Regulation Versus Competition: Which Leads to the Most Energy Efficiency?

Rick Tempchin.. Edison Electric Institute
William LeBlanc, Barakat & Chamberlain, Inc.
Steven Wu, Stanford University

Numerous regulatory and market-based strategies have been implemented to help jumpstart new or improved energy technology development and to induce consumers to buy more energy-efficient products. This paper investigates the trade-offs involved between *competitive forces* and *regulation* in promoting energy efficiency. We hypothesize that as the operating cost attribute becomes more important to consumers, and the suppliers become more competitive, the energy efficiency of products will naturally evolve in the marketplace.

We analyze major energy-using technologies to determine their historical rate of efficiency improvements compared to the regulatory standards they must meet. We also review the product attributes that are most likely to be dominant in customer purchase decisions of each end-use application.

Next, several market-based and regulatory mechanisms are reviewed. We note that each specific mechanism works best only under particular circumstances relating to the level of R&D spending, the trade ally network, the consumer buying habits, and the degree of intefuel competition.

The results demonstrate that for the residential market, those end uses that are highly competitive from a fuel-use standpoint and have relatively high operating costs also have equipment available that *is* far more energy-efficient than the current standards. In the commercial sector, the data did not appear to support our hypothesis. We conclude that policymakers should analyze the specific markets carefully using this type of framework before proceeding with market intervention programs. Particularly, fuel substitution programs in markets with a natural incentive to improve operating cost attributes would likely stifle further energy-efficiency development.

Introduction

Increasing the energy efficiency of appliances, equipment, and buildings has been a major topic of interest among policymakers, utilities, state regulators, and various interest groups in the United States and other countries. Numerous methods to increase efficiency have been employed over the years with varying degrees of success. In the electric and gas utility businesses, there has been much debate recently about the benefits and costs of various forms of competition and regulation. Proponents of competition often claim that the market optimizes the overall efficiency of electricity and gas use relative to cost. Proponents of regulation and strict integrated planning often claim that the market has barriers and imperfections that preclude it from making appropriate energy-efficiency decisions, especially with regard to environmental impacts.

In this paper, we propose a framework to determine whether the market is likely to improve and promote energy efficiency in a given end-use application. Using this framework, we hope to provide a basis for determining whether specified end-use markets are best left alone to increase energy efficiency or whether these markets could benefit from some form of regulatory assistance to accelerate the penetration of technologies.

The hypothesis we hope to test in this paper is that high supplier competition coupled with consumer interest in operating cost attributes of end uses will generate a natural market for energy-efficient equipment development.

Approach

We start by presenting two dimensions to consider when looking at markets for energy end-use equipment. The two dimensions are the importance of operating costs in customer purchase decisions and the degree of supplier competition.

In the next two sections we briefly discuss how consumers view energy-related purchases and the array of regulatory and policy options available to improve the energy efficiency of equipment. In the following section, we categorize several important end uses according to the two dimensions identified above. Then we test our hypothesis against available data. Finally, we draw some conclusions about which markets are most likely to produce advancements in energy efficiency without market intervention and which markets could benefit from various market push and pull strategies.

Background: The Changing Energy-Efficiency Picture

From the 1920s through the 1970s, supply-side efficiencies for electricity improved dramatically, leading to lower costs. According to one study cited by the Quad Report, "Consumption advanced at 7% per year...in the 1950s and 1960s as real electricity prices declined by 70%... Engineers built larger.. generation plants, increasing average [plant] size sevenfold." As supply-side efficiency gains tapered off in the 1970s and 1980s, increased interest in demand-side efficiencies emerged. A wide variety of studies have shown that significant economic savings are available if current end-use equipment were to be replaced by more efficient equipment. The 1993 *Annual DSM Industry Report* of the Association of DSM Professionals notes that one study projects over 57 million MWh in savings by 1996 from DSM programs (ADSMP 1994).

Dimensions of Energy-Efficiency Development

Before we can determine whether energy efficiency is likely to develop at a rapid pace through the use of market forces, we discuss the two key dimensions of energy end-use markets. After describing the two dimensions in detail, we then present them in matrix form.

The Importance of Operating Cost in Customer Purchase Decisions

Consumers purchase a product after weighing the value of the product against its cost. The product's value is typically made up of the consumer's impression of a number of product attributes. To facilitate our analysis, we have identified several attributes that we believe cover the most important categories of consumer interest in energy-using equipment. These attributes are:

- First cost
- Operating cost
- Reliability (maintenance needs, lifetime, ease of repair, downtime)
- Aesthetics (appearance, environmental attractiveness, prestige)
- Function (features, comfort, convenience, ease of use)

When consumers are faced with a purchase decision, they sort the attributes of the product into their areas of greatest concern. Some attributes are critical but others can be overlooked as incidental. For example, when consumers purchase a refrigerator, they often have a maximum price they can afford, require a certain size, and have a strong desire for an ice-maker. Operating cost is often of negligible concern, and reliability is so uniform among manufacturers that it is almost irrelevant to the decision. Consumers tend to purchase refrigerators with higher life-cycle costs than the energy-efficient models that have the features they desire the most.

Another important aspect of in the customer purchase decision is the information available about attributes. Information about aesthetics and first cost is usually fully available in a purchase decision, and function is often well-defined in the sales process. However, operating costs are highly uncertain, even with energy cost charts available on appliances. Likewise, reliability is highly uncertain, and many suppliers respond to the uncertainty by offering extensive guarantees. Given that consumers tend to be guided by the knowledge that is made available to them, operating costs often become lost among the other product attributes.

Degree of Supplier Competition

The development and delivery chain for end-use equipment is quite extensive. Basic research and development (R&D) is often funded by the government through national laboratories and universities. Applied research is conducted by manufacturers and other interested groups, such as the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI). This study is particularly interested in the involvement of fuel suppliers in the development and application of end-use products. The involvement of EPRI and GRI is roughly analogous to oil company investments in automobile energy efficiency and battery companies funding the development of portable appliances. If electric and natural gas vehicles become more common, oil, natural gas, and electric suppliers may in fact start to promote "their" types of vehicles.

Information on R&D budgets for manufacturers is generally not available since it is proprietary information. The U.S. Department of Energy (DOE) 1994 fiscal year estimated budgets for various applications of interest are:

- Thermally activated heat pumps: $7,250,000
- Space conditioning: $1,000,000
- Refrigeration systems: $3,897,000
- Lighting: $3,043,000

GRI allocated approximately $34 million to R&D for end-use applications in 1993 (ADSMP 1994). In 1992, planned GRI allocations to specific end-uses included approximately $7.5 million for commercial space conditioning, $2 million for commercial heat pumps, $4 million for residential space conditioning, $6 million for residential heat pumps, and $18 million for industrial customer applications R&D (GRI 1991).[1]

EPRI funded approximately $24 million for research on end-use applications in 1993 (ADSMP 1994). This research included nearly $5 million for commercial space conditioning, $2 million for residential heat pumps, and $10 million for industrial processes (Bran 1992).[2] Over the past ten years, EPRI end-use research has focused on markets in which natural gas options are also available. EPRI has also been interested in increasing the energy efficiency of other electricity-using equipment, such as commercial lighting, over the past five years.

The interest of EPRI and GRI on behalf of their utilities provides market-based improvements in the availability of highly efficient end-use equipment. These organizations work closely with manufacturers to bundle energy-efficiency attributes with other value-added customer features. These two organizations are also working closely with trade allies to facilitate the delivery of new products to customers.

Customer Behavior and Market Barriers

Customers purchase energy-using products based on a complex and varied decision-making process. Their purchase decisions are closely related to the discussion of product attributes, consumer needs, and market-driven change. When a customer makes what is theoretically considered a suboptimal decision based on life-cycle cost analysis "market barriers" such as higher first costs, lack of information, risk of new technology, and search costs are often cited as reasons for the customer's decision.

In our framework, programs which educate customers as to the value of incorporating life-cycle cost and customer value considerations into their decisions are of particular concern. One could speculate that the market should take or has already taken these market barriers into consideration and that regulation is not necessary. However, recent DSM programs have provided customers and trade allies with value-added services that benefit all stakeholders.

Particular value can be added by a variety of techniques; some of these techniques are market-based and some are regulatory-based. Our premise is that in some end-use arenas and applications, market competition is adequate to ensure the appropriate advancement of energy-efficient equipment, but in other arenas market intervention may be warranted. In cases where market intervention can push or pull the adoption of energy-efficient equipment, some regulatory mechanisms may be more effective than others.

Figure 1 uses the two key dimensions discussed in this section to identify the end-use situations where energy efficiency may be best promoted by the market and where energy efficiency may be best promoted by market intervention.

Regulatory and Market-Based Options

Many mechanisms have been used to increase the adoption of energy-efficient equipment. The mechanisms employed tend to vary according to the jurisdiction of the entity intervening in the market. State and federal governments frequently use building and appliance standards as their main agent of change. State public utility commissions have jurisdiction over utilities, so demand-side management programs and integrated resource planning are often their vehicle of choice. Independent groups may choose to develop buying cooperatives to encourage manufacturers and vendors to invest in more energy-efficient designs.

The following list presents three common market intervention mechanisms and the types of market barriers they are designed to overcome.

- Equipment, appliance, and building standards. Standards are typically applied by federal, state, and local governments. They provide a floor for the energy efficiency of new products and buildings. By eliminating the lowest efficiency applications, standards force all suppliers to incorporate design

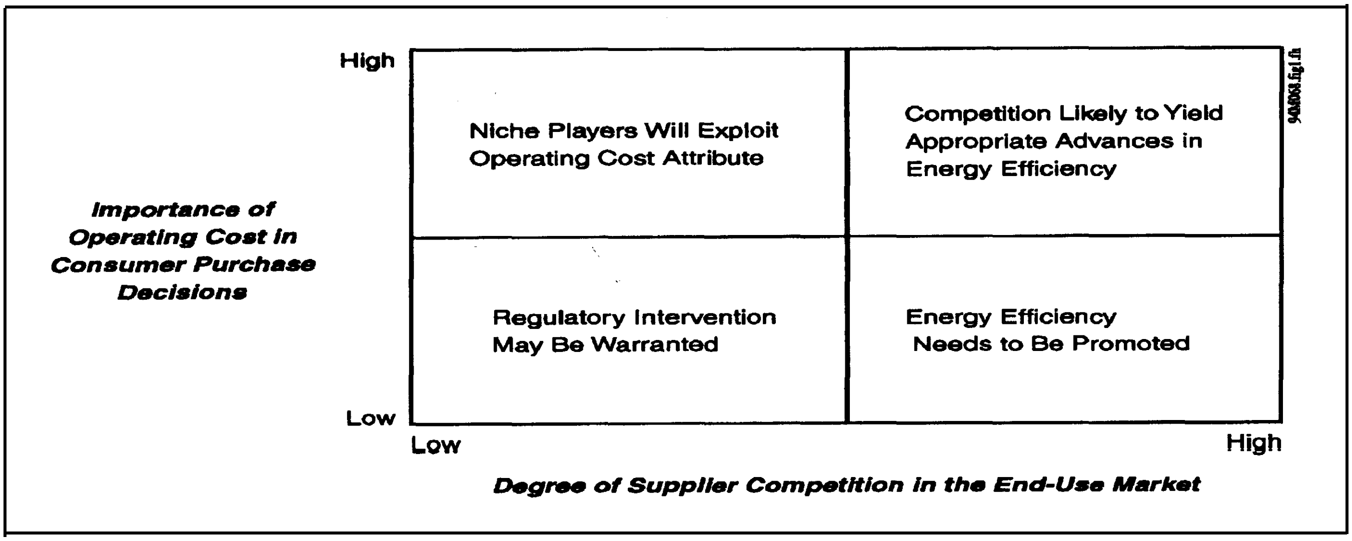

Figure 1. Two Key Dimensions: When Competition or a Regulatory Approach Is Warranted

changes that provide lower life-cycle costs even. though they are likely to increase first costs.

- Demand-side management. DSM has largely been used as a market pull strategy to encourage consumers and their trade allies to move product choice to the most efficient technologies available. DSM may encourage manufacturers to invest in more advanced product designs because they may hope that they can gain market share. DSM programs are often designed to overcome first cost barriers; however, these programs also provide substantial information on efficient technologies and their applications.

- Information programs. Various interest groups, including government, nonprofit, and for-profit entities, provide information on the value of adopting energy-efficient products. The motives of these entities include profit, environmental enhancement, and social improvement objectives.

Within each of these three broad categories of market intervention mechanisms, dozens of options can be applied. The most appropriate market or regulatory mechanism in a given industry depends on the particular characteristics of that industry, its customer applications, its specific market barriers, and the R&D investments being made in the industry by public and private groups.

Categorizing End Uses

Referring back to the four-cell matrix presented earlier, we can begin to categorize various end-use applications into the appropriate cells. Some end uses have highly developed competitive mechanisms based on the operating cost characteristics of the competing products. However, other end uses that have high energy use are purchased primarily on the basis of function and aesthetics. The following end-use categories serve as a useful starting point for our discussion of the relative merits of markets and regulatory mechanisms in different situations.

- Space heating. Four primary technology options are available to consumers in this category: electric resistance heat, electric heat pumps, gas furnaces, and oil furnaces. First cost, operating cost, and reliability are likely to be the attributes that consumers are most interested in. Also, both gas and electric suppliers have an incentive to promote the equipment that uses their fuel. Accordingly, R&D for heat pump and gas heating applications has been substantial, as shown by DOE, EPRI and GRI budgets. Both manufacturers and utilities have sought to increase energy efficiency of these products to maintain their market shares and profits. Regulatory intervention specifying the type of equipment consumers could buy in this end-use market would interfere with this natural market motivation and would likely lead to suboptimal level of energy-efficiency investments.

- Space cooling. Although one technology option, electric cooling, has dominated this end-use market for most of the past few decades, gas cooling technologies are emerging. As in the space heating market, both of these competing technologies emphasize operating costs as one of the primary sales attributes of their products. Also, space cooling needs are most prominent in commercial applications where the operating costs of cooling can be substantial. Thus, the competitive market for this end use is likely to provide a strong incentive for the producers of space-cooling equipment to conduct R&D into higher efficiency products and to promote efficiency in their sales efforts.

- Water heating. Until very recently, consumers could only choose between two water heater technologies: gas and electric resistance (although solar has a small market share). However, new heat pump water heaters are emerging as another competitor in this marketplace. First cost, operating cost, and reliability are again likely to be the most important attributes for consumers.

- Residential refrigeration. Refrigerators are powered by electricity in all but a few rare applications. Thus, purchasers are likely to perceive that first cost, function, and aesthetics are the attributes of primary concern.

- Commercial lighting. Lighting is powered exclusively by electricity. Consumers can choose from a wide variety of lighting options. The main categories are incandescent, fluorescent, and high-intensity discharge. Customers are interested in various attributes. of a product in this end use. First cost, operating cost (including maintenance), function, and aesthetics are all likely to be of great concern and come into play in the purchase decision.

Figure 2 summarizes our findings on how to categorize the specified end uses according to the matrix illustrated in Figure 1.

Testing the Hypothesis

Earlier, we speculated that as supplier competition increases and as the operating cost attribute becomes more important for a particular end use, the more likely it is that the energy-efficiency attribute of products in this end use will be developed. In this section, we look at the main energy-consuming end uses in the residential and commercial sectors to determine the following:

- Current energy consumption

- The role of standards in pushing the development of energy efficiency

- The current availability of products that exceed efficiency standards

Residential End Uses

Space heating, water heating, space cooling, and refrigeration account for approximately three-fourths of residential energy consumption (DOE 1994).

Table 1 lists these major end uses with their 1990 energy consumption, the energy savings that would be realized if National Appliance Energy Conservation Act (NAECA) Standards were met by all appliances, and the savings that would be realized if all appliances were the "best available" technologies, that is, the best available of those already on the market.

The results appear to confirm our expectations. Standards do not improve the efficiency of the mix of appliances for the three end uses–space heating, space cooling, and water heating—that have high supplier competition, particularly when that competition is driven by interfuel competition, and where operating cost is an important attribute. In these situations, the market promotes cost-effective energy-efficiency decisions. Also, the commercial availability of higher efficiency equipment

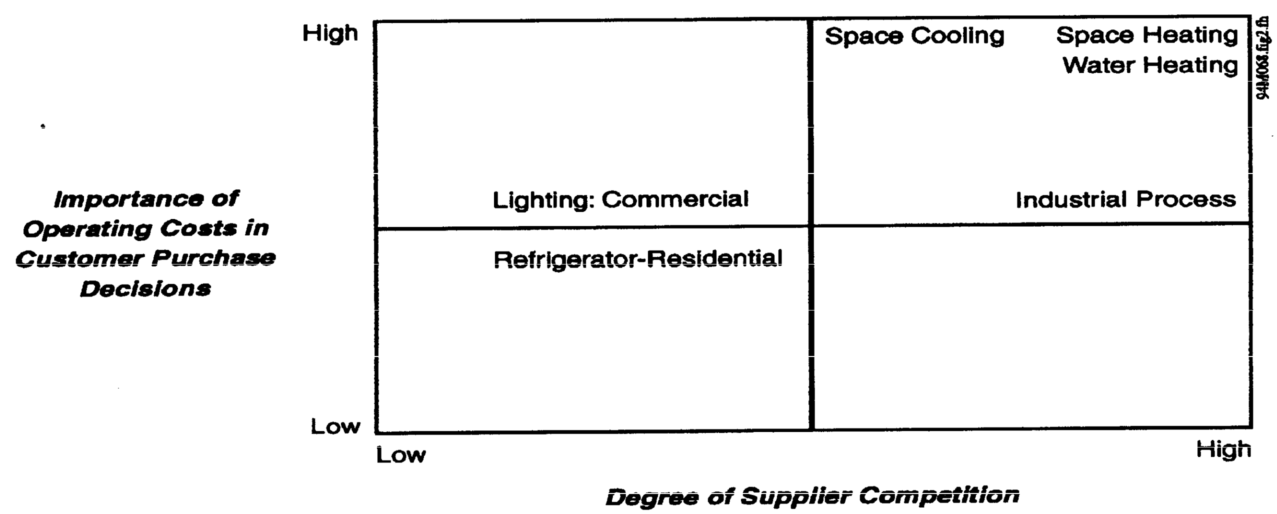

Figure 2. Categorization of Selected End Uses by the Two Key Dimensions

Table 1. 1990 Energy Use for Selected Residential End Uses and Potential Savings

	1990 Energy Use (quads)	Savings If All Appliances Meet NAECA Standards	Savings If All Appliances Are Best Available Technology
Space heating	6.23	.18 (2.8%)	0.86 (14%)
Space cooling	1.27	.04 (3.1%)	0.42 (33%)
Water heating	3.62	.05 (1.4%)	1.73 (48%)
Refrigeration	1.76	.61 (34.7%)	0.17 (10%)

already offers great room for efficiency improvements for these three end uses.

For refrigeration, by contrast, standards appear to be the source of most improvements in the energy efficiency of the products. In fact, most of the energy savings due to new standards come from refrigeration. Also, little improvement is available in the market now beyond what is required for the standards. Over the past 20 years, the energy efficiency of residential refrigeration has improved more than most other residential technologies (see Figure 3), but these improvements appear to have been caused by the improvement standards that started in the 1970s in California. (A large state like California can have a dramatic effect on energy efficiency because its population accounts for nearly 13% of the U.S. market.) Refrigerator efficiency had actually deteriorated before the 1970s; in fact, the energy consumption of refrigerators had risen threefold per unit, although the size and features of refrigerators had improved (OTA 1992).

The potential for improving the energy efficiency of space heating and space cooling is large. In particular, the heat pump has been developed rapidly for use in space heating and space cooling. Today, the best available heat pump is 92% more efficient than the 1990 average stock (16.4 versus 8.56 SEER) and 64% more efficient than the 10.0 SEER standard of NAECA (DOE 1994). Gas heating competes quite successfully with electric heating for market share. In 1988, the market penetration of gas heating in new single-family homes was 60%, the penetration of electric heat pumps was 26%, and the penetration of electric resistance heat was 4% (ACRI 1991).3

The potential for improving the energy efficiency of water heating is also large. Today, the best available gas appliances are 69% more efficient than the average 1990 stock, and the best electric-resistance water heaters are 17% better than the average 1990 stock. Heat pump water heaters now available have coefficients of performance of 2.5 and greater (DOE 1994) but have limited market acceptance to date. Natural gas and electricity both have substantial market shares of water heating.

Commercial End Uses

Space heating, space cooling, and lighting account for more than three-fourths of all commercial-sector energy use. Table 2 shows 1990 energy consumption for these

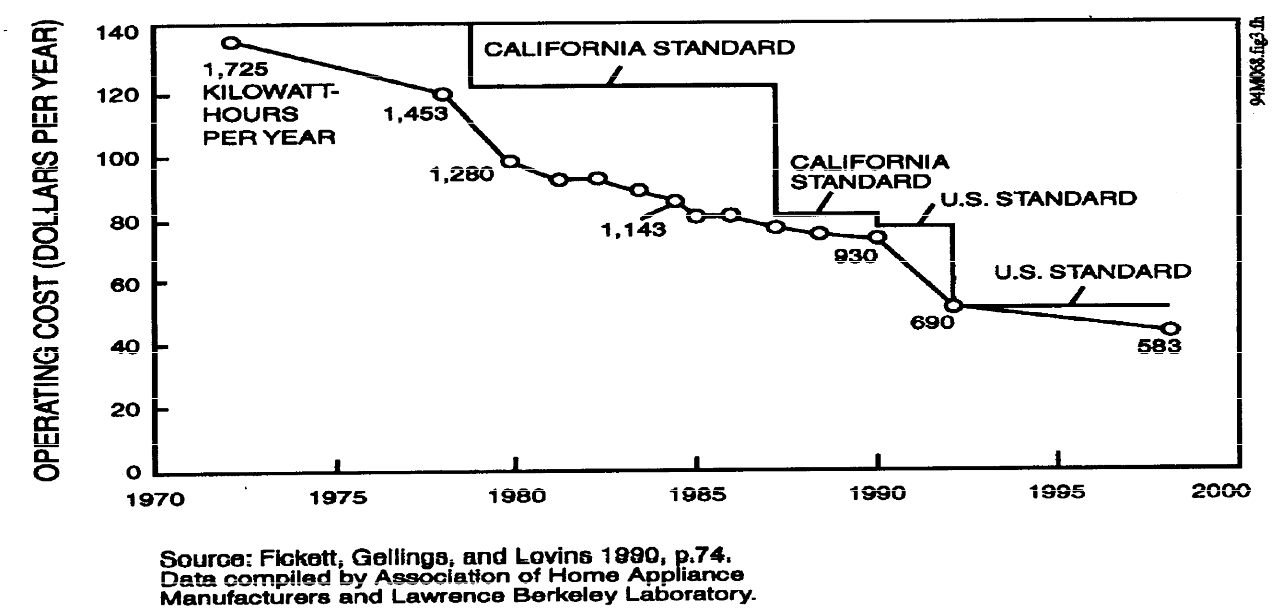

Figure 3. Regulation-Driven Improvements in the Efficiency of Refrigeration, 1970-2000

Table 2. 1990 Energy Use for Selected Commercial End Uses and Potential Savings

	1990 Energy Use (quads)	Savings If All Equipment Meets EPAct Standards	Savings If All Equipment Is Best Available Technology
Space heating	3.91	.04 (1.0%)	.18 (4.5%)
Space cooling	2.54	.18 (7.1%)	.24 (9.0%)
Lighting	3.63	.33 (9.0%)	1.2 (33%)

end uses, the energy savings that would be realized if all equipment were replaced with equipment meeting Energy Policy Act Standards, and the savings that would be realized if all equipment were changed to the best available technologies (DOE 1994).

These results do not seem to support our hypothesis. Although standards appear to have the most effect on lighting (the end use with the least interfuel competition), lighting also has the most potential for improvement with commercially available technology. One explanation for this discrepancy is that commercial lighting has been an important focus of utility DSM programs and energy service company projects.

Space cooling may be the most interesting end use to watch in the commercial sector in the next five to ten years. First, the government-mandated phaseout of CFCs may induce large changes in the current stock of cooling technologies. Second, gas-cooling technologies have been developing rapidly, so the electric side has an incentive to make its own improvements. In 1990 the best available reciprocating chillers were only 27% better than the average stock, but we expect to see major improvements in the upcoming years.

Regulation or Competition?

Regulating the energy efficiency of end-use equipment poses two basic questions:[4]

1. Are private-sector companies developing and promoting higher efficiency products as it becomes economically attractive for them to do so?

2. Are consumers purchasing advanced energy-efficient equipment when-it is advantageous for them to do so?

The type of program that might be attractive from the regulatory side depends on which market barrier is apparent. We first discuss our conclusions for the residential sector for the first question, above.

- Where interfuel competition is high and consumers are interested in the operating costs of the equipment, energy-efficiency development is strong. Although government R&D spending is useful to advance this development, the market appears to work in a way that yields rapid improvements. Under these circumstances, any attempt to mandate markets for specific equipment is likely to be counterproductive because it will clash with the suppliers' desire to gain market share.

- In markets where interfuel competition is not a factor, standards affect the efficiency of the bulk of appliances. Utility DSM programs, when large and mature, may also be able to influence these markets through their buying power. In addition, other buyer aggregation programs, such as the Earth Comfort Geothermal Heat Pump Program, could create additional incentives for manufacturers to develop energy efficiency. Government-sponsored R&D in these markets may be useful to determine the appropriate economic level of the standards. We also are hopeful that the private sector will develop bundles of energy services that include the financing and leasing of equipment and energy.

To answer the second question, we must determine if consumers are purchasing advanced energy-efficient technologies when it is in their economic interest to do so. The consumer purchase side of the energy-efficiency business is more complex than the equipment development side. Therefore, regulatory decisions concerning consumer purchases will be difficult and involved.

- For technologies in which operating costs are an important factor in the purchase decision, manufacturers, trade allies, and utilities have incentives to promote energy efficiency as an attribute of an appliance. This incentive becomes stronger as energy prices rise and become a larger part of the overall cost equation. Interfuel competition should intensi~ this market-driven incentive to increase the sales of energy-efficient appliances. Mandated fuel-substitution programs would likely lessen the incentive for manufacturers, trade allies, and utilities to promote the operating cost attribute of their equipment, as they would no longer have control over the consumer decisions in the market.

- For technologies in which operating costs are less important to consumers and supplier competition is weaker, regulation could accelerate the adoption of new technologies. From a consumer standpoint, a mandate for enhanced information about operating costs would be a primary concern. By increasing consumers' awareness of the link between energy efficiency and its associated benefits (such as lower life-cycle costs and improved environment), information programs assist the natural market evolution toward energy efficiency (Tempchin and LeBlanc, 1992). However, competition among equipment suppliers (i.e., lighting manufacturers) can drive efficiency even where fuel competition is not present.

- When market barriers besides lack of information preclude consumers from purchasing the most economic energy solutions, regardless of available technology or supplier competition, other market intervention mechanisms may need to be applied. Because first cost is so overwhelmingly important in many purchase decisions, financing and rebates can be useful to encourage purchases of energy-efficient equipment. Many DSM programs make use of these techniques, as do manufacturers and energy service companies. However, these programs must work in tandem with the natural forces of the market to be most effective and to have the desired long-term effects. Any regulatory mechanism that lessens the natural incentive of suppliers or trade allies to improve the operating cost attributes of their equipment would have the long-term effect of suppressing the development of energy efficiency.

Endnotes

1. Gas Research Institute, 1992-96 Research & Development Plan, GRI, Chicago, IL, 1991.

2. Ingrid Bran. EPRI Spreadsheet, Customer Systems Division Budget Allocation, October 13, 1992.

3. Air-Conditioning and Refrigeration Institute, Statistical Profile of the Air-Conditioning, Refrigeration, and Heating Industry, June 1991.

4. A third question that is posed by regulating the energy efficiency of end-use equipment is, "What other stakeholders are interested in promoting energy efficiency, and how do they affect the market?" Obviously, various interest groups hope to promote energy efficiency, but this analysis is beyond the scope of this paper.

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