WHAT HAVE WE LEARNED FROM EARLY MARKET TRANSFORMATION EFFORTS?

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ABSTRACT

Recently utilities and government have begun to alter the way they approach energy conservation and efficiency objectives—from audits and rebates to strategic market interventions designed to effect sustainable shifts toward more efficient products and services. A number of these "market transformation" activities are now far enough along that it is possible to examine both the shifts that have occurred in the market and the role of these activities in fostering those market changes. This paper reviews eleven efforts currently underway and provides qualitative and, where possible, quantitative information on their progress in effecting market transformation. Although it is difficult to attribute particular market shifts to specific policies or programs, it appears that many of the market transformation approaches examined in this paper are having a positive market impact, as evidenced by increased sales of high-efficiency products and changes in manufacturer, dealer, and consumer behavior.

INTRODUCTION

In the last few years, utilities have sought alternatives to traditional demand-side management programs. Governments have assumed a market-stimulating role in energy efficiency. Both have sought to leverage private capital and ingenuity to improve the efficiency of energy-using products. And the concept of market transformation has been born and evolved.

While no single definition exists, market transformation generally refers to the process by which collective action, policies, and programs effect a positive, lasting change in the market for energy-efficient technologies and services, such that these technologies and services are produced, recommended, and purchased in increasing quantity. Underlying this concept is the assumption that strategic actions have the potential to fundamentally change the course of the evolution of markets such that efficient products or services can ultimately flourish in the absence of incentives (Schlegel and Prahl 1994). The specific approaches that can contribute to market transformation range from traditional forms, such as information programs and rebates, to commercialization incentives and market infrastructure development. These approaches are used to achieve energy efficiency improvements at all levels in the distribution chain—from manufacturers through end users.

In the residential sector, for example, market transformation activities can target consumers to induce changes in their attitudes toward energy efficiency, and concomitant changes in their purchasing practices. In the commercial sector, market transformation activities can include educating equipment dealers and contractors as well as building owners and operators about higher-end technologies and practices. If the owners' and operators' experience is favorable, their behavior may be permanently modified, such that dealers and contractors stock, recommend, and install high-efficiency products and building owners and operators purchase them. Market transformation activities can also focus on the supply side of the distribution chain, inducing manufacturers, through aggregate purchase commitments, energy labeling programs, or incentive payments, to produce more efficient products.

Several studies provide an overview of market transformation efforts in which government and utilities have encouraged more rapid improvements in, or accelerated adoption of, energy-efficient technologies (e.g., Flanigan and Fleming 1994; Geller and Nadel 1994; Nadel and Geller 1995; Schlegel and Prahl 1994). Some of these reviews assess the effectiveness of market transformation efforts from the recent past. Increased interest in market transformation, however, has spurred several new initiatives, some of which are now far enough along that it is possible to conduct a preliminary assessment of their effectiveness. This paper reviews a number of current market transformation efforts and provides qualitative and, where possible, quantitative information on their progress in transforming the markets for energy-efficient products. It does not pretend to be a rigorous evaluation, but rather a status report, based in large part on interviews with program managers, manufacturers, and others involved in the efforts, on the state of the art in market transformation programs. Information and insights gleaned from these efforts can improve the effectiveness of future market transformation programs.

PROCURING MORE EFFICIENT REFRIGERATORS

The market transformation strategy chosen by a number of organizations to move the refrigerator/freezer market to higher levels of efficiency has been technology procurement—coordinated mass purchases of highly efficient technologies. Three technology procurement efforts, in particular, are noteworthy: (1) Sweden's Board of Industrial Technology (NUTEK) small refrigerator procurement; (2) the Super-Efficient Refrigerator Program (SERP); and (3) the New York Power Authority and Consortium for Energy Efficiency apartment-sized refrigerator initiative. Each of these efforts is described below.

NUTEK Refrigerator Procurement

NUTEK focused its refrigerator procurement on small apartment-sized refrigerators with the goal of facilitating the development and purchase of units 40 percent more efficient than models available at the time. This level of efficiency improvement was determined achievable with better insulation and improved heat exchangers and compressors.

NUTEK first sought and found purchasers who agreed initially to purchase at least 500 units, although there was a clear implication that if the refrigerator worked well, additional purchases would be forthcoming. These purchasers comprised mainly housing management companies, which account for a large portion of small refrigerator purchases.

The buyers group then collectively developed technical specifications for an apartment-sized refrigerator. The specifications required that the refrigerator consume no more than 1.0 kilowatt-hour (kWh)/liter/year—nearly 20 percent more efficient than the best model on the market (1.2 kWh/liter/year) and approximately 30 percent more efficient than the average small refrigerator used in Sweden (1.4 kWh/liter/year). Additional incentives were added for units that performed below 0.9 kWh/liter/year. Further, the specifications required manufacturers to prominently display energy consumption information for consumers to use in making purchasing decisions and to consider environmental factors (e.g., refrigerant type and recycling and disposal of units) in refrigerator manufacture and use.

Based on these specifications, a request for proposals (RFP) was drawn up and five manufacturers responded. AB Electrolux won the bid in June 1990 and by December 1990, Electrolux had developed a 290 liter (10 cubic feet) prototype that consumed 0.78 kWh/liter/year—35 percent more efficient than the most efficient model on the market (NUTEK).

The NUTEK procurement and promotional campaign appear to have contributed to a number of shifts in the Swedish refrigerator market in the years following the initial procurement. With regard specifically to the initial procurement, purchases of the unit far exceeded that anticipated in the initial bid. The buyers group alone purchased 632 of the Electrolux units between 1991 and

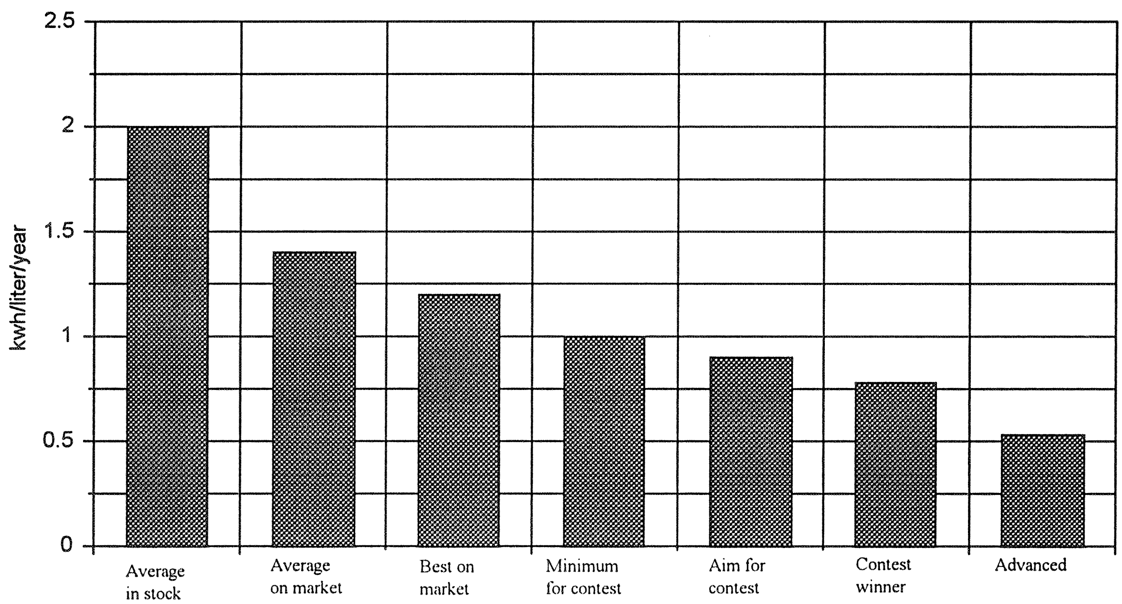

Figure 1: Energy Consumption of Small Refrigerators in Sweden
Source: NUTEK

1994 and additional purchases resulted in total sales of 3,350 units. Per unit energy savings also exceeded expectations. NUTEK measured the performance of units purchased by the buyers group and found their average energy consumption to be much lower than that estimated by Electrolux in its bid.

With respect to broader market transforming impacts, the availability and sales of energy-efficient apartment-sized refrigerator models increased dramatically following the competition. According to Hans Nilsson of NUTEK, "the [initial] demand pull released a supply push in which [major manufacturers] quickly (and voluntarily) joined the winner in this niche market." Prior to the competition only one available model consumed less than 1.1 kWh/liter/year. (Note that data on the number of models that consume less than 1.0 kWh/liter/year—the target specified in the

RFP—are not available.) This was the case until the procurement was completed in 1991. After the competition, the number of such models increased markedly each year, such that the share of available models under 1.1 kWh/liter/year went from 0.8 percent in 1991 to 22 percent in 1994.

Sales of these models also increased substantially. A NUTEK study indicates that energy-efficient models introduced subsequent to the procurement gained market share rapidly—from virtually no market to 7.5 percent of small refrigerator sales in 1993. Further, builders that specialize in "environmentally adapted" buildings are widely specifying the new apartment-sized refrigerator products. This second wave of demand is thought to have resulted from the increased choice currently on the market (Nilsson 1996). And, at the same time, the price for energy-efficient refrigerators decreased, making energy efficiency more affordable (Johnson and Bowie 1995).

A factor that confounds attributing market shifts solely to the NUTEK procurement is a European Union (EU) energy labeling program developed in 1992 and first implemented (on refrigerators) in 1995. At the time, Sweden was not a member of the EU and, therefore, was not responsible for implementing the labeling program. Nonetheless, manufacturers that sell products on the European market (both in EU and non-EU countries) may have shifted their product offerings in response to the EU label, potentially affecting the availability (and sales) of efficient equipment on the Swedish market. In fact, a survey of the literature of three European manufacturers indicates that the average reported energy efficiency of the stock of new refrigerators improved by between 4.3 and 27.7 percent in the two- to three-year period from 1993 or 1994 to 1995 (Waide, Lebot, and Hinnells 1995).

The NUTEK solicitation, combined with complementary initiatives such as appliance labeling, appears to have helped establish a significant market niche for high-efficiency small refrigerators in Sweden. Small refrigerators, however, comprise only a small fraction of the refrigerator/freezer market in Sweden. While modest efficiency improvements are likely to occur in the remaining market segments as a result of energy labeling, much work remains to transform those market segments to higher-efficiency levels, as well as to further increase the market share for high-efficiency apartment-sized refrigerators.

The Super-Efficient Refrigerator Program (SERP)

In the early 1990s, both the U.S. Department of Energy (DOE) (for the initial National Appliance Energy Conservation Act [NAECA]) and the U.S. Environmental Protection Agency (EPA) conducted analyses on the feasibility of improving refrigerator energy efficiency. These analyses indicated that significant reductions in refrigerator energy consumption could be achieved with existing technologies. Recognizing the magnitude and potential for energy savings and capitalizing on changes in refrigerator designs that industry was expected to make to comply with a 1995 CFC phaseout, a number of interested parties (including EPA, the American Council for an Energy-Efficient Economy, the Natural Resources Defense Council, Pacific Gas and Electric Company, and the Washington State Energy Office) initiated discussions in 1990 on ways to encourage manufacturers to improve refrigerator efficiency. Negotiations and planning meetings involving an increasing number of utilities and other parties led to the founding of the Super-Efficient Refrigerator Program, Inc. (SERP) in September 1991. As an initial step, SERP drafted a detailed RFP calling for the development and commercialization of a "super-efficient" CFC-free refrigerator.

In 1992, SERP members proposed paying more than $30 million in financial incentives and offered this money on a per-unit basis as a "Golden Carrot" in a contest for refrigerator manufacturers willing to develop and market a refrigerator that was: (1) full featured; (2) at least 25 percent more efficient than 1993 federal standards require; and (3) CFC free (in both refrigerant and insulation). After reviewing bids from 14 manufacturers and testing prototypes from 2 semi-finalists, SERP selected Whirlpool as the winner of this competition in June 1993 (Feist et al. 1994).

The original SERP refrigerator was a 22 cubic foot side-by-side unit that achieved energy savings of nearly 30 percent relative to the 1993 NAECA standard. In 1995, Whirlpool announced additional SERP models (including 25 and 27 cubic foot units) that were even more efficient than the original unit. Currently, Whirlpool's SERP models exceed national efficiency standards by 38 to 41 percent. These SERP refrigerators are now available to consumers at retail outlets in the service territories of participating utilities. Whirlpool receives incentive payments from the utilities when it sells qualifying models in their service territories.

To what extent have the SERP units transformed the refrigerator market? Sales figures, one indicator of market transformation, suggest that SERP has had little impact. As of December 1995, sales of SERP units were below the scheduled rate laid out in Whirlpool's proposal (Sandahl et al. 1995). Whirlpool attributes the slow sales primarily to the time and effort required of dealers to process the paperwork necessary to receive a rebate (Anderson 1996). This is in part a consequence of participating utilities' requirements that the manufacturer tightly track and verify unit sales for each participating utility. Others believe that Whirlpool's limited promotion and training for dealers and distributors have hurt unit sales (IRT 1994). In addition, the small niche market that the SERP units serve (in total, side-by-side units account for approximately 30 percent of the refrigerator/freezer market) may limit the potential for SERP to have broad market transforming impacts.

Despite relatively low sales and the narrow niche that the SERP program has targeted, SERP has made a number of significant contributions to moving the U.S. market for refrigerators toward greater levels of efficiency. First, SERP stimulated the introduction of a new highly efficient refrigerator in record time. By combining a number of "off-the-shelf" technologies, Whirlpool was able to produce a highly efficient refrigerator in about half the time that it typically takes to produce a new product. And some observers suggest that as a result of Whirlpool's efforts other refrigerator manufacturers were able to accelerate the transition of their refrigerator lines away from CFCs a year before the scheduled phaseout (Lee 1996).

Second, the SERP contest, together with a handful of aggressive utility incentive programs, is believed to have motivated other manufacturers to develop and test market similar high-efficiency products. Manufacturers, such as Amana and General Electric (GE), have entered the national market with efficient CFC-free refrigerators, and have plans to continue these lines. Shortly after SERP units became available, Amana offered a line of refrigerators 25 percent more efficient than the 1993 NAECA standard (Lee 1996). Further, Whirlpool elected to market the SERP units in non-SERP territories under its own "Energy-Wise" label. However, low initial sales of these units have led Whirlpool to stop producing and selling the Energy-Wise units (Anderson 1996).

Finally, a recent Pacific Northwest National Laboratory (PNNL) study of the SERP process revealed that manufacturers, in general, believe that SERP had some influence on the proposed 1998 federal refrigerator standard (Sandahl et al. 1995). In November 1994, after nearly two years of negotiations, the Association of Home Appliance Manufacturers (AHAM) and a coalition of energy efficiency groups, state energy offices, and utilities announced an agreement on a new standard. While the technical details of the SERP model were not discussed in the negotiations, the SERP model was referenced as evidence that an energy-efficient, CFC-free refrigerator could be produced cost-effectively. Further, efficiency advocates, knowing SERP efficiency levels, were reluctant to drop below them in the negotiations. In July 1995, DOE issued a notice of proposed rulemaking (NOPR) that proposed a refrigerator standard nearly identical to this negotiated agreement. These standards reduce energy use of the most popular refrigerator/freezers by nearly 30 percent—similar to those of the winning SERP model.

Because SERP was the first program of its kind in the United States, manufacturers', utilities', and others' experience with SERP is likely to affect their willingness to participate in similar market transformation programs. According to PNNL, most utilities and manufacturers interviewed on the SERP process indicated that they might participate in future Golden Carrot programs, although their decision would be contingent on elements of the program's design as well as its implementation (Sandahl et al. 1995). PNNL is currently conducting a formal impact evaluation of SERP that is anticipated to be completed in late 1996.

Apartment-Sized Refrigerator Procurement

Despite federal efficiency standards, apartment-sized refrigerators offer significant additional efficiency gains that are considered both feasible and cost-effective. To address this, the New York Power Authority (NYPA) joined forces with the Consortium for Energy Efficiency (CEE) to broker bulk purchases of more efficient apartment-sized refrigerators in the U.S. By allowing housing authorities and utilities to piggyback on a contract between NYPA and refrigerator manufacturers, this effort offers manufacturers a larger potential market and purchasers more reasonable prices for apartment-sized refrigerators.

The impetus for the initiative was a localized effort by NYPA to work with the New York City Housing Authority (NYCHA) to procure more efficient refrigerators for public housing.
With input from CEE, DOE, EPA, and others, NYPA developed a RFP for a super-efficient apartment-sized refrigerator that was released for bid in May 1995. The initial RFP set target efficiency levels for four years, specifying that manufacturers deliver the best current technology for the first year of the program (1996), a unit that is 30 percent more efficient than the 1993 standard for the second year of the program, and units with even higher efficiency levels for the third and fourth years of the program.

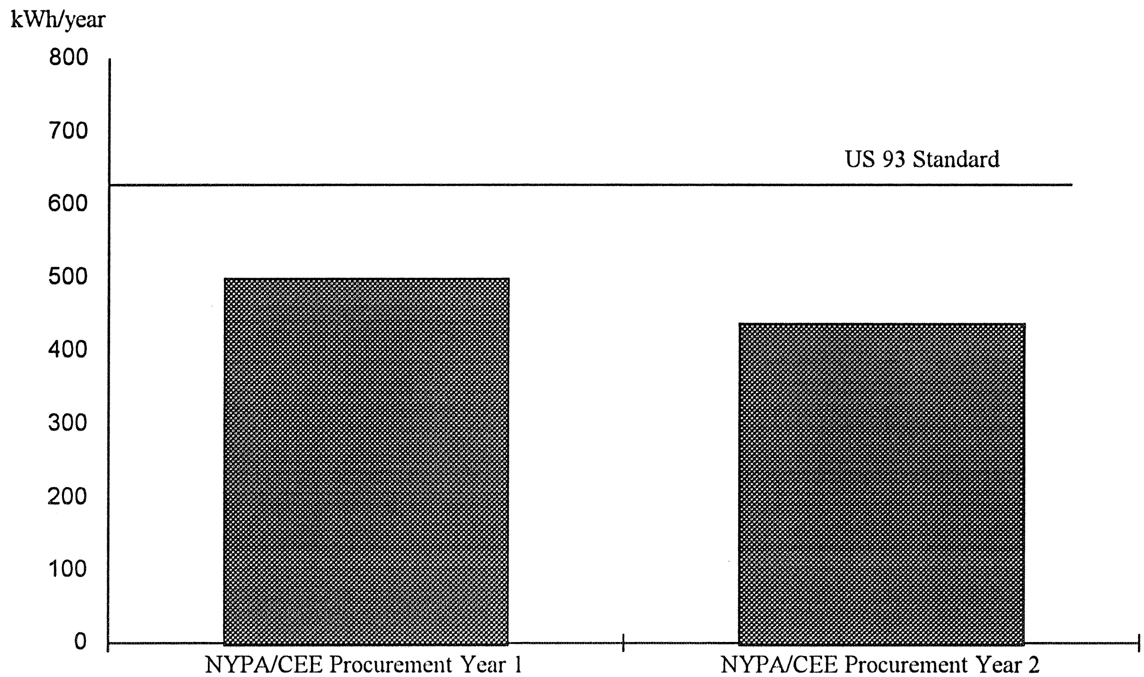

Figure 2: Annual Energy Consumption Requirements for the NYPA/CEE Procurement
Source: CEE 1995a

Four manufacturers expressed an interest in this RFP, however, none was willing to commit to the requirements of the third and fourth years. At the time NYPA was negotiating with manufacturers on the scope and content of the RFP, Congress was taking action to limit DOE's ability to implement new appliance efficiency standards. The uncertainty over future standards translated into reluctance on the part of several manufacturers to invest in developing products that meet target efficiency levels far into the future (i.e., consistent with a four-year specification) (Brown 1996).

In response to these concerns, NYPA developed a second RFP that limited manufacturer requirements to those of the first two years. Three manufacturers bid on the second RFP. For some manufacturers, even committing to the second year savings was a stretch. Of the three that bid on the RFP, General Electric won the bid for the first year's savings, but only Maytag offered an apartment-sized refrigerator that met the second year's requirement. Historically, Maytag has not been a big player in the apartment-sized refrigerator market. Because the company had not yet invested in redesigning products to meet the CFC phaseout schedule, however, it was ready to make the additional investment needed to simultaneously achieve the required energy efficiency improvements. With its bid, which was very aggressively priced, the company enters this market niche in a very significant way. Some indicate that Maytag's bid has already spurred efficiency-based competition in the apartment-sized refrigerator market (Brown 1996).

Preliminary marketing efforts by CEE indicate that the market transformation potential of the NYPA procurement is substantial. At Maytag's insistence, however, the maximum number of piggyback orders to the NYPA contract will be limited to 40,000 units. A number of housing authorities are strongly interested in the new product, and CEE anticipates that it can secure commitments to purchase at least 40,000 units each year (in addition to NYPA's order of 20,000 units annually for NYCHA) (Wisniewski 1996). With few exceptions, utilities have been less willing than housing authorities to commit resources to procuring energy-efficient apartment-sized refrigerators in the face of diminishing demand-side management dollars, although several proactive utilities have expressed an interest in large purchases.

TURNING CLOTHES WASHERS ON THEIR SIDE FOR GREATER ENERGY EFFICIENCY

Most clothes washers sold today have much in common with units sold 30 years ago. In fact, for some manufacturers, designs have changed little over this period. From an energy perspective, clothes washer efficiency was fairly stable in the 1980s and early 1990s, but the average energy consumption of new clothes washers dropped 17 percent in 1994 when new federal efficiency standards took effect. Much more efficient washers, however, that use less than half the energy and nearly half the water of conventional models, are currently on the market. But these models use horizontal-axis designs, which are very different from the vertical-axis designs that predominate in the U.S. market. Efficiency gains in laundry equipment can also be realized with increased washer spin-speeds, which decrease the water content of clothes at the end of the wash cycle, thereby reducing dryer energy use by 30 percent or more.

Historically, many market and non-market barriers have inhibited the spread of high-efficiency washers, with the result that the market share of these high-efficiency washers in 1994 was on the order of 1 percent. Price, in particular, has been cited as a key barrier. According to Vince Anderson of Whirlpool, "despite the good payback available to the consumer, the historic price premium (roughly $200 or more) is at a level that significantly reduces sales potential" (Anderson 1996). Another major barrier is Americans' past experience with high-efficiency designs. The one U.S.-built high-efficiency unit on the market in the past needed repair more often than the average washer. To overcome these barriers, a number of initiatives aimed at improving efficiency in the clothes washer market have come together in the 1990s. These initiatives include:

- Announcements by DOE in 1991 and 1994 that they are very interested in horizontal-axis washer technology and are considering using this technology as the basis for setting new federal efficiency standards (DOE 1991; DOE 1994a).

- A joint R&D program by the Electric Power Research Institute and Maytag to develop a new, improved horizontal-axis design (EPRI 1995a).

- Development of an initiative by CEE in which many utilities use the same efficiency specifications to provide significant and focused promotional activities for high-efficiency, high water extraction clothes washers (CEE 1995b).

- Formation of the utility consortium The High-Efficiency Laundry Metering and Marketing Analysis project (THELMA) to conduct market research, performance testing, and in-field metering on high-efficiency clothes washers in order to learn how to better promote these washers to consumers (Pope 1995).

These efforts have been proceeding steadily and often in coordination with each other. For example, 16 energy utilities and many water agencies have signed up for the CEE initiative and many of these utilities as well as EPRI and DOE are also part of the THELMA consortium (CEE 1995b). However, some of these initiatives have also faced some barriers. For example, limited availability of high-efficiency washers has made it difficult to enroll additional utilities in the CEE program. Also, opposition by some manufacturers to stringent clothes washer efficiency standards has contributed to a Congressional moratorium on new appliance efficiency standards in 1996.

Overall, however, these different initiatives appear to be having an impact on the U.S. clothes washer market. In 1991, only one U.S. manufacturer produced washers meeting the CEE specifications and imports of complying models were very limited. By 1994, one small U.S. manufacturer began producing a new high-efficiency, high-spin-speed washer and three out of the four major U.S. manufacturers had announced their intention to introduce new high-efficiency models, with the new units expected to reach the market place in 1996 and 1997 (CEE 1995b). In September 1996, the first of these models will enter the market (Frigidaire 1996). Also, imports of high-efficiency washers appear to have picked up significantly, with several European manufacturers actively marketing such washers throughout the United States (deLaski 1996; Pope 1996).

Preliminary discussions with manufacturers and importers reveal that several factors have contributed to their decisions to develop and market new high-efficiency models. First and foremost, U.S. manufacturers appear to be motivated by the possibility of new federal efficiency standards. Second, the new high-efficiency washers have the added benefits of improved cleaning performance and less wear and tear on clothes. These factors make marketing the new washers much easier. Third, the consumer appeal of substantial energy and water savings from these washers, combined with demonstrated utility and government interest in promoting and providing incentives for high-efficiency washers, has influenced manufacturers and importers. In spite of the uncertainty concerning new federal efficiency standards, U.S. manufacturers are continuing their efforts to develop and commercialize new high-efficiency clothes washers.

Thus, at this point, the different clothes washer initiatives have contributed to three important market conditioning effects: (1) impending commercial availability of high-efficiency products from multiple major manufacturers; (2) electric and water utility and government interest in promoting the products; and (3) the possibility of more stringent standards in the future. Still, the market share of these high-efficiency machines is very low and is likely to remain low until units are mass-marketed by major U.S. manufacturers. Also, even when models are widely available, it is uncertain how consumers will respond to the new models and the different marketing initiatives. It is also unclear whether DOE will proceed with new clothes washer efficiency standards. Thus, while significant progress has been made, it will probably be several years before we will know whether these initiatives were successful in their goal of transforming the U.S. clothes washer market.

TAKING A BYTE OUT OF OFFICE EQUIPMENT ELECTRICITY USE

In the early 1990s, several forces came together to effect efficiency improvements in office equipment, beginning with personal computing equipment. First, as a result of initial studies of the magnitude of office equipment power loads and the trends in power consumption, a group of utilities, government agencies (including EPA and DOE), and energy efficiency advocates, led by the Electric Power Research Institute (EPRI), formed the Office Technology Efficiency Consortium. This Consortium strives to increase office equipment energy efficiency and improve load characteristics, power quality, and tolerance to power line disturbances without compromising either competitive features or user productivity. To achieve these goals, the Consortium has emphasized the need for, and has contributed to the development of, more reliable data, government or corporate purchasing specifications, and utility-sponsored information programs to create a market for efficient office equipment.

Growing interest in office equipment efficiency led EPA to query manufacturers about the technical feasibility of incorporating power management features into personal computers (PCS). Based on positive manufacturer responses, EPA worked with manufacturers to develop the ENERGY STAR Computers Program—a voluntary labeling program designed to encourage the development, production, and sale of energy-efficient, power-managed office equipment.

EPA launched the program in June 1992 by announcing it at a Consortium-sponsored workshop to heighten awareness of the importance of more efficient office equipment. Later that year, in October 1992, the Energy Policy Act of 1992 (EPAct) was signed into law, and with it DOE was required to oversee the development of a manufacturer-centered voluntary information program to encourage the marketing and purchasing of more efficient office equipment products. Consortium members were instrumental in suggesting this provision to Congress. Office equipment efficiency was on the agenda of manufacturers, government agencies, and utilities, and the ENERGY STAR specification provided an efficiency requirement around which these players could rally.

The initial phase of the ENERGY STAR program required manufacturers to produce PCS and monitors capable of switching to a low power mode (i.e., at or below 30 watts [W]) when not in active use. Participating manufacturers, in turn, were entitled to use the ENERGY STAR label in promoting their products. In 1993, EPA expanded its ENERGY STAR program to include printers (with requirements similar to those of PCS) and signed partnership agreements with printer manufacturers that comprised more than 95 percent of all printers on the market.

In the wake of these efforts, on Earth Day 1993, President Clinton signed Executive Order #12845 into law, requiring federal agencies to purchase ENERGY STAR PCS, monitors, and printers. The Executive Order delivered to manufacturers the largest office equipment market in the world and, together with the relatively low cost of adding power management capability to office equipment, helped mobilize rapid manufacturer participation in the ENERGY STAR program. During the 1994 fiscal year alone, federal agencies purchased at least 292,000 compliant PCS, 167,000 monitors, and nearly 65,000 printers. These purchases save the federal government an estimated $5 million in energy costs annually (Dolin 1996; EPA 1995).

EPA estimates that in 1995 ENERGY STAR PCS comprised approximately 70 percent of new sales. Furthermore, 80 to 85 percent of computer monitors now on the market are estimated to comply with ENERGY STAR requirements. ENERGY STAR printers didn't appear on the market until June of 1993, but rapidly reached high market penetration. By the end of 1994, more than 95 percent of the printers on the market were believed to be ENERGY STAR compliant. Data validating these estimates should be available in late 1996 (Fanara 1996; Latham 1996).

Some program design problems as well as technical incompatibilities, however, have eroded the potential energy savings from Energy Star products. Early in the program, for example, EPA did not require computer manufacturers to ship their PC models with the power-management feature already "enabled." Thus, even though the equipment was capable of powering down, it did not unless the user intervened and set up the feature. A recent study by Lawrence Berkeley National Laboratory (LBNL) reveals that only 10 percent of Energy Star PCS currently in the field are enabled (Koomey et al. 1995). In October 1995, EPA addressed this problem by modifying the Energy Star program to explicitly require manufacturers to ship PCS with the "sleep" feature enabled. Additionally, local area network (LAN) activity and compatibility issues can limit the energy savings from PC power management features. For example, for certain high-end computers intended for network use, network "polling" functions can keep the PC awake, thereby limiting the effectiveness of the Energy Star features. Further, computers not generally intended for network use can disconnect from the network upon entering the low-power mode. To respond to this problem, EPA now requires manufacturers to specify in their product literature if a product is not intended for network use (Latham 1996; McMahon, Piette, and Kollar 1995).

Despite these problems, a recent study by LBNL indicates that the ENERGY STAR program has already saved about 3 billion kWh annually in the United States Together with new fax machine and copier specifications (finalized in 1994 and 1995, respectively), which rounded out the suite of office equipment programs, ENERGY STAR is projected to save about 17 billion kWh per year in the United States by the year 2010 (Koomey et al. 1995).

Spurred by manufacturer interest, the EPA ENERGY STAR program has effected considerable change in the supply of efficient office equipment. To expand its programs' effectiveness, however, EPA recognizes the need to motivate consumers as well. A survey conducted in 1993 indicated that only nine percent of respondents were familiar with the ENERGY STAR label (COPEE 1994). As a result, EPA intends to launch a significant media education campaign on the benefits of energy-efficient equipment in late 1996.

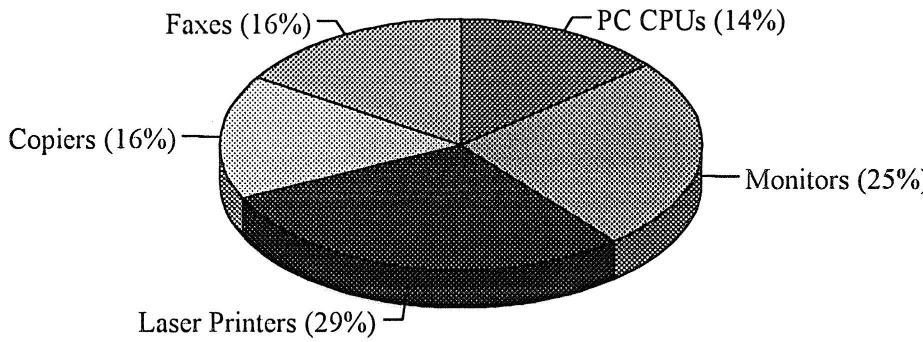

Figure 3: Share of 2010 Projected Electricity Savings
Source: Koomey et al. 1995

On the international front, manufacturers from 21 countries and territories outside the United States have joined the ENERGY STAR program in order to use the ENERGY STAR label both in the United States and in other markets. Additionally, EPA made considerable progress toward an international set of ENERGY STAR criteria in October 1995 by negotiating an agreement with the Japanese government to implement an International ENERGY STAR Office Equipment Program. EPA is also working with the European Commission to further develop a common internationally recognized set of ENERGY STAR criteria.

COOLING DOWN AIR CONDITIONER ELECTRICITY USE

Residential Central Air Conditioner Initiatives

Air conditioner energy use generally coincides with periods of peak electricity demand. As a result, improving air conditioning energy efficiency is of particular interest to electric utilities. As of 1994, electric utilities offered more than 300 programs to promote high-efficiency electric space heating and cooling to their residential customers (EPRI 1995b). These incentive programs, however, tend to be extremely diverse, targeting varied efficiency levels and generally focusing on seasonal and not peak performance metrics. The Consortium for Energy Efficiency (CEE) sought to remedy these problems by developing residential air conditioner program guidelines for utility incentive and promotional programs. In doing so, it seeks to minimize the confusion generated by diverse utility programs, send a clear market signal for high-efficiency products to manufacturers, and increase high-efficiency equipment availability.

The CEE initiative, which covers single-phase unitary and split system air conditioners and heat pumps up to 65,000 Btu per hour of cooling capacity (i.e., 5 tons), has two components:

(1) The equipment efficiency component, consists of multiple efficiency tiers with eligibility determined on the basis of SEER (a measure of average seasonal performance) and EER (a measure of peak load performance) for cooling performance and HSPF for heating performance. The initial efficiency tiers are based on equipment that is approximately 15 percent more efficient than average equipment being sold today (e.g., a tier 1 SEER level of 12 relative to a 1994 sales-weighted average air-conditioner SEER of 10.6). A series of higher tiers (i.e., SEER 13 [tier 2]; SEER 14 [tier 3]; and SEER 15 and higher [an advanced tier]) are based on additional efficiency improvements, for which higher incentives are recommended.

(2) An installation component that includes a set of installation guidelines for contractors to follow. Few utility programs focus any effort on improving installation practices—a critical component in ensuring efficient system performance. CEE recommends that utilities incorporate the installation guidelines in their programs to maximize actual energy savings, but utilities are not required to adopt this component to participate in the initiative.

To date, eight utilities participate in the residential air conditioner and heat pump initiative. These utilities serve about 15 percent of the residential customer base in the United States (CEE 1995c).

CEE has encountered some difficulties in marketing the program to utilities, and in particular, in determining whether programs that either include some but not all of the CEE efficiency tiers or offer promotions but not financial incentives should qualify. In these areas, CEE has tended to be fairly conservative and has appeared overly restrictive to some potential participants. In late 1995, CEE approved a set of program modifications that clarify and simplify the program to address many of these issues. These include requiring that utilities support only tier 1 efficiency levels, and expanding the methods of participation to include not only financial incentives but also "significant and focused promotional/educational activity." Furthermore, as the electric utility industry restructures, CEE has had to adapt to a changing perspective in the industry regarding energy-saving programs (Marge 1996).

Complementing the CEE initiative is EPA's new ENERGY STAR program for heat pumps and air conditioners, which was unveiled in April 1995. The primary thrust of the program is to improve manufacturer product offerings and market share for high-efficiency products. The ENERGY STAR Heat Pump and Air Conditioner Program requires that manufacturers produce units with a minimum SEER of 12 and a minimum HSPF of 7. These criteria were based on the CEE tier 1 requirement. However, unlike CEE, EPA does not require that manufacturers also meet a peak-load cooling performance requirement. Thus far, 11 manufacturers have signed on to the program. In addition to the manufacturer component of the program, EPA has initiated a marketing campaign and has begun a series of pilot distributor and contractor training activities. Through this latter effort, EPA hopes to educate dealers and distributors on the benefits of high-efficiency equipment and improve the likelihood that they will stock and install ENERGY STAR compliant products.

In addition, DOE has also begun a rulemaking to determine new efficiency standards for central air conditioners and heat pumps (DOE 1993). The standard-setting process is proceeding slowly and at the earliest will be completed in late 1998. The new standards will probably take effect in the first few years of the next century. An initial analysis prepared for the rulemaking indicated that, depending on equipment size and characteristics, efficiency levels of SEER 13 to 15 can be cost-effective for consumers (DOE 1994b). However, some important issues, which have not been addressed in the analysis thus far, may reduce the final standard to somewhat lower efficiency levels. Still, electricity and peak demand savings of approximately 20 percent or more relative to the current SEER 10 standard are likely as a result of these new standards. The success of the CEE and EPA programs may affect this rulemaking.

Improved sales of tier 1 equipment and increased availability of high-efficiency equipment across the board may evidence the effectiveness of the CEE initiatives, utility programs in general, and EPA's efforts. First, data from the Air-Conditioning and Refrigeration Institute (ARI) on air conditioner and heat pump sales for 1993 and 1994 show that, on average in 1994, 16.1 percent of air conditioner and heat pump shipments had a SEER of 12 or more, up from 12.7 percent in 1993. (Note that in regions with aggressive utility programs high-efficiency units comprise a much greater share of total shipments. For example, 30 to 40 percent of air conditioner shipments to Maryland, New Jersey, and Iowa, had an SEER of 12 or more [ARI 1995]). The proportion of units with SEER of 14 or more, however, was the same in 1993 and 1994 (0.4 percent) (Martz 1995). As of 1995, ARI no longer provides this data to the public. However, several industry observers suggest that SEER 12 equipment accounted for approximately 25 percent of sales in 1995, while sales of SEER 13 and higher equipment remained low. Second, a database of available models shows that in early 1994, 23 percent, 10 percent, 1.4 percent, and 0.1 percent of models met CEE tiers 0, 1, 2, and 3, respectively (tier 0 was a temporary tier with a SEER of 11). By late-1995 these percentages had increased to 43 percent, 27 percent, 7 percent, and 2 percent (CEE 1995d; CEC 1995).

Results of interviews with manufacturers and distributors indicate that uniformity among utility programs has increased over the past several years which has helped to solidify manufacturer interest in developing products at the tier 1 level (i.e., SEER 12). To the extent that the CEE, and EPA initiatives have contributed to improving uniformity among programs, their influence on manufacturer product offerings has been significant. Manufacturers also point out other factors, namely higher profit margins, marketing opportunities in the replacement market, and the potential to differentiate their products from their competitors in the marketplace, that contribute to manufacturers' decisions to produce high-efficiency products.

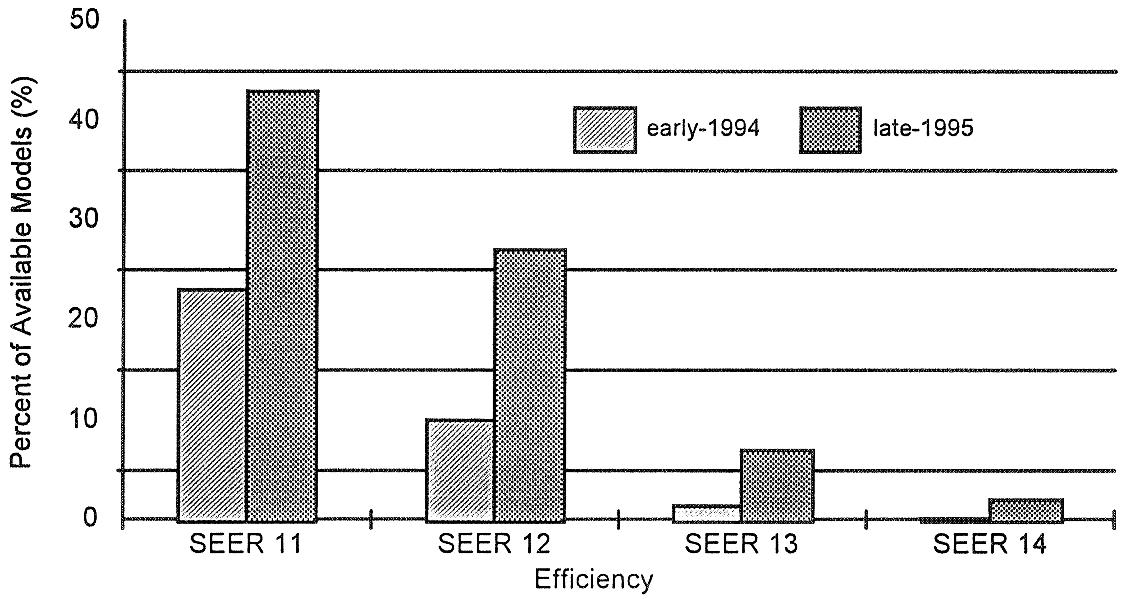

Figure 4: Share of Residential Air Conditioner and Heat Pump Models
Source: CEE 1995d, CEC 1995

However, at least one manufacturer competing at the highest efficiency levels, feels that the CEE program has not been a factor in his company's success in marketing existing products or in new product development decisions. Nonetheless, manufacturers that have not tended to produce high-efficiency equipment have entered the market for tier 1 equipment and are slowly building interest in developing products that meet the higher efficiency tiers. At the 1996 International Air Conditioning, Heating, and Refrigeration Exposition, for example, several manufacturers announced new SEER 12, 13 and 14 units and a number of other manufacturers expressed an interest in finding out which utilities were promoting products at the higher efficiency levels.

New federal efficiency standards, if enacted, could complete the transformation of the residential central air conditioner and heat pump markets to at least the tier 1 level. In fact, the significant and growing market share of tier 1 products is likely to make a standard based on tier 1 relatively uncontroversial. Transformation to higher-efficiency levels is slower, however, although a few utilities in regions with significant market acceptance of tier 1 levels (e.g., Florida Power & Light, Pacific Gas & Electric, and Potomac Electric Power Company [PEPCO], among others), have begun to successfully emphasize higher efficiency levels in their programs. The average efficiency for central air conditioners incentivized under PEPCO's 1995 rebate program, for example, was SEER 13 (Neme 1996; Shiemann 1996; Wilson 1995).

Commercial Air Conditioning Initiatives

CEE's residential air conditioner and heat pump initiative is complemented on the commercial side by its High Efficiency Commercial Air Conditioning (HECAC) initiative, which covers unitary, three-phase equipment (CEE 1994a). Historically, the commercial unitary air conditioning market has been dominated by first cost considerations and there has been little effort to promote high-efficiency equipment in the market. In 1989, in an effort to improve the efficiency of commercial unitary air conditioners and heat pumps, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) developed a set of recommended practices for new commercial construction that includes efficiency levels for unitary air conditioners. Since 1989, many states have adopted this ASHRAE standard as part of their state building codes. In 1992, the U.S. Congress established minimum efficiency standards for unitary commercial air conditioners and heat pumps up to 240,000 Btu per hour cooling capacity based on the ASHRAE standard. The CEE program was designed to promote commercial air conditioning equipment that is more efficient than this standard.

Like CEE's residential air conditioning program, HECAC consists of multiple efficiency tiers: an initial tier based on equipment approximately 10 percent more efficient than average equipment being sold today; and a higher tier, based on additional efficiency improvements, for which higher incentives are recommended. For example, for a 10 ton cooling capacity unit, the federal standard requires an 8.9 EER, and CEE's first and second tiers are 10.0 and 12.0 EER respectively. Participants in the HECAC initiative include 16 utilities that serve about 20 percent of U.S. electric utility customers (CEE 1994a; CEE 1995c).

A number of activities have worked in concert with the CEE initiative to move the market toward high-efficiency commercial air conditioning equipment. First, concurrent with the development of the CEE initiative, EPRI and Lennox engaged in a cooperative research and development effort to develop a line of very high-efficiency unitary equipment, with one objective being to meet CEE's second tier (Blatt 1992). The results of this effort, the Lennox L-series, is gradually being commercialized over the 1995-1996 period (Stockwell 1995). Second, EPA has funded the California Institute for Energy Efficiency to develop a prototype 10-ton commercial air conditioner that exceeds CEE's second tier. Through this effort a prototype was designed, built, and underwent field testing. Preliminary results indicate that the efficiency of this prototype falls short of their goal of 12.9 EER due to problems caused by the hurried construction of the prototype, but that the unit is still more efficient than any product now on the market and achievement of the original goal should be possible with more careful construction (O'Neal and Davis 1995). Finally, ASHRAE has begun to develop a new set of efficiency standards for packaged commercial air conditioners as part of its model building code. The initial draft ASHRAE standard is similar in stringency to the CEE tier 1 level (ASHRAE 1996).

Assessing the effectiveness of these efforts is difficult because data on the sales-weighted efficiency of commercial packaged air conditioners are not publicly available. What is available are various analyses of the percent of units on the market that meet certain efficiency targets. For example, a June 1993 analysis by the Air Conditioning and Refrigeration Institute (ARI) prepared for CEE found that approximately 14 percent of the units then on the market met CEE tier 1 while no models met CEE tier 2 (Wethje 1993). During 1994 and 1995 the proportion of models meeting CEE tier 1 grew substantially. An analysis comparing the early 1994 California Energy Commission database on commercial packaged air conditioners and heat pumps with the updated November 1995 version revealed that nearly half of the new models added to the database during 1994 and 1995 met CEE tier 1 (Suozzo 1995). As of early 1996, an analysis of ARI's database indicates that a total of 23 percent of models met tier 1 (Marge 1996).

Based on discussions with manufacturers, increased utility and consumer interest in high-efficiency equipment prompted many of the major manufacturers to introduce new high-efficiency product lines to complement their existing standard efficiency lines in 1993 and 1994. To the extent that CEE spurred more uniformity among utility programs at the tier 1 level, the CEE initiative contributed to this market shift. In addition, by 1994 preliminary drafts of the new ASHRAE standard were available to manufacturers and these drafts have had an impact on product development efforts since under federal law, development of a new ASHRAE standard triggers, and forms the basis for, a new set of federal standards.

Manufacturers, however, have shown little interest in CEE's second tier. For example, the Lennox L-Series generally falls midway between CEE tiers 1 and 2, and none of the units meet tier 2. It appears that this is due to several factors including the costs associated with research and development needed to achieve tier 2 levels, changes in utility focus away from energy efficiency to customer service programs, and the larger size and higher price of tier 2 equipment relative to tier 1 equipment, which make it difficult for tier 2 equipment to compete in the marketplace. To address this issue, in early 1996, CEE proposed lowering the tier 2 efficiency requirements to levels 10 percent above the new ASHRAE level. With these new levels, the high-efficiency Lennox series will generally achieve tier 2 levels (CEE 1996).

Furthermore, while tier 1 units are now widely available, they still represent a relatively small portion of equipment sales. One utility involved in the CEE program estimates that about 10 percent of commercial unitary equipment sales in its territory met CEE tier 1 in 1995. On the other hand, the various efforts to promote this equipment have increased manufacturer comfort with these efficiency levels and, as a result, most if not all major manufacturers are supporting the efficiency levels in the draft ASHRAE standard. When this standard and its companion federal standard are completed, the transformation of the market to tier 1 will be complete.

FROM THE GROUND UP: OVERCOMING BARRIERS TO GEOTHERMAL HEAT PUMPS

Geothermal heat pumps (GHPs) take advantage of the ground's relatively stable temperature and capacity as a heat source and sink, to efficiently heat and cool residences or small commercial buildings (EPA 1993). GHPs have been on the market for many years, with one of the earliest installations in the U.S. dating back approximately 60 years. Until the 1970s, however, the primary mechanism for transferring heat to and from the ground was through an "open loop" system. This system relied on accessible and plentiful groundwater and, therefore, limited the number and types of applications for which the technology was appropriate In the 1970s, the development of "closed loop" systems rendered the technology feasible in a much wider range of applications (Pratsch 1996).

In the late 1980s, efforts to advance GHPs, funded by the Electric Power Research Institute (EPRI), the National Rural Electric Cooperative Association (NRECA), the International Ground Source Heat Pump Association (IGSHPA), and a few utilities, focused on research and development, establishing industry design standards, and training installers. From these efforts, a seven part national teleconference series for GHPs was launched in July 1992, which served both to introduce the technology to the electric utility industry on a much broader basis and to develop a strong public/private partnership.

In recent years, the GHP industry has been growing at a rate of roughly 10 to 20 percent annually, with estimated sales of 40,000 GHPs in 1994. Nonetheless, high initial costs for the in-ground loop system, lack of a market infrastructure for training and installation, and lack of consumer awareness and confidence have limited GHP sales (GHPC 1995).

To spur this market, the Geothermal Heat Pump Consortium (GHPC), a collaborative of electric utilities, the Department of Energy (DOE), the Environmental Protection Agency (EPA), and other public and private sector organizations, was formed in November 1994. Under the GHPC's National Earth Comfort Program—the primary vehicle for transforming the GHP market—the Consortium set aggressive goals to increase GHP installations to 400,000 units by 2001. The GHPC is taking a three-pronged approach to promoting GHPs, addressing each of the key barriers to increased use of GHPs (GHPC 1996a).

- High initial costs. GHPs typically cost consumers around $6,000 to $8,000 installed (Pratsch 1996). To address the high first cost barrier the GHPC is: (1) supporting the development, demonstration, and commercialization of technologies that reduce the first cost or at least improve the performance of GHP equipment; and (2) identifying and demonstrating innovative financing and incentive programs to help customers overcome the first cost barriers. For example, the GHPC is co-funding nine utility pilot programs, each with innovative program design elements, that include efforts to phase-out or replace rebates with low-cost financing options (GHPC 1996b).

- Infrastructure. To improve the infrastructure for GHPs, the GHPC has determined that it needs to improve and expand technical training, strengthen the existing design tools and other technical resources, and ensure that environmental regulation, licensing provisions, and building codes and standards are consistent and ensure environmentally safe installations at fair prices.

- Technology awareness and confidence. The GHPC hopes to build a self-sustaining market for GHPs by building consumers', contractors', and others' awareness of and confidence in the technology. To accomplish this, GHPC is developing a national public awareness campaign to effectively communicate GHP benefits to interested parties. In addition, the GHPC is engaging in regional cost-sharing with selected utility partners to demonstrate model programs.

EPA and DOE fund other activities that support the GHPC's efforts to promote GHPs. For example, EPA is working with DOE to investigate opportunities for incorporating GHPs in new and retrofit applications in military bases. EPA is also developing an environmental guidance document on GHPs to inform potential users about regulations on activities that affect the use of GHPs (e.g., well water drilling) and potential impacts of substances, such as anti-freeze, used in GHPs. Furthermore, EPA, through its ENERGY STAR program, labels efficient GHP products and provides recognition to manufacturers of GHP products that meet EPA's efficiency specification (Offutt 1996). DOE funds specific GHP technical developments to test and improve the cost-competitiveness of alternative GHP installations and to monitor the associated energy savings (Pratsch 1996).

The Consortium for Energy Efficiency (CEE) also worked to promote GHPs through its Geothermal Heat Pump Initiative (CEE 1994b). CEE's initiative provided a model for utilities, which specified efficiency tiers, system design elements, and recommended installation practices for very high-efficiency GHP systems. Utility participation, however, was limited to two utilities due in part to the fact that many interested utilities currently participate in the GHPC effort. And, given the challenges of building market infrastructure and awareness, steady improvements in equipment efficiency, and utilities' move away from rebates, most utilities were not interested in formally incorporating efficiency tiers into their programs. As a result, CEE voted to drop the program in June 1996 (Wisniewski 1996).

Despite cutbacks and delays in federal funding that have slowed some of the implementation of GHP activities, the potential for transforming the GHP market looks promising and early results indicate that utility interest is significant and manufacturer product efficiencies are improving. As of early 1996, 121 utilities (representing more than 50 percent of residential electric customers) and more than 200 trade allies had joined the GHPC. In addition, a number of manufacturers have introduced new, more efficient models, while phasing out less efficient models, or have introduced water-heating capability into their GHP designs, which improves both system efficiency and cost-effectiveness, particularly in moderate climates. Also, some manufacturers and loop designers are beginning to change the way that they market GHPs—altering the way that they specify commercial GHPs to improve the economics for the consumer. For example, a number of manufacturers are beginning to specify GHPs together with a cooling tower for businesses with a high summer cooling load. This systems approach improves overall cost-effectiveness and marketability of GHPs to the consumer. In fact, a number of systems are coming in as competitive on a first-cost basis with competing commercial heating, ventilating, and air-conditioning (HVAC) technologies (L'Ecuyer 1996).

Finally, it appears that GHP sales are increasing. A recent analysis of data from the Air-Conditioning and Refrigeration Institute and from individual manufacturers suggests that in 1994 roughly 50,000 to 70,000 GHPs were sold—more than twice that sold in 1990 (although some of the difference can be explained by changes in the type of products included in sales figures for these years). The analysis also indicates that between 1994 and 1995 alone, GHP sales increased by 18 to 34 percent (L'Ecuyer 1996; McGrath 1996). Improved data collection and tracking, however, are needed to better assess the impacts of GHP market transformation efforts.

GOING RESIDENTIAL WITH GAS-FIRED HEAT PUMPS

Over the past ten years, the Gas Research Institute (GRI) has funded the development of a gas-fired heat pump primarily for residential applications. Gas-fired heat pumps are a breakthrough technology that allow users to heat and cool their homes using a natural gas engine-driven (or absorption-driven) system. The resulting product—the Triathlon—was designed by Battelle and is manufactured by York. The Triathlon couples a 5 horsepower single-cylinder natural gas engine, designed to last from 12 to 15 years, with a high-efficiency compressor. An engine heat recovery system provides supplemental heat, and a high-efficiency gas-fired auxiliary boiler provides instantaneous additional heating in very cold weather. The Triathlon's microprocessor tracks the space-conditioning load and controls the amount of heating or cooling delivered to the conditioned space.

The Annual Fuel Utilization Efficiency (AFUE) for the Triathlon is 126 percent, compared to 90 percent for a typical high-efficiency gas furnace, and its cooling performance is comparable to electric alternatives. One recent field test reported a cooling Coefficient of Performance (COP) of 1.128 (approximately equivalent to a SEER 12 electric air conditioner or heat pump on a complete fuel cycle basis). This makes the Triathlon competitive with products that meet tier 1 of CEE's residential air conditioner and heat pump program and EPA's ENERGY STAR criteria (Technologies for Energy Management 1996).

In 1989, 10 units were installed for testing in various climates across the country. These field tests, completed in 1992, were apparently successful in demonstrating the product's performance and reliability. York then undertook a 50 unit market demonstration that eventually led to full-scale production in July 1995.

Studies by York indicate that at national average electricity prices, annual operating costs for the Triathlon are 26 percent lower than that of a SEER 12 electric heat pump and competitive with high-efficiency furnace/electric air conditioner combinations. Because the system has a high initial cost, in many locations the payback period is not very attractive—12 years using national average figures. In locations with high electric-to-gas price ratios and with significant heating and/or cooling loads, however, the economics are much more favorable (Cler 1995; Technologies for Energy Management 1996).

A consortium of gas utilities, under the auspices of the American Gas Cooling Center (AGCC), has developed programs to provide incentives towards the purchase of a limited number of heat pumps, with the incentives gradually decreasing as sales increase. Specifically, the consortium has committed $14.45 million to "buy down" the initial manufacturing cost of the first 25,000 units. When sales of the engine-driven system exceed 50,000 units, York will begin to reimburse consortium members for their initial investments (Nadel and Geller 1995). York is also increasing its product offerings to include a model that takes advantage of electric resistance back-up (instead of a gas boiler). This new product is expected to cost roughly $1000 less than the current product.

Assistance in marketing the Triathlon has come from the U.S. Environmental Protection Agency's (EPA's) ENERGY STAR gas-fired heat pump program, which has York as its charter partner. EPA is currently working with the AGCC to help market the Triathlon in several regions of the country in which EPA is promoting high-efficiency heating, ventilating, and air-conditioning (HVAC) equipment. For example, in Richmond, Virginia, EPA is working with the local gas utility and a financing partner to provide utility incentives plus financing to support the installation of the Triathlon. In addition, EPA is conducting workshops to train HVAC distributors and dealers on the benefits of, and how to market, ENERGY STAR products (Banwell 1996). At the same time, York is conducting an extensive training program that will prepare distributors, dealers, and local utility representatives to promote the product.

The Triathlon's high initial cost, however, has proven to be a substantial barrier to increased sales. Sales are reportedly considerably below initial targets. Although specific figures are not being released by York or gas industry groups involved in the project, one utility representative estimated that approximately 800 units were sold in 1995, and an estimated 1,500 have been sold thus far in 1996. Furthermore, in some regions contractors are including high mark-ups on the wholesale cost in order to protect themselves against risks, such as unforseen installation and maintenance costs (Berokoff 1995). Depending on contractor mark-up, installed costs can range from $7,000 to $9,000, approximately $4,000 more than a standard gas furnace and electric air conditioner (Cler 1995).

The commercialization of the residential gas-fired heat pump represents the first stage in the market transformation process. To this end, GRI has contributed in a significant way by funding the development of a gas heat pump. The key barriers that remain, however, include high initial costs and, in some cases, high contractor mark-ups. The AGCC-led consortium and EPA have temporarily reduced, and are working to more permanently mitigate, the high initial cost barrier. York is currently working with members of the consortium and local contractors to address the issue of high contractor mark-ups. Thus, despite lower than expected initial sales, the market's growth potential seems significant.

In addition to GRI's activities to develop the engine-driven gas-fired heat pump, DOE has supported Phillips Engineering and Oak Ridge National Laboratories in the development of an advanced gas-fired generator-absorber heat exchange (GAX) heat pump. Prototype tests indicate that the product has a heating performance of approximately 1.9 COP and a cooling performance of 0.7 COP, rendering the GAX a very viable space conditioning option, particularly in areas with high heating loads. Carrier Corporation has licensed the technology and is planning to further develop and introduce the unit in the next few years. The AGCC is also working with Carrier to develop a program to support and market the GAX units (Fiskum 1996; Sweetser 1996).

HEATING UP THE MARKET FOR HIGH-EFFICIENCY FURNACES

In 1982, the Public Service Commission (PSC) of Wisconsin issued a directive requiring certain utilities in the state to offer programs to weatherize the homes of low-income rate payers. Under this directive, the major gas and electric utilities were required to provide weatherization services to low income customers free of charge and to install energy conservation measures, including high-efficiency gas furnaces, that met a five-year simple payback (Airriess and Banerjee 1985; Schlegel, McBride, and Thomas 1990). Utilities performed an audit—including a heating equipment evaluation—then took bids from local contractors for the installation of the measures recommended in the audit. Because installing high-efficiency furnaces (e.g., Annual Fuel Utilization Efficiency [AFUE] of 90 percent), particularly as replacements for existing units, garnered significant energy savings and was easily delivered through local contractors, many utilities began offering not only low-income services, but also high-efficiency gas furnace rebates to other customers. By the mid-1980s, utility rebate programs to promote high-efficiency heating equipment, and furnaces in particular, were fairly widespread.

From 1982 through 1991 almost half of all furnaces were replaced with high-efficiency furnaces and more than 90 percent of the furnaces replaced in the early 1990s were replaced with high-efficiency systems. This compares with significantly lower high-efficiency furnace penetrations in nearby states. In Michigan, for example, only a third to a half of new gas furnaces sold in the state are high-efficiency models (HBRS, Inc. 1996).

In response to an increasing demand for high-efficiency gas furnaces, prices declined such that the costs of full condensing furnaces are now substantially less in Wisconsin than in most other northern states. An informal survey of contractors in Dane County, Wisconsin (e.g., the Madison region), suggests that the average installed cost for a high-efficiency furnace in the region was around $1,650 compared with $2,000 to $2,250 in neighboring states (Schlegel and Prahl 1994). A more comprehensive study comparing the markets for gas furnaces in Michigan and Wisconsin, however, indicates that the incremental cost of moving from standard efficiency furnace (e.g., AFUE of 80 percent) to a high-efficiency model for a 1600-square-foot home is approximately $70 less in Wisconsin (e.g., $390 in Wisconsin compared to $460 in Michigan) (HBRS, Inc. 1996).

As the saturation of high-efficiency gas furnaces increased and the market for these products appeared "sustainable," many utilities and the PSC withdrew rebates for high-efficiency furnaces in 1988 and 1989. Thus, Wisconsin's nearly five years of utility rebates, together with weatherization programs, succeeded in making high-efficiency gas furnaces the norm. Analysts believe that the key factor leading to transformation of the Wisconsin furnace market was contractor education. Their theory suggests that utility low-income and rebate programs enabled and, in some cases even required, contractors to become familiar with high-efficiency gas furnaces. In so doing, contractors recognized that full-condensing furnaces were often more reliable than standard furnaces, could generate higher than average profit margins, and were more likely to be specified by competitors. These factors, together with the fact that contractors in this largely "replace-on-failure" market play a key role in consumer purchasing decisions, were critical in shifting purchasing patterns toward high efficiency in Wisconsin (Schlegel and Prahl 1994).

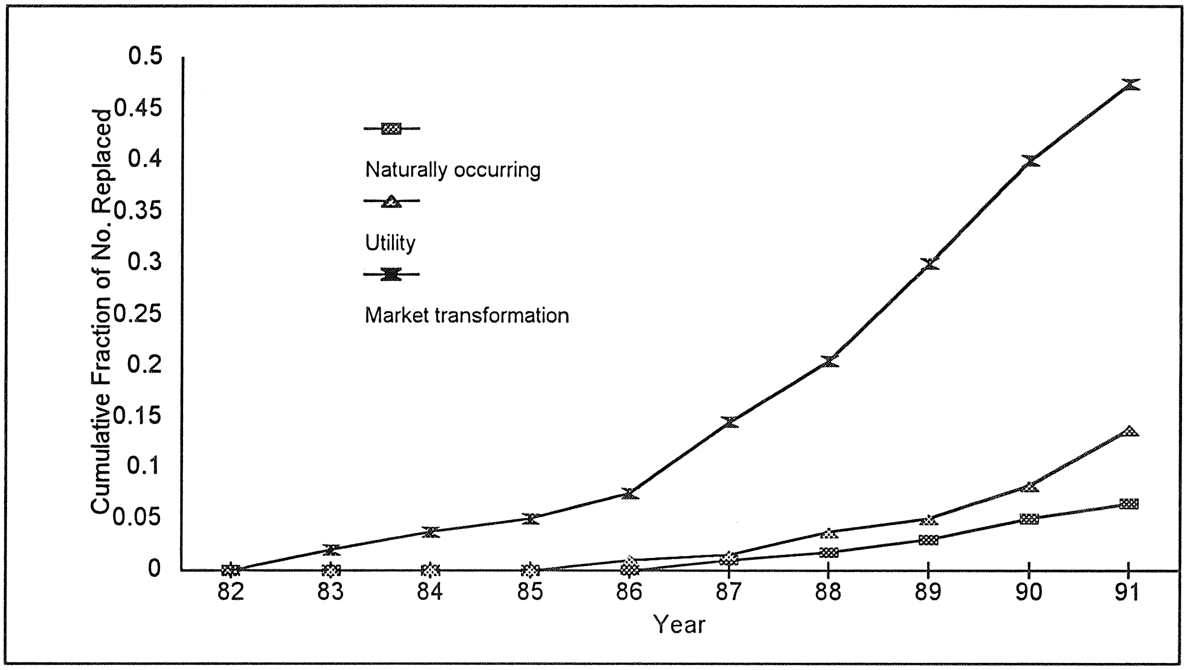

Figure 1: High-efficiency Furnace Replacements - 1982 - 1991
Source: Schlegel and Prahl 1994

Over the past few years, a number of studies have been conducted throughout Wisconsin to assess the drivers of distributor, retailer, and consumer decisions with regard to stocking, selling, or purchasing high-efficiency residential equipment (Van Liere, Vig, and Feldman 1994). These studies generally suggest that in Wisconsin, more so than in other states, participants in all levels in the equipment distribution system value energy efficiency, making high-efficiency products an easier sell.

A recent study in the Milwaukee area sheds light on the behavior of contractors *vis a vis* energy efficiency. In communicating with their customers about what type of system to purchase, heating, ventilating, and air-conditioning (HVAC) equipment contractors indicated that they encourage their customers to consider long-term savings when making a purchasing decision, and that they always recommend energy-efficient equipment, even if it costs the consumer a bit more up front. According to this study, the majority of contractors said that the Milwaukee market for forced air furnaces has been permanently transformed toward energy-efficient equipment and that they do not expect to see a decline in the efficiency level of heating equipment sold as utility rebate programs are eliminated or scaled back (Opinion Dynamics 1995).

MOBILIZING ENERGY EFFICIENCY IN MANUFACTURED HOMES

Manufactured homes comprise a significant portion (about 30 percent) of new housing starts in the Pacific Northwest and across the United States. Construction and energy efficiency standards for these homes, however, are not regulated by local or state building codes. Instead the U.S.

Department of Housing and Urban Development (HUD) sets national construction standards including energy efficiency requirements for manufactured homes that preempt state and local governments from establishing tighter (or looser) requirements (Lee et al. 1995).

This lack of local regulatory authority, together with studies that showed that manufactured homes in the Northwest used much more energy per square foot than site-built homes, prompted the Bonneville Power Administration (BPA) to conduct a series of projects and programs to upgrade manufactured home efficiency. In the mid-1980s, BPA initiated a multi-year program to increase its understanding of the manufactured homes industry and its products, to develop a working relationship with the industry, and to implement actions to improve energy efficiency (Onisko and Lee 1992).

In 1987, BPA developed an energy efficiency requirement for manufactured housing equivalent to Model Conservation Standard (MCS) for site-built homes. A sample of manufactured homes built to the new standard was monitored to assess achievable energy savings and suggested significant cost-effective energy savings potential. In the same year, BPA began offering payments to manufactured home buyers to upgrade their purchase to a high-efficiency manufactured home under the Super Good Cents program (Lee and Bennet 1992). These activities increased the average efficiency level of manufactured homes and set the stage for the Manufactured Housing Acquisition Program (MAP), a four-year program launched in April 1992.

The foundation of MAP was a voluntary agreement between BPA, participating utilities, and producers of manufactured homes. Participating utilities agreed to pay money directly to the manufacturers to cover the cost of manufacturer-initiated efficiency improvements. The manufacturer-incentive approach was chosen for a number of reasons. First, earlier studies by BPA showed that payments to manufacturers for energy efficiency upgrades were likely to have more financial leverage than incentives to buyers. As a result of mark-ups, every $1,000 increase in materials costs to the manufacturer would amount to about $1880 in added costs to the consumers. By reducing manufacturer costs, and thereby reducing mark-ups, consumer costs are decreased (Lee et al. 1995). Second and related, the individual efficiency measures, while cost-effective in the aggregate to utilities, were not perceived as cost-effective to individual consumers. Third, by working directly with the manufacturers and educating consumers, BPA hoped that the program would have a lasting impact well beyond the program's planned end date of April 1996.

Although not mandatory, all manufacturers and almost all utilities in the region chose to participate in MAP. The incentive payment of $2,500 for each electrically heated home was arrived at through negotiations between the utilities and home manufacturers and based on estimated savings of MAP homes relative to typical homes being bought in the Pacific Northwest. This payment amount was renegotiated to $1,500 per unit following revisions to the HUD code in October 1994, which increased the energy efficiency requirements and left less difference between a standard and a MAP home. MAP homes saved 20 to 25 percent of the energy consumed in a typical home in the first phase of the program and about 15 percent after the HUD code was revised (see Table 1) (Lee et al. 1995).

Table 1 Energy Savings from MAP (kWh/year per home)		
Home heating	**Phase 1**	**Phase 2**
All heating types	3,814	2,500
Electric resistance heating	4,725	3,012

Source: Lee et al. 1995

In planning for MAP, BPA estimated that roughly 48,000 new MAP-compliant homes would be built during the four-year program implementation phase. Instead, by mid-1995, the number of homes that complied with the MAP exceeded projections by about 8,000, costing utilities an additional $12 million in incentive payments. As a result of this cost over-run and reduced utility support for demand-side management, a number of utilities initiated steps to withdraw from MAP prior to its planned end-date. An earlier impact evaluation conducted by Regional Economic Research (RER), which reported lower-than-anticipated energy savings, also influenced a number of utilities' decision to withdraw from the program. Thus, by July 1995, all participating utilities stopped providing incentives to manufacturers for efficient manufactured homes.

The findings of RER, however, conflict with those of others, including Battelle-Pacific Northwest Laboratories, which found that MAP was cost-effective as an acquisition program and even more cost-effective (about 1 cent per kWh) if market transformation effects were considered. As a result of these findings and uncertainty over initial studies by RER and others, a number of investor-owned utilities (IOUs) are now considering conducting a new evaluation of the benefits of MAP efficiency levels (Lee 1996).

Despite its early demise, MAP has had a number of lasting impacts on the market for manufactured homes, according to a preliminary analysis. First, the program accelerated the introduction and adoption of MAP efficiency levels, from 30 percent (or virtually 0 percent not including Super Good Cents Homes) to 100 percent of manufactured homes in just six months. In the absence of MAP, this leap in efficiency is likely to have taken many years. Second, many consumers have come to expect the MAP features and many dealers have become used to selling them. For many manufacturers and dealers, for example, MAP became a symbol of "quality" housing that offered distinct marketing benefits. After the program ended, in fact, manufacturers sought, and agreed to pay for, continued state certification of high-efficiency manufactured homes. Since the end of the program, there has been some erosion of the market toward less-efficient homes, particularly for lower end homes. One estimate, by the state energy offices currently involved in certifying homes, indicates that roughly 65 percent of manufactured homes being produced in the Pacific Northwest as of early 1996 were being built to MAP specifications, although initial estimates developed for BPA suggest that this proportion is likely to be somewhat higher. It will take additional data collection and analysis to determine the market share of MAP home in 1996 and a number of years to determine if this market will erode further or remain largely converted to high-efficiency manufactured housing (Lee 1996; Peach 1996).

CONCLUSIONS

The examples presented in this paper provide evidence of shifts in the markets for key products, including increased availability of models, increased sales of high-efficiency products, and changes in manufacturer, dealer, and consumer behavior. Although it is difficult to attribute particular market shifts to specific policies or programs, it appears that many of the efforts examined in this paper are having a positive impact on these markets. Unfortunately, it is not always clear whether these shifts would have occurred in the absence of the market transformation activities, indicating a need for more careful planning (e.g., establishing baselines and evaluation plans) from a program's inception. And it remains to be seen if these market shifts are sustainable.

That said, of the market transformation efforts examined here, those that strive to increase efficiency (at low or no incremental cost to the consumer) appear to be most successful in effecting rapid shifts in the market. Costs to manufacturers to add power management capabilities to office equipment products under the Energy Star Office Equipment programs, for example, are minimal and have little impact on the price of office equipment. Thus, the energy-saving features become a no- or low-cost selling point for office equipment manufacturers. Gradual but steady changes in the market characterize those market transformation efforts with mid-level incremental costs, such as furnaces and the tier 1 air conditioner products. And efforts with high incremental costs, such as the gas heat pump initiative and the advanced air conditioner tiers, appear to move most slowly toward market transformation.

A number of efforts demonstrate that large increases in efficiency are possible when there are significant monetary incentives or public image benefits. In the case of SERP, the combination of incentives and publicity, together with an imminent CFC phaseout, spurred the development of a refrigerator 40 percent more efficient than the existing standard. Sales of these models, however, have not been as strong as hoped. Similarly, the promise of a considerable market for apartment-sized refrigerators under the NYPA/CEE procurement motivated Maytag to enter a market niche, which previously it had not targeted, at a time when it needed to convert its lines to CFC free. In the case of clothes washers, a technological leap is expected in the next few years as new high-efficiency products enter the market place in response to utility incentives, growing consumer interest, and possible new federal efficiency standards.

A few programs have sought to promote both modest and substantial efficiency improvements simultaneously through the use of multiple tiers, with limited success in transforming the market for the products with the highest efficiency gains. Experience thus far with the CEE air conditioner programs, for example, indicates that manufacturers and other market actors tend to focus on only one tier at a time and thus, while second tiers may provide useful advance warning about future promotional targets, they have little impact on current product sales. The exceptions to this rule are where high usage and substantial incentives combine to provide attractive consumer economics, as is the case with residential air conditioners in some areas.

While there are many different approaches for promoting market transformation, the best approach or set of approaches will depend on the nature and status of the technology being promoted and the barriers that need to be overcome. Where the desired technologies are not presently on the market or only available in limited quantities and at very high cost, technology procurement (e.g., like SERP or the apartment-sized refrigerator initiative) can develop a large enough market so that product costs are reasonable. In cases where high-efficiency products are available but have a small market share, a multi-pronged approach—combining incentives; training for dealers, contractors, or installers; and consumer education—is often needed to grow the market. Once high-efficiency products have a substantial market share, however, codes or efficiency standards can be very effective completing the transformation process. Other largely successful "end games" are characterized by modest incremental costs (e.g., office equipment) or extensive supplier/purchaser interest (e.g., furnaces in Wisconsin).

In addition, manufacturer and consumer responsiveness to technologies promoted through market transformation efforts will affect the success of the effort. Both manufacturers and consumers are more likely to participate in or support a market transformation effort where the promoted technology provides benefits in addition to energy savings, such as cleaning clothes better. Manufacturers are also more likely to be engaged in a market transformation effort that they perceive as providing a jump-start on marketing efforts for products at soon-to-be mandated efficiency levels.

Given the diversity of products and initiatives, there are likely to be exceptions to these "rules." However, there is one conclusion that will generally hold true: market transformation takes a long time. In all of the case studies, at least five years and sometimes as much as ten years are likely to elapse before a market is significantly transformed. Parties involved in the process need to sustain their commitments for many years before seeing the full benefits of successful market transformation.

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