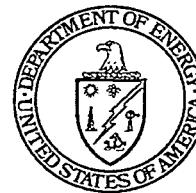


Partnerships for Technology Introduction—

Putting the Technologies of Tomorrow
into the Marketplace Today

Report to Congress on Sections 127 & 128 of the
Energy Policy Act of 1992

Building Equipment Division
Office of Building Technologies
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy



April 1995



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Section 127: Report on the Potential of Cooperative Advanced Appliance Development

(a) IN GENERAL.—Not later than 18 months after the date of the enactment of this Act, the Secretary shall, in consultation with the Administrator of the Environmental Protection Agency, utilities, and appliance manufacturers, prepare and submit to the Congress, a report on the potential for the development and commercialization of appliances which are substantially more efficient than required by Federal or State law.

(b) IDENTIFICATION OF HIGH-EFFICIENCY APPLIANCES.—The report submitted under subsection (a) shall identify candidate high-efficiency appliances which meet the following criteria:

- (1) The potential exists for substantial improvement in the appliance's energy efficiency, beyond the minimum established in Federal and State law.
- (2) There is the potential for significant energy savings at the national or regional level.
- (3) Such appliances are likely to be cost-effective for consumers.
- (4) Electric, water, or gas utilities are prepared to support and promote the commercialization of such appliances.
- (5) Manufacturers are unlikely to undertake development and commercialization of such appliances on their own, or development and production would be substantially accelerated by support to manufacturers.

(c) RECOMMENDATIONS AND PROPOSALS.—The report submitted under subsection (a) shall also—

- (1) describe the general actions the Secretary or the Administrator of the Environmental Protection Agency could take to coordinate and assist utilities and appliance manufacturers in developing and commercializing highly efficient appliances;
- (2) describe specific proposals for Department of Energy or Environmental Protection Agency assistance to utilities and appliance manufacturers to promote the development and commercialization of highly efficient appliances;
- (3) identify methods by which Federal purchase of highly efficient appliances could assist in the development and commercialization of such appliances; and
- (4) identify the funding levels needed to develop and implement a Federal program to assist in the development and commercialization of highly efficient appliances.

Section 128: Evaluation of Utility Early Replacement Programs for Appliances.

Within 18 months after the date of the enactment of this Act, the Secretary, in consultation with the Administrator of the Environmental Protection Agency, utilities, and appliance manufacturers, shall evaluate and report to the Congress on the energy savings and environmental benefits of programs which are directed to the early replacement of older, less efficient appliances presently in use by consumers with existing products which are more efficient than required by Federal law. For the purpose of this section, the term "appliance" means those consumer products specified in section 322(a).



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Preface

This report to the U.S. Congress has been prepared on behalf of the Secretary of the U.S. Department of Energy (DOE) in response to Sections 127 and 128 of the Energy Policy Act of 1992 (EPAct), Pub. L. 102-486, which deal with the potential energy savings and cost-effectiveness of highly efficient appliances.

DOE engaged in an intensive effort to estimate the potential for six categories of appliances; develop an understanding of the market barriers to commercialization; and identify how partnerships with utilities, manufacturers, and other government and private sector entities can transform the appliance market by mitigating the barriers.

Between October 1993 and March 1994, DOE held eight workshops to identify what is preventing highly efficient appliances from attaining greater market acceptance. Over 200 appliance manufacturers, utilities, retailers, distributors, and heating and air-conditioning contractors, as well as state and local governments and non-profit organizations, participated in these forums. They offered varied perspectives on the issues and suggested ways the Federal Government might help.

DOE analyzed the possible impact of many emerging highly-efficient technologies and the measures that could be employed in improving markets. A consolidated report of this analysis, entitled *"Partnerships for Technology Introduction: Supplemental Information"*, has been published in conjunction with the report to Congress. It includes feedback from the workshops, a list of

workshop participants, and the results of the DOE analysis. The supplemental information can be obtained from DOE or the National Technical Information Service.

Topics in the consolidated report include the following:

- *Results and Recommendations from Manufacturer's Workshops to Accelerate Commercialization of Highly Efficient Appliances and Equipment*
- *Results and Recommendations from Sales, Distribution, and End-Use Workshops*
- *EPAct Section 127/128 - Technical and Institutional Analyses - Residential and Commercial Building Equipment*
- *Federal Policy Options for Cooperative Development and Deployment of Advanced Appliances and Equipment*
- *Section 128 of EPAct: Early Replacement of Appliances*

Data and information in this report emanate from research conducted by DOE national laboratories, DOE support contractors and DOE's Energy Information Administration. Although there has been a nationwide trend toward using the metric system of measurement, this report uses the English system, which is still the standard within U.S. industry.



Definitions

Annual Fuel Utilization Efficiency (AFUE) is a DOE-developed measure of efficiency for direct-fired heating systems, i.e., furnaces and boilers; it includes the relative efficiencies of start up and cool down periods and all other operating losses and credits but does not include distribution (duct) losses or electrical energy used.

Best-Available products are the most efficient products available that can perform the end-use function for a specific application and have a simple economic payback of ten years or less. The availability of the product in the marketplace at a specific time or geographic location is not relevant, as long as the product has been manufactured and sold in sufficient number of units and the technology used is readily available. Field demonstration products do not qualify as best available.

British thermal unit (Btu) is a measure of heat energy. It is the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

Carbon Equivalent is a way to quantify greenhouse gas emissions. Carbon dioxide, a greenhouse gas, is a by-product of fossil fuel consumption. Saving energy reduces the amount of carbon consumed in the energy production process. For example, one quad energy saved = 16.1 million metric tons of carbon equivalent saved.

Coefficient of Performance (COP) is a measure of the steady-state heating and/or cooling efficiency of air conditioners, heat pumps, chillers, and other refrigeration equipment. It is the ratio of the heating/cooling energy delivered to the electricity or fuel energy consumed. Typical values range from 2.0 to 3.0, which is equivalent to being 200 to 300 percent efficient. Coefficients of performance can be over 100 percent because they include the free energy derived from ambient air or ground sources.

Economic Potential is defined as the primary energy savings per year obtained by the penetration of highly efficient equipment in the marketplace, driven by its economics relative to competing equipment for the same application.

Energy Efficiency Ratio (EER) is a measure of the steady-state cooling efficiency of room air-conditioners and heat pumps. It is calculated by dividing the cooling output, in Btu per hour, by the power draw in watts at a given outdoor temperature. EER is often used to measure the peak performance of air-conditioning systems. Typical values are 8-12 Btu per watt-hour.

Energy Factor (EF) is a measure of efficiency for hot water heaters. It is calculated by dividing the amount of daily hot water output by the daily energy input, in Btu.

Heating Seasonal Performance Factor (HSPF) is a measure of efficiency for an electric heat pump throughout the heating season. It is analogous to a seasonal energy efficiency ratio (SEER) rating, which is defined below. It measures equipment efficiency under varying outdoor temperatures and accounts for losses from cycling, defrosting, and backup resistance heat. It is calculated by dividing the total heating output (Btu) of an electric heat pump during its normal annual usage period for heating by the total electricity input in watt-hours during the same period. Typical values are 6.8-9.0 Btu per watt-hour.

Lumens per Watt (LPW) is the measure of lamp effectiveness in converting energy into visible light.

Luminaire Efficacy Rating (LER) is a measure of the effectiveness of a fluorescent lighting system. The system includes the lamp, ballast and fixture.

Near-Term Development are products that can be brought to market by the late 1990s with minimum technical risk and a simple economic payback of ten years or less; for example, a technology that is fully developed but not yet incorporated in the product line offered by a manufacturer.

Payback is the ratio of the installed, first-cost premium for highly efficient appliances relative to baseline products, to the annual operating cost savings, less any annual maintenance cost increment, if any.

Quad is an abbreviation for one quadrillion Btu, or 10^{15} Btu. In 1990, total U.S. energy consumption totaled approximately 85 quads. Burning 170 million barrels of crude oil would release about one quad of energy.

Seasonal Energy Efficiency Ratio (SEER) is a measure of efficiency for an electric heat pump or central air-conditioner throughout the cooling season. It is calculated by dividing the total cooling output of an air-conditioner during its normal annual usage period for cooling in Btu by the total electrical energy input during the same period in watt-hours. It differs from EER in that it includes cyclical losses and calculates efficiency under varying outdoor conditions.

Technical Potential for each end use function is defined as the primary energy savings per year obtained by instantaneously replacing today's stock of baseline appliances with new highly efficient appliances whenever feasible. Each appliance included in the report is expected to have an average economic payback of ten years or less. For example, solar water heating was deemed feasible in sunbelt regions of the country and space heating and cooling options were deemed feasible in northern and southern climates, respectively.



Abbreviations

AFUE -- Annual Fuel Utilization Efficiency	GAX -- Generator Absorber Heat Exchange
BA -- Best Available Technology	HID -- High Intensity Discharge Lamp
Btu -- British Thermal Unit	HSPF -- Heating Seasonal Performance Factor
CEE -- Consortium for Energy Efficiency	HVAC -- Heating, Ventilation, and Air-Conditioning
CFC -- Chlorofluorocarbons	IR -- Infrared Reflective Lamp
CFL -- Compact Fluorescent Lamps	KWH -- Kilowatt-Hour
COP -- Coefficient of Performance	LBL -- Lawrence Berkeley Laboratory
DOE -- U.S. Department of Energy	LER -- Luminaire Efficacy Rating
EIA -- Energy Information Administration	LPW -- Lumens per Watt
EF -- Energy Factor	NTD -- Near-Term Development Technology
EER -- Energy Efficiency Ratio	PNL -- Pacific Northwest Laboratory
EPA -- Environmental Protection Agency	Quad -- One Quadrillion Btu (10^{15} Btu)
EPAct -- Energy Policy Act of 1992	SEER -- Seasonal Energy Efficiency Ratio
ESCOs -- Energy Service Companies	SERP™ Inc. -- Super Efficient Refrigerator Program, Incorporated
FTC -- Federal Trade Commission	SDHW -- Solar Domestic Hot Water



Executive Summary

Overview

This report to Congress was prepared on behalf of the Secretary of the U.S. Department of Energy (DOE) in response to Sections 127 and 128 of the Energy Policy Act of 1992 (EPAct), Pub. L. 102-486. Section 127 of EPAct directs DOE to assess the energy savings potential "for development and commercialization of appliances and building equipment which are substantially more efficient than (currently) required by Federal or State law."

In preparing the report to the Congress, DOE has assessed the national and regional energy savings potential of products already on the market and those that will be available to consumers by the late 1990s. The Department has also examined the present cost-effectiveness of these emerging appliances as mature technologies.

To help in its assessment, DOE organized eight workshops at which representatives from manufacturing and building industries, utilities, retailers and wholesalers, public interest groups and Federal and state government agencies could express their views. The information derived from these workshops was key to the formulation of the report's general and specific recommendations.

DOE has concluded that the Federal Government can effectively stimulate the market for emerging technologies by forming partnerships with the appliance industry and other interested parties promoting the use of highly efficient appliances. Based on the interaction with industry at the eight workshops and through direct contact, DOE has concluded that Federal action and technical assistance is not only desired by industry, but crucial to the expansion of these markets.

Section 128 of EPAct requires an assessment of the energy savings and environmental benefits of replacing older, less efficient appliances with more efficient products than currently required by Federal law. Since early replacement of appliances is but one possible market-stimulating action, DOE has elected to include its discussion as part of the overall report to the Congress. DOE has concluded that early replacement programs can be effective for some technologies and in particular regions of the country. To be considered for early replacement programs, an appliance should: 1) be cost effective and incrementally more energy efficient than products that just meet minimum standards or 2) employ the technology which makes energy and eco-

nomic sense from a regional (climate) sense. The latter includes highly efficient products that would not be cost-effective under average conditions, such as condensing furnaces, which are clearly cost-effective in extreme northern climates. Further detail may be found in the supplemental information to this report.

The energy savings potential for six categories of appliances and building equipment was estimated, including:

- water heating
- space heating
- space cooling
- refrigeration
- lighting
- laundry.

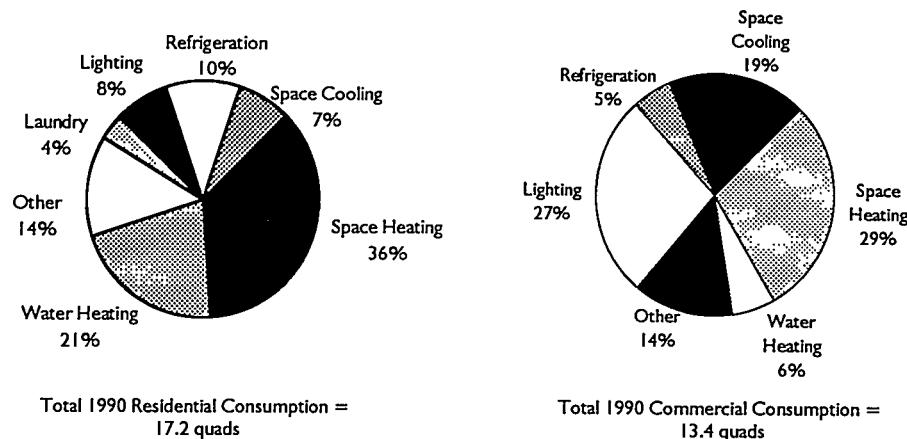
These appliances are the six largest consumers of primary energy in the building sector with 86 percent of total building energy use.

In addition to energy savings potential, DOE sought to understand the market barriers to broad commercialization of these technologies and to identify the Federal role in working with utilities, manufacturers and other government and private sector entities to transform the appliance market by mitigating these barriers. The term "market transformation" is defined as *the modification of an existing supply and demand relationship through planned actions by public and private sector organizations to reduce market barriers and create a self-sustained market for highly efficient products*. Therefore, DOE's main goal in promoting technology development and short-term market pull programs is to quickly create market demand that can be sustained.

DOE's immediate goal is to reduce building sector energy demand in the year 2000 by at least one-half quad through cost-effective investments in energy efficiency. One-half quad of energy is about the same amount as the annual primary electricity consumption in Argentina. If this goal is reached, over \$3 billion (1992 dollars) would be freed for capital investments, personal savings, and consumer spending annually. A study by the American Council for an Energy Efficient Economy indicates that one-half quad of energy savings could result in a net increase of as many as 30,000 jobs by the year 2000. One-half quad of savings would also reduce



1990 Buildings Sector Primary Energy Consumption



Source for Residential Consumption: Pacific Northwest Laboratory Memorandum, Original Sources: Lawrence Berkeley Laboratory, 1993, *Model Output Residential Energy Consumption Survey*, February 1993. Source for Commercial Consumption: Pacific Northwest Laboratory Memorandum, Original Sources: *Annual Energy Outlook* and Arthur D. Little & Co., both 1993.

greenhouse gases by about 8 million metric tons carbon equivalent annually.

An important side benefit of the DOE and industry partnerships will be greater international competitiveness. The American appliance industry has faced few challenges as serious as today's international competition. Foreign product manufacturers have deeply penetrated U.S. markets that were once the exclusive domain of domestic manufacturers. With larger domestic markets for highly efficient products solidifying financial positions, U.S. firms can begin to market and compete globally from a much stronger position. Important markets are opening in Europe for heat pump technologies and in Eastern European and developing countries for a full range of appliance products.

Findings

In 1990, the United States consumed about 85 quads of primary energy which translates to a national energy bill of over \$550 billion per year. The U.S. buildings sector used approximately 30.6 quads of energy, over 35 percent of all U.S. primary energy consumption; 17.2 quads in the residential sector, and 13.4 quads in the commercial sector. Therefore, the buildings sector energy bill is about \$200 billion. The buildings sector is also responsible for two-thirds of the nation's electrical demand. Consumption in each building sector is shown in the pie charts.

The Department of Energy's Energy Information Administration (EIA) has projected that overall demand will reach 106 quads of primary energy by the year 2010 at the current rate of growth. With rising energy consumption, our national energy bill in 2010 is projected to reach about \$950 billion (1992 dollars). The buildings sector bill would be \$332.5 billion annually. Increasing energy use presents a host of other problems aside from higher energy bills, including greater oil imports (EIA forecasts a 68 percent increase between 1990 and 2010) and greater pollutant emissions (EIA forecasts a 23 percent increase in greenhouse gas emissions between 1990 and 2010).

Many studies have indicated that energy efficiency improvements will have many economic benefits, such as lower consumer energy bills, reduced cost of energy services, reduced oil imports, reduced energy intensity in manufacturing, the creation of new jobs and improved international competitiveness and other important national concerns. For example, a study by the American Council for an Energy Efficient Economy indicates that if annual U.S. energy consumption were reduced by 7.5 quads through highly cost-effective efficiency investment, nearly 500,000 new jobs might be created by the year 2000. The information on job creation is taken from a 1992 report on energy efficiency and job creation by the American Council for an Energy Efficient Economy.

DOE has determined that one of the quickest ways to reduce national energy consumption is to focus on the



building sector because of the existing inefficiencies in the sector and the resulting potential for cost-effective energy savings if the inefficiencies were eliminated. One of DOE's primary programs is to promote the use of cost-effective, highly efficient appliances and building equipment that either are currently on the market or will be by the late 1990s. In this report, the former are referred to as "best available" technology and the latter as "near-term" development technology.

"Best available" products are the most efficient products available that can perform the end-use function for a specific application. In determining what products could be deemed "best available," DOE has included products that may not be available in every region of the country. However, to be considered, each "best available" appliance must be currently on the market, be readily available, and sold in a sufficient number of units. Field demonstration products do not qualify as best available technology.

"Best available" products present an immediate energy savings opportunity because they have been commercialized and are available. Typically, "best available" products capture only a very small fraction of the available market, often only a few percent, even if they are clearly cost-effective. Such products may need the assistance of short-term enhancement programs to expand their markets.

"Near-term" development technologies often hold greater potential for savings or have the potential to capture a larger market share than "best available" technologies. As defined for this report, these technologies must still go through a development and commercialization stage that could take up to five years. Therefore, market transformation efforts will be somewhat longer term, and energy savings from many of these technologies will generally not begin to occur until after the turn of the century.

Although a complete transition to the most energy efficient products is improbable, if not impossible, DOE hypothetically explored the energy savings that might result from such a transition. DOE found that approximately 11 quads annually (which translates into annual savings of about \$73 billion and more than 176 million metric tons carbon equivalent of greenhouse gases) could be saved in the longer-term if the entire current appliance stock were replaced with "best available" and "near-term" technology.

Of the approximately 11 quads of savings, DOE projects that about 2.9 quads would come from minimum Federal efficiency standards already in place or which will be in place by the end of the century. Furthermore, it is likely that "best available" and "near-term" technologies with less than a three year payback

will gradually increase their market share even without Federal assistance. Even so, DOE estimates that the majority of the 11 quads of potential savings is unlikely to be realized by current standards or market forces alone.

In view of the very large potential for savings, a goal of saving one-half quad of energy by 2000 appears very reasonable. Through carefully targeted government action, DOE, in conjunction with other government agencies and organizations, can encourage and facilitate this transition by encouraging market demand in the near term and creating opportunities to significantly improve the efficiency of the national appliance stock.

DOE has determined that higher first cost is likely the most significant barrier to the purchase of highly efficient appliances. DOE has also found that consumers are more apt to purchase products that will "pay back" in up to three years. Often, the cost of new products, manufactured in small volumes, can often be reduced substantially by increasing their market penetration. Therefore, in examining appliances for this report to the Congress, DOE has taken the approach that appliances with current average simple paybacks of 10 years or less are potential candidates for market transformation programs. Very cost-effective products may simply require efforts to increase consumer awareness and confidence. Products with somewhat longer paybacks may be candidates for market pull and other incentive programs to "buy down" their cost to the consumer, thus making them a more attractive option. The added benefit of most market-pull and temporary incentive programs is increased appliance sales which often results in economies of scale for the manufacturer and lower appliance costs to the consumer.

The economic justification for highly efficient appliances are often regionally sensitive and it often changes dramatically for consumers living in non-average conditions. For example, a very high efficiency gas furnace may have an average payback of more than ten years, but in northern U.S. climates the payback period may be less than eight years and thus a candidate for a regional incentive program. An example of such an occurrence in Wisconsin is noted later in this report.

DOE has concluded that for technologies with a simple payback of ten years or less, it may be possible to structure short-term incentive programs to boost sales where those technologies have paybacks of less than ten years, and create a product market for which no financial incentives will be necessary. Emerging technologies may not be economically justified to the consumer at their introduction, but the price usually comes down as the market matures. Also, a product can obtain a higher market penetration at a given payback period if the



consumers behavior pattern is modified through information and education. Therefore, a major goal of the DOE program will be to modify purchase behavior through product marketing programs.

General Recommendations

Participants at the workshops that DOE held in conjunction with the preparation of this report identified at least five impediments or barriers preventing development and full market penetration of highly efficient appliances:

- *high first costs and limited consumer resources and incentives*
- *insufficient information to guide purchases*
- *lack of a suitable supporting infrastructure, including installers, retailers and wholesalers*
- *low consumer interest in highly efficient products*
- *technical risk or perception thereof.*

Participants at the workshops agreed that the Federal Government can play an important role in minimizing these barriers, thereby accelerating the availability of highly efficient appliances and increasing their market penetration. The Federal Government can act as a catalyst to bring utilities, manufacturers, state and local governments, consumer groups and others into collaborative partnerships to advance appliance energy efficiency by:

- *stimulating the market for more efficient appliances and building equipment*
- *accelerating introduction of highly efficient, near-term development products*
- *establishing longer term, applied research and development projects to advance appliance design and manufacturing.*

The workshop participants recommended that the Federal Government take the following actions:

- *field testing* - Evaluate appliance technologies, such as heat pump water heaters, to provide accurate, credible and verified real-world performance data essential to utilities and others providing market financing.
- *appliance labeling* - Work with other federal agencies and private sector groups to develop

voluntary, national labeling programs for "best available" energy efficient products. Continue working with the Federal Trade Commission to improve the current labeling system for products covered under Federal minimum efficiency standards.

- *demand-side management support* - Support utility demand-side management programs by providing seed funding to establish technology-specific collaboratives and by providing technical assistance from national laboratories or contractors to support programs.
- *buyer groups* - Create public and private sector buyer groups that purchase large quantities of "best available" or "near term" technologies, as an incentive for manufacturers to begin large-scale production of these technologies.
- *private collaborative support* - With other Federal agencies support, existing utility and industry collaboratives, including energy service companies, to establish financing for "best available" technologies programs, such as the Super Efficient Refrigerator Program. DOE would provide seed funding and technical expertise to these collaboratives.
- *market aggregation* - Work to change Federal, state and local government, and institutional procurement practices to make government a market leader in buying energy efficient products, as is being accomplished through the leadership of the Federal Energy Management Program.
- *early replacement* - Provide technical and analytical support to utilities and others interested in developing early replacement programs.
- *improved installation, sales, and service infrastructure* - Develop national or regional contractor training and recognition programs which will tie in with voluntary accreditation and certification programs.
- *consumer education* - Work with EPA, utilities and appliance manufacturers to coordinate a nationwide advertising campaign to broaden the market interest for energy efficiency and to link energy efficiency with responsible environmentalism and sustainability.

Conclusions and Specific Recommendations

Research, analysis, and consultation conducted by DOE have led to the following conclusions:

- *Significant national and regional energy savings, of at least one-half quad and environmental benefits in the form of greenhouse gas reductions can be achieved by the 2000 by expanding the market for highly efficient appliances already on the market and those expected to be commercially available by the late 1990s.*
- *Market barriers hinder this potential from being realized.*
- *Potential collaboration partners believe Federal actions can have a significantly positive effect on the market by helping to remove these barriers.*

In support of its market transformation efforts, DOE will continue supporting technology research and development programs. Through cost-shared relationships, DOE will continue to work with industry to develop and assist in the commercialization of new concepts within each technology such as it has done with the gas absorption heat pump.

Further, DOE has initiated a fully integrated program to catalyze the replacement of existing appliances with advanced appliances and building equipment. Funding for such a program has been appropriated in FY 1995 and is in the Department's budget request for FY 1996.

DOE is challenged with synthesizing and coordinating a number of programmatic measures to advance appliance energy efficiency. DOE believes its strongest

role is in technology development. It will continue advancing appliance technology by helping industry develop new highly efficient products and by supporting performance testing, rating, certification and labeling. A major request made by industry and utilities at each of the workshops was for DOE to provide clear and concise product and energy performance information to consumers, utilities, and others buying or providing financing for highly efficient products.

The second major DOE initiative will be as a catalyst to stimulate government and private sector market aggregation. DOE believes that government and private sector market aggregation can rapidly increase sales of highly efficient products through volume purchasing. Through this initiative DOE will support utility and other private sector financial incentive programs that reduce first costs to consumers. DOE will help entities interested in accelerating replacement by providing appropriate analysis. It will also encourage a knowledgeable and motivated sales, service and installation infrastructure that will stimulate selection, purchase and efficient operation of highly efficient appliances. Finally, DOE will provide information and support efforts to motivate customers to purchase highly efficient appliances.

The key to DOE's success will be the development of successful working partnerships with utilities, appliance manufacturers, state and local governments, other Federal agencies, energy service companies, consumer groups, and others in the building and appliance industry. This strategy will allow for a cost-shared, collaborative approach to market transformation.



Partnerships for Technology Introduction

In accordance with Section 127 of the Energy Policy Act of 1992 (EPAct), the U.S. Department of Energy has conducted an assessment of the potential for substantial improvement in national and regional appliance energy efficiency beyond the minimum established by Federal and State law. In making the assessment, DOE has analyzed potential primary energy savings for six different appliance categories without respect to fuel type. In preparing these analyses, DOE has examined several different candidate technologies in each of the six categories. Starting with the Federal minimum energy efficiency standards as a baseline, the relative efficiency and potential energy savings of each technology was scrutinized and then a "simple payback" economic test was applied. To be considered a candidate, each technology had to have a simple payback, before the application of financial

incentives, of ten years or less. In a widely held rule of thumb, most technologies require a simple payback of three years or less to become attractive consumer options. However, products with longer paybacks (up to seven to ten years) will still result in cost savings greater than most consumers can earn through alternative investments. In addition, the cost of new products, manufactured in small volumes, can often be reduced substantially by increasing their market penetration.

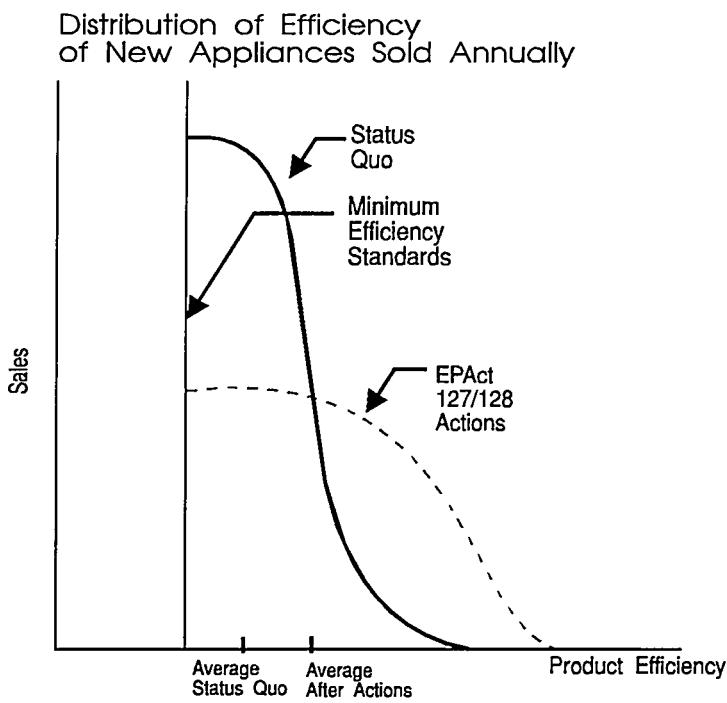
In preparing this report, DOE also surveyed appliance manufacturers, utilities, other government agencies, wholesalers, retailers, contractors, energy service companies, and other private and public sector entities to determine the barriers to widespread adoption of highly efficient technologies and what programs the Federal Government could institute to help improve markets. This information and DOE's recommended actions may be found in the body of this report to the Congress.

This report concludes that substantial energy savings could be achieved if cost-effective technologies were more widely used. DOE's most effective role in this endeavor is to become a catalyst for "market transformation" in the appliance industry. As declared by the participants in the eight workshops, DOE is an important source of financial and technical support and an unbiased source of product information for consumers and for those entities, like utilities, interested in providing financial incentives.

The term "market transformation" is defined as *the modification of an existing supply and demand relationship through planned actions by public and private sector organizations to reduce market barriers and create a self-sustained market for highly efficient products.*

Figure 1 depicts "market transformation" as the effect of public and private sector action on increasing the average efficiency of appliances. Through Federal mandatory standards, the minimum efficiency of many new appliances has

Figure 1:
Market Transformation





already been increased. Over time, these minimum efficiency standards should improve overall energy efficiency and reduce energy consumption by 2.9 quads of energy annually. The solid line curve depicts the "status quo," or no market transformation action. The dashed line curve represents the greater market share of highly efficient appliances resulting from market transformation.

The "technical potential" exists to reduce building sector energy consumption by approximately one-third, or approximately 11 quads of energy, below 1990 consumption levels. "Technical potential" is defined as the energy savings obtained by replacing today's stock of baseline appliances with new highly efficient appliances whenever feasible. For example, solar water heating was deemed feasible in sunbelt regions of the country and space heating and cooling options were deemed feasible in northern and southern climates, respectively. Technical potential does not necessarily mean all of the products necessary to save 11 quads are currently economically justified. Many of the products are just now emerging and are more costly than they will be when the market for them matures.

If technical potential were achieved in the long term, residential and commercial energy bills would fall by approximately \$73 billion of the \$200 billion spent each year. The President's Climate Change Action Plan set a short-term goal of reducing annual energy use by one-half quad by the year 2000 through cost-effective efficiency investments. If this goal is reached, over \$3 billion would be freed for capital investments, savings and consumer spending annually. The American Council for an Energy Efficient Economy has estimated that one-half quad of energy savings could result in a net increase of as many as 30,000 jobs by the year 2000. One-half quad of savings would also reduce greenhouse gases by million metric tons carbon equivalent by the year 2000.

Federal Role

Participants in eight manufacturer, utility and retailer/contractor workshops held by DOE, repeatedly emphasized the important role that the Federal Government can play in accelerating the market availability and penetration of appliances. The government can act as a coordinator to bring together parties such as utilities, manufacturers, retailers, and state and local governments interested in advancing appliance energy efficiency.

Several factors make now a good time for the Federal Government to expand into such a role. First, government and industry acknowledge that cost-effective energy efficiency measures provide real

Definition of Appliances

The term appliance used throughout this report refers to commercial and residential building equipment that uses energy and performs a useful function. These appliance types are:

- space heating
- space cooling
- water heating
- refrigeration
- lighting
- laundry

Cooking appliances, office equipment, small appliances such as vacuum cleaners and microwave ovens were not included in this study. Nevertheless, significant improvements in energy-efficiency may be possible for each of these appliances, and Federal program efforts may focus on them.

benefits to the economy. Second, manufacturers are recognizing the increased market potential for energy efficiency and are beginning to market their products accordingly. Third, many sources of non-Federal financing for energy efficiency measures are now available to be leveraged with Federal money. These sources of finance include utilities, the mortgage and loan markets, energy service companies, and state and local governments. Since funding sources are volatile (for example, the current uncertainty over utility demand-side management programs) the Federal Government must be in a position to stimulate new sources as existing programs expire or shift their focus.

Working partnerships will be the key to success in accelerating commercialization. A solid foundation for these partnerships has been laid through the eight workshops, and DOE is building on these relationships.

DOE has already successfully formed partnerships with industry to transfer information, reduce initial product costs, and transform product markets. One notable example is the creation of the National Fenestration Rating Council, which has helped transform the U.S. window market. In less than five years, the sales of highly efficient windows have increased by 33 percent, and the price differential between highly efficient windows and conventional windows has fallen. Other Federal market transformation programs are, however, in their infancy and have not received significant funding. DOE believes that expanding its appliance research, development and demonstration program, emphasizing public/private partnerships, will lead to more successes and significant energy and cost savings.



Energy Savings and Economic Potential

In 1990, the United States consumed about 85 quads of primary energy which translates to a national energy bill of over \$550 billion per year. The U.S. buildings sector used approximately 30.6 quads of energy, over 35 percent of all U.S. primary energy consumption; 17.2 quads in the residential sector and 13.4 quads in the commercial sector. Therefore, the buildings sector energy bill is about \$200 billion. The buildings sector is also responsible for two-thirds of the nation's electrical demand.

The Department of Energy's Energy Information Administration (EIA) has projected that overall demand will reach 106 quads of primary energy by the year 2010 at the current rate of growth. With rising energy consumption, our national energy bill in 2010 is projected to reach about \$950 billion. The buildings sector bill would be \$332.5 billion annually. Increasing energy use presents a host of other problems besides higher energy bills, including greater oil imports (EIA forecasts a 68 percent increase between 1990 and 2010) and greater pollutant emissions (EIA forecasts a 23 percent increase in green house gas emissions between 1990 and 2010).

Many studies have indicated that energy efficiency improvements will have many economic benefits such as lower consumer energy bills, reduced cost of energy services, reduced oil imports, reduced energy intensity in manufacturing, the creation of new jobs, improved international competitiveness and other important national concerns. For example, a study by the American Council for an Energy Efficient Economy states that if annual U.S. energy consumption were reduced by 7.5 quads, nearly 500,000 new jobs might be created by the year 2000.¹

The analysis conducted for this report indicates that hypothetically, approximately 11 quads could be saved if a complete transition to highly efficient technologies were made in both the residential and commercial sectors. If this savings had occurred in 1990, about \$73 billion in energy costs would have been saved. In 2010, annual energy savings of over 11 quads would mean almost \$99 billion in cost savings.

The "technical potential" of over 11 quads includes 2.9 quads that could be saved by replacing the entire national stock of appliances with appliances meeting current minimum Federal efficiency standards. Federal minimum efficiency standards have, and will continue, to play a major role in improving appliance energy efficiency by prohibiting the sale of energy inefficient products. However, minimum standards do not generally increase the sale of "best available" appliances for several reasons. First, because the

standards are national, they are primarily based on "average" climate conditions, usage patterns, energy prices and other such factors, whereas "best available" technology is usually marketed initially to a narrow spectrum of consumers. Second, the standards must be demonstrated to be both technically feasible and economically justified, which makes it less likely that new, emerging technologies, for which there is little performance information, would be adopted as the minimum.

Federal Minimum Efficiency Standards

Over the past twenty years, Congress has directed DOE to establish minimum efficiency standards for refrigerators, refrigerator-freezers, dishwashers, clothes dryers, clothes washers, water heaters, central air conditioners, central air conditioning heat pumps, furnaces, direct heating equipment, kitchen ranges and ovens, room air conditioners, fluorescent lamp ballasts, and swimming pool heaters.

The appliance efficiency standards program consists of three parts — testing, labeling and Federal energy conservation standards. The Department of Energy is responsible for establishing test procedures and setting standards. The Federal Trade Commission is responsible for prescribing rules for labeling the covered products. The Federal Trade Commission is also responsible for determining which products to label and has required labels for most covered products.

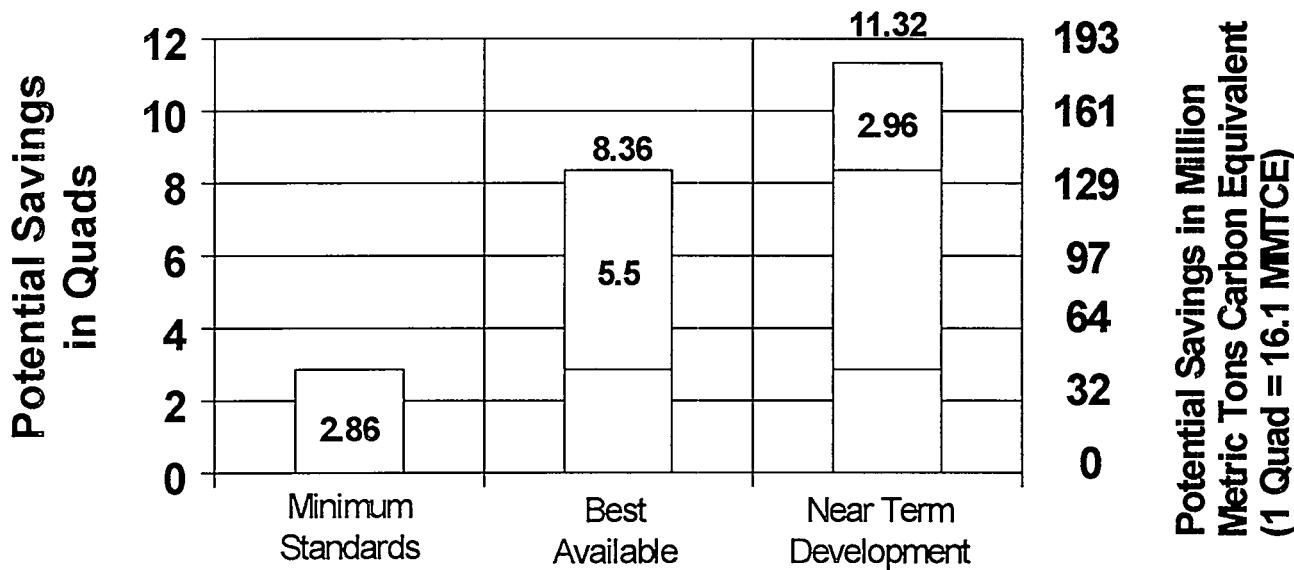
The Federal minimum efficiency standards are designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. In setting standards, DOE assesses the economic impact on manufacturers and consumers, the life-cycle cost savings to the consumer, and the projected energy savings, as well as other factors.

For consumers with higher than average utility rates or high appliance usage, efficiencies higher than the minimum would be cost effective. This report explores ways to induce consumers to purchase higher-than-minimum-efficiency appliances when their circumstances warrant such purchases.

If the entire national stock of appliances were replaced by today's "best available" appliances, approximately 8.4 quads could be saved annually, 5.5 quads more than would be saved if the appliance stock were replaced by appliances which only met minimum Federal efficiency standards. Moreover, if the entire national appliance stock were replaced with appliances incorporating technologies that are expected to be available by the late 1990s, an additional 3.0 quads could be saved. These savings potentials are depicted graphically in Figure 2.

While available on the market, most of these "best available" technologies have yet to replace more traditional appliances and achieve a large market share. To take advantage of the savings potential in "best avail-

Figure 2: Cumulative Primary Energy Savings Potential



able" products by 2000, DOE must expand its involvement in commercialization and marketing activities in connection with the private sector. The requirements for improving markets for "near-term" development products are slightly different because they more closely fit DOE's traditional research and development role. Products in "near-term" development still require additional research, product testing, and other development activities. For these products to reach their long-term potential in a timely manner, DOE will have to work closely with industry to promote development and commercialization activities.

Tables 1 and 2 portray the potential annual savings achievable in residential and commercial buildings for each of the six appliance categories examined. Table 1 also characterizes the savings possible from improving thermal distribution systems in housing.

For each appliance category, the potential savings shown includes the portion attributable to upgrading the appliance stock to 1993 Federal minimum efficiency standards, to the "best available" appliances, and to "near-term" technology. In order to be included in this report, each of the appliances listed in Tables 3 through

8 had to pass a simple payback test requiring an average payback equal to or less than ten years. This simple test was applied because payback periods beyond ten years are beyond the scope of short and medium-term market pull programs in average conditions. For products with a payback period of ten years or less, it is possible to structure incentive programs that boost sales and create a larger product market for which no financial incentive programs are eventually necessary.

It should be noted that some of the candidate technologies found in this report have average paybacks of more than ten years but have been included because they are economically justified on a regional basis. Economic payback is regionally sensitive and it changes dramatically in some cases for consumers living in non-average conditions. For example, very efficient heating systems are cost justified in very cold climates, but may not be in moderate and warm climates. It should also be noted that some of the technologies identified in this report have, or are expected to have, paybacks of less than three years. These technologies are likely to penetrate the market even without additional support,



although focused demonstration and information programs might substantially accelerate this process.

Residential Sector Potential

Upgrading the national residential appliance stock to the level of current minimum efficiency standards would save 1.7 quads annually (see Table 1). An additional 4.2 quads could be saved if the entire national appliance stock were replaced by "best available" appliances. The savings from use of "best available" technology amounts to over 20 percent of the energy used in the residential sector.

Further upgrading the residential appliance stock with technologies expected to be commercialized by the late 1990s could save an additional 1.2 quads. Thus, 7.1 quads could be saved by immediate or near-term replacement of the total current stock of appliances.

Table I: Residential Appliances Annual Technical Potential Savings
(In Quads of Primary Energy) [10]

End Use	1990 Energy Use [1]	Savings from Federal Minimum Efficiency Standards [2]	Additional Savings from "Best Available" Technology	Additional Savings from Near-Term Technology Development	Total Potential Savings
Water Heating	3.62	0.32	1.71	0.35	2.38
Space Heating [3]	6.23	0.34	0.81	0.22	1.37
Space Cooling [4]	1.27	0.15	0.35	[5]	0.50
Distribution Systems	[6]	n/a	0.34	n/a	0.34
Refrigeration	1.76	0.82	0.12	0.1	1.04
Lighting	1.31	0	0.42	0.52	0.94
Laundry	0.61 (0.97) [7]	0.09	0.44	0	0.53
Other	2.34	0.02 [8]	[9]	[9]	0.02
Total	17.14	1.74	4.19	1.19	7.12

[1] Source: Pacific Northwest Laboratory Memorandum, Original Sources: Lawrence Berkeley Laboratory, May 1993, *Model Output and Residential Energy Consumption Survey*, February 1993.

[2] Energy use if all appliances in 1990 inventory were replaced by appliances meeting minimum Federal efficiency standards.

[3] "Best available" space heating products include gas condensing furnaces, two-speed ground source heat pumps and standard electric heat pumps. Near-term development products include gas engine driven heat pumps, 2-speed ground source heat pumps and standard electric heat pumps.

[4] "Best available" space cooling products include variable-speed electric central air-conditioning, high efficiency room air conditioners and two-speed ground-source heat pumps. "Near-term development" space cooling products include gas-engine driven heat pumps, high efficiency room air conditioners and two-speed ground-source heat pumps.

[5] Savings potential considered to be negligible.

[6] 1990 energy use factored into space heating and cooling energy use.

[7] Number in parenthesis includes energy use for hot water used in clothes washing. Hot water savings for laundry are included in savings estimates.

[8] Reduction in energy consumption achieved by use of dishwashers that meet minimum Federal efficiency standards.

[9] Not evaluated.

[10] All values rounded to two decimal places

Commercial Sector Potential

Upgrading the national commercial appliance stock to the level of minimum efficiency standards required by EPAct would reduce consumption by 1.1 quads. The additional potential energy savings for the sector using "best available" technology is estimated to be 1.3 quads, about 10 percent of the commercial sector's use. Like the estimate for residential energy consumption savings, this estimate is based on replacing the entire stock of major energy-consuming appliances with new products. Upgrading the commercial appliance stock to technologies expected to be commercialized by the late 1990s could result in an additional savings of approximately 1.8 quads. The total potential savings for the commercial building sector is estimated to be more than 4.0 quads.

**Table 2: Commercial Appliances Annual Technical Potential Savings
(In Quads of Primary Energy) [6]**

End Use	1990 Energy Use [1]	Savings from Federal Minimum Efficiency Standards [2]	Additional Savings from "Best Available" Technology	Additional Savings from Near-Term Technology Development	Total Potential Savings
Water Heating	0.79	0.11	0.14	0.23	0.48
Space Heating	3.91	0.04	0.18	0.42	0.64
Space Cooling	2.54	0.18	0.24	0.14	0.56
Refrigeration	0.72	0.00	0.23	[3]	0.23
Lighting [4]	3.63	0.79	0.52	0.98	2.29
Other	1.84	[5]	[5]	[5]	[5]
Total	13.43	1.12	1.31	1.77	4.20

[1] Source: Pacific Northwest Laboratory Memorandum, Original Sources: *Annual Energy Outlook* and Arthur D. Little & Co., both 1993.

[2] Energy savings if all appliances in 1990 inventory were replaced by appliances meeting minimum Federal efficiency standards.

[3] Additional savings potential from "near-term development" technologies, relative to "best available" technologies, is considered negligible.

[4] "Best available" products include compact fluorescent lamp luminaires for 73 percent of Edison sockets and dimmable fluorescent ballasts for daylighting and dimming. "Near-term development" products include compact fluorescent luminaires for 73 percent of Edison sockets, compact electrodeless fluorescent lamps for all incandescent reflector (IR) lamps (3 percent of Edison sockets), improved high intensity reflector lamps for remaining Edison sockets; scotopically rich lamps for 90 percent of fluorescent lamps, electrodeless high intensity discharge lamps for all interior and exterior high-intensity discharge (HID) lamps, and integrated sensors for all fluorescent and incandescent lamp stock.

[5] Not evaluated.

[6] All values rounded to two decimal places.



Candidate Technologies

DOE has identified many appliances that meet the EPAct criteria of being "substantially more efficient than (currently) required by Federal or state law" and "potential for significant savings at the national level." Tables 3 through 8 provide information on many of these appliances in the following categories: water heating, space heating, space cooling, commercial refrigeration, lighting, and major home appliances. Each table compares information on the energy efficiency of current appliance stock, appliances meeting minimum Federal efficiency standards, and appliances with improved efficiency. Information in each table is illustrative of suitable technologies; however, there may be other technologies that also offer significant energy savings.

In addition to determining the potential energy savings of candidate technologies, DOE calculated an average "payback period" for each technology as a screen to determine which products were economically viable. "Payback period" was determined as the ratio of the installed-cost premium for highly efficient appliances to the annual operating cost savings, including maintenance cost differences. Since high first cost is a large inhibitor to customer interest in a product, payback period is a useful and simple economic surrogate for life-cycle cost studies.

The candidate technologies were also examined on the basis of where their greatest economic potential lies. For example, space heating and space cooling were addressed on the basis of average northern and southern U.S. climate and thermal loads, respectively. This put the market viability of the candidate technologies into proper perspective. Consequently, the payback period associated with the incremental cost of a condensing gas warm air furnace will be considerably shorter in an above average-sized house in Detroit than in a below average-sized house in Birmingham, Alabama.

For the purposes of this report, candidate technologies had to have payback periods of zero to ten years to qualify. Since consumer interest for products with payback periods of more than two to three years and no additional financial incentive is usually low, products with a payback period of more than ten years are not considered cost-effective and are beyond the scope of short to medium range market transformation programs. For products with payback periods of ten years or less, it is possible to structure short-term incentive programs that can immediately boost sales and create a sustained product market for which no financial incentives are necessary. For example, an industry rule of thumb for market viability of com-

mercial building products is that once a product achieves 10 percent market share, it will sustain itself. However, the same is not always true for residential products in which products may still require incentives unless they have relatively short payback periods.

The candidate technologies examined in this report are either:

- products with high technical energy savings potential and already in the marketplace, but not widely adopted due to price differentials or other market factors or
- products with high energy savings as demonstrated by industry, but not brought to market because of obstacles, such as a high payback period or
- products in advanced stages of development with excellent energy savings potential, but not sufficient near-term market potential.

Water Heating

Energy use for hot water represents 21 percent of residential energy consumption and six percent in the commercial sector. Replacing national stock with equipment meeting minimum efficiency standards would yield a savings of 0.43 quads annually (0.32 in the residential sector, of which 0.15 is from laundry standards, and 0.11 in the commercial sector); however, replacing the stock with "best available" technology and "near-term development" technology would save a total of 2.86 quads (2.38 residential, 0.48 commercial) or over 60 percent of 1990 consumption levels (see Tables 1 and 2).

In recent years, the efficiency improvements of water heaters have been marginal, with most of those improvements the result of better tank insulation and improved heat transfer. However, a number of highly efficient gas and electric water heaters are now on the market (see Table 3). For example, new electric heat pump water heaters have an average energy factor (EF) of 2.4, which is well above the national stock average of 0.85 EF for electric resistance water heaters and 0.50 for gas water heaters. Heat pump water heaters can be widely used in both residential and commercial buildings. In addition, there are soon to be marketed gas water heaters that have an EF as high as 1.38, more than twice as efficient as the minimum standard requirement of 0.55 EF for gas water heaters. Accelerated market penetration of "best available" and "near-term" development technologies could reduce water heating energy use by 40-60 percent.



When compared to residential electric resistance water heaters, heat pump water heaters can be cost-effective. They reduce energy consumption by 64 percent with an economic payback period of two years for the heat pump unit alone. In the same situation, standard gas water heaters are also cost-effective, but solar and condensing gas water heaters have longer payback periods and would require research and development to reduce cost or incentives to obtain a large market share.

Space Heating

Space heating consumes more primary energy than any other end-use function in both the residential and commercial building sectors. It accounts for 32 percent of residential building energy consumption and 31 percent of commercial building energy consumption. Space heating represents a large source of potential energy savings in both sectors. As is shown in Tables 1 and 2, the technical potential exists to reduce space heating consumption in the residential sector by 1.37 quads, and in the commercial sector by 0.64 quads.

Table 3: Examples of Highly Efficient Options for Residential and Commercial Water Heating

BASELINE PRODUCTS			EFFICIENT ALTERNATIVES			% Energy Savings beyond Minimum Standards	Technical Potential (Quads) beyond Minimum Standards
Product	1990 Stock Average Efficiency	Minimum Efficiency Standards	Product	Status [1]	Improved Efficiency		
WATER HEATING (RESIDENTIAL)							
Electric Resistance	0.85 EF [2]	0.85 EF	Heat Pump Water Heater	BA	2.40 EF	64%	1.17
			Solar Water Heater	BA	n/a [3]	60%	1.10
			Condensing Gas Water Heater	BA	0.86 EF	70%	0.19 [4]
			Standard Gas Water Heater	BA	0.55 EF	54%	0.15 [4]
Gas Water Heater	0.50 EF	0.55 EF	Condensing Gas Water Heater	BA	0.86 EF	36%	0.54
			Absorption Heat Pump	NTD	1.38 EF	60%	0.89
WATER HEATING (COMMERCIAL)							
Gas or Oil Fired	0.60 EF	0.78 (Thermal) 0.73 EF	Condensing Gas Water Heater	BA	0.88 EF	15%	0.07
			Engine Driven Heat Pump	NTD	1.5 EF	50%	0.20
Electric Resistance	0.95 EF	0.95 EF	Electric Heat Pump	BA	2.0 EF	50%	0.06
			Adv. Elec. HPWH	NTD	3.5 EF	70%	0.07

[1] BA = Best Available Technology and NTD = Near-Term Development Technology on market by the late 1990s.

[2] EF = Energy Factor.

[3] Solar water heating systems are not rated by EF. No equivalent EF is given.

[4] Based on replacing 15% of stock. Only 15% of homes with electric water heaters have natural gas.

The energy efficiency of heating systems has increased steadily over the past 20 years, partially because of the promulgation of minimum Federal efficiency standards for residential heating equipment and the development of new technology. Improvements in various technologies have led to the availability of residential heating products with greatly increased efficiency, as shown in Table 4. Many of these technologies, especially condensing furnaces and boilers, are also used in the commercial sector.

Although significant improvements have been made, tremendous energy savings potential remains. Federal minimum efficiency standards for both residential and commercial heating equipment are significantly lower than efficiency levels of the most efficient products available on the market. Some residential and commercial space heating technologies save up to 68 percent more energy than minimum standards (see Table 4).

Typically, gas and oil furnaces and boilers are used in commercial applications. Condensing furnace and boiler technology would improve efficiency by 10 to 15 percent with an average payback from five to ten years in the northern regions of the U.S. In the residential sector, there are a variety of technologies that could replace conventional gas and electric technologies and increase efficiency. Most of these technologies will require incentive programs to gain large market shares because their average payback period is over five years. In addition, thermal distribution systems must be efficient for variable speed electric heat pumps to be optimally effective.



Table 4: Examples of Highly Efficient Options for Residential and Commercial Space Heating

BASELINE PRODUCTS			EFFICIENT ALTERNATIVES			% Energy Savings beyond Minimum Standards	Technical Potential (Quads) beyond Minimum Standards
Product	1990 Stock Average Efficiency	Minimum Efficiency Standards	Product	Status [1]	Improved Efficiency		
SPACE HEATING (RESIDENTIAL)							
Gas Furnace	0.68 AFUE [2]	0.78 AFUE	Condensing Gas Furnace	BA	0.95 AFUE	19%	0.35
			Gas Engine Driven Heat Pump	NTD	1.27 COP [2]	33% [3]	0.84
			GAX [2] Absorption Heat Pump	NTD	1.3 COP	28% [3]	0.72
Electric Heat Pump	5.8 HSPF [2]	6.8 HSPF	Variable Speed Air Source Heat Pump	BA	10.2 HSPF [2]	33% [3][4]	0.09 [3]
			Variable Speed Air Source Heat Pump with Integrated Water Heating	BA	9.0 HSPF	60% [4]	1.24 [5]
			Two Speed Ground Source Heat Pump	BA	3.81 COP	45% [3][4]	0.11 [3]
			Two Speed Ground Source Heat Pump with Integrated Water Heating	BA	3.56 COP	68% [4]	1.41 [5]
Electric Resistance Furnace	1.0 COP	1.0 COP	Standard Electric Heat Pump	BA	6.8 HSPF	50% [3]	0.40
SPACE HEATING (COMMERCIAL)							
Gas and Oil Furnaces and Boilers	80% (boilers)	83% (boilers)	Condensing Furnace	BA	0.95	15%	0.10
			Condensing Hydronic Boiler	BA	0.92	10%	0.08
			Gas Engine Driven Heat Pump	NTD	1.4 COP	40%	0.60

Space Cooling

Space cooling represents 7 percent of residential building energy and 19 percent of commercial building energy consumption. From 1980 to 1990, electricity used for residential air-conditioning increased by 50 percent, as most new homes in the sunbelt and many of those in northern climates were built with central air-conditioning. Energy used in the commercial sector for space cooling has risen because of the vast commercial expansion of the 1980s and also because of the expanded use of office equipment such as computers, facsimiles, and copy machines. The technical potential exists to reduce space cooling consumption by 0.5 quads in the residential sector and 0.56 quads in the commercial sector, almost a 30 percent reduction from 1990 consumption levels. (see Tables 1 and 2.)

Fortunately, the efficiency of cooling equipment has risen steadily over the past ten years, which has partially offset the rise in energy consumption caused by increased cooling loads and greater reliance on air-conditioning. However, there is still a significant potential for energy savings in space cooling in both the residential and commercial building sectors. Table 5 lists several advanced technologies that are either commercially available now or will be in the near term and that have the potential to substantially raise the stock average efficiency of cooling equipment. For example, currently available variable speed air-conditioners are 41 percent more efficient than minimum requirements and almost twice as efficient as the 1990 stock average.

The "best available" residential central air-conditioners are variable-speed units

that have average payback periods of eight to ten years when compared with 10.0 SEER units in southern U.S. climates. Advancements in commercial chillers usually have lower payback periods of zero to three years. Advanced unitary air-conditioners and heat pumps for commercial buildings have payback periods from five to six years.

[1] BA= Best Available Technology and NTD = Near-Term Development Technology on market by the late 1990s.

[2] AFUE = Annual Fuel Utilization Efficiency; HSPF = Heating Seasonal Performance Factor; COP= Coefficient of Performance; GAX = Generator Absorber Heat Exchange.

[3] Savings from heating and cooling products includes all modes of operation.

[4] An inefficient duct system can adversely affect equipment efficiency and severely reduce the expected savings when single-speed air conditioners or heat pumps are replaced with more efficient variable or two-speed equipment.

[5] Savings for heating, cooling and water heating products includes all modes of operation.



Table 5: Examples of Highly Efficient Options for Residential and Commercial Space Cooling

BASELINE PRODUCTS			EFFICIENT ALTERNATIVES			% Energy Savings beyond Minimum Standards	Technical Potential (Quads) beyond Minimum Standards
Product	1990 Stock Average Efficiency	Minimum Efficiency Standards	Product	Status [1]	Improved Efficiency		
SPACE COOLING (RESIDENTIAL) [6]							
Electric Central Air-Conditioner	8.56 SEER [2]	10.0 SEER	Variable Speed Central Air Conditioner	BA	16.9 SEER	41%	0.27 [3] [5]
			Two Speed Central Air Conditioner	BA	15.0 SEER	33%	0.22 [3] [5]
Electric Room Air-Conditioner	7.69 EER [2]	9.0 EER	Hi Efficiency Room A/C (<10,000 Btu/h)	BA	12.5 EER	28%	0.02 [4] [5]
SPACE COOLING (COMMERCIAL)							
Centrifugal Chiller	0.87 kW/ton	0.78 kW/ton	Advanced Centrifugal Chiller	BA	0.65 kW/ton	17%	0.06
				NTD	0.50 kW/ton	36%	0.12
Reciprocating Chiller	1.40 kW/ton	1.40 kW/ton	Advanced Reciprocating Chiller	BA	1.1 kW/ton	21%	0.07
				NTD	0.91 kW/ton	35%	0.11
Unitary Air Conditioning & Heat Pump	1.77 kW/ton	1.64 kW/ton	Advanced Unitary A/C & H/P	BA	1.2 kW/ton	27%	0.11
				NTD	1.0 kW/ton	39%	0.16

[1] BA = Best Available Technology and NTD = Near-Term Development Technology on market by the late 1990s.

[2] SEER = Seasonal Energy Efficiency Ratio; EER = Energy Efficiency Ratio.

[3] An inefficient duct system can adversely affect equipment efficiency and severely reduce the expected savings when single-speed air-conditioners or heat pumps are replaced with more efficient variable or two-speed equipment.

[4] Based on replacing 30 percent of the stock. Room air-conditioners with capacities of approximately 10,000 Btu/h account for only 30 percent of current shipments. Larger units included under commercial sector.

[5] Average potential for the southern United States.

[6] Refer to space heating (table 4) for heat pump cooling options.

Distribution Systems

Duct losses in heating and cooling distribution systems result from a combination of factors including leakage; inadequate insulation; and improper design, sizing, and placement of distribution ducting and piping.

It is estimated that over 0.3 quads of energy could be saved annually in the existing housing stock if existing mitigation technologies were applied to forced-air heating and cooling systems (see Table 6). Sealing leaking ducts and adding insulation to ductwork and piping can result in immediate

and long-lasting reductions in energy consumption, especially when the ductwork or piping lies outside the conditioned space such as in the attic or crawl space. Savings within the existing building stock is limited, however, by the inaccessibility of those distribution systems which are within enclosed wall and floor cavities.

In new buildings, better approaches to initial design and construction have the potential to virtually eliminate heating and cooling distribution systems as a source of energy inefficiency. New technologies are now being prescribed for designing and constructing buildings as integrated systems that take into account requirements for space conditioning, including proper placement of heating and cooling systems within conditioned space. This "systems" approach allows smaller heating and cooling energy sources and distribution systems to be used, resulting in both energy and initial cost benefits.

Improving thermal distribution systems in housing provides an efficient and cost-effective method of reducing energy consumption. Insulating and sealing ductwork in, and removing heating and cooling equipment from, unconditioned spaces in single family residences, can reduce energy

Table 6: Distribution System Energy Savings Potentials for 1990 Housing Stock

System Type	1990 Stock Average Efficiency	Minimum Efficiency Standards	Product	Status [1]	Improved Efficiency	% Savings of Space Heating and Cooling Energy Use	Technical Potential (Quads) [2]
DISTRIBUTION SYSTEMS (RESIDENTIAL)							
Single-Family, Forced-Air, Ducts in Unconditioned Space, Sunbelt	0.60	NA	Insulated and Sealed Ductwork	BA	0.72	17%	0.23
Single-Family, Forced-Air, Ducts in Unconditioned Space, Frostbelt	0.60	NA	Insulated and Sealed Ductwork	BA	0.72	17%	0.11
TOTAL							0.34

[1] BA = Best Available Technology

[2] The technical potential for distribution systems was derived from information provided by Brookhaven National Laboratory.



consumption by 0.34 quads with a two to three year payback. Improved thermal distribution systems enable the efficiency gains of systems that employ variable-speed heat pumps.

Commercial Refrigeration

Commercial refrigeration presents a unique situation in commercial building energy use. It uses five percent of energy consumption in the commercial sector, yet 85 percent of that amount is concentrated in refrigeration at retail food stores—by far the most concentrated use within the residential and commercial sectors. Refrigeration systems vary widely from location to location, and Federal minimum requirements have been difficult to establish. However, field test results have demonstrated energy savings potential of up to 60 percent using best available technology (see Table 7). By incorporating these technologies into the commercial sector, 0.23 quads of energy could be saved annually over 1990 consumption levels with existing technologies (see Table 2). This number represents a potential savings of over 30 percent.

Typical efficiency improvements to commercial refrigeration systems are from improved cooling unit components, ice machine components, and improved compressor and condenser technology. The average payback period for the improved components is from

two to three years and four years for more efficient compressors and condensers.

Lighting

Lighting consumes the second largest amount of electricity in the commercial sector behind space heating. It accounts for 27 percent of commercial sector energy use and seven percent of residential use. The use of existing energy efficient commercial lighting technologies could reduce energy use for lighting by almost 1.3 quads per year, or 36 percent of 1990 lighting energy use. While more modest, the potential savings in the residential sector could be as high as 32 percent from use of existing technology.

Several cost-effective measures can improve the energy efficiency of commercial lighting. These include replacing magnetic ballasts with high-frequency electronic ballasts (up to 75 percent improvement); replacing inefficient fluorescent lamps with more energy efficient lamps (up to 25 percent improvement); replacing high intensity discharge lamps (HID) with new electrodeless models (up to 40 percent improvement); and using better lighting controls, including occupancy sensors (up to 20 percent improvement). Also, the use of dimmable fluorescent ballasts with daylighting controls and integrated sensors that control all lighting in an individual workspace can provide additional energy savings in the commercial sector.

Table 7: Examples of Highly Efficient Options for Commercial Refrigeration

Baseline Products			Efficient Alternatives			% Energy Savings	Technical Potential (quads)
Product	1990 Stock Average Efficiency	Minimum Efficiency Standards	Product	Status [1]	Improved Efficiency		
REFRIGERATION (COMMERCIAL)							
Unit Coolers	1.5 COP [2]	[3]	W/Improved Components	BA	3.7 COP	60%	0.09
Ice Machines	0.6 COP	[3]	W/Improved Components	BA	1.0 COP	37%	0.04
Centralized	1.56 COP	[3]	W/best efficiency compressor and evaporative cooled condenser	BA	2.0 COP	20%	0.10

[1] BA= Best Available Technology

[2] COP = Coefficient of Performance

[3] There are no existing Federal minimum efficiency standards at this time.

Incandescent lamps account for over 90 percent of residential lighting energy use and about 15 percent of commercial energy use. The most common replacement for incandescent lamps is the compact fluorescent lamp (CFL). Substituting a compact fluorescent lamp for an incandescent bulb triples the efficiency of the light source. Other highly efficient technologies, including a compact electrodeless fluorescent lamp, the halogen infrared-reflective lamp (IR), and a coated filament lamp, are in near-term development.

Improving commercial lighting systems by using efficient luminaires, electronic ballasts, and improved lamp technology to replace standard incandescent and fluorescent lamp systems is very cost-effective, with average payback periods of a year or less. Employing automatic control systems for the purposes of using daylighting is also cost-effective with an average payback period of one to two years. Average



Table 8: Examples of Highly Efficient Options for Residential and Commercial Lighting

Baseline Products			Efficient Alternatives			% Energy Savings beyond Minimum Standards	Technical Potential (Quads) beyond Minimum Standards
Product	1990 Stock Average Efficiency	Minimum Efficiency Standards	Product	Status [1]	Improved Efficiency		
LIGHTING (RESIDENTIAL)							
Standard Incandescent Bulb	13.5 LPW	15 Lumens per watt [2]	CFL (Electronic Ballast)	BA	60 LPW	75%	0.40
			CFL Efficient Luminaire	BA	70 LPW	80%	0.42
			Compact Electrodeless Fluorescent	NTD	50 LPW	70%	0.09
			Improved Halogen Infrared Reflecting Lamp	NTD	25 LPW	40%	0.43
LIGHTING (COMMERCIAL)							
Incandescent	13.5 LPW	10.5-15 LPW [3] 15 LPW [2]	CFL (Electronic Ballast)	BA	60 LPW	75%	0.16
			CFL Dimmable Ballast	BA	60 LPW	78%	0.22
			CFL Efficient Luminaire	BA	70 LPW	80%	0.27
			Compact Electrodeless Fluorescent	NTD	50 LPW	70%	0.03
			Improved Halogen IR Lamp	NTD	25 LPW	40%	0.18
Fluorescent Lamps [5]	63 LPW	64-80 LPW	Scotopically Rich Lamp	NTD	NA	25%	0.44
High Intensity Discharge Lamps	85 LPW	90 [4]	Electrodeless HID Lamp (Interior)	NTD	150 LPW	40%	0.03
	85 LPW	90 [4]	Electrodeless HID Lamp (Exterior)	NTD	150 LPW	40%	0.18
Controls	NA	NA	Dimmable Fluorescent Ballast	BA	NA	13%	0.25
	NA	NA	Dimmable Fluorescent and Incandescent Integrated Sensors	NTD	NA	20%	0.39

[1] BA= "Best Available" Technology and NTD=Near Term Development Technology, on market by the late 1990s.

[2] No minimum standard has been established; 15 LPW is projected 1998 stock average.

[3] Incandescent reflector standards only.

[4] Stock average in 1998, no minimum standard has been set for these lamps.

[5] A new luminaire efficacy rating (LER) for fluorescent lighting systems is in the approval process. The system includes lamp, ballast and fixture.

payback periods for improving residential lighting systems range from two to eight years.

Refrigerators

In 1990, refrigerators and freezers accounted for 1.76 quads, or 10 percent of residential energy use. For that same year, the stock average efficiency was 1223 KWH. However, with Federal minimum energy efficiency standards having an effect, the 1991 purchase average efficiency for residential refrigerators was 857 KWH/yr, a reduction of 30 percent.

The Federal minimum efficiency standards for new refrigerators set energy consumption limits based on the adjusted volume of the refrigerator. For example, the current Federal minimum efficiency standard for an 18 cubic-foot, top-mounted refrigerator is approximately 670 KWH/yr. However, the "best available" refrigerators are up to 15 percent more efficient than the minimum standards, and near-term development technology represents up to 30 percent savings above minimum standards (see Table 9).

Residential refrigerator efficiency programs are often part of utility demand-side management programs because they provide an efficient means of consumer cost savings. Typical payback periods for "best available" technology is approximately two years.



Laundry

Although laundry represents only a small portion of residential sector energy use, significant long-term savings are possible through technology improvements and reduction in hot water use. The total potential savings from advances in technology are 0.53 quads of energy, 55 percent of total 1990 laundry energy use.

In the past twenty years, the energy efficiency of washers has improved over 35 percent, largely because of reduced use of hot water, lower rinse temperatures, and improved water-level controls. Since 90 percent of the energy consumption in clothes washers is attributable to water heating, most energy efficiency improve-

ments have focused on reducing water consumption. The horizontal axis washer is an example of design technology that reduces water consumption by approximately 62 percent over conventional, vertical-axis washers. The horizontal axis washers that are now on the market have an average payback period of two to three years.

The sales weighted, annual energy use for clothes dryers has decreased only slightly over the last twenty years, and there are no currently available products that are more efficient than the average. However, heat pump dryers currently under development will improve clothes dryer efficiency by as much as 65 percent.

Table 9: Examples of Highly Efficient Options for Residential Major Appliances

Baseline Products			Efficient Alternatives			% Energy Savings beyond Minimum Standards	Technical Potential (Quads) beyond Minimum Standards
Product	1990 Stock Average Efficiency	Minimum Efficiency Standards	Product	Status [1]	Improved Efficiency		
REFRIGERATION (RESIDENTIAL)							
Refrigerators	1223 KWH/yr	670 KWH/yr [2]	Baseline w/improved components	BA	570 KWH/yr	16% [3]	0.12
			Improvements Demonstrated per DOE/AHAM ARC CRADA	NTD	470 KWH/yr	30%	0.22
LAUNDRY							
Vertical Axis Clothes Washer	0.69 ft3/KWH/ cycle	1.18 ft3/KWH/ cycle	Horizontal Axis	BA	3.07 ft3/KWH/ cycle	62%	0.16 [4]
			High Spin Speed	BA	1.69 ft3/KWH/ cycle	30%	0.08 [5]
Electric Resistance Clothes Dryer	2.69 lbs/KWH	3 lbs/KWH	Heat Pump Dryer	NTD	8.6 lbs/KWH	65%	0.28
			Gas Fired Clothes Dryer	BA	2.67 lbs/KWH	65%	0.28 [6]

[1] BA = "Best Available Technology" and NTD = Near Term Development Technology, on market by the late 1990s.

[2] Federal minimum efficiency standards based on a typical 18 cubic-foot, automatic defrost refrigerator with top-mounted freezer.

[3] Based on general availability of 15% rebate models.

[4] Includes hot water energy savings.

[5] Dryer energy savings.

[6] Based on replacing 15% of stock. Only 15% of homes with electric clothes dryers have access to natural gas.



Barriers

Workshop participants pointed out that although substantial energy savings can be achieved by increasing the market penetration of highly efficient appliances, a number of barriers constrain the market for these appliances. These marketplace barriers are grouped in four categories: price, information, infrastructure, and technical.

Price constraints are defined by the higher first cost price tags that often come with more highly efficient equipment. Studies by the Association of Home Appliance Manufacturers have shown that potential for energy savings is not an adequate consumer incentive if the first cost of the more efficient appliance is significantly higher than the more commonly used appliance. Consumers tend to purchase lower cost units that adequately meet their needs and do not consider the life cycle costs of their purchase. This is especially true when appliances are replaced at the end of their useful life or the product fails. Conversely, utility demand-side management programs have demonstrated that financial incentive programs can increase sales of highly efficient equipment and enable the product to assume a sustainable market share once the incentives are ended.

Information constraints refer to the lack of readily available and understandable information that would enable consumers to make informed, cost-effective purchase decisions. Although some products carry an energy efficiency label, many consumers are not able to use the information on the labels to discern the differences in products. Builders provide prospective home buyers little, if any, information about appliance energy efficiency. Many emerging energy efficient products lack adequate performance data. Without reliable performance, durability, and life-cycle cost information, utilities are reluctant to establish product-specific demand-side management programs.

Infrastructure constraints refer to characteristics of the appliance industry that impede the growth of the highly efficient appliance market. In many cases, qualified individuals to support the sales, installation, and maintenance of these appliances are lacking. In addition, according to those in attendance at the workshops, 75 to 90 percent of the purchase decisions about heating and cooling equipment and water heaters are influenced by the recommendations of the contractor/dealer. Individuals making those recommendations often have neither the training nor the incentive to sell more advanced equipment.

Technical constraints refer to barriers that appliance manufacturers face in introducing new appliance technologies. DOE learned from its manufacturer workshops that low consumer interest in highly effi-

cient appliances imposes an economic risk on the manufacturer who is developing and producing appliances that are significantly different from those currently used, e.g., heat pump water heaters.

Consumers, including commercial consumers, hesitate to purchase building appliances that have high first costs, as well as unknown performance, reliability, and maintenance characteristics. Policies and programs that reduce consumers' concerns about advanced appliances will improve the market for this equipment.

These barriers are interrelated. A complex strategy and a wide range of Federal actions are needed to accelerate the use of highly efficient appliances. The general and specific actions that follow will allow DOE to act as a catalyst for new product introduction and market transformation while minimizing Federal involvement and expenditures in what should largely be a private sector action.

Recommended General Actions

A number of policies and programs are available to the Federal Government to advance appliance energy efficiency. DOE is challenged with interweaving these options to establish a Federal role in the development and commercialization of advanced technologies.

As a result of input received from the workshop participants, seven general Federal actions were identified for incorporation into DOE's appliance market transformation program:

- *technology development* - advancing appliance technology by helping industry develop new highly efficient products
- *performance testing, rating, certification and labeling* - providing clear and concise product and energy performance information to consumers, utilities, and others buying or providing financing for highly efficient products
- *utility and other financial incentives* - reducing first cost(s) to the consumer by helping stimulate financial incentive programs
- *government and private sector market aggregation* - rapidly increasing sales of highly efficient products through volume purchase projects
- *accelerated replacement* - creating a demand for highly efficient appliances while simultaneously removing old, inefficient appliances from service



- *improved installation, sales, and service infrastructure* - encourage a knowledgeable and motivated sales, service and installation infrastructure that will stimulate selection, purchase and efficient operation of highly efficient appliances
- *information dissemination and consumer education* - ensuring that consumers are informed and motivated to purchase highly efficient appliances

The following provides more detail on the options that the Federal Government has to choose from:

1. Technology Development

Objectives

- To advance appliance technology development
- To develop highly efficient products.
- To provide technical data and analysis to support other policy options.

Scope

- Provide direct funding to national laboratory, university and private sector research.
- Provide jointly funded cooperative product development with industry and small business R&D firms.
- Verify product performance, including evaluation of cost-effectiveness and environmental and utility impacts.
- Stimulate private sector R&D through purchase incentives.

The impact of Federal support to develop appliance technology includes reduced technical and financial risk for industry, shorter product development cycles with earlier product introduction, and enhanced industrial competitiveness for domestic industry. As examples, DOE has supported development of electric fluorescent lighting ballasts, integrated water heating air-conditioners and heat pumps, efficient supermarket refrigeration systems, and efficient refrigerator compressors.

- *DOE can continue long-term applied research and advanced technology development programs. Through cost-shared relationships, DOE would work with industry to explore new concepts.*

DOE concludes that Federal appliance research and development programs serve an extremely useful purpose because they help advance new technology concepts. Industry often chooses not to fund long-term, more fundamental research and technology development due to perceived market or profitability limita-

tions for a particular type of appliance. Therefore, the technical assistance DOE and its national laboratories provide to industry is very important.

Technology Development

DOE is working with Phillips Engineering of St. Joseph, Michigan and the Carrier Corporation to develop the United States' first advanced-cycle gas-fired absorption heat pump. By eliminating chlorine-based refrigerants, this heat pump significantly reduces depletion of the atmospheric ozone.

2. Performance Testing, Rating, Certification and Labeling

Objectives

- To provide clear, concise, and standardized product information that can be provided to purchasers for unbiased comparisons of product energy efficiency.
- To provide information on new technologies in support of other policy options.

Scope

- Develop test procedures that assess product performance to provide accurate data for consumers.
- Improve the information base that is key to the DOE/Federal Trade Commission and other labeling programs.
- Establish "best available" certification and labeling programs, in addition to DOE/Federal Trade Commission labels.
- Develop whole building performance rating systems that include appliances.

Product certification and labeling of appliances can be potentially the most effective mechanism for influencing point-of-sale transactions. In addition, testing, rating, certification and labeling efforts directly support several other policy options. Organizations operating incentive programs and aggregated purchasing programs need accurate, unbiased appliance performance data to justify program decisions. Policies directed toward an improved sales infrastructure and better informed appliance purchasers begin with effective certification and labeling information.

DOE intends to evaluate and, where appropriate, work with the Federal Trade Commission and others to improve and restructure appliance performance testing, rating, certification and labeling programs so consumers, utilities, code officials, and other "purchase influencers" will have information available to make appliance purchase decisions which incorporate energy efficiency considerations.



New Rating Program

One notable DOE success in the voluntary rating/labeling area is the National Fenestration Rating Council, a government/industry collaborative established to create a national rating system for windows, doors, and skylights. The Council began with seed money from DOE and is now essentially self-supporting. Between July 1993 and December 1994, the Council certified over 16,000 separate fenestration products. The Council has helped transform the window market. The availability of credible energy performance information has made product advertising about efficiency performance possible and has led to increased sales of energy efficient products. DOE is currently working to establish similar programs for lighting and office equipment, as required by EPAct.

- *DOE can evaluate new appliance technologies to establish real-world performance and reliability data essential to expanding the market for highly efficient appliances.*

By evaluating appliance products which are not yet commercially available, DOE can help determine the operating characteristics and maintenance needs of new appliance technologies. Obtaining and disseminating data on appliance performance and reliability through product evaluations can be of great value to utilities with demand-side management programs and to commercial and residential consumers who want safe and cost-effective products.

DOE can use Federal and non-Federal facilities to research performance, reliability, safety and maintenance characteristics of new appliances. New technology demonstrations can be useful both for new appliance technologies, such as natural gas-fired heat pumps, and for appliance technologies which have had little market penetration, such as ground-source heat pumps and heat pump water heaters.

- *DOE can continue to work with the Federal Trade Commission on product labeling.*

Federal law requires that manufacturers of certain appliances affix Federal Trade Commission energy labels to their products. Existing appliance labels provide the consumer with estimates of annual energy operating costs based on the national average cost of either electricity, natural gas, or fuel oil. The FTC will begin in 1995 to place relative energy efficiencies on the label which will allow for easier product comparisons. The labels do not, however, provide information on the life expectancy of the appliance and provide no information on the environmental emissions associated with the product. The national retailers and representatives of small appliance stores who attended the utility and manufacturer workshops responded very favorably to the idea of revising Federal Trade Commission labels to

include information on the life-cycle energy cost of the appliance.

- *DOE and other federal agencies and private sector groups can work together to develop voluntary, national labeling programs for "best available" energy efficient products on which other voluntary rating and labeling programs can be based.*

Federal New Technology Demonstrations

Two 15-ton, natural-gas-powered air-conditioners have been installed in a multi-purpose building at Willow Grove Naval Air Station in Philadelphia, Pennsylvania, as part of the Federal Energy Management Program's test bed program. Cooperating in the venture are ThermoKing of Minneapolis, Philadelphia Electric Company; and Pacific Northwest Laboratory (PNL).

Preliminary results from Willow Grove indicate that more than \$120,000 can be saved during the 15-year life of the equipment. The gas air-conditioning units have a discounted payback period of less than two years, making it a technology attractive to the public and private sector.

Since consumers cannot always use the Federal Trade Commission labels to identify "best available" models, a number of private and governmental organizations have been developing independent labeling programs that designate "best available" products based on energy efficiency or other environmental criteria. Examples include the utility-based "Power-Smart" program, the Green Seal program, the Environmental Choice program sponsored by Environment Canada, Green Cross, and product-specific programs such as the EPA "Energy Star"™ program for computer equipment.

There is growing concern that the proliferation of such energy and "eco-labels" will add confusion rather than clarity to the market. Multiple labeling systems make it difficult for consumers to know which logo to look for and which sources to trust when a product qualifies for one label but not another. Manufacturers may also find it difficult to choose among the competing product endorsements in deciding how to market to environment- and energy-conscious buyers.

- *DOE can increase the emphasis on appliance efficiency in home energy rating systems, energy efficient mortgages, and building code "point systems" such as those found in California's Title 24 building codes.*

Consumers respond to financial incentives; hence, DOE is working to promote financial tools—mortgages and energy efficient loans—that will accelerate market penetration. In the past, many home energy rating systems have focused on improving the performance of



"Golden Carrot™" Program

The Super Efficient Refrigerator Program, Inc. (SERP, Inc.) was established by a consortium of private and public utilities to encourage U.S. appliance manufacturers to develop and market a chlorofluorocarbon-free and highly efficient refrigerator-freezer, years before it would have otherwise come onto the market. Twenty-four utilities raised \$30 million to fund the SERP™, Inc. program.

Whirlpool was chosen to develop the new refrigerator and, in 1994, began marketing refrigerators that are at least 25 percent more efficient than the 1993 Federal minimum efficiency standard. Whirlpool will receive a portion of the \$30 million for each of the first 250,000 highly efficient CFC-free refrigerators it sells.

the building envelope, but have not included the benefits from the efficiency of home appliances and builder-supplied equipment. To strengthen existing or proposed new home energy rating systems and energy efficient mortgage and loan programs, DOE can work with the Department of Housing and Urban Development, the secondary mortgage market, and home energy rating system providers to assure that home energy rating systems take into account the efficiency of appliances.

3. Utility and Other Private Sector Financial Incentives

Objective

- To reduce the first cost of highly efficient appliances.

Scope

- Strengthen existing utility incentive programs through research, validation of data and results, and new demand-side management concepts.
- Encourage utility incentive programs through technical assistance to utilities and state regulatory agencies.
- Establish and strengthen private sector incentive programs.
- Support state and local government incentive programs with technical and market data.

Federal action to encourage the private sector to create incentives can greatly increase sales of highly efficient appliances. Incentives directly reduce the higher first cost of these appliances.

Federal involvement in appliance incentives has the following goals: 1) more effective targeting of utility demand-side management expenditures; 2) an increase in the number of areas served by utility incentive programs; and 3) a significant increase in financial,

technical, and organizational resource levels for incentives through non-utility programs.

Utilities spent over \$2 billion on demand-side management incentive programs in 1993. These programs exert a major influence on the market and are considered essential for the success of national appliance "market pull" efforts. However, utility demand-side management expenditures were concentrated in just a few areas of the country. Fewer than one-third of the utility incentive programs were directed toward energy conservation. Growth in utility demand-side management programs currently appears to be slowing down in the face of increased competition and regulatory agency uncertainty about real energy savings and cost-effectiveness. By providing technical and analytical support to utilities, utility regulators, and utility collaboratives, DOE can help ensure that cost-effective utility demand-side management efforts will be fruitful and ongoing.

Non-utility programs are also important. If utility demand-side management programs are on the decline, the two most important financing options for energy efficiency may be energy service companies and energy efficient mortgages and loans.

Energy service companies (ESCOs) have long been viewed as an attractive option for commercial buildings because they address an entire building and because the building owner is somewhat removed from the process. With the apparent decline of demand-side management programs, energy service companies are now viewing the residential sector as a possible market.

Another method of financing energy efficiency is still in its infancy. Energy efficient mortgages and loans are just emerging within the residential sector. Established previously by the secondary mortgage market, these mortgage and loan programs may eventually surpass direct utility financing as the most prevalent funding source for residential energy efficiency.

As part of its market transformation program, DOE is working with both of these sources to define and expand their market.

- DOE could support utility demand-side management programs by providing seed funding for technology-specific collaboratives and technical assistance from its national laboratories or contractors.

DOE can support utility demand-side management efforts by providing technical and financial assistance to strengthen evaluation practices and regulatory incentives and establish common databases on technologies, program results, and market trends. DOE would disseminate data on the load profiles of



energy efficient equipment and data on the performance, cost and operating characteristics, and utility impacts of appliances. Many workshop participants encouraged DOE to include third-party testing and assessment of emerging, near commercial technologies in its technical and financial assistance program.

- *DOE and EPA could support existing utility and industry collaboratives that establish financing programs for "best available" technologies. DOE would provide seed funding and technical expertise to these collaboratives.*

Collaboratives provide a forum for manufacturers, utilities, and others to meet and understand each other's information and planning needs. Consortia can link utilities and manufacturers so that the latter can coordinate their production plans with demand-side management programs. During the workshops, manufacturers explained that the inconsistency of utility rebate programs made it difficult for them to plan production runs. Coordinated utility rebate programs will enable national manufacturers and retailers to better coordinate production schedules, promotion, and rebate programs for more effective market penetration.

DOE and EPA are supporting utility consortia because utilities have the resources to move the appliance market toward greater efficiency. The "Golden Carrot"™ program organized by the Super Efficient Refrigerator Program™, Inc., (SERP™) is but one example of utilities pooling their resources to transform the appliance market.

DOE and EPA could expand their technical and financial support for national market transformation activities such as the Consortium for Energy Efficiency, as well as various regional and state-level consortia and non-profit organizations. Collaboratives could also contribute to efforts to improve appliance efficiency by pooling information and resources on innovative financing techniques, such as leasing. Collaboratives would also provide financial resources to improve the training of installation and service contractors.

- *DOE could help public utility commissions and utilities develop and evaluate new and existing demand-side management concepts for advancing appliance energy efficiency.*

DOE could testify before state public utility commissions to encourage utilities and state regulators to acquire demand-side management resources that will be cost-effective in minimizing the energy bills of most utility customers in the long run. DOE would encourage states to adopt ratemaking procedures which ensure that a utility's investments in demand-side resources are at least as profitable as its investments in

supply-side resources. Specifically, DOE can encourage ratemaking procedures to give appropriate consideration to income lost from reduced sales because of investments in conservation and efficiency.

Several innovative demand-side management concepts were proposed in the workshops and in

Consortium for Energy Efficiency

The Consortium for Energy Efficiency (CEE) is a U.S. highly efficient technology promotion organization founded by groups involved with SERP™, Inc., which were interested in seeing success replicated with other appliance technologies. CEE is aimed at encouraging and helping to improve the process by which utilities and others provide incentives to manufacturers to produce and market more efficient products. Utilities, environmental groups and public agencies are a part of CEE. Although both SERP™, Inc., and CEE work with manufacturers to achieve the energy efficiency missions of their organizations, neither organization's membership is open to manufacturers.

discussions with various stakeholders. Some of the ideas meriting further study and exploration are

- differential rate structures
- differential hook-up fees
- equipment leasing
- performance warranties and savings guarantees
- revenue-neutral rebates
- end-use metering

4. Government and Private Sector Market Aggregation

DOE could work with the General Services Administration, the Defense Logistics Agency and other Federal agencies, state and local governments, and private sector entities such as energy service companies to concentrate the purchasing power of the Federal Government and the private sector on the highly efficient appliance market, thus accelerating market penetration.

An active Federal market aggregation policy can reduce first cost by increasing production volume, product awareness, and incentives for more manufacturer investment.

- *DOE could work with EPA, DoD, GSA and others to create public and private sector buyer groups that purchase large quantities of "best available" technologies.*

DOE advocates the formation of coordinated public and private sector buyer groups to improve the



Objective

- To rapidly increase sales of highly efficient appliances through large-scale purchasing projects.

Scope

- Provide technical, administrative, and marketing support to establish large-scale purchasing programs by
 - utilities
 - energy service companies
 - regional or national chains of commercial buildings
 - home builders
 - major retail and hotel/motel chains
 - Federal Government agencies
 - state and local governments
 - weatherization services
 - large institutions, co-ops, and industry associations

markets for and reduce the first cost of appliances. The larger volume of business should reduce product costs because manufacturers will be able to take advantage of economies of scale. Participants in these buyer groups are likely to be large purchasers of appliances, such as national companies, state and local governments, universities, energy service companies, and owners of large facilities. DOE would provide technical support and help form and coordinate purchase commitments from these groups.

- *DOE would work to change Federal, state and local government, and institutional procurement practices to make government a market leader in buying energy efficient products.*

The power of Federal, state, local, and institutional purchasing as a tool for creating or expanding markets for highly efficient appliances is significant. A strong emphasis on government procurement of energy efficient products is authorized under provisions of EPAct, as well as in Executive Order 12902, President Clinton's directive on energy efficiency and water conservation at Federal facilities. Implementing actions being developed or proposed by DOE or GSA include:

- establishing purchasing criteria that would advocate "best available" appliances which achieve at least a 10 percent better efficiency than Federal minimum efficiency standards for covered products, and the upper 25th percentile of efficiency for products not covered by minimum efficiency standards

- obtaining information on energy efficient products, as well as on-line advice and assistance on government's "electronic commerce" databases and CD-ROM systems.

Sole source procurement requirements make it difficult for Federal facility managers to purchase

Solar Hot Water

The solar industry benefits from large-scale programs that lead to economies of scale in manufacturing and reduced marketing costs.

DOE is working with utilities and the solar industry under an initiative called USH₂O to reduce the costs of solar domestic hot water systems. One utility, the Sacramento Municipal Utility District (SMUD), launched a Solar Domestic Hot Water (SDHW) Program in 1992 to reduce electricity use and peak electricity demand by accelerating the market acceptance of solar hot water heaters through a rebate scheme that promotes reduced system costs, as well as a financing plan that enables customers to realize immediate positive cash-flows.

The objective of the program is to have approximately one-half of the utility's residential electric water heating market be solar—20,000 systems by the year 2000. With typical solar systems saving 40-65 percent in energy, an energy savings of 48,300 MWh per year and a demand reduction of 7.4 MW are expected.

Approximately 1500 systems had been installed as of late 1993. An additional 1800 systems were targeted for 1994.

emerging energy efficient appliances. DOE would work with GSA and DoD to design and test a "developmental procurement" model for energy efficient appliances which are not yet widely available. In this model, a manufacturer develops the product on the basis of specifications designated by the government. Using this method, the Federal Government would be able to support and purchase emerging energy efficient appliances.

DOE would work with GSA to see that Federal appliance purchasing criteria are coordinated with other governmental and utility programs to maximize effectiveness.

Power-Saving Computers

One notable procurement success is the Administration's decision to require Federal agencies to purchase computers and printers with low standby power consumption. Because the Federal Government is such a large purchaser of computers and manufacturers want to sell to the government, manufacturers began to produce "Energy Star" SM computers. Once the power-saving design was built into the microcircuitry at the heart of the computer, it became part of virtually every computer, as it costs nothing more to produce a power-saving chip once it has been designed.

5. Accelerated Replacement

Objective

- To create a demand for highly efficient appliances while simultaneously removing old, inefficient appliances from service.

Scope

- Retire redundant or unneeded energy-using appliances, without replacement
- Replace inefficient appliances with appliances that are much more efficient than minimum standards.

Appliance replacements usually occur in an emergency situation due to product failure; products are often replaced with similar appliances that are the lowest first-cost products that just meet Federal minimum efficiency standards. Appliances are seldom replaced on a planned basis considering the low life-cycle cost which includes its annual operating expense. Typically the consumer does not select a dissimilar product offering higher efficiency, such as a heat pump water heater replacing an electric resistance water heater. Therefore, accelerated replacement programs provide an opportunity for non-emergency decision-making that could result in significant energy savings.

Based on its examination and assessment of these programs, DOE considers the most important factor to be replacing older appliances with new appliances that are considerably more efficient. This means that there must be a "significant" net energy benefit from replacement and, further, there must be a net economic benefit to consumers. No early replacement program is justified if replacement results in only small incremental savings. In order to achieve a larger net energy benefit, accelerated replacement programs that promote appliances for which there is little difference between minimum efficiency standards and "best available" are not recommended.

Early replacement programs may provide the only incentive to move to a more energy efficient appliance of a different class. Some technology areas, for example, electric resistance hot air furnaces have been slow to improve their efficiency. In this case, energy efficient alternatives of a different class (such as various heat pump technologies) provide the greatest opportunity for savings. In the absence of Federal minimum energy standards that require the adoption of these technologies, however, some other mechanism must provide the push toward improved efficiency.

The Department has determined that early replacement programs can be an effective market trans-

formation tool, yielding net positive energy benefits, when two general criteria are met. This determination, and the analysis that supports it, may be found in the supplemental information to this report. The criteria are:

Successful Accelerated Replacement Programs

Between 1982 and 1989, a Wisconsin gas utility offered a rebate program for early replacement of furnaces to lower winter peaks and lower gas supply costs. During the program about 100,000 gas furnaces were replaced in Dane County (Madison), about 80 percent of the market. Most of the replacements were condensing gas furnaces. Customers received a \$150 rebate for a product that carried a \$450 premium, or about one third of the increased cost. This created a 30 percent market share for condensing gas furnaces. The market share has since risen to 50 percent since the rebates ended in 1989. Manufacturers are now fighting for the condensing furnace market, some with price cutting and others with their own rebates.

In Ontario, Canada, about 11,000 geothermal heat pumps replaced conventional air source heat pumps in both new construction and existing houses (about 50/50 new/replacement). Customers received either a \$2,000 rebate or a low-interest loan up to \$12,000. The program ran from 1991 to 1993. Ontario Hydro estimates that the program is saving 34 megawatts of avoided winter peak power demand. The utility believes the program has not only saved energy but that it has established a strong market for geothermal heat pumps in Ontario and as a side benefit has established knowledgeable sales, installation and repair industries within the Province.

- *the replacement product should have a projected annual energy consumption lower than products just meeting the current Federal minimum efficiency standards, and have a significantly lower annual energy consumption than the product it is replacing.*
- *the product being replaced should have a remaining life between 25 percent to 75 percent of its anticipated total life.*

Additionally, to assure a significant net energy savings, the selection of a specific early replacement appliance must be based on an analysis that considers: 1) the age and energy consumption of the appliance being replaced, 2) the consumption level of the replacing appliance and, 3) the effective date and consumption anticipated by future standards.

Another requirement for an early replacement program is the removal of the replaced appliance from service. It is a common practice when replacing a functional appliance to sell it or give it away to a second owner.

The concept of early replacement is not new; manufacturers commonly target early replacement sales as one road to significant market share and net income increases. However, manufacturer replacement pro-



grams seldom target energy efficiency. Product marketing decisions are more often based on the anticipated ability to influence consumer behavior through marketing of style, features, and price. In these cases, consumer purchase decisions are frequently driven by market hype rather than by need or cost justification.

Establishing energy efficiency-based early replacement programs is a difficult decision for most manufacturers. Energy efficiency is still not a key to consumer purchasing decisions. Therefore, the normally higher first costs of highly efficient appliances is a deterrent to both consumer interest and manufacturer promotion of such equipment in early replacement marketing initiatives. Third-party financial incentive programs are usually required before either the consumer or the manufacturer is involved. The analysis performed for accelerated replacement clearly shows that an early replacement program for some appliances that yield a net positive energy benefit may not be attractive to the consumer without the addition of a financial incentive program to enhance cost-effectiveness. Conversely, if some products yield better net energy and economic benefits, then they may provide the basis for an early replacement program without the necessity of economic incentives.

If third party incentives are available, then product choices must be made. Typically, a product must have an average cost payback period marginally less than three years or have an exceptional energy savings potential in a particular section of the country that will substantially decrease the average payback period for a particular product. An example of each situation is presented in the box above.

The key to productive early replacement programs is not to exclude any products from consideration by virtue of a predetermined (average) cost justification criteria. Research has shown that a certain segment of the population will purchase energy efficient products even with longer payback periods. Rather, the Department should help promote the early replacement of appliances in markets where the energy saving benefits are great and where anticipated cost reductions and behavior modification will transform the market to enable highly-efficient products to freely compete. The Department should not attempt to predetermine cost-effective requirements for the consumer; this is restrictive and should not be the Federal role.

The Federal Government should help determine if there are overall societal benefits, such as energy, cost, and environmental savings that result from early replacement and retirement programs for highly efficient products. If overall societal benefits do exist, the Federal Government should consider partnerships with progressive manufacturers, utilities and retail/

Early Replacement Opportunities

Early replacement offers significant potential energy savings for the following residential end uses:

- horizontal axis clothes washers replacing top-load clothes washers
- rebate refrigerators replacing pre-standards models
- electric heat pumps replacing resistance furnaces with central air conditioning
- condensing gas furnaces replacing standard gas furnaces

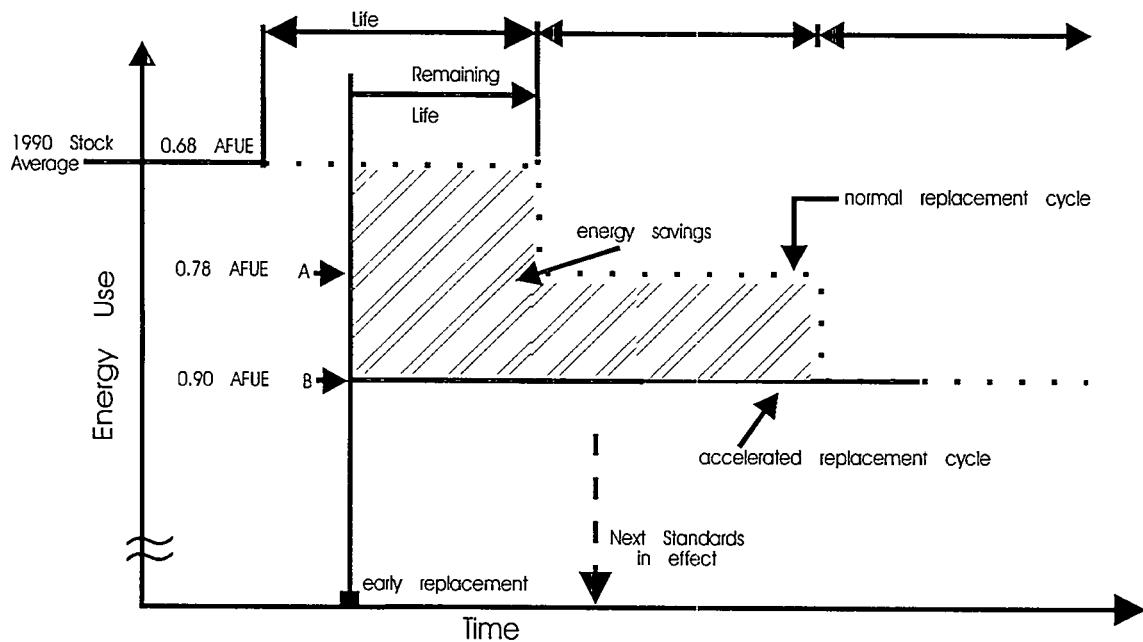
wholesale outlets to develop an overall implementation strategy. The Government goal should be to promote effective programs and to provide third party information that would help solidify the programs. The manufacturer goal should be to use the opportunity from a short-term replacement program to build a sustained product market and let market forces determine the success or failure of early replacement programs.

As stated above, early replacement programs are most effective when large, immediate appliance efficiency improvements can be implemented, and when the current appliance has approximately 25 percent to 75 percent of its useful life remaining. Additional justification for early replacement may surface if the consumer is not expected to upgrade their appliance without some form of incentive program. This is especially true when the "best available" technology is considerably more efficient than Federal minimum efficiency standards and product sales trends indicate that the highly efficient appliances will not attain a significant marketshare in the near-term. There is a "time value" to accelerated replacement programs. They yield increased short-term energy savings and reductions in greenhouse gas emissions.

Figure 3 is an illustration of this concept. The 1990 stock average efficiency for gas furnaces was an AFUE of 0.68. The current minimum Federal efficiency standard for gas furnaces is an AFUE of 0.78. However, in many Northern U.S. climate zones, such as the Madison, Wisconsin example on the previous page, condensing gas furnaces with AFUEs between 0.90 and 0.95 can be cost effective, and minimum standards are not expected to be raised to the 90 percent efficiency level in the near future. Therefore, the energy and cost savings derived by installing condensing gas furnaces in Northern U.S. climates to replace conventional gas furnaces makes this a viable candidate for an early replacement program.

Accelerated replacement programs can complement the effect of Federal minimum efficiency standards as a driving force for improved energy efficiency

Figure 3: Early Replacement of Gas Furnaces (Example)



A: current minimum standards level

B: level of energy use for future minimum standards & for early replacement model

because they can hasten consumer purchase of highly efficient appliances especially for appliances for which there are no, or relatively low, minimum efficiency standards. The use of accelerated programs as a complement to standards can provide energy savings and environmental benefits that might not otherwise occur.

Under the circumstances outlined above, DOE believes early replacement programs can be very attractive. Governments and utilities can encourage and, to a limited degree, subsidize such programs. DOE has prepared a separate analysis report on this topic (listed in the Preface of this report) to evaluate the role the Federal government could play in a national early replacement program.

- DOE can provide technical and analytical support to utilities interested in developing early replacement programs.

DOE would help utilities develop program design options for early replacement programs. Once these

programs have been developed and instituted, DOE would evaluate their effectiveness.

In general, pilot programs are needed to establish eligibility criteria, to monitor actual costs and energy savings and to demonstrate cost-effective early replacement programs.

- DOE could work with GSA to determine if early replacement of appliances is cost-effective on a life-cycle basis in Federal facilities.

An early replacement program for appliances in Federal or Federally-funded buildings is worthy of further study. Such a program could be extended to local housing authorities that receive Federal funding.

- DOE can help educate consumers about economic and environmental benefits of early replacement.

The Federal Government owns millions of appliances of all kinds in its thousands of facilities worldwide. By operating an early replacement program in its own facilities, the Federal Government could lead by



example, demonstrate the benefits of early replacement, and learn how to create an effective program.

Objective

- To help create a knowledgeable and motivated work force that will stimulate the selection, purchase, and efficient operation of highly efficient appliances.

Scope

- Promote education activities, including information delivery, training, and certification.
- Promote recognition and award programs to provide motivation.
- Direct education and incentive activities to serve all elements of the appliance delivery and maintenance infrastructure including
 - building equipment designers and specifiers
 - code officials
 - builders
 - installation and service technicians
 - equipment operators
 - sales personnel.

6. Improved Installation, Sales and Service Infrastructure

Purchase decisions about heating and cooling equipment and water heaters are strongly influenced by the recommendations of the contractor/dealer. In the workshops, representatives of the heating and cooling industry estimated that 75 to 90 percent of customers purchase the equipment recommended by the contractor/dealer. The individuals making those recommendations often have neither the training nor the incentive to sell highly efficient equipment. Educated and motivated contractors and dealers will directly increase the level of sales. The effectiveness of appliances will also be improved through proper installation and servicing.

DOE could assist the private sector's efforts to improve the installation, sales and service infrastructure of the appliance industry so more advanced appliances are sold and are properly installed and maintained.

- *DOE could work with the Department of Labor; the heating, cooling and water heating industry; and others to improve the training of industry contractors.*

Federal policies to improve the training of heating and cooling contractors can be built into the existing

training programs run by manufacturers, distributors, trade schools, and local adult education programs. Heating and cooling contractors are a prime target. They generally purchase their products from distributors rather than directly from manufacturers, and distributors organize most of the training. One impor-

Training Program Impacts

The North Carolina Alternative Energy Corporation (NCAEC) surveyed homes in North Carolina and found numerous cases in which the installed efficiency of residential air-conditioners and heat pumps was about 30 percent below the equipment's rated values (SEER ratings).

To deal with this problem, NCAEC instituted a training and certification program for field service technicians. The additional training for technicians has improved the quality of installations and maintenance; the program has proven to be cost-effective. Pacific Gas and Electric has funded a similar program in California that has improved system efficiencies by 12 to 18 percent.

tant approach to improving the education and training of heating and cooling contractors is to work with the distributors to educate contractors about selling, installing, and maintaining highly efficient equipment.

Rather than start from scratch, DOE could build on the work of existing heating and cooling training programs, such as the advanced heat pump training program run by North Carolina's Alternative Energy Corporation (see box). Also, Federal programs to improve the training of heating and cooling contractors should include incentives for contractors to spend resources on training and education.

- *DOE could work with other Federal agencies to develop national or regional contractor recognition programs which will tie in with voluntary accreditation and certification programs.*

Unless architects and mechanical engineers specify highly efficient equipment for new or renovated buildings, contractors will not install this equipment because bidding processes give the project to the lowest cost bidder.

DOE could work with the American Institute of Architects; the American Society of Heating, Refrigerating and Air-Conditioning Engineers; the Association of Energy Engineers; and other organizations to improve the education and training that architects and mechanical design engineers receive on heating, cooling, and water heating systems.

DOE could also review the feasibility of establishing a fellowship program to educate building energy professionals in cross-disciplinary specialties like heating and cooling design, operation and maintenance. Such programs do not currently exist.

- *In conjunction with manufacturers and utilities, DOE could work with the wholesale and retail industries, to establish a national sales incentive, training and recognition program for sales staff and installers.*

An important aspect of marketing appliances is ensuring that sales and service personnel, who exert a major influence on the purchase decision, have incentives to sell and install highly efficient systems and are adequately trained to service and install them. One of the major conclusions of the manufacturer and utility workshops, is that contractors, installers, and other "purchase influencers" do not currently have such incentives and training.

Consumers are not encouraged to purchase appliances with higher efficiencies because salespeople are not able to adequately explain appliance energy labels. Because highly efficient appliances often carry a premium price, salespeople sometimes steer customers away from these appliances.

By helping the appliance industry develop programs that give cash incentives to sales personnel to sell more efficient models, DOE may be able to use its leverage to stimulate more sales of highly efficient appliances with minimal Federal resources.

Objective

- To ensure that consumers are informed and motivated to purchase highly efficient appliances.

Scope

- Establish generic education information on the benefits of energy efficiency.
- Generate targeted information on specific appliance options.
- Generate information targeted to specific industry groups on a range of appropriate technologies.
- Coordinate cooperative promotion campaigns by utilities, retail chains, manufacturer associations, trade groups and others.
- Support information, education and labeling programs related to accelerated retirement and replacement programs and other Federal policy options.

7. "Customer" Information and Education

In its effort to advance appliance energy efficiency beyond that required by Federal minimum standards, DOE can educate the public about the importance of energy efficiency.

- *DOE could work with the private sector and EPA to develop information and education programs that will expand consumer awareness of the economic and environmental benefits of energy efficiency and make energy-use comparisons between various appliances easier.*

Private sector stakeholders would like Federal assistance in creating demand for energy efficient products through a joint industry/government advertising campaign to promote the use of efficient products and to establish the link between energy efficiency and environmental protection.

- *DOE could work with EPA, utilities, and appliance manufacturers to coordinate a multi-year nationwide advertising campaign to broaden the market for energy efficiency and to link energy efficiency with responsible environmentalism.*

Perhaps the strongest message received from industry participants in the DOE workshops was that a nationwide Federal education and advertising program needs to be established. Because the Federal Government is an important third party and because its national advertising campaigns for other causes have had such a great effect, industry perceives the Federal Government's generic support of energy efficiency to be paramount to changing consumer demand.

The goal of the advertising campaign would be to make energy efficiency as much the "right thing to do" as recycling is today. The role of DOE and EPA would be to bring together the various parties and convey the benefits of supporting a "generic" energy efficiency campaign.

A national campaign would be too costly to be funded by the taxpayer. DOE would provide the leadership and direction for the advertising campaign; the utilities and industry would pay for the advertising time because they stand to benefit.

- *DOE could work to improve the information resources and decision-making tools available to consumers and utilities on appliance efficiency.*

Individual consumers and large institutional buyers need information about the relative energy efficiency of various products, as well as tools that will enable them to translate efficiency information to annual and lifetime cost differences. This information



must be presented in a useful form from a credible source. DOE and EPA can play a role in collecting and

Information Program

The EPA Green Lights program is aimed at advancing appliance energy efficiency by eliminating informational and institutional barriers to the more widespread use of highly efficient appliances.

The Green Lights program is based on "volunteerism"; getting "Green Lights Partners"—corporate, government, and non-profit organizations—to voluntarily commit to making all cost-effective lighting efficiency improvements within five years of becoming a Partner. EPA provides Green Lights Partners with recognition and information guides about energy efficient lighting.

disseminating this information and making the information analysis tools widely available.

DOE could coordinate a system of databases on energy efficient products. The database will include performance characteristics and information about the availability of products. Several organizations currently compile energy consumption information for a specific type of product, for a limited set of users, or on an *ad hoc* basis. But this information on energy efficient products is scattered, incomplete, and often inaccessible to the average buyer.

State energy offices also collect information on appliance energy efficiency, for various purposes, including compliance with efficiency standards, assistance in planning utility demand-side management programs, and outreach to potential purchasers.

DOE could lead a cooperative effort aimed at expanding and coordinating these existing efforts. In addition, an "Energy Efficient Product Data Network" could be implemented through voluntary agreements among existing and new providers of primary data or compilers of public and private databases.

This coordinated effort must also include cost-effective methods for disseminating information to users. Examples include print or electronic product directories; "electronic kiosks" in retail stores; automated toll-free "800" phone lines; fax-on-demand services in response to phone inquiries; information disseminated through regional centers; and catalogues highlighting preferred products of special interest to government and corporate buyers.

Conclusions and Specific Recommendations

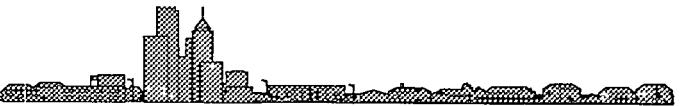
Research and analysis conducted by DOE have led to the following conclusions:

- *National and regional energy savings of at least one-half quad and environmental benefits in the form of greenhouse gas reductions can be achieved by expanding the market for highly efficient appliances already on the market and those that can be commercially available by the late 1990s.*
- *Cost savings of over \$3 billion per year and up to 30,000 jobs may be created nationwide.*
- *Numerous technical, economic, and market barriers hinder the realization of this potential.*
- *Potential collaboration partners believe Federal actions can have a significant, positive effect on the market by helping to remove these barriers.*

The key to DOE's success in accelerating the commercialization of highly efficient appliances will be the development of successful working partnerships with utilities, appliance manufacturers, state and local governments, other Federal agencies, energy service companies, consumer groups, and others in the building and appliance industry. This strategy will allow for a cost-shared, collaborative approach to market transformation.

Specifically, DOE's role as a catalyst should be molded around the following specific actions:

1. Forming industry/utility/government collaboratives directed toward applied research and technology development.
2. Demonstrating a Federal commitment to energy efficiency and lowering greenhouse gas emissions by providing the resources to support the working partnerships and by the conversion of all Federal facilities to highly efficient appliances.
3. Boosting consumer awareness and investment in more energy efficient and cost-effective appliances by conducting third-party evaluations and creating a general awareness of the benefits of highly efficient appliances and lending credibility to manufacturer product claims through analysis and laboratory and field testing.
4. Promoting a public awareness campaign which creates consumer preference for highly efficient appliances in conjunction with appliance manufacturers, retailers and wholesalers, utilities, energy service companies, and public interest groups.



5. Forming narrow interest partnerships with
 - specific retail organizations to create new marketing initiatives
 - individual product manufacturers to create new marketing initiatives; and
 - individual product manufacturers to support promising technologies.

DOE is uniquely positioned to lead this endeavor. Through years of working with industry on product development and standards and through its association with tangential efforts to raise product sales, DOE has gained substantial insight into the "profitable" opportunities associated with Federal investment to boost market acceptance of highly efficient technologies. It has developed sound relationships with industry and a credible position among consumers. As a result of its long-term research program, DOE has gained a singular perspective on the energy and environmental benefits of currently available products and those that will become available before the turn of the century. In preparing this report to the Congress, DOE has acquired a better understanding of the barriers and the knowledge to overcome them. DOE also has the ability and human resources to form the coalitions and collaboratives necessary to mount an accelerated market development program and the credibility and prestige among the market players to successfully implement it.

The process that led to the preparation of this report is a milestone in building successful public-private appliance partnerships. The effects of the process will continue long after the report's publication. DOE will use the findings and conclusions from the report in a cooperative effort with EPA, other Federal agencies, utilities, manufacturers, and other private sector partners. Together, the partners can generate cost-effective strategies for eliminating market barriers.

The Federal Government must work with market players who affect both the supply and demand of energy efficient appliances. DOE envisions an increased market demand for highly efficient appliances. In this market, manufacturers, utilities, and others will provide and support technologies that increase the number of advanced appliances available on the market and customers will be able to purchase in volume and use appliances that reduce energy consumption.

DOE is challenged with synthesizing and coordinating a number of programmatic measures to advance appliance energy efficiency. DOE is in the process of choosing a mix of market transformation projects that are based on the options identified in this report. For each project DOE will select candidate technologies based on performance capabilities, cost-effectiveness

nationally or regionally, and on the likelihood that a working partnership with the private sector can be arranged and would be productive. For each project, DOE will select an appropriate mix of options from the seven listed in this report. Perhaps the most significant goal of each of these projects, beyond energy savings and environmental benefits, is modifying consumer behavior patterns. A government program will only be successful if consumer purchases of highly efficient appliances increase to the point that each product's market sustains itself once external programs are terminated.

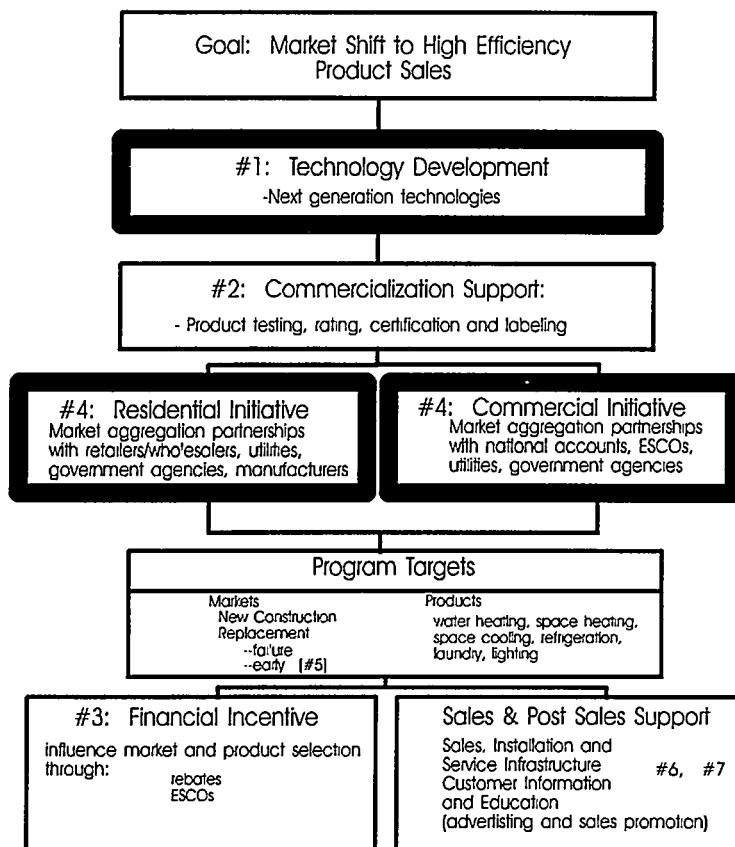
Therefore, in selecting technologies for specific projects DOE will follow five rules of thumb:

1. All technologies chosen will be cost-effective at present or would be able to become cost-effective if supported by a short or medium term incentive program;
2. Projects can be either regional or national depending on the expected benefits of their implementation and products will not be excluded from consideration by virtue of a national average cost analysis;
3. DOE will help promote appliances where energy savings benefits are great and where anticipated cost reductions and consumer education could lead to a sustainable market for the product;
4. DOE will support government, utility and other financial incentive programs that reduce first cost to consumer if such incentives are likely to result in benefits that exceed their costs and they are directed at technologies that have the potential to be viable without such incentives in the near future; and
5. DOE will participate in on-going or new partnerships where DOE may be the catalyst for action, but the role of its partners is to generate and fund cost-effective programs.

The basis for DOE's action will be the seven policy options listed under the Recommended General Actions section. Figure 4 illustrates the interaction of each of these seven programmatic measures described in the general recommendations section of this report. The bold numbers correspond to each measure. DOE believes its strongest role is in #1: **technology development**. It will continue advancing appliance technology that is not yet cost-effective or ready for market, but with significant opportunities for technological advancement. This will be done by helping industry develop new highly efficient products and by supporting performance testing, rating, certification and labeling programs for those that do not have large markets or whose energy benefits are not widely known. A major request made by industry and utilities



Figure 4: Highly Efficient Appliance Development and Commercialization Program



at each of the workshops was for DOE to provide clear and concise product and energy performance information to consumers, utilities, and others buying or providing financing for highly efficient products.

The second major DOE initiative will be as a catalyst to stimulate government and private sector market aggregation programs. Market aggregation is #4 on Figure 4. DOE believes that government and private sector market aggregation can rapidly increase sales of highly efficient products through volume purchase projects. These programs would target products that currently have only limited markets mainly because of cost barriers and for which expanded markets could reduce consumer costs. Through this initiative DOE will support government, utility and other financial incentive programs that reduce first costs to consumers. DOE will support entities interested in creating accelerated retirement/replacement programs by providing appropriate analysis. It will also encourage a knowledgeable and motivated sales, service and installation infrastructure who will stimulate selection, purchase and efficient operation of highly efficient appliances with small or no markets. Finally,

DOE will provide information and support efforts to motivate customers to purchase highly efficient appliances that are very cost-effective, but have limited markets but could be easily marketed.

DOE has the opportunity to work with the utility sector to strengthen existing utility incentive programs and to increase participation in demand-side management programs. Electric and gas utilities have started these programs to provide incentives to "pull" more energy efficient appliances into the market. DOE intends to help utilities strengthen the technical basis for incentive programs and provide sound field test data.

DOE intends to continue to support appliance manufacturers by providing cost-shared research and development funding and technical support. DOE can also establish information programs designed to stimulate consumer purchases of highly efficient appliances and help formulate strategies to address issues in international competitiveness. The appliance industry can, through collaboratives formed with DOE, reduce the risks involved when developing longer term, advanced products; increase the market demand for newer products through education and information efforts; and improve sustainable markets by lowering unit costs.

DOE intends to work with Federal and State government agencies and large national accounts to concentrate their purchasing power on the highly efficient appliance market, thus accelerating market penetration. It will also work with national buyers to form "buyer groups" that can rapidly increase the level of sales through large-scale purchase agreements. Emerging "technology procurement" programs are a model for utility/manufacturer/government collaboration. Existing collaboratives such as the Super Efficient Refrigerator Program and the Consortium for Energy Efficiency demonstrate that specially formed partnerships can stimulate sales and spur product development.

Finally, DOE intends to work with energy service companies and the mortgage industry to establish and strengthen private sector financial incentive programs. Although utility demand-side management programs



are currently the leading source of funding for energy efficiency, their uncertain duration makes other financing mechanisms desirable. Energy service companies are a prime example of "free market" programs that can sustain energy efficiency without Federal financing. The establishment of energy efficient mortgages and loans by the secondary and primary mortgage industry would also provide long-term financing for energy efficiency. DOE can provide technical support to help energy service companies better understand building energy interactions and technology performance and reliability, thereby helping to lower their risk. DOE can also develop and publicize guidelines for energy service companies that help consumers understand the energy services to be provided. In addition, other actions outside the above partnerships, dealing with broad issues such as infrastructure, information and communication will be initiated.

To date, DOE's appliance efforts have included longer term, basic and applied research; minimum efficiency standards and test procedures; and modest market stimulation through its Federal Energy Management Program. DOE research support has worked industry to develop some of the highly efficient products currently on the market. However, DOE has not previously engaged in a significant support effort to commercialize appliances.

To perform the functions outlined in this report, DOE will assemble a cadre of broad interest partnerships directed at:

- conducting applied research and technology development in conjunction with appliance manufacturers;
- measuring and validating the energy performance of many currently available and near-

term technologies and providing this information to Federal and state agencies, utilities and energy service companies for use in evaluating technologies;

- strengthening on-going market aggregation and transformation programs and providing seed funding to new initiatives; and
- stimulating market aggregation purchase actions by large national accounts, such as national hotel/motel chains.

DOE has received funding for such endeavors in FY 1995 and has requested additional funding in the FY 1996 department budget. DOE will not provide funding for financial incentive programs. Rather, it will help assemble the proper organizations and tools to expand existing and new private sector incentive programs.

DOE looks forward to working with its Federal, state, industry and utility partners to establish a broad, comprehensive national program for promoting appliance energy efficiency. Although DOE's goal of saving one-half quad of energy by the year 2000 may seem modest in relation to the overall potential, DOE expects to help create a sustainable market for emerging technologies that will eventually result in greater savings. According to industry, once a particular product attains a significant market share (commonly 10 percent for commercial building products and usually higher for residential products), it is considered to be part of an established market and will increase in sales accordingly. Through its market transformation program, DOE plans to stimulate many such products in the next several years so that highly efficient appliances will become a conventional piece of new building design or appliance replacement.