.[36] And as energy costs are typically buried in overall rental costs, there is little incentive to reduce energy use. Many larger commercial buildings have multiple tenants but only one energy meter, and energy costs are apportioned according to square footage or other criteria, rather than actual use, thereby reducing further the financial incentive for efficiency.

There are some opportunities for implementing efficiency when the space is initially set up. Those renting commercial space are often responsible for supplying all interior fixtures and equipment, and for retail space this usually includes lighting futures as well. However, turnover in the retail space market is quite rapid, and therefore many renters of retail space have a short time horizon when making lighting equipment choices. Therefore first costs and lighting quality are the chief criteria when making these choices, and operating costs are of less concern.

The relative insignificance of energy costs in comparison to labor costs often results in management attention and interest being directed elsewhere. A typical office building in the United States contains about 270 square feet of floor space per office worker.[37] If one assumes an average cost (salary plus benefits) per employee of $40,000 per year, this works out to about $150 per square foot per year for salaries, which dwarfs the $1.70 per square foot per year spent on energy (table 3-7). In other words, energy costs are on the order of 1 percent of labor costs in a typical office building.

This problem is compounded by the persistent perception that efficiency means discomfort and inconvenience. As noted throughout this report, energy efficiency does not have to reduce comfort—indeed, many technologies enhance both comfort and energy efficiency. However the perception that efficiency means "freezing in the dark" persists, and if an owner believes that a technology may reduce productivity then he or she will not allow its use, because any energy savings would pale next to the perceived productivity loss.[38] A survey of small businesses found that energy efficiency was thought to require turning down heat or turning off lights,

33 R.F. Burch, ''Where Have We Failed? Problems in Facilities Operation and Maintenance, '' in F. Payne (cd.), *Strategies for Energy Efficient Plants and Intelligent Buildings* (Lilburn, GA: Fairmont Press, 1987), p. 205.

34 Ibid., p. 203.

35 Excludes government-owned buildings. U.S. Department of Energy, Energy Information Administration, *Commercial Building Characteristics 1989,* DOE/EIA-0246(89) (Washington, DC: June 1991), p. 83.

36 For example, only 35 percent of commercial floor space allows occupant control of heating and/or cooling equipment. U.S. Department of Energy, Energy Information Administration, *Commercial Building Characteristics 1989*, DOE/EIA-0246(89) (Washington DC: June 1991), p. 212.

37 Building Owners and Managers Association International (BOMA), *1990 BOMA Experience Exchange Report*, Washington, DC, p. 27. There is considerable uncertainty in this number; a separate survey estimates it at 430 square feet per office worker (U.S. Department of Energy, Energy Information Administration, *Commercial Building Characteristics 1989*, DOE/EIA-0246(89) (Washington DC: June 1991), p. 13).

38 This is especially a concern with lighting retrofits. See ''Lighting the Commercial World, *EPRI Journal*, vol. 14, No. 8, December 1989, p. 9.

and these were not considered acceptable options, because a cold, underlit store would discourage customers .39

SUMMARY AND CONCLUSIONS

Understanding how and why energy efficient technologies and practices are often neglected—despite their apparent attractiveness on a life-cycle cost basis—is essential for designing policies to encourage greater use of these technologies.

The methods consumers use to make energy-related decisions often work against energy efficiency. Individuals pursue several goals when making energy-related decisions, such as minimizing first cost, minimizing time to make the decision, or minimizing risk by using the same thing that worked previously. Very few pursue the goal of minimizing life-cycle costs. For example residential building contractors typically select equipment based on first cost, ease of installation, and brand familiarity. And when future savings do enter into a decision, they are heavily discounted. For example implied consumer discount rates in appliance selection can exceed 50 percent.

There are often no incentives, financial or otherwise, for efficiency. A contractor bidding on a job will often win the job if he or she has the low bid—which often requires specifying low first-cost, inefficient equipment. And although energy costs in the aggregate are considerable, they are often low in relation to other costs. In a typical office, for example, energy costs are on the order of 1 percent of labor costs; therefore management and capital are often drawn to other areas. Designing a low-energy commercial building may require the use of innovative designs that might not work as predicted, and unless this greater risk is rewarded it will not be taken.

Over one-third of households, and one-quarter of commercial building floor space, is rented or leased rather than owner-occupied; in these buildings there is a reduced incentive both to invest in efficient equipment and to operate equipment efficiently.

Energy efficiency is just one of many attributes to consider when making complex choices, and its benefits are often seen as relatively intangible and uncertain. For example, a builder faced with the decision of investing $1,000 in insulation or $1,000 in landscaping will probably choose landscaping, as prospective buyers often value visible, tangible objects more highly. When making complex decisions that require the consideration of many attributes, people may focus on a limited number of these attributes-typically the most visible and tangible. For example, one room air conditioner may be small, quiet, and have electronic controls, while another is larger but with more cooling capacity and a different first cost; these features, rather than energy efficiency, often dominate the choice process.[40]

Energy efficiency is often (mis)perceived as conflicting with other goals. For example, small business owners equate efficiency with dark, cold stores, which is bad for business, and as a result show little interest in efficiency.

Many people believe that consumers are relatively unwilling to invest in energy efficiency. Whether or not this is true is difficult to determine; nevertheless the *belief* that it is true influences decisions of builders and manufacturers on what to build, manufacture, and sell.

The result of these factors is that cost-effective and societally beneficial opportunities for increased energy efficiency are often neglected.

This somewhat gloomy list of good reasons for a less than optimal outcome can be seen as an opportunity and a challenge, rather than as an insurmountable barrier. Considerable progress has been made in overcoming technical and economic barriers, as discussed in chapter 2. What remains is to correct some key market imperfections. Chapter 4 discusses past Federal actions to implement energy efficiency in buildings, and chapter 5 offers policy options to overcome these market imperfections and to encourage the use of cost-effective energy efficient technologies in buildings.

[39] P. Komor and R. Katzev, "Behavioral Determinants of Energy Usc in Small Commercial Buildings: Implications for Energy Efficiency,' *Energy Systems and Policy, vol.* 12, 1988, p. 237.

[40] In some situations the consideration of other attributes leads to increased energy efficiency. As mentioned above, for example, some commercial building owners invest in very efficient technologies not to reduce operating costs but to demonstrate their environmental ethic.