MARKETS FOR ENERGY EFFICIENCY:
DEVELOPMENT, CHALLENGES, AND OPPORTUNITIES
An analysis of the joint impacts of regulation and market forces on efficient residential and commercial end-use equipment.

by

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Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of

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ABSTRACT

The production of electricity has significant economic and environmental consequences, including the contribution of anthropogenic CO_2 emissions to Climate Change. The failure of existing agreements and the possibility of future global commitments has led to a detailed analyses of mitigation strategies for reducing US CO_2 emissions. Primary emphasis will be given to the "least regrets" strategies, those which have minimal economic costs and potentially significant CO_2 reduction potential.

One of the most desirable of these strategies is improving energy efficiency, reducing the amount of electricity used to achieve the same end-use. Energy efficiency can produce direct economic benefits through reduced participant expenditures on energy as well as yielding environmental benefits realized through reduced generation of electricity and the resultant associated environmental impact. The efficiency of existing end use technologies has gradually increased over time, spurred by numerous market and regulatory drivers. This gradual change in equipment stock over time can be classified as autonomous improvements in energy efficiency.

This thesis tests the view and demonstrates that the current trends in autonomous energy efficiency improvements will continue, that they are important, and that they are insufficient to meet stated US policy goals of greenhouse gas reductions. Furthermore, these trends illustrate what instruments can aid in improving the penetration rates of efficient end use technologies, if and when it is determined by policy makers that it is necessary to do so.

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1. INTRODUCTION

This thesis tests the view and demonstrates that the current trends in autonomous energy efficiency improvements will continue, that they are important, and that they are insufficient to meet stated US policy goals of greenhouse gas reductions. Furthermore, these trends illustrate what instruments can aid in improving US energy efficiency if and when it is determined by policy makers that it is necessary to do so.

The US has steadily reduced its energy intensity, measured as primary energy use per unit of GDP, as its economy has matured. Energy intensity improvements are caused by many factors, including technology change, demographic change, economic change, and behavioral change. This thesis focuses on technology change and resultant penetration of newer, more efficient residential and commercial end-use equipment. This gradual change of technologies over time can also be classified as autonomous improvements in energy efficiency.

Examining the penetration rates of new efficient equipment under existing market forces and drivers can teach important lessons for possible future actions directed at improving energy efficiency.

1.1 Definition & Benefits of Energy Efficiency

Energy efficient equipment consumes less energy than inefficient alternatives while delivering equivalent or greater energy services, such as lighting, heating and cooling. This thesis will only focus on cost-effective energy efficiency technologies, those whose energy savings exceed their incremental cost.

Energy efficiency can produce direct economic benefits and yield environmental benefits realized through reduced generation of electricity and the resultant associated environmental impact.

Energy efficient end-use equipment can have higher initial costs than less efficient alternatives. However, by installing cost-effective energy efficient equipment, consumers receive both direct and indirect benefits that exceed the additional incremental cost for efficient equipment. Reducing the amount of electricity needed to achieve specific end-uses produces direct bill savings through reduced operating costs. Some types of equipment have longer lifetimes than inefficient alternatives, reducing labor and replacement costs. These savings persist over the lifetime of the equipment installed, yielding impressive returns from the initial investment in energy efficiency. Some energy efficient equipment can also produce indirect benefits such as improved lighting levels and improved temperature comfort levels. By reducing their energy-related operating costs, businesses can reduce their costs and increase their profit margin, improving their competitive positions both nationally and internationally.

Energy efficiency also has potentially large macro-economic impacts. Decreasing energy costs allows consumers to spend or save significant amounts of money, increasing the total gross domestic product.

1.2 Background

The combination of the oil price shocks of the 1970s and the advent of Federal environmental regulations significantly altered the ways consumers and regulators viewed energy consumption.

Whereas energy, and specifically electricity, had been viewed as an intermediate good (as opposed to the final end-use) with declining costs and minimal external costs, the events mentioned above changed those assumptions, increasing the importance of improving energy efficiency.

Market forces had always factored into the penetration of energy efficient technologies. By reducing their energy costs, businesses could profit maximize or reduce their prices and increase their market share. However, if future electricity prices were expected to decline, the cost-effectiveness of efficiency improvements would decrease as the future value of energy savings declined. When faced with the prospects of stable or increasing energy prices, businesses began to focus more of their attention on reducing their energy inputs.

Early Federal efforts were aimed at reducing America's dependency on imported oil, and reducing the rate of fossil fuel resource depletion. These early efforts at energy conservation (reducing energy use at the expense of end-use) evolved into programs which encouraged energy efficiency, which yield net present value savings while reducing energy use. The recent efficiency-promoting regulations have focused on market-based solutions to encourage efficiency, thereby creating a self-sustaining industry which will continue to expand.

Increasingly strident environmental regulations have also affected the way consumers view electricity. The federal regulations targeted towards the environmental effects of energy consumption, particularly electricity generation, has forced consideration of the externalities (additional impacts) of energy consumption, particularly pollution. By reducing the amount of consumed energy, the costs associated with pollution are reduced.

1.3 Problems and Solutions for Energy Efficiency Markets

Despite the gradual improvement and the numerous benefits of energy efficiency, it is clear that the US has consistently under-invested in energy efficiency (EMF). There are several explanations for this phenomenon. There are numerous market imperfections which prevent the full penetration/adoption of energy efficient equipment. Foremost among these are barriers to information, uncertainty about quality and performance, and shorter discount rates for consumers, particularly in industry and commerce.

The conjunction of market forces, environmental concerns, and the associated federal regulations and programs have acted to promote the efficient use of energy and spur the growth of the energy efficient equipment market. Improved technological development of end-use equipment and certain existing governmental programs have helped address the barriers and market failures, increasing the penetration rates of energy efficient equipment. These programs show what has worked and provide insight on possible future actions to increase efficiency.

1.4 Global Climate Change

While Climate Change will not be specifically analyzed in this thesis, the policy implications are central to the topic of efficiency. The failure of existing agreements and the possibility of future global commitments has led to a detailed analyses of mitigation strategies for reducing US CO_2 emissions. Primary emphasis will be given to the "least regrets" strategies, those which have minimal economic costs and potentially significant CO_2 reduction potential.

One of the most desirable of these strategies is improving energy efficiency. This thesis will demonstrate what the impacts of autonomous energy efficiency improvements has and will be by 2001 on US Carbon Emissions. While insufficient to meet the US stated goal of reducing Carbon Emissions to 1990 levels by the year 2000, these efficiency improvements have had a significant impact both on bill and emission reductions.

1.5 The Markets for Energy Efficient End-Use Equipment

This thesis will identify and analyze the spectrum of energy efficient products for the residential and commercial sectors, by major end-use category. It will cover lighting technologies, heating ventilation and air conditioning (HVAC) equipment, appliances, and other energy saving technologies. It will present a disaggregated, or 'bottom up', picture of the markets for energy efficient end-use equipment by quantity and value. A brief discussion of the international markets for energy efficiency is also presented.

This bottom-up approach sheds light on individual technologies, presenting an accurate picture of the penetration rates of specific energy saving technologies that will contribute to the predicted improvement in overall US efficiency. It also permits an analysis of specific current and future governmental actions which can spur their widespread adaptation. This disaggregated analysis reveals the specific economic and environmental impacts of efficient end-use equipment in the US.

As the following table shows, the market for energy efficient equipment is extremely robust, and is expected to continue to grow through the year 2001, and is expected to increase at an average annual growth rate (AAGR) of over 7 percent.

TABLE 1.1
TOTAL VALUE OF ENERGY EFFICIENCY MARKET
($millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Lighting	NA	1,346	1,566	1,577	1,789	1,943	3,676	11.8 (1992-2001)
Appliances	10,650	11,155	11,879	12,673	13,008	13,742	18,931	5.9
HVAC	5,722	6,149	6,550	7,849	8,389	9,292	15,739	10.6
Other	7,298	7,449	7,610	7,773	7,935	8,093	8,922	2.0
TOTAL	23,670	26,099	27,605	29,872	31,121	33,070	47,268	7.2

source: US Dept. of Commerce, Bureau of the Census, Author

1.6 Summary

Autonomous energy efficiency improvements (AEEI) have significantly reduced consumer's energy costs and potential US Carbon Dioxide emissions. The combination of market forces and regulations have combined to produce a self-sustaining drive to improve efficiency. While the US will not meet its stated policy goal of reducing carbon emissions to 1990 levels, the use of efficient equipment has had a significant impact in reducing electricity and natural gas use and associated pollution.

TABLE 1.2
ELECTRICITY SAVINGS FROM THE USE OF ENERGY EFFICIENT END USE EQUIPMENT
(billions kWh)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Lighting	NA	22.7	48.3	78.2	96.4	101.0	184.4	26.1 (1992-2001)
Appliances	6.2	13.0	22.3	32.9	42.3	52.5	115.4	33.8
HVAC	6.4	14.0	22.3	31.9	41.8	51.1	111.5	33.0
Other	7.9	16.0	24.4	33.0	41.9	51.	101.9	29.1
TOTAL	20.5	65.7	117.3	176	222.4	255.6	513.2	37.9

source: US Dept. of Commerce, Bureau of the Census, US EPA, Author

TABLE 1.3
GAS SAVINGS FROM THE USE OF EFFICIENT EQUIPMENT
(billion Btu)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Appliances	15,966	30,446	48,670	67,662	84,856	102,540	198,812	28.7
HVAC	41,140	83,280	134,980	188,920	240,940	296,325	631,873	31.4
Other	3,100	6,500	10,500	14,900	19,700	25,300	63,700	35.3
TOTAL	60,206	120,226	194,150	271,482	345,496	424,165	894,385	31.0

source: US Dept. of Commerce, Bureau of the Census, US EPA, Author

These savings will reduce US carbon emissions by 82.7 million metric tons per year by 2001, and will save consumers over $37 billion per year in reduced energy expenditures.

Increased governmental programs aimed at improving the penetration rates of efficient technologies will only further improve efficiency, particularly if they utilize the lessons learned from existing programs.

CHAPTER II

2. EXISTING ELECTRICITY USE, OVERALL SAVINGS, & MARKET FAILURES

In order to properly assess the impacts of energy efficiency improvements, a detailed study of how electricity is consumed is necessary. The following chapter presents residential and commercial electricity consumption patterns by end use, allowing for accurate calculations of potential savings from efficiency improvements.

This chapter also presents estimates on the total US potential savings from energy efficiency improvements. These estimates, although they contain a great deal of uncertainty, demonstrate that improving energy efficiency can meet or exceed stated US policy goals of reducing CO_2 emissions. Analysis of overall improvements in energy intensity are also presented.

Despite the benefits from improving energy efficiency and the gradual improvement in overall energy intensity, the US has consistently underinvested in efficient end-use equipment. In order to correct this problem, an understanding of the market barriers and market failures is necessary. Effective regulatory solutions can only be crafted by correctly diagnosing the problems in the efficiency marketplace.

2.1 US Electricity Use

United States is the world's largest total consumer of electricity both nationally and per capita. In 1995, the latest year of statistical data to be released, US sales of electricity increased 2.7 percent to 3,013 billion kilowatt-hours (kWh) (EIA7). Residential energy use increased to 1,043 billion kWh, or 35 percent of total US electricity use. Commercial use increased to 863 billion kWh, or 29 percent of total US demand. Industrial and other sectors (including governmental) energy use was 1,108 billion kWh, or 37 percent of total demand (EIA7).

The environmental impacts were equally large. Air emissions from electric utility operated fossil-fueled steam electric plants were estimated at less than 12 million tons of sulfur dioxide (SO2), 7 million tons of nitrogen oxide (NOx), and 1,968 million tons (1.9 gigatons) of carbon dioxide emissions. The total amount of SO_2, NOx, and CO_2 emissions decreased from 1994 levels. This decrease is mostly due to utilities' efforts to comply with the Clean Air Act Amendments of 1990 (EIA 7).

The total revenue received from consumers was $208 billion in 1995. The total average rate was 6.89 cents/kWh (EIA 7).

2.1.1 Electricity End-Use

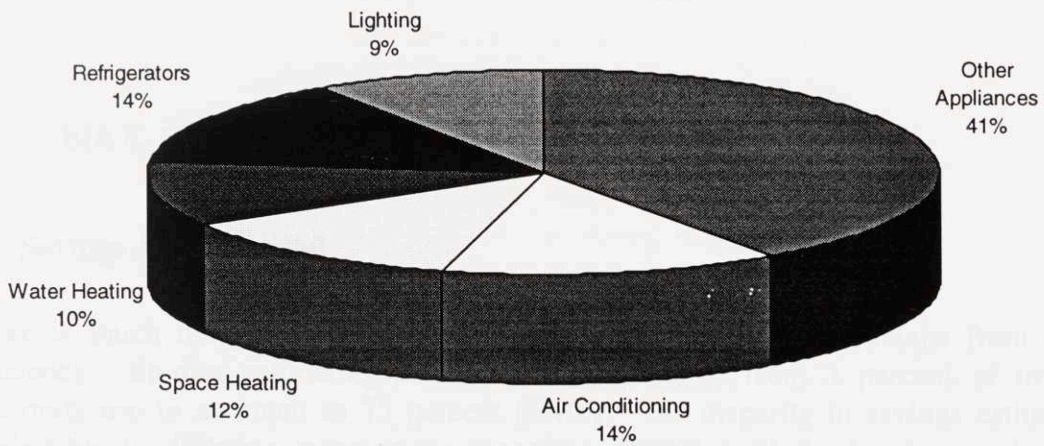
Energy, specifically electricity, serves a wide range of end use needs such as lighting, heating, cooling, and operating a variety of appliances.

RESIDENTIAL

The largest use of electricity in the average US household is for appliances, which consume over half of all electricity consumed by the residential sector. Lighting, heating, cooling, and water heating consume the remainder. The following chart presents residential end-use consumption.

CHART 2.1

Percent of Total Residential Electricity Consumption



source: EIA 3, 1995

No single appliance dominates residential electricity consumption. Televisions consume 7.4 percent of the average electricity use, clothes dryers use 5 percent. Freezers use 4.4 percent and ranges and ovens use 2.8 percent of the total, with other appliances representing 20.7 percent of electricity consumption.

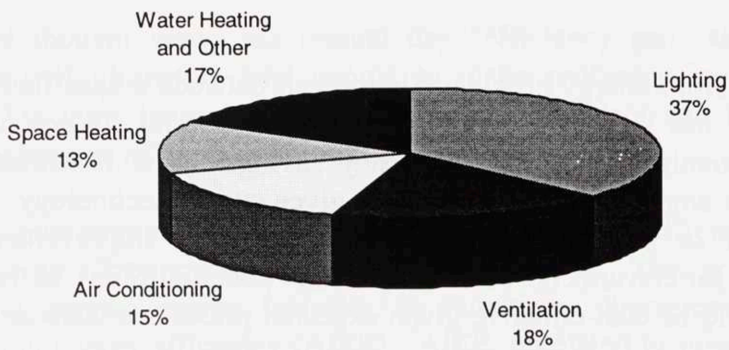
Natural gas is used predominantly for space heating and water heating. Space heating accounts for about 70 percent of all household consumption of gas while water heating accounts for 25 percent. Total household consumption of gas was 5,274 trillion Btu in 1993 (EIA 3).

COMMERCIAL

The largest use of electricity for the commercial sector is lighting. For some types of facilities, lighting can account for more than 50 percent of total electricity consumption. The following chart presents commercial electricity consumption by end-use.

CHART 2.2

Percent of Total Commercial Electricity Consumption



source: EIA 8, 1995

2.2 Savings And Potential

There is much disagreement over the actual total potential for savings from energy efficiency. Studies estimating electricity savings range from 3 percent of total US electricity use to as much as 75 percent (EMF). The disparity in savings estimates is attributable to differing assumptions regarding definition of the baseline and savings potential, differing estimates of penetration rates for new technologies, and different assumptions regarding consumer behavior.

The following table presents the results of several studies on the potential of energy efficiency for reducing US carbon dioxide emissions from all energy sources.

TABLE 2.1
PERCENT REDUCTION IN CO_2 EMISSIONS FROM ENERGY EFFICIENCY

STUDY	Americas Energy Choices	National Academy of Sciences	Office of Technology Assessment	Alternative Energy Future
year for estimate	2010	1989	2015	2010
Residential and Commercial Sectors	28	52	30	22

source: EMF, 1996

The potential savings from energy efficiency is the gap between a specified benchmark and the lower energy use if certain conditions prevail. Several studies use different definitions of the potential for energy efficiency savings. The maximum technical potential is the highest amount of savings possible given current technology. This figure should only be used as a policy goal, as many efficiency improvements are not economically feasible for consumers. Techno-economic potential refers to the maximum conservation that would be cost-effective given expected prices and costs and consumer behavior.

The selection of the benchmark can be a key determining factor in estimating the potential savings from efficiency. Some studies use the current electricity consumption patterns as the benchmark, and calculate future savings based on replacing old equipment. Some studies attempt to incorporate future technological improvement in end use equipment and calculate potential based on the incremental gains from improving efficiency over what would have been achieved in the absence of increased efficiency-promoting efforts. Large estimates of efficiency potential have been criticized because of their dependence on low discount rates and their omission of hidden costs.

Based on observed historic behavior, consumers appear to be strongly influenced by the initial equipment costs. This behavior is sometimes approximated in energy system models by using an investment hurdle rate (rate of return required), which can range from 20-40%. There is a wide disparity between hurdle rates among studies estimating efficiency potential, which can significantly affect total potential figures. This behavior is partially attributable to consumers evaluating efficiency investments based on a "payback period," whereby investments which do not pay for their initial cost within a specified period are not pursued. This type of investment planning strategy ignores projects which produce large amounts of savings over the long run, and causes many positive net present value investments to be passed over.

Efficiency improvements may not lead to equivalent reductions in energy use, as improved productivity may be a source of economic growth and resultant increased use in electricity. This is known as the rebound, or snap-back, effect. How much rebound exists from specific efficiency gains is an empirical issue that has yet to be resolved.

Energy system model analyses have shown that the projected declines in energy intensity are not dependent on increasing prices for electricity over the short to medium time horizon. Under scenarios which incorporated prices increasing by 25% over a 20 year time period, mid-term energy demand only declined 3-8% (EMF). There are several factors which explain this behavior. The primary explanation is that many energy consuming types of equipment have long lives, and will only be replaced when their useful lives are over. This produces a lag between the efficiency of installed products and the efficiency levels of new equipment.

One school of thought views the present day “efficiency gap” as transitory because market forces will ultimately lead people to make profitable investments in energy efficiency. This view ignores the very real market barriers and market failures that prevent full realization of these opportunities.

Despite the controversy over the actual potential for energy efficiency, it is clear that overall US energy efficiency has been steadily improving. This gradual improvement, measured by aggregate energy intensity, is sometimes characterized as autonomous improvements in energy efficiency (AIEE). AIEE, unrelated to price, reflect equipment change and shifts in consumer choices and activities. Estimates of declines in US aggregate energy intensity range from .6% to 1% per year (EMF). This decline is due to technological advancements, end-use shifts, fuel substitution, capital turnover, slower growth in certain activities, and the effects of efficiency standards.

2.3 Market Barriers/Market Failures

Many obstacles prevent the full adoption of all cost-effective investment in energy efficient end-use equipment. These obstacles can be separated into two categories; market barriers and market failures.

Market barriers are obstacles to investment. These barriers are present in the markets for energy efficient end-use equipment. They include risks and uncertainties about future energy costs and the related cost-effectiveness of efficiency investments, concerns about technical performance, and costs of adoption such as shut down costs (EMF). Although market barriers do increase the actual costs of investments in energy efficiency, they do not explain the large gap in potential and actual energy savings from efficiency improvements.

Market failures prevent consumers from making economic purchasing decisions. The markets for energy efficiency contain several such failures, including: imperfect information, improper discounting of future savings and short planning horizons by consumers, split incentives, and improper pricing of electricity.

Failures associated with information occur when consumers are not made aware of the full costs and benefits of the end use equipment they are purchasing. Without reliable information on future benefits, consumers may purchase equipment based only on initial cost, ignoring energy efficient options which could save more in the long run.

When evaluating equipment options, consumers may discount savings from energy efficient equipment at improperly high rates due to lack of true information on cost savings. By discounting future savings, the higher initial cost of efficient equipment may lead to inefficient purchasing decisions.

Some businesses use an arbitrary cut off date, or "pay-back period", during which savings from efficient equipment must equal the incremental cost of the efficient product. By evaluating projects on this criteria, businesses seek to minimize the risk of their investments, and undervalue future energy cost savings. Such business practice eliminates many efficient alternatives which could produce savings for long periods of time. When an artificial planning horizon such as a pay-back period is used to make project decisions, there is an under-utilization of economic energy efficiency resources.

There are numerous cases where equipment purchasing decisions are separated from energy use considerations. This creates a market failure because the purchase was made based only on initial cost while the user would have selected equipment with lower life-cycle costs (which include energy savings). This type of market failure can occur for certain types of new construction, where the contractor is choosing the equipment but the owner pays the bill. They also occur in the "landlord/tenant" situation, either where the landlord chooses the equipment but the tenant pays the bill or where the tenant chooses the equipment but the landlord pays the bill (EMF).

There is also a market failure associated with the proper pricing of electricity. Prices charges by electric utilities do not reflect the true total costs of generating electricity. These costs include environmental externalities and other externalities such as energy security risks. The exclusion of these costs will cause consumers to over-consume electricity because they are not charged the full costs, resulting in a sub-optimal situation where society must absorb the dead weight loss associated with the external costs (i.e. pollution) of electricity consumption. If consumers faced the true costs of electricity, the cost effectiveness of efficiency improvements would increase and overall energy intensity would improve.

2.4 Summary

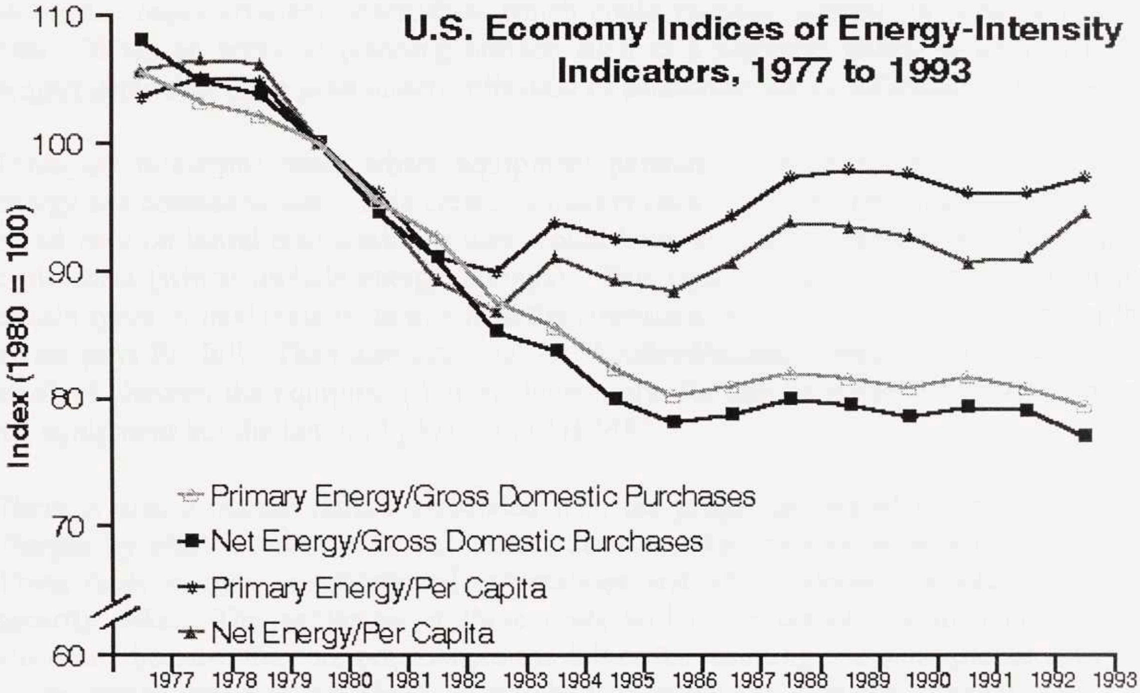
Despite the benefits of investing in energy efficiency, market barriers and failures have prevented the adoption of all cost effective energy efficient end use equipment, leading to an efficiency gap. However, the energy efficiency industry has continued to grow due to the strength of numerous drivers, both market-based and regulatory. Recognizing and understanding the forces which prevent full adoption of efficient end use equipment will allow for effective regulations to be crafted, increasing the rates of autonomous improvements in energy efficiency.

CHAPT III.

3. FORCES DRIVING EFFICIENCY

There are many forces which are driving the markets for energy efficiency and which are aimed at mitigating and overcoming the various market barriers and market failures discussed in Chapter II. These forces include price-related market forces, increasing environmental concerns, policy-driven regulatory actions designed to address energy efficiency market barriers and failures, and technological improvements in end use equipment. All of these forces have increased improvements in energy efficiency, as measured by energy intensity.

CHART 3.1



Note: Gross Domestic Purchases used to develop the indices is in constant 1987 dollars.
Sources: Energy Informaation Administration, Office of Energy Markets and End Use, *Annual Energy Review 1993*, U.S. Department of Commerce, Bureau of Economic Analysis, National Trade Data Bank, National Income and Products Accounts, Quality Series.

As Chart 3.1 demonstrates, the US has gradually reduced its energy consumption per unit of economic growth, most significantly between 1977 and 1983, but more gradually since then. One of the critical factors in this improvement has been technology change and capital turnover of end-use equipment.

There are several factors which truly influence the rate of long term technical change, the true measure of autonomous energy efficiency improvements. They are:

- savings produced through concentrated research and development efforts,
- mid-term price induced energy saving substitution behavior, and
- policy-induced energy savings.

This thesis concentrates on the latter two factors.

3.1 Market Forces

One of the most significant driving forces in the markets for energy efficient equipment is the costs of electricity. While improving efficiency is always good business practice, the directed improvement in energy efficient end use equipment has its roots in the 1970s. The OPEC induced oil price shocks of 1973 and 1979 had a tremendous impact on US electric utility practices. Electric utilities were able to steadily reduce the average costs of electricity throughout the 1950s and 60s. When electricity prices were falling, consumers had little incentive to improve their energy efficiency, especially if the value of future savings was constantly decreasing. The events of the 1970s radically changed those expectations. Faced with significantly higher oil prices and faulty demand forecasts, electric utilities over-invested in costly alternative sources of power. This caused the real price of electricity to significantly increase during the 1970s and 80s.

Increasing electricity costs (price times usage) forced consumers to account for the efficiency of equipment when making purchasing decisions. Higher electricity prices led to increased cost-effectiveness for investments in energy efficiency, and the resultant increase in the markets for energy efficient end-use equipment.

3.2 Environmental Concerns

Increasing awareness of the environmental impacts of energy consumption has also served to increase the use of efficient end use equipment.

3.2.1 Clean Air Act and Amendments

Awareness of the environmental effects of electricity generation also increased in the 1970s. Whereas the states were previously responsible for environmental regulations, the passage of the Clean Air Act of 1970 ushered in a new era of Federal environmental stewardship. Recognizing that broad solutions were required to address the environmental impacts of energy consumption, the Clean Air Act included numerous provisions designed to reduce the amount of related pollution. The Act and its amendments (1977, 1990) significantly influenced the planning and practices of electric utilities.

The Clean Air Act (CAA) and Amendments of 1990 (CAAA) regulate the total amount or the concentration of certain pollutants, pollutants which are byproducts of electricity production. The regulation of Sulfur Dioxide (SO_2), Oxides of Nitrogen (NOx), and limits on the concentration of tropospheric ozone (O_3) have impacted electric utility practices. To meet federal and local regulations, electric utilities are faced with potentially expensive improvements and upgrades to their generators. The costs of combustion modifications, fuel switching, and end of stack pollution control equipment can significantly affect operating costs. One of the differences in the later amendments was an increased reliance on market forces to achieve the same regulatory goal. By shifting away from traditional command and control style regulation, Congress created new mechanisms which allows for businesses to reduce certain types of pollution in the most cost effective way possible.

One of these cost effective means of reducing pollution concentration levels is through energy efficiency. By encouraging efficiency and reducing the associated environmental impacts of electricity generation, electric utilities can avoid more costly investments in pollution control technology. One study found that an electric utility company could use energy efficiency to reduce its CAAA compliance costs by $96-131 million by reducing demand and the associated emissions (Levin).

3.2.2 Global Warming and Climate Change

The threat of global climate change has also increased the attractiveness of energy efficiency to policy makers.

Greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_2) trap reflected infrared heat in the atmosphere, and can increase atmospheric temperatures. These temperature changes could lead to numerous potentially disastrous consequences such as an increase in sea level, a shift in precipitation with its associated agricultural impacts, increased number and severity of hurricanes, typhoons, tidal waves, drought, flooding and other extreme weather phenomena.

The atmospheric concentration of greenhouse gases has steadily increased over the last century. This increase is attributable to increased anthropogenic activity, particularly fossil fuel consumption. The Intergovernmental Panel on Climate Change (IPCC) concluded that continued accumulation of anthropogenic greenhouse gases in the atmosphere would lead to climate change whose rate and magnitude would likely have important impacts on natural and human systems (IPCC). Because carbon dioxide is an unavoidable byproduct of fossil fuel consumption, energy use has a direct impact on the rate of accumulation of greenhouse gases.

Because energy efficiency is a low/no cost mitigation measure, it has been embraced as a key element in the US governments commitment to reduce GHG emissions. Numerous actions and programs have been initiated to increase efficiency and reduce resultant GHG emissions, as presented in section 3.5.

3.3 Regulatory Actions

One of the key driving forces in energy efficiency markets has been direct Federal regulations targeted towards enhancing the markets for energy efficiency. These regulations have addressed a variety of market barriers preventing full adoption of cost effective energy efficiency. They have increased the amount of available information on energy efficiency (Energy Policy And Conservation Act), addressed some of the split incentives present in new building construction (Energy Conservation Standards for New Buildings Act), and have affected the market for appliances by banning the production of certain inefficient products (National Appliance Energy Conservation Act and the Energy Policy Act). By eliminating the low-end of efficient products, these regulations will save consumers an estimated $22 billion through the year 2000 and reduce emissions by over 50 million tons of carbon dioxide and 750,000 tons of nitrogen oxide (EPA1).

Government-sponsored research has also impacted the markets for energy efficient devices. According to the Congressional Research Service, the Federal Government has spent a total of $5.7 billion on energy efficiency research and development since 1973. This research has spurred technological advances that have saved American homeowners and businesses $226 billion, and will save billions more over the lifecycle of the efficiency improvements (Sustainable Energy Budget Coalition).

3.3.1 Energy Policy And Conservation Act Of 1975

The Energy Policy and Conservation Act of 1975 ("EPCA") established an energy conservation program that included test procedures, appliance labeling, and minimum efficiency standards. EPCA included standards for refrigerators, air conditioners, heatpumps, furnaces, dishwashers, clothes washers and dryers, direct heating equipment, kitchen ranges and ovens, water heaters, pool heaters, television sets, and fluorescent lamp ballasts.

This legislation required all major appliances to show the yearly energy costs of operation on a black and yellow EnergyGuide label. The EnergyGuide figures are based on the estimated annual amount of energy needed to operate the appliance and the national average electricity rate. The label also displays the estimated annual cost of the model compared with the lowest and highest available models, allowing for easy comparison. The EnergyGuide labeling system allows for transparency in energy consumption comparison. Consumers now have easy-to-understand information to use in their appliance purchasing decisions.

3.3.2 The Energy Conservation Standards For New Buildings Act Of 1976

This act required new Federal buildings to meet building energy performance standards. These standards covered several aspects of construction designed to improve the energy efficiency of new facilities. The standards were voluntary for residential and commercial buildings. Most of the states have implemented their own building codes covering energy efficiency for new construction.

3.3.3 National Appliance Energy Conservation Act

In 1987, the US Congress passed the National Appliance Energy Conservation Act (NAECA). In 1988, Congress added the National Appliance Energy Conservation Amendments. These pieces of legislation established minimum standards of energy efficiency for major appliances. Appliances covered by NAECA include refrigerators and freezers, air conditioners, lamp ballasts, incandescent reflector lamps, clothes washers and dryers, dishwashers, kitchen ranges and ovens, pool heaters, television sets (standards which were later dropped), and water heaters.

3.3.4 Energy Policy Act Of 1992

The Energy Policy Act of 1992 ("EPACT") added standards for some fluorescent and incandescent reflector lamps, plumbing products, motors, commercial water heaters and HVAC systems. It also allowed for the future development of standards for many other products. The Department of Energy has been instructed to periodically update the standards (EREC).

One of the most significant measures in EPACT is a ban on the production of certain lamps. Specifically, certain 8-foot fluorescent lamps with less than 80 lumens/watt, certain 4 foot and U-shaped lamps, and certain inefficient incandescent reflector lamps can no longer be produced after 1995.

Additionally, EPACT requires that every state meet or exceed minimum established energy codes for commercial buildings. Such codes can include requirements on lighting efficacy and other efficiency standards such as minimum lighting controls. The proposed revised standard also includes a table indicating maximum power densities (watts/square foot) for various space and function types.

3.3.5 Recent Regulatory Developments

Congress had enacted a one year moratorium (effective April 1996) on the promulgation of new appliance standards to address the concerns about the potential effects of updated efficiency standards on consumers, manufacturers, and workers. The Department of

Energy worked with members of the appliance community and examined the impacts of the appliance program. They made several improvements to the previous rulemaking procedure for issuing new appliance standards, including:

- earlier involvement of stakeholders
- increased predictability of the rulemaking timetable
- increased use of outside technical expertise
- earlier elimination of impractical design options
- more in-depth analysis of impacts
- use of more transparent and robust analytical methods
- support of efforts to build consensus
- greater consideration of non-regulatory approaches
- establishment of an Advisory Committee on Appliance Efficiency Standards

(EPA1)

These improvements addressed Congressional concerns and allowed the continuation of the promulgation of new standards as required by EPACT, including the new efficiency standard for refrigerators that was announced in April 1997. It was estimated that consumers lost $2 million per day for every day the new refrigerator standard was delayed (Energy Conservation News).

3.4 Integrated Resource Planning

One of the most significant drivers for energy efficient equipment was the advent of integrated resource planning by electric and gas utility companies. Pioneered by Amory Lovins in the 1970s, integrated resource planning significantly altered how electric utilities planned to meet US energy demand.

In the 1970s, US electric utility's costs of generating electricity rapidly rose after decades of gradually decreasing energy costs. These cost increases were caused by high oil prices resulting from the OPEC-related oil price shocks, and by the rising costs of nuclear energy. Utility companies repeatedly requested rate increases from their state utility commissioners to cover their increasing costs of operation.

Integrated Resource Planning was a new regulatory framework that allowed the utility companies to consider both supply side and demand side options when planning to meet future energy demand. Supply side options include traditional new generating capacity. Demand side options were programs and technologies that reduced energy use at costs less than the incremental cost of generating new electricity. Utilities could now either build new power plants to meet rising demand, or they could promote energy efficiency through demand-side management programs ("DSM"). Energy efficiency would create savings- "negawatts"- which would be used to meet rising demand. Cost effective programs could save energy at per kWh rates that were significantly lower than the projected costs of building new power plants, keeping rates lower than they would have been in the absence of energy efficiency programs. DSM programs would also remove the need for costly and contentious siting hearings for new plants.

By comparing both supply and demand options and choosing the combination with the lowest cost, least cost integrated resource planning allowed utility companies to meet demand while saving hundreds of millions of dollars in avoided costs. These costs include electricity generation, fuel purchases, costs of transmission and distribution, line losses, and capacity and infrastructure expansion (Levin).

Demand side management programs encompass a wide array of activities designed to improve energy efficiency. DSM programs include informational programs on energy efficient products, promotional efforts for certain products and/or services, rebates for energy efficient equipment to lower the up-front costs and improve profitability, and other market transformation activities. These activities have had a large impact on the penetration of efficient end-use equipment.

From 1990 to 1995, utility investments in DSM grew to over $2.5 billion per year. (EIA 2) at costs much lower than the cost of generating electricity. One survey found that DSM programs save electricity at an average cost of 2.1 cents per kWh, while reducing annual electricity use by 2 percent nation-wide (Hadley & Hirst). In 1996, US utilities spent an estimated $2.2 billion on DSM programs (EIA 12).

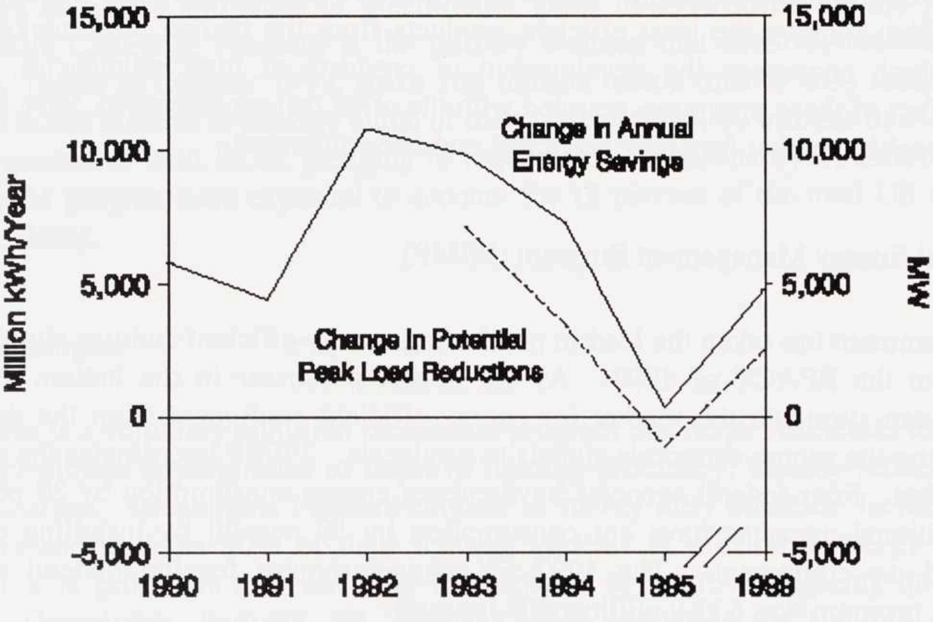
TABLE 3.1
US ELECTRIC UTILITY DEMAND SIDE MANAGEMENT PROGRAMS
PROGRAM ENERGY SAVINGS AND COST
(savings in millions kWh, cost in $1,000,000s)

	1991	1992	1993	1994	1995	1996	2000
Energy Savings	24,848	35,563	45,294	52,483	57,421	63,138	79,340
Cost	1,804	2,348	2,744	2,716	2,421	2,243	2,258

source: EIA 2, 1996, EIA 12, 1997

The following chart presents actual and projected changes in energy savings from demand side management programs.

CHART 3.2
CHANGES IN DSM-INDUCED ENERGY SAVINGS



Source: EIA 2, 1996

The dip in the growth rate for DSM-induced savings is attributable to the effects of restructuring on electric utility practices. Although DSM spending is not projected to significantly increase, it is projected to continue to significantly contribute to increasing energy efficiency. A more detailed analysis of this trend is presented in Chapter V.

3.5 Government Programs

Numerous government programs have directly or indirectly spurred the markets for energy efficient end-use equipment. These programs are a combination of market push programs, which remove the least efficient products from the market, and market pull programs, which encourage the development of products of high efficiencies. The combined effect of these programs, coupled with the other drivers discussed, have served to nurture a healthy market for energy efficient end-use equipment.

3.5.1 Federal Energy Management Program (FEMP)

The US government has taken the lead in purchasing energy-efficient end-use equipment, as laid out in the EPACT of 1992. As the largest purchaser in the nation, the US government can stimulate the market for energy efficient equipment from the demand side by sending the proper economic signals to producers. FEMP coordinates the energy reduction effort. Four federal agencies have cut net energy consumption by 20 percent, and six additional agencies have cut consumption by 10 percent by installing energy efficient end-use equipment. The 1997 FY budget request for the Federal energy management program was $31.9 million (EE Journal).

3.5.2 Low Income Home Energy Assistance Program

The Low Income Home Energy Assistance Program (LIHEAP) provides block grants to states, territories, and Indian tribes to fund low income energy assistance programs. These programs assist low-income households by providing energy-saving weatherization equipment or other energy-related home repair. These programs may take the form of cash payments, vouchers, or payments to a third party. In FY 1997, $1 billion was designated for LIHEAP (NE/Mid-West Institute).

3.5.3 US DOE Weatherization Assistance Program

Since its inception in 1976, this program has lowered the heating energy costs of 4.4 million homes by an average of 18.2 percent, saving the equivalent of 12 million barrels of oil. In fiscal year 1997, the WAP is budgeted at $120.8 million (NE/Mid-West Institute). Weatherization assistance takes the form of improved insulation, weather-stripping, and other energy saving technologies (Ogden).

3.5.4 US DOE Climate Challenge Program

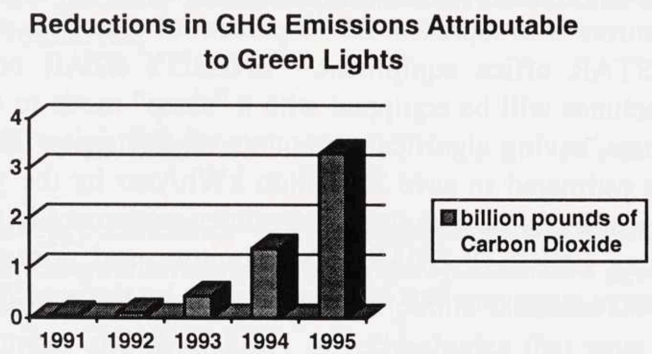
As part of the United Nations Framework Convention on Climate Change, the US has committed to reduce emissions of green-house gases to 1990 levels by the year 2000. The Climate Challenge Program is the primary element that involves electric utilities. The plan, issued in October 1993, seeks 108 million metric tons of CO_2 reductions and calls on electric utilities to provide much of them. As of 1995, 79 utilities had voluntarily signed agreements with DOE, pledging to reduce CO_2 emissions by 41 million tons by 2000. DSM programs are expected to account for 18 percent of the total US reductions (Clinton, Gore).

3.5.5 Greenlights

Greenlights is a voluntary pollution prevention program that helps businesses identify and achieve profitable opportunities to improve lighting efficiency, thereby reducing power plant emissions. Greenlights Partners commit to survey their domestic facilities within five years and upgrade 90% of their lighting systems to maximize energy efficiency wherever it is profitable and wherever it maintains or improves lighting quality. On average, Greenlights Partners are realizing 46% reduction in lighting electricity consumption and returns on their investments of 40% or greater. EPA provides technical support to participants, as well as employee education and public recognition for participant's environmental contribution.

The program began in 1991. By 1996, over 2000 participants had upgraded their lighting systems. These upgrades reduced electricity use by more than 2 billion kWh/year, preventing over 3.3 billion pounds of Greenhouse gas emissions per year while saving more than $172 million per year in reduced operating costs (EPA 2).

CHART 3.3



source: EPA 2, 1996

EPA plans to increase the number of participants to 6,000 by the year 2000. This would yield an annual estimated electricity savings of 30.5 billion kWh, reducing greenhouse gas emissions by 7.5 million metric tons (EPA 2).

3.5.6 ENERGY STAR Buildings

ENERGY STAR buildings is a comprehensive energy efficiency program for commercial facilities that includes lighting and air distribution, heating, and cooling equipment. The ENERGY STAR buildings program is a five stage upgrade strategy that capitalizes on system interactions to maximize energy savings and minimize equipment costs. The first stage is for buildings to participate in the green lights program and install energy efficient lighting. Stage two includes checking and adjusting building systems and developing and implementing an ongoing, preventative maintenance program. During stage three, participants are advised to install window films, roof coverings and insulation, and to purchase energy star office equipment. Stage four is the appropriate time to upgrade variable air volume systems with variable speed drives, reduce fan system oversizing, and replace motors with smaller higher efficiency motors. In the final stage, participants are ready to replace or upgrade chillers, pumps and compressors, and replace electric resistance heat where possible. In its first year (1995) 71 organizations joined the ENERGY STAR buildings program. This number increased to 137 by 1997. For the next five years, EPA has set a goal to increase membership to 3,500 participants. This would reduce electricity consumption by an estimated 12 billion kWh, reducing green house gas emissions by 3.1 million metric tons (EPA 2).

3.5.7 ENERGY STAR Office Equipment

Office equipment accounts for 7 percent of commercial electricity consumption. Research shows that much of this energy is wasted. Computers are only used for an average of four hours per day, and 30-40 percent are left running on nights and on weekends. EPA has signed partnership agreements with industry-leading office equipment manufacturers who represent 85-95 percent of the office equipment market to market ENERGY STAR office equipment. ENERGY STAR computers, monitors, printers, and fax machines will be equipped with a "sleep" mode to automatically power down when not in use, saving significant amounts of electricity. The use of ENERGY STAR computers is estimated to save 22 billion kWh/year by the year 2000. The US government, the largest buyer of computer and printer equipment in the world, has taken the lead in purchasing ENERGY STAR PCs, monitors, and printers, projected energy reductions that will save taxpayers $40 million annually by the year 2000.

3.5.8 ENERGY STAR Central Air-Conditioners, Air-Source Heat Pumps, Geothermal Heatpumps, Furnaces And Boilers

EPA has launched a new series of ENERGY STAR programs designed to encourage the purchase of energy efficient HVAC equipment. The programs are a series of voluntary partnerships between EPA and manufacturers of HVAC equipment. The goal is to encourage widespread demand for high-efficiency products. The ENREGY STAR label will designate products that are "highly efficient". ENERGY STAR labels on air source heat pumps and air conditioning units are at least 20 percent more efficient that products currently meeting the minimum Federal Government standards. ENERGY STAR furnaces are in the 90-96 percent efficiency range. EPA is working with manufacturers, financial institutions, HVAC distributors and dealers, and electric utilities to promote the efficient technologies, and to make it easier for builders and homeowners to select it as their system of choice. In some areas, ENERGY STAR qualifies equipment can be financed through ENERGY STAR loans from banks and other financial institutions. ENERGY STAR loans were created with special terms to make equipment easier to purchase. Some loans have special interest rates, longer repayment periods, or both. (EPA5-7).

3.5.9 The Motor Challenge

This program is a partnership between government and stakeholders such as manufacturers and environmental organizations designed to reduce electricity consumption by 25 billion kWh/year by the year 2000 through the use of energy efficient electric motor-driven systems. The program will help industry adopt a systems approach in developing, purchasing, and managing motors, drives, and motor-driven equipment like pumps and compressors (DOE).

The Motor Challenge Program, started in 1993, includes information dissemination activities, demonstration projects, market assessments, collections of databases, and market transformation initiatives.

3.5.10 Consortium For Energy Efficiency

The Consortium for Energy Efficiency (CEE) is a nonprofit corporation made up of utilities, environmental and public interest groups, and government agencies. Formed in 1991, the CEE is dedicated to helping private and public interests form partnerships to accelerate the development and availability of technologies that save energy, maintain customer satisfaction, and enhance environmental quality. CEE has initiated programs promoting efficient residential air conditioning and heat pumps, commercial air conditioning, residential and small commercial lighting, efficient refrigerators, high efficiency washers, and geothermal heat pumps.

3.5.11 Energy Efficient Mortgages

The Federal Housing Administration, Fannie Mae, Freddie Mac, the Veterans Administration, various lenders, and several electric utilities have introduced financing products for energy efficiency upgrades. These programs seek to provide capital for efficiency investments. Home buyers are being encouraged to install energy efficient end-use equipment at the time of purchase financed through energy efficient mortgages (EEMs). The energy efficiency upgrades will produce a constant stream of energy cost savings over the duration of the product lives, insuring the profitability of the mortgage. Currently 23 states have at least one lender who facilitates EEMs.

A. The Federal Housing Administration

The FHA is authorized by the Energy Policy Act of 1992 to offer up to $8,000 above the qualifying loan amount for cost-effective energy efficient retrofit measures at the time of home resale. The FHA EEM also applies to new construction, and can finance 100 percent of the cost of energy efficiency improvements. The FHA is currently establishing an EEM pilot program for existing homes in Alaska, Arkansas, California, Vermont, and Virginia.

B. Fannie Mae and Freddie Mac:

In Colorado, Fannie Mae and Freddie Mac have loan programs that allows borrowers to finance energy efficiency upgrades in new homes and resales as long as the increase is less than or equal to the present-value calculation of the rated energy savings. Under Fannie Maes's Community Home Buyers Program and Freddie Mac's Affordable Gold Program, purchasers with income at or below the national median can finance efficiency upgrades with a minimal down payment. (Ogden)

Fannie Mae is also pilot testing an unsecured home-improvement loan at below-market interest for up to $15,000. This energy loan program is operated with PG&E and third party lenders. If successful, Fannie May Says it will take the program nationwide. (Verdict

C. Pacific Gas and Electric:

In California, PG&E has teamed with three lenders to automatically qualify buyers for an additional 10 percent mortgage, at below-market interest rates, for homes that are rated 10-25 percent more efficient that the California State energy code. Demand for these loans has far exceeded expectations. The lenders involved are now marketing these new incentives nationwide to utilities and ratings organizations interested in promoting energy-efficient financing.

3.6 Summary of Programs

These forces have all affected the markets for energy efficient end use equipment in numerous ways. The following chart summarizes the existing programs, and categorizes them based on technologies affected and by program type. Information and technical support programs disseminate facts and specifications for specific technologies, and are aimed at overcoming lack of consumer awareness. Demand Side programs increase the demand for efficient equipment, either through encouraging installation or through increasing the availability of financing resources for efficiency purchases. Supply Side programs encourage the manufacturing development of efficient technologies, and can aid in the transformation of markets for efficient end use equipment.

TABLE 3.2
PROGRAMS AFFECTING THE MARKETS FOR ENERGY EFFICIENCY

PROGRAM	TECHNOLOGY				PROGRAM TYPE			PUBLIC/ PRIVATE
	Lights	Appliances	HVAC	Other	Information /Technical support	Demand Side	Supply Side	Partnership
FEMP	X	X	X	X		X		
LIHEAP				X		X		
WAP				X		X		
Greenlights	X				X	X		X
ENERGY-STAR	X		X	X	X		X	X
Motor Challenge				X	X		X	X
CEE	X	X	X		X	X	X	X
EEM			X	X		X		X
Utility DSM	X	X	X	X	X	X	X	

3.7 Technological Improvements

The markets for energy efficient end-use equipment have realized remarkable gains in improved performance. These improvements have lowered the initial costs of efficient equipment, increasing the profitability of efficiency investments. They have also improved performance which addressed concerns about the reliability of efficient alternatives.

Overall, the improved development of efficient end-use equipment has led to increased consumer acceptance of energy saving devices. This increased acceptance will contribute to the predicted overall increase in sales as discussed in Chapter IV.

3.8 Market Synthesis

The conjunction of the forces discussed above have significantly affected the markets for energy efficient end use equipment. They have encouraged a paradigm shift in consumer purchasing decisions, and life-cycle energy costs are no longer completely ignored. Price-related market forces, increasing environmental concerns, policy-driven regulatory actions designed to address energy efficiency market barriers and failures, and technological improvements in end use equipment have all aided in increasing the penetration rates of energy efficient technologies, and consequently increased improvements in overall US energy efficiency.

CHAPTER IV

4. CURRENT AND FUTURE MARKETS FOR ENERGY EFFICIENT END-USE EQUIPMENT

As the following sections demonstrate, the markets for energy efficient end-use equipment are extremely robust. They are large and have maintained a significant growth rate over. The value of this market has grown from $23.6 billion in 1991, and is expected to exceed $ 47 billion by 2001. The use of efficient equipment will significantly reduce energy use and resultant greenhouse gas emissions.

The following chapter presents data on specific energy savings devices and equipment. The analysis is divided into several sections covering the most significant end-use categories. They are:

- LIGHTING
- APPLIANCES
- HEATING, VENTILATION, AND AIR CONDITIONING
- BUILDING MATERIALS AND OTHER ENERGY SAVING DEVICES

Methods for Shipments and Value Calculations:

The 1991-1995 shipments and value data is primarily US census data. The 1996 data is based on the latest available information. Forecasts for the year 2001 are based on average annual growth rates.

Methods For Savings Calculations:

Calculating savings from the installation of energy saving devices is an extremely subjective but not random process. Assumptions regarding the baseline energy usage, existing stock, and rate of change of efficiency improvements can significantly affect results. In most cases, energy savings were calculated based on new units replacing units of average electricity use, as measured by the Residential and Commercial Energy Use Surveys (EIA 3,4,8). In some cases, savings were based on efficient equipment replacing traditional inefficient equipment (specifically lighting). Yearly savings were calculated based on typical usage patterns as estimated by the EIA. In all cases, the total amount of energy saved from installation was measured over the lifetime of the replacement product. For a more detailed presentation of the savings calculations, refer to Appendix A.

4.1 ENERGY SAVING DEVICES IN THE LIGHTING SECTOR

Lighting accounts for 9 percent of residential electricity consumption and for over 37-50 percent of the electricity used by commercial buildings.

The overwhelming majority of lights in residential households are incandescent, the least efficient type of lighting. If all bulbs that were used 4 or more hours per day were replaced with efficient compact fluorescent bulbs, 31.7 billion kWh/year would be saved, or 35 percent of all currently residential electricity used for lighting in 1993 (EIA 5).

Commercial buildings are primarily illuminated with standard fluorescent lighting. Standard fluorescent lighting was used for 41 percent of the total floor space. Thirty four percent of commercial floor space is lit with some type of efficient fluorescent, nineteen percent is lit with incandescent lighting, and the remainder is lit with high intensity discharge (HID) and other types of lighting (EIA 6).

Incandescent bulbs serve approximately 19 percent of the lighted commercial floorspace, but account for 37 percent of lighting energy consumption. Substantial amounts of energy could be saved by converting to efficient lighting (EIA6). Only four percent of the commercial buildings in the US used some type of compact fluorescent light (EIA6). Overall, optimistic scenarios of efficiency upgrades estimate that lighting upgrades can save 231.9 billion kWh/year in the commercial sector alone (EIA6).

Markets For Efficient Lighting Equipment

As the following table demonstrates, the energy efficient lighting market has demonstrated strong growth from 1991 through 1996. This trend can be expected to continue through 2001.

TABLE 4.1
VALUE OF THE EFFICIENT LIGHTING MARKET
($1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1992-2001 (%)
Compact Fluorescent	NA	104,545	112,762	107,448	131,156	151,550	271,279	**10.2**
Tungsten Halogen	71,773	80,991	92,598	82,926	86,243	89,692	111,129	**5.6**
Fluorescent	NA	110,172	139,171	157,958	219,210	268,030	534,430	**19.0**
HID	216,045	238,285	252,296	288,786	353,368	424,864	987,810	**16.4**
Ballasts	718,317	812,287	969,542	940,746	999,808	1,009,806	1,771,386	**9.4**
TOTAL	**NA**	**1,346,280**	**1,566,369**	**1,577,864**	**1,789,785**	**1,943,942**	**3,676,034**	**11.8**

source: US Department of Commerce, Bureau of the Census, Author

LIGHTING TECHNOLOGIES

There are numerous energy efficient types of lighting products. The following will be covered in this report:

- COMPACT FLUORESCENT
- TUNGSTEN HALOGEN
- EFFICIENT FLUORESCENT
- METAL HALIDE
- HIGH PRESSURE SODIUM
- ELECTRONIC BALLASTS
- LED LIGHTING
- REFLECTORS

QUALITY INDICATORS

There are several indicators of a lamp's performance. The color rendering index (CRI) measures an object's perceived color under a light source. Lamps with a CRI of 100 give illumination equivalent to sunlight. Those with CRIs of below 60 give poor illumination quality (a blue-ish light). Installing efficient with high CRI's is essential for customer acceptance. Lumens/watt measures the amounts of lumens (a measure of illumination) per energy input, a good measure of efficiency. In order to properly compete in the lighting market, efficient products need to satisfy these lighting quality indicators.

4.1.1 COMPACT FLUORESCENT LIGHTING

One of the most cost-effective, easy to install energy saving devices is the Compact Fluorescent Light (CFL). Most of these bulbs can be screwed into existing incandescent fixtures with no modification. In some cases, lamp harps and other minor fixture modifications may be necessary to accommodate the slightly larger CFL bulb.

A typical CFL will last 10,000 hours, and will use up to 75 percent less electricity than a conventional bulb while maintaining or improving light quality. Their energy savings and maintenance savings make CFLs an extremely attractive investment. Despite their obvious benefits, CFLs are underutilized. They are present in only 8.9 percent of all US households, and less than 1 percent of all lights used 15 minutes per day or longer are efficient compact fluorescents (EIA 5).

TABLE 4.2
SHIPMENTS OF COMPACT FLUORESCENT LIGHT BULBS
(quantity in 1000s, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	NA	23,987	24,759	26,067	30,290	35,000	57,660	**10.0**
value	NA	104,545	112,762	107,448	131,156	151,550	271,279	**10.2**

source: US Department of Commerce, Bureau of the Census, Author

CHART 4.1
CALCULATION OF BENEFITS OF INSTALLING 1 CFL

1 Compact Fluorescent Light Bulb		Incandescent Light Bulb
SL 18w		75 Watt
Cost: $17.00		Cost: $.50
Hours/Day =6.7	VS	Hours/Day=6.7
Hours/Year = 2445.5		Hours/Year = 2445.5
Rated Lifetime = 1000 hours		Rated Lifetime=750 hours
Electricity Use = 44.02 kWh/year		Electricity Use = 183.41 kWh/year
discount rate 5%		
residential electricity rate of 6.5c/kWh		

SAVINGS FROM INSTALLING 1 CFL:
139.4 kWh/year over 4 years
$9.06 per year in reduced electricity bills and $1.63 in bulb replacement cost savings total $42.76 in savings,

net present value of installing 1 CFL = $21.72

internal rate of return = 160%

The use of compact fluorescent lamps can yield significant energy savings over the next five years.

TABLE 4.3
ENERGY SAVINGS FROM CFLs
(millions kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	NA	3,344	6,795	10,429	14,651	16,187	36,643

source: US Department of Commerce, Bureau of the Census, DOE, Author

CONSORTIUM FOR ENERGY EFFICIENCY RESIDENTIAL AND SMALL COMMERCIAL LIGHTING INITIATIVE

The CEE initiative has three primary objectives: to maximize DSM program cost-effectiveness for participating utilities, to encourage superior screwbase CFL products, and to stimulate the market to increase the production, distribution, purchase, and installation of energy efficient lighting products for homes and small businesses. The initiative encourages the payment of DSM rebates directly to manufacturers to reduce the wholesale cost of CFLs. This results in larger retail price decreases than for direct rebates to consumers. The initiative also shares resources among participating utilities, reducing participating utilities administrative costs of running DSM programs.

The CEE initiative is expected to produce the following benefits:
- Help build a stronger, more robust market for CFLs
- Increase DSM program cost effectiveness
- Increase sales of CFLs
- Complement existing utility DSM efforts
- Provide economies of scale for CFL manufacturers
- Provide technical support for utility participants

THE SOUTHERN CALIFORNIA EDISON EXPERIENCE

Southern California Edison (SCE) pioneered the use of direct manufacturer incentives of CFLs in 1991 as a way to minimize DSM administration costs. The SCE approach provided incentives directly to manufacturers. This reduces the amount of dealer markup, reducing final costs of CFLs for consumers. Most importantly, this program eliminated the administrative burden of handling customer coupons and individual rebate payments. SCE found this technique to be tremendously successful both in terms of selling CFLs and reducing DSM program costs. Using this approach, the company sold nearly 1,000,000 CFLs in 1992 alone. Administrative costs were about 10% of total program costs, a significant improvement over earlier programs. The number of retailers carrying CFLs and the amount of shelf space devoted to them in the SCE service territory also increased. SCE also found that it was easier to set DSM program budgets in advance because manufacturers compete (bid) for a set amount of incentives (CEE 1).

4.1.2 TUNGSTEN HALOGEN LAMPS

Tungsten-halogen lamps use enhancements to conventional incandescent technology to provide improved efficiency, longer lamp life, and a whiter, brighter light. They are suited for specific applications such as directional or controlled light. Tungsten-Halogen lights contain halogen gas in the bulb, which reduces the filament evaporation rate. This increased the lifetime of the bulb as high as 4x that of a conventional bulb. The CRI of these bulbs is 100 and the efficacy ranges from 18-38 lumens per watt, as compared to 16 for conventional bulb (PG&E).

The primary residential application for these lamps is for desk lighting and floor lamps. Commercial applications of tungsten-halogen lamps include accent or display lighting, or where full range dimming is needed. Although sales of tungsten-halogen lamps have increased between 1991 and 1995, the lights require special fixtures and tend to get very hot, which has limited market size.

TABLE 4.4
DOMESTIC SHIPMENTS OF TUNGSTEN HALOGEN LAMPS
(quantity on 1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	9,556	11,071	13,775	11,431	11,934	12,459	17,915	**7.8**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.5
VALUE OF DOMESTIC TUNGSTEN HALOGEN LAMP MARKET
(value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	71,773	80,991	92,598	82,926	86,243	89,692	111,129	**5.6**

source: US Department of Commerce, Bureau of the Census, Author

The following table shows the amount of energy savings from the use of tungsten halogen lamps instead of conventional incandescent lamps.

TABLE 4.6
ELECTRICY SAVINGS FROM TUNGSTEN HALOGEN LAMPS
(million kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	122.3	172.3	211.8	190.3	189.3	197.6	282.1

source: US Department of Commerce, Bureau of the Census, DOE, Author

4.1.3 ENERGY EFFICIENT FLUORESCENT LIGHTING

Efficient types of fluorescent lighting include T-8 lamp and U-shaped fluorescent lamps. U-shaped lambs can replace inefficient incandescent lamps, while T-8s can replace inefficient fluorescent lamps. T-8 lamps are characteristically slimmer in appearance than standard T-12 lamps, 1" in diameter as opposed to the standard 1-1/2". The slimmer T-8 enables the use of a high quality double coating of phosphors within the lamp. These lamps have three main advantages over the standard T-12 fluorescent lighting system. They are:

- Greater efficiency
- Improved light output over the life of the lamp
- Superior color rendition index performance

TABLE 4.7
SHIPMENT OF LINEAR RAPID START T-8 FLUORESCENT LAMPS
(quantity in 1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	NA	27,066	41,187	53,299	66,752	79,869	227,691	**23.4**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.8
SHIPMENTS OF U-SHAPED FLUORESCENT LAMPS
(quantity in 1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	NA	11,889	11,857	13,715	17,463	23,101	46,062	**14.8**

source: US Department of Commerce, Bureau of the Census, Author

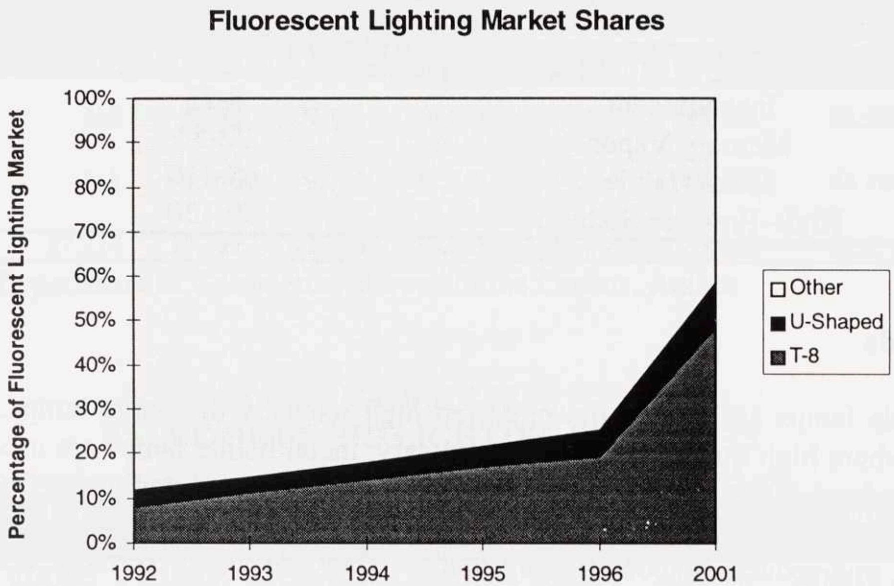
TABLE 4.9
NET VALUE OF EFFICIENT FLUORESCENT LIGHTING SHIPMENTS
(value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	NA	110,172	139,171	157,958	219,210	268,030	534,430	**19.0**

source: US Department of Commerce, Bureau of the Census, Author

As the following chart illustrates, energy efficient lighting is expected to significantly increase its market share. Shipments of efficient fluorescent lighting will increase from eleven percent in 1992 to fifty eight percent by 2001. T-8 lamps will represent just under fifty percent of total fluorescent lighting shipments, ten percent of the total shipments will be U-shaped lamps.

CHART 4.2
GROWTH IN MARKET SHARE OF EFFICIENT FLOURESCENT LIGHTING



The following table presents the energy savings from the use of efficient lighting.

TABLE 4.10
ENERGY SAVINGS FROM EFFICIENT FLUORESCENT LIGHTING
(millions kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	NA	2,632	5,730	9,502	11,635	14,560	36,412

source: US Department of Commerce, Bureau of the Census, DOE, Author

4.1.4 HIGH INTENSITY DISCHARGE (HID) LIGHTING PRODUCTS

HID lamps are highly efficient lighting sources. There are three main types of HID lighting: mercury vapor, metal halide, and high pressure sodium. Each of these lights requires a specific ballast, and has a significantly higher initial cost. The low operating cost and high efficiency leads to a rapid recovery of the lighting investment.

Lamp Type	Lumens per Watt
Incandescent	8-23
Mercury Vapor	22-58
Metal Halide	65-110
High- Pressure Sodium	50-130

Metal Halide

Metal Halide lamps are among the preferred high intensity discharge lamps. Used in situations where high quality lighting is necessary, metal halide lamps are used in many applications from office down lighting to illumination of sports stadiums. Compared to incandescent or mercury vapor lamps, they offer substantial energy savings, generate less waste heat, and reduce air conditioning loads. They are 2x to 5x more efficient that incandescent lamps. Metal halide lamps are available in a variety of sizes, and their lifetimes range from 2,00-20,000 hours. They are a good retrofit for systems using incandescent lighting of 150 watts or higher. Warm-up for these lights can take from 2-10 minutes. Metal halides are sensitive to low starting temperatures, and lamp life will be reduced if they are frequently started in temperatures below 10 degrees F.

High Pressure Sodium Lamps

High Pressure Sodium Lamps (HPS) were developed in the 1960's as an energy efficient alternative to mercury vapor lamps for exterior use. These lamps are useful in applications where high color rendering is not a priority. HPS lamps have a lifetime of 10,000-24,000 hours. Their reliability has led to their widespread use in such applications as illuminating parking lots, roads, and airports.

Mercury Vapor

Mercury vapor lamps have the lowest initial cost of the HID lamps, they are also the least efficient of the HID lamps. They have a poor Color Rendering Index, and produce a blue/white illumination. Although their rated life exceeds 24,000 hours, their lumen depreciation rate is the worst. Mercury vapor lamps are available in sizes from 40-1000 watts. Because of their lower cost and longer life, applications for these lamps include industrial and commercial lighting, outdoor parking and security lighting, and road lighting. Due to their inferior performance and inefficiency, mercury vapor lamps are becoming obsolete, losing out to more efficient HID lamps

TABLE 4.11
US SHIPMENTS OF HID LIGHTING
(1000s of lamps)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
Mercury Vapor	NA	4,689	4,611	4,783	4,745	4,759	4,853	**.3**
Metal Halide	NA	5,732	7,101	8,668	10,433	12,396	32,528	**21.3**
HP Sodium	NA	9,076	9,761	11,558	14,467	18,488	45,489	**19.7**
TOTAL HID	**17,714**	**19,497**	**21,473**	**25,009**	**29,645**	**35,643**	**82,870**	**15.0**

source: US Department of Commerce, Bureau of the Census, Author

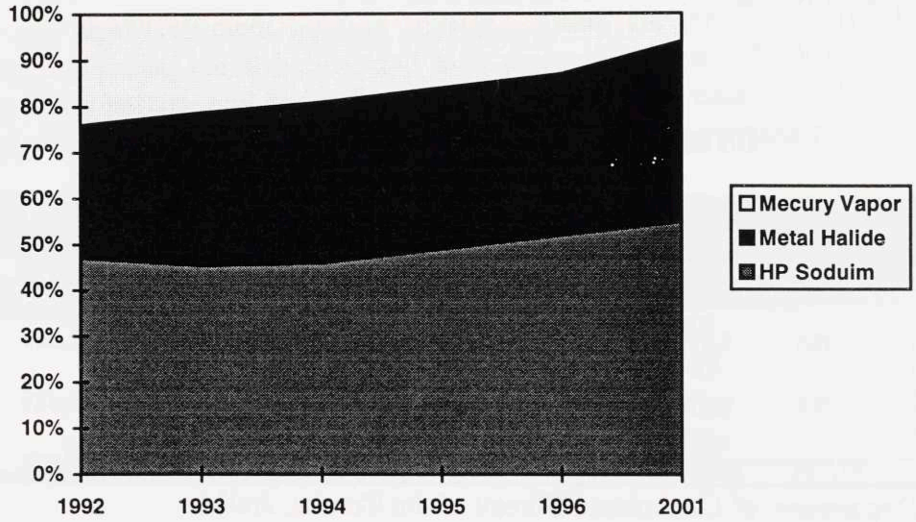
TABLE 4.12
VALUE OF US HID LIGHTING SHIPMENTS
(value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	216,045	238,285	252,296	288,786	353,368	424,864	987,810	**16.4**

source: US Department of Commerce, Bureau of the Census, Author

As the following chart illustrates, shipments of efficient HID lighting increase their market share from seventy six percent in 1992 to over ninety three percent by 2001. High pressure sodium lights can be expected to hold approximately fifty five percent of the HID lighting market in 2001.

CHART 4.3
GROWTH IN MARKET SHARE OF EFFICIENT HID LIGHTING



The following table shows the energy savings from the use of efficient HID lighting.

TABLE 4.13
ENERGY SAVED FROM THE USE OF HID LIGHTING
(millions kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	NA	15,934	34,063	55,806	66,644	65,802	95,644

source: US Department of Commerce, Bureau of the Census, DOE, Author

4.1.5 BALLASTS

A fluorescent lamp ballast serves two primary functions: it provides the high initial voltage necessary to start the lamp, and it regulates current during lamp operation.

Magnetic ballasts contain a magnetic core of plates wrapped with aluminum or copper wiring. Older more inefficient ballasts used as much as 16 W to power two T-12 lamps. Such ballasts can no longer be sold in the US as required by the National Appliance Energy Conservation Act of 1987. Efficient magnetic ballasts are available that use higher grade materials and use approximately 8 W.

Electronic Ballasts regulate voltage using solid-state components. Electronic ballasts reduce the power requirements of lamps and provide many additional benefits, including; reduced flicker, reduced noise, reduced heat output, and reduced weight. Electronic ballasts can also be operated with dimmable lights. The costs of electronic ballasts range from $18-$30, compared to $10-15 for a typical magnetic.

TABLE 4.14
TOTAL SHIPMENTS OF BALLASTS
(quantity in 1000s, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	88,729	97,034	107,428	108,114	105,236	106,962	200,026	**8.4**
value	718,317	812,287	969,542	940,746	999,808	1,009,806	1,771,386	**9.4**

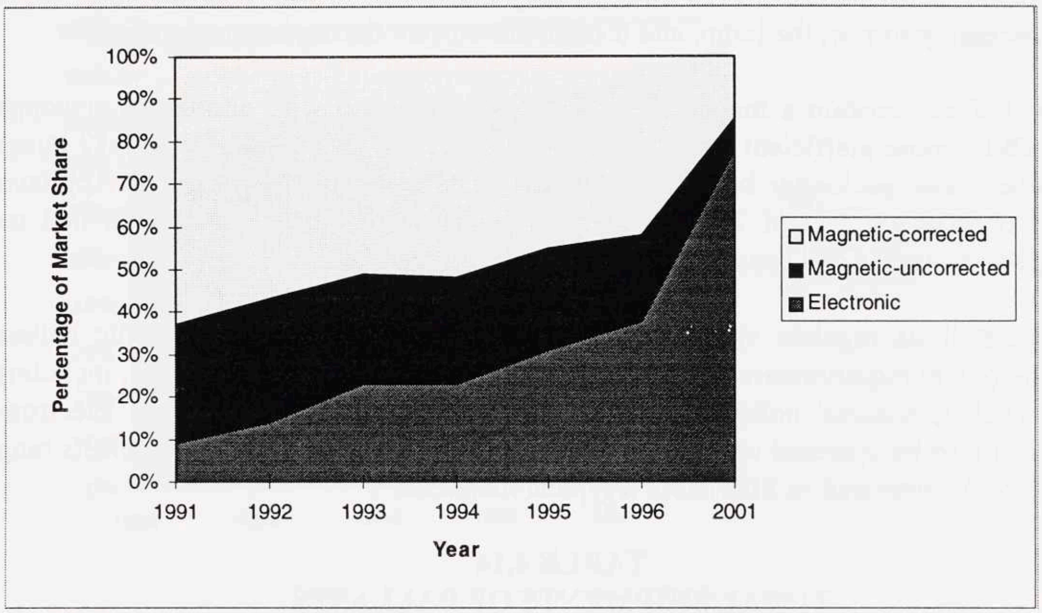
source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.15
SHIPMENTS OF BALLASTS BY TYPE
(1000s of units)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
Magnetic-uncorrected	24,919	28,363	28,150	27,517	24,901	20,236	13,337	**-7.8**
Magnetic-corrected	55,467	55,379	54,790	55,991	47,597	42,471	29,073	**-6.1**
Electronic	8,343	13,292	24,488	24,606	32,738	37,874	157,616	**33.0**

source: US Department of Commerce, Bureau of the Census, Author

CHART 4.4
MARKET SHARE OF EFFICIENT LAMP BALLASTS



source: US Department of Commerce, Bureau of the Census, Author

The following table presents the energy savings from the use of efficient ballasts.

TABLE 4.16
ENERGY SAVED FROM EFFICIENT BALLASTS
(millions kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	266	692	1,488	2,276	3,324	4,269	15,443

source: US Department of Commerce, Bureau of the Census, DOE, Author

STANDARDS

DOE has labeled additional standards for fluorescent lamp ballasts high priority due to the additional potential energy savings. The engineering analysis for increased standards was completed with strong endorsement from industry (EREC).

4.1.6 LIGHT EMITTING DIODES (LED)

In incandescent lamps, light is created by passing energy through a resistive metal filament. Most of the energy given off is wasted as heat. Light emitting diodes create light through a very different process. Electrons in semiconductors move from high to low energy states, releasing photons in a portion of the visible light spectrum—emitting a bright color of light. Since its introduction in 1962 as an indicator lamp source, LED technology has evolved rapidly into a promising illumination source. With a life cycle that will outlast just about any product into which it is installed, LEDs have a magnitude of applications, from traffic signals to exit signs. Today's LEDs can emit 450 lumens per watt, and can operate for over 700,000 hours (Listwa).

EXIT SIGNS

Approximately 30-35 billion kWh of energy are being consumed by the estimated 100-225 million exit signs in use throughout the US today. To date, less than 7 percent have been replaced with LED lights (Mule Lighting).

The vast majority of signs in use are the early incandescent signs. These old signs used two 20-30 watt lamps, typically in use for twenty four hours per day. Light Emitting Diode ("LED") exits signs have numerous benefits to earlier incandescent or even fluorescent exit signs. Their longer lifetimes produce additional safety benefits, there is little chance of fixture failure.

LED lamps use 96 percent less energy than incandescent lamps, and 80% less than fluorescent lamps. They are rated for 80-100 years of reliable service life. The LED exit sign retrofit market has been estimated at $20 million for 1996 (Mule Lighting).

They following chart presents savings and payback data for a typical LED exit lamp retrofit:

CHART 4.5
LED RETROFIT PAYBACK EXAMPLE
(Based on 100 exit fixtures)

COSTS	INCANDESCENT	FLUORESCENT	LED
Energy (watts)	40	17	1.65
burn hours/year	8760	8760	8760
cost/kWh ($)	.1	.1	.1
ANNUAL ENERGY COST	$3,504	$1,489	145
Maintenance Costs	2,175	675	none
Replacement Costs	1,595	875	none
TOTAL ANNUAL COSTS	$7,274	$3,039	$145

source: Mule Lighting, Author

SALES AND ENERGY SAVINGS

Although sales of LED exit signs are not tracked, an estimated 7 million have been installed through 1996, reducing US electricity consumption by an estimated 2,353 million kWh/year.

TRAFFIC SIGNALS

Significant energy savings are being achieved by replacing incandescent lamps in traffic signals with LEDs. Estimates from the Department of Transportation suggest that there are more than 5,000,000 signal lights in operation in the US, estimated to draw over 500MW of electricity. The annual energy costs for a large signalized intersection can range from $2,000 to $3,000 annually. Although LED retrofits are costly, payback is typically achieved in less than five years (Listwa).

RETROFIT EXPAMPLE

A major test is being conducted in Philadelphia, which has about 2,500 controlled intersections with 25,000 lamps burning simultaneously. 27 intersections have had the red lights in their traffic signals replaced with LEDs. Energy savings are estimated to yield $25-50 electricity bill reductions from each bulb replaced (Listwa). LED traffic signal retrofit projects are also underway in parts of California, Oregon, and Colorado (EEPC).

EPA ENERGY STAR Exit Signs

EPA has signed partnerships with industry leading exit sign manufacturers to recognize the most energy efficient models. EPA and these manufacturers will promote these superior products that qualify for the ENERGY STAR label. An ENERGY STAR exit sign uses less than 5 watts per face, powered primarily by CFLs or LEDs.

4.1.7 REFLECTORS

In some cases, up to 30 percent of light output from fluorescent lights is trapped inside the light fixture. Mirror-like reflectors can direct more usable light out of light fixtures, allowing for the removal of unneeded fixtures while actually increasing overall lighting levels. Delamping reduces fixture and lighting costs, as well as reduces the cooling load placed on air-conditioning systems, leading to extremely short payback periods. Reflectors are usually installed as part of an entire lighting fixture upgrade/retrofit. When installed in conjunction with efficient T-8 lamps and electronic ballasts, the new lighting system can yield impressive savings.

Specular reflectors are mirror-like devices that can be mounted inside existing fluorescent fixtures to direct more light out of the fixture. Specular reflectors are commonly used today to renovate old and inefficient fluorescent fixtures. When reflectors are installed, up to half of the lamps in each fixture can be removed, yielding up to 50 percent energy savings with slightly reduced overall lighting levels. Use of reflectors can also cut air conditioning load, representing up to 20% of the total energy savings (EPRI).

The typical four lamp trouffer has a luminaire efficacy (a measure of how much light leaves the fixture) of 54.8 %, and uses 2.2 watts/sq. foot. When the fixture is retrofitted with 2 new t-8s, a custom reflector, and an efficient ballast, the luminaire efficiency increases to 88.8 %, and uses .75 watts/sq. foot (Ranieri).

The payback period for this type of fixture retrofit is 1.7-2.6 years, depending on the types of replacement lamps used, types of fixtures, etc. (EPRI).

The following chart presents an example of savings generated by a complete lighting retrofit:

CHART 4.6
SAMPLE COMPLETE LIGHTING RETROFIT SAVINGS

Existing Fixture:

type: 2x4 Recessed Troffer		
Lamp Type: F-40 T12 CW	Lamp Qty: 4	Watts: 34
Ballast Type: Standard Magnetic	Ballast Qty: 2	Watts: 16
Hours of operation: 3,060	Existing Wattage: 168	
KW Demand: 2.52	cost per kWh: .065	
Annual Energy Cost: $501.23	Annual Maintenance Cost: $76.50	

TOTAL ANNUAL OPERATING COST: $577.73

Retrofit With T-8 lamps, Electronic Ballast and Reflector

type: 2x4 Recessed Troffer		
Lamp Type: FO32 T8	Lamp Qty: 2	Watts: 32
Ballast Type: Electronic/BF .88+	Ballast Qty: 1	Watts: 12
Hours of operation: 3,060	Retrofit Wattage: 76	
KW Demand: 1.1	cost per kWh: .065	
Annual Energy Cost: $227	Annual Maintenance Cost: $58.35	

TOTAL ANNUAL OPERATING COST: $285.10
ANNUAL ENERGY SAVINGS BENEFIT: $ 292.63
NET PROJECT COST: $1,265
SIMPLE PAYBACK PERIOD: 51.9 months
INTERNAL RATE OF RETURN: 24.8 % (15 year lifetime)
PROJECT NET PRESENT VALUE: $706

(Parkansky)

Actual data on reflector sales is not tracked and manufacturers will not release their data due to confidentiality concerns. However, it is clear that the potential market for reflectors is extremely large. Out of the 4.8 million commercial buildings with 68 million square feet, less than 10 percent have been retrofitted with some type of efficient lighting system. Of these, only an estimated 3.3 percent have installed reflectors (Park).

4.1.8 Emerging Technologies: The Solar 1000tm Daylight Lamp

The Daylight Lamp can be called the fourth generation light source---following the incandescent lamp, the fluorescent tube, and the high intensity discharge lamp. This technology is characterized by a light outburst similar to daylight, high efficacy and long life. It has low installation costs and low maintenance and energy costs.

The patented principle is based on exciting sulfur (or a similar material) enclosed in a glass bulb with microwave energy. The sulfur is ionized and emits visible light with a spectrum closely resembling daylight. CelsiusTech Electronics, a Swedish Firm with special expertise in microwave and power supply technology, has refined the lamp design and is distributing the lamp in Europe. The light can be dimmed, and may be installed in conjunction with light management control systems.

The lamp is suitable for lighting large areas. An installation is in place at the US Air and Space Museum in Washington DC, and has doubled the light levels compared with traditional lighting methods, halving lighting costs. The largest installation in Europe is at the Swedish Postal Sorting Terminal in Sundvall (Celsius Tech Electronics).

The technical specifications of the Daylamp are:

Lighting intensity:	130 lumens
Power consumption:	1.3 kW
Warm up time:	25 seconds
Ambient temp:	-20 to 60 degrees C
Expected life	
-excluding mangnetron:	45,000 hours
-including mangnetron:	15,000 hours

4.2 APPLIANCES

Appliances are the largest electricity consumer in the residential sector. However, more efficient appliances typically have higher costs than less efficient alternatives. Because consumers are more concerned with initial rather than life cycle costs, the average efficiency of installed equipment is low. Due to their long lifetimes and high hours of operation, energy efficient appliances can save significant amounts of electricity.

Appliance efficiency has gradually improved since the 1970s, and is expected to make additional gains due to numerous Federal efforts related to appliance standards. Overall, the use of efficient appliances is expected to reduce electricity demand by over 115 billion kWh/year by 2001compared to projected energy use with existing inefficient equipment.

Markets For Energy Efficient Appliances

The market for energy efficient appliances is expected to realize modest growth through 2001. The main markets for appliances are for new construction and for replacement of non-functioning units. Because appliances are rarely retrofitted before the end of their useful lives, the markets for energy efficient appliances will continue to enjoy steady growth.

TABLE 4.17
VALUE OF THE US ENERGY EFFICIENT APPLIANCE MARKET
($millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Dishwashers	764	810	1,041	1,081	1,020	1,103	1,635	**8.1**
Clothes Dryers	910	974	1,060	1,186	1,103	1,128	1,599	**6.3**
Clothes Washers	1,840	1,718	1,804	2,015	1,838	1,844	1,874	**.3**
Kitchen Range/Ovens	2,224	2,220	2,352	2,440	2,435	2,489	2,774	**2.1**
Microwave Ovens	486	505	511	478	359	335	238	**-8.8**
Refrigerators	3,363	3,941	3,938	4,209	4,752	5,190	8,068	**9.2**
Water Heaters	1,063	987	1,173	1,264	1,501	1,653	2,743	**7.7**
TOTAL	**10,650**	**11,155**	**11,879**	**12,673**	**13,008**	**13,742**	**18,931**	**5.9**

source: US Department of Commerce, Bureau of the Census, Author

MARKET CATEGORIES

This report addresses the following types of appliances:

- DISHWASHERS
- CLOTHES DRYERS
- CLOTHES WASHERS
- KITCHEN RANGES AND OVENS
- MICROWAVE OVENS
- REFRIGERATORS
- WATER HEATERS

QUALITY INDICATORS

There are several indicators which measure the efficiency of appliances. Many are rated by an energy factor, or in terms of the energy needed per cycle. Refrigerators are regulated based on adjusted energy use per year.

4.2.1 DISHWASHERS

The efficiency of dishwashers has improved steadily, most significantly in 1994 when the NAECA standards took effect. Over 43.7 million US households own dishwashers (EIA 3).

TABLE 4.18
US SHIPMENTS OF DISHWASHERS
(excluding portable, quantity in 1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	4,015	4,641	5,662	4,952	4,967	5,281	7,182	**6.3**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.19
VALUE OF US DISHWASHER SHIPMENTS
(millions of $)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	764	810	1,041	1,081	1,020	1,103	1,635	**8.1**

source: US Department of Commerce, Bureau of the Census, Author

The following table presents the recent trends in efficiency improvements of dishwashers in the US.

TABLE 4.20
ENERGY EFFICIENCY OF DISHWASHERS
SHIPMENT WEIGHTED AVERAGES

Year	Energy Consumption/Unit kWh/Cycle	Efficiency Energy Factor
1991	2.67	.37
1992	2.66	.38
1993	2.56	.39
1994	2.14	.47
1995	2.07	.48

source: AHAM 3, 1996

Although their potential savings from efficiency improvements is low, the long lives of efficient dishwashers will have a significant impact on US electricity consumption by 2001.

TABLE 4.21
ENERGY SAVED FROM EFFICIENT DISHWASHERS
(millions kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	23	62	257	968	1,771	2,626	7,777

STANDARDS

TABLE 4.22
ENERGY EFFICIENCY DISHWASHER STANDARDS

Product Class	Energy Factor (cycles/kWh) 5/94
Compact Dishwasher	.62
Standard Dishwasher	.46

source: EREC

All dishwashers manufactured after 1/1/88 are equipped with an option to dry without heat (EREC).

DOE does not plan to actively pursue rulemaking in the next two years due to the potentially low cumulative additional potential energy savings. Dishwashers have been labeled a low priority product for additional standards.

4.2.2 DRYERS

Over 54.7 million US households have clothes dryers (EIA 3). The efficiency of electric and gas dryers has improved marginally since 1972. Average energy consumption from dryers has only decreased 5.4 percent for electric dryers and 17.9 percent for gas dryers. This is a relatively mature technology with relatively low potential for significant additional cost-effective energy efficiency savings (AHAM 4).

TABLE 4.23
SHIPMENTS OF CLOTHES DRYERS
(quantity in 1000s, value in $millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
gas -	988	1,105	1,207	1,219	1,187	1,244	1,578	**4.5**
electric (& coin operated)	3,176	3,387	3,573	3,793	3,665	4,000	4,631	**2.9**
Total value US Shipments	910	974	1,060	1,186	1,103	1,128	1,599	**6.3**

source: US Department of Commerce, Bureau of the Census, Author

The following table presents the estimated energy savings from the use of efficient clothes dryers.

TABLE 4.24
ENERGY SAVINGS FROM THE USE OF EFFICIENT DRYERS
(millions kWh, MMBtu)

	1991	1992	1993	1994	1995	1996	2001
electric	69.4	143.5	221.7	304.7	384.8	472.3	949.4
gas	79,000	167,000	264,000	361,000	456,000	556,000	1,130,000

source: US Department of Commerce, Bureau of the Census, DOE, Author

STANDARDS

The following table presents the existing standards for clothes dryers.

TABLE 4.25
CLOTHES DRYER STANDARDS

Product Class	Energy Factor (lbs. /kWh) effective 5/94
Electric-standard	3.01
Electric-compact (120v)	3.13
Electric-compact (240v)	2.90
Gas	2.67

Due to the development of efficient clothes washers with improved moisture extraction, additional potential savings from more stringent dryer standards are reduced. DOE does not plan to pursue additional rulemaking. This is considered a low priority product for additional standards (EREC).

4.2.3 CLOTHES WASHERS

The national penetration rate for clothes washers is extremely high. Eighty-six percent of the homes in the US have clothes washers (AHAM). Overall, the demand for clothes washers is relatively stable, exhibited by the low growth rate in sales. The efficiency of clothes washers has increased steadily, most significantly in 1994 when the NAECA standards went into effect.

TABLE 4.26
SHIPMENTS OF CLOTHES WASHERS
(quantity in 1000s, value in $millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	6,404	6,205	6,500	6,819	6,606	6,662	6,953	.8
value	1,840	1,718	1,804	2,015	1,838	1,844	1,874	.3

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.27
TRENDS IN ENERGY EFFICIENCY AND CONSUMPTION FOR CLOTHES WASHERS

Year	Energy Consumption (kWh/cycle)	Efficiency (Energy Factor)
1991	2.68	1.01
1992	2.67	1.02
1993	2.71	1.00
1994	2.23	1.21
1995	2.22	1.23

Source: AHAM 5, 1996

The following table presents the estimated energy savings from the use of efficient clothes washers.

TABLE 4.28
SAVINGS FROM THE USE OF EFFICIENT WASHERS
(million kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	341	505	829	1,144	1,463	1,784	2,420

source: US Department of Commerce, Bureau of the Census, DOE, Author

Horizontal Axis Washers:

Horizontal axis washers are extremely efficient side loading washers. Their use can save an estimated 580 kwh/year when used with electric water heat and can save an estimated 5000 gallons of water/year (CEE), yet they are estimated to have less than 1% of the market share.

In 1996, horizontal axis washers had sales of 100,000 (Wisniewski). The market share for these extremely efficient washers is projected to grow to 5-10 percent by the year 2000, equaling 500,000-1,000,000 units.

Some of the market barriers to adoption of horizontal clothes washers include:

- limited availability and selection
- low customer awareness
- higher initial cost
- distrust of new technology
- longer cycle time

The current US market for horizontal axis washers is primarily being met by European companies. However, several US companies are developing efficient washers.

Frigidaire began national distribution of its Gallery Tumble Action Washer in October 1996. An identical machine sold under the Gibson label will be available early in 1997.

Maytag has announced that it plans to introduce efficient washers in June/July of 1997

Whirlpool has announced that it is developing a highly efficient washer that will be available in 1998.

Speed Queen/Amana has announced that it is developing a horizontal axis washer that will be available in June 1997.

STANDARDS

DOE considers clothes washers a high priority product for increasing the efficiency standards due to the large amount of potential energy and water savings available through highly efficient washers.

CONSORTIUM FOR ENERGY EFFICIENCY
HIGH EFFICIENCY CLOTHES WASHER INITIATIVE

The consortium for energy efficiency (CEE) is a nonprofit corporation made up of utilities, environmental and public interest groups, and government agencies. CEE is dedicated to helping private and public interests form partnerships to accelerate the development and availability of technologies that save energy, maintain customer satisfaction, and enhance environmental quality.

As of January 1997, utilities servicing 16 percent of US households planned to participate in the CEE Clothes Washer Initiative by implementing programs promoting efficient washers. Many of these programs involve incentive payments, while others are strictly educational or promotional in nature. In order to qualify for the CEE program, a washer must meet or exceed the following specifications:

TABLE 4.29
CEE CLOTHES WASHER INITIATIVE SPECIFICATIONS

CEE Category	**Energy Factor** (ft^3 /kwh/cycle)	**Water Factor** (gals/ft^3)	**Remaining Moisture Content**
DOE Standard	1.18	13.3	62%
1A	2.50	11.0	No req.
1B	2.50	11.0	50%
1C	2.50	11.0	40%
2A	3.25	9.5	No req.
2B	3.25	9.5	50%
2C	3.25	9.5	40%

source: CEE 2

The CEE is promoting six categories of washers, with varying levels of incentives offered by participating utilities.

Examples of participants' programs include:

Pacific Gas & Electric and local water utilities will offer rebates ranging from $100-175, depending on which level of CEE specifications a particular washer meets. In addition, six water utilities will offer an additional $50-75 rebate to their customers.

Sacramental Municipal Utility District offers rebates ranging from $75-150, depending on CEE efficiency level. This program began in September of 1996, and will continue through 1997 and possibly beyond.

Interstate Power of Iowa offers a $250 rebate for customers who purchase a horizontal axis washer. This rebate will be offered through the end of 1997 and possible beyond.

Commonwealth Electric of Massachusetts is implementing a promotional program which will include demonstrations and product information provided directly to customers through brochures and possible customer newsletters.

4.2.4 KITCHEN RANGES AND OVENS

Energy efficient kitchen ranges and ovens have better insulation and more efficient heating units. They can also be equipped with digital controls to allow more flexible and efficient energy use. Over fifty eight million US households have kitchen ranges or ovens.

TABLE 4.30
SHIPMENTS OF KITCHEN RANGES AND OVENS
(quantity in 1000s, includes net imports)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
electric	8,427	8,433	9,058	9,660	9,727	10,087	12,100	**3.7**
gas	2,465	2,892	3,022	3,341	3,260	3,504	5,028	**7.4**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.31
VALUE OF SHIPMENTS OF KITCHEN RANGES AND OVENS
($ millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
electric	1,615	1,620	1,731	1,791	1,775	1,816	2,033	**2.4**
gas	609	600	621	649	660	673	741	**2.0**
Total	**2,224**	**2,220**	**2,352**	**2,440**	**2,435**	**2,489**	**2,774**	**2.1**

source: US Department of Commerce, Bureau of the Census, Author

The following table presents the electricity and gas savings form the use of efficient kitchen ranges and ovens

TABLE 4.32
ENERGY SAVINGS FROM EFFICIENT KITCHEN RANGES AND OVENS
(millions kWh, MMBTU)

	1991	1992	1993	1994	1995	1996	2001
electric	101.1	202.3	311.0	426.9	543.6	664.7	1,340.0
gas	123,000	267,000	418,000	585,000	748,000	924,000	2,017,000

source: US Department of Commerce, Bureau of the Census, DOE, Author

STANDARDS

The NEACA 1987 and 1998 regulations did not set minimum standards of efficiency for kitchen ranges and ovens. However, effective January 1990, gas kitchen ranges and ovens with an electrical supply cord shall not be equipped with a constant burning pilot light (EREC).

The Department of Energy has listed Cooking Products (including ovens, ranges and microwave ovens) as high priority products for additional efficiency standards due to their moderate potential energy savings, the recommendations of stakeholders, and the limited DOE resources needed to complete rulemaking.

4.2.5 MICROWAVE OVENS

Microwave ovens can save considerable amounts of energy when compared to ranges and ovens. Microwave ovens cook food 25% to 80% faster and use 1 kW/hour versus 12 kW/hour for a conventional range or oven. Over 81.3 million housing units had microwave ovens in 1993 (RECS). Although the share of US microwave oven shipments will continue to decline, the overall US market for microwaves will continue to grow through 2001.

TABLE 4.33
SHIPMENTS OF MICROWAVE OVENS and MICROWAVE RANGES/OVEN UNITS
(quantity in 1000s, value in $millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	3,459	3,606	3,855	3,431	2,710	2,568	1,965	**-6.5**
value	486	505	511	478	359	335	238	**-8.8**
Total US sales (less exports + imports	**7,594**	**7,828**	**8,931**	**10,106**	**10,094**	**10,858**	**15,627**	**7.5**

source: US Department of Commerce, Bureau of the Census, Author

The following table presents the energy savings from using microwave ovens instead of conventional kitchen ranges and ovens.

TABLE 4.34
ENERGY SAVINGS FROM THE USE OF MICROWAVE OVENS
(million kWh/year)

	1991	1992	1993	1994	1995	1996	2001
savings	1,740	3,534	5,581	7,898	8,471	9,165	12,863

source: US Department of Commerce, Bureau of the Census, DOE, Author

4.2.6 REFRIGERATORS

Ninety nine point eight percent of the homes in the United States use a refrigerator, a total of 96.5 million units. Out of these, 85 percent are frost-free types. Only 18 percent of the total number of refrigerators installed are less than 4 years old.

This large number of inefficient units represent a large potential for energy savings. The average annual kWh consumption for US refrigerators is 1155kWh/year (EIA 3), compared to new efficient units which can operate on 400-500 kWh/year.

TABLE 4.35
SHIPMENTS OF HOUSEHOLD REFRIGERATORS
(quantity in 1000s, value in $millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	7,599	9,396	9,676	10,305	11,062	12,181	19,724	**10.1**
value	3,363	3,941	3,938	4,209	4,752	5,190	8,068	**9.2**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.36
REFRIGERATOR ENERGY EFFICIENCY AND CONSUMPTION TRENDS

Year	Energy Consumption/Unit (kWh/year)	Efficiency (Energy Factor)
1991	857	8.44
1992	821	8.80
1993	660	11.13
1994	653	11.19
1995	649	11.22

source: AHAM 6

TABLE 4.37
ENERGY SAVINGS FROM THE USE OF ENERGY EFFICIENT REFRIGERATORS
(millions kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	2,264	5,355	10,145	15,318	20,916	27,079	68,585

source: US Department of Commerce, Bureau of the Census, DOE, Author

Automatic defrost refrigerators with top mounted freezers represent 62.6 percent of total shipments. Manual defrost refrigerators represent 12.7 percent, while units with automatic defrost and side-by-side or bottom mounted freezers represent 23.7 percent of the US shipments (AHAM 6).

STANDARDS

The following table presents the new US standards for refrigerators and freezers.

TABLE 4.38
REFRIGERATOR/FREEZER STANDARDS

Product Class	Old Maximum Annual Energy Consumption (kWh) 1990	New Maximum Annual Energy Consumption (kWh) 1993
Refrigerators and refrigerator-freezers—manual defrost	16.3 AV + 316	13.5 AV + 299
Refrigerator—partial automatic defrost	21.8 AV + 429	10.4 AV + 398
Refrigerators-automatic defrost ("AD") with top mounted freezer without ice service	23.5 AV + 471	16.0 AV + 355
Refrigerators-AD with side mounted freezer without ice service	27.7 AV + 488	11.8 AV + 501
Refrigerators-AD with bottom mounted freezer without ice service	27.7 AV + 488	16.5 AV + 367
Refrigerators-AD with top mounted freezer with ice service	26.4 AV + 535	17.6 AV + 391
Refrigerators-AD with side mounted freezers with ice service	30.9 AV + 547	16.3 AV + 527
Upright freezers-manual defrost	10.9 AV + 422	10.3 AV + 264
Upright freezers-automatic defrost	16.0 AV + 623	14.9 AV + 391
All other freezers	14.8 AV + 223	11.0 AV + 160

AV= adjusted volume, calculated from volume of fresh food section + adjustment factor x freezer volume
Source: EREC, 1997

DOE has announced that new efficiency standards for refrigerators would go into effect in July of 2001. These standards would require 30 percent more energy savings from the new, efficient appliances (Boston Globe).

SERP Refrigerators

One of the most creative market forcing programs was the Super Efficient Refrigerator Program (SERP), also known as the "Golden Carrot" program. To encourage manufacturers to develop and market refrigerators that are substantially more efficient than the 1993 standards, a group of electric utilities, government agencies, and consumer and environmental groups joined together to launch a new market transformation program. $30 million in incentive money was promised to the manufacturer who could promise the most energy savings at the lowest cost per kWh. SERP received 14 bids, including bids from major manufacturers. To be eligible, bids had to contain CFC-free designs. The winning design was manufactured by Whirlpool, and uses approximately 40 percent less energy than required by the 1993 Federal standards.

Approximately 25,000 SERP refrigerators were sold in 1994. These products will save over 135.3 million kWh of energy and reduce CO_2 emissions by about 85,719 metric tons during their useful lives. The Program's goal is to have 250,000 SERP refrigerators in the market in the next few years.

For more information on the program, call 1-800-927-3985 (within participating utilities' service territories only).

CONSORTIUM FOR ENERGY EFFICIENCY REFRIGERATOR INITIATIVE

Launched in conjunction with the US DOE, The US EPA, the New York Power Authority, and nine participating utility companies, this program encourages bulk purchases of energy-efficient apartment-sized refrigerators by utilities and HUD assisted properties. The goal of the program is to stimulate sales of highly efficient appliances through aggregation of large volume purchases and other market-oriented approaches. In 1996, the program encouraged the installation of 20,000 efficient GE units in HUD properties. Maytag has been selected to deliver an efficient unit under the Maytag Magic Chef Label beginning in March 1997 at a cost of $308 per unit. Initial quantities of these low priced efficient units to be distributed are expected to be limited to 60,000. The CEE has taken a lead role in marketing this initiative nationally, and acts as a facilitator in the placement of bulk orders of highly efficient refrigerators. The Maytag Magic Chef Unit is anticipated to consume 437 kWh/year, as opposed to an average energy consumption of older units of 1,200 kWh/year (CEE 3).

This initiative's goal is to stimulate the transformation of the market for efficient products. The target number of units was set at a level to encourage manufacturers to produce the highly efficient product lines. CEE has had discussions with Maytag, Whirlpool, GE and Frigidaire to introduce a model which would consume less than 400 kWh/yr., a 10% improvement in efficiency. This new model would be distributed in 1998 at levels comparable to the 1997 goal. This CEE initiative is expected to continue through 1999 (Wisniewski).

4.2.7 WATER HEATERS

Over 99 percent of all US households use a water heater. Thirty nine percent are electric and fifty four percent are gas-fired units. The remainder are oil, propane, and indirect-fired water heaters. Because of their high annual energy consumption and long lives, the savings from efficient water heaters can be quite large.

TABLE 4.39
SHIPMENTS OF WATER HEATERS
(1000s of units)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
electric	3,689	3,211	3,747	4,021	4,080	4,208	4,908	**3.1**
gas	3,941	3,562	4,494	4,682	4,234	4,352	4,994	**2.7**
other	136	154	114	130	107	102	83	**-4.0**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.40
VALUE OF US SHIPMENTS OF WATER HEATERS
($millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
Electric	447	401	473	516	515	536	656	**2.9**
Gas and Other	616	586	700	748	986	1,117	2,087	**10.4**
Total	**1,063**	**987**	**1,173**	**1,264**	**1,501**	**1,653**	**2,743**	**7.7**

source: US Department of Commerce, Bureau of the Census, Author

The following table presents the electricity and gas savings from the use of efficient water heaters. Savings from the use of efficient indirect and other types of water heaters have been converted into MMBtu savings with gas water heaters.

TABLE 4.41
SAVINGS FROM THE USE OF EFFICIENT WATER HEATERS
(million kWh, trillion Btu)

	1991	1992	1993	1994	1995	1996	2001
Electric	1,722	3,221	4,971	6,849	8,754	10,719	21,505
Gas and Other	15.76	30.01	47.99	66.72	83.65	101.06	195.66

source: US Department of Commerce, Bureau of the Census, DOE, Author

STANDARDS

The Department of Energy has set efficiency standards for water heaters based on an Energy Factor Rating. The energy factor is based on three factors: the recovery efficiency-how efficiently the heat from the energy source is transferred to the water, standby losses-the percentage of heat lost per hour from the stored water, and cycling losses. The standards, which went into effect on January 1, 1990 are:

- Gas water heater .62 - (.0019 x rated storage volume in gallons)
- Electric water heater .93 - (.00132 x rated storage volume in gallons)
- Oil water heater .59 - (.0019 x rated storage volume in gallons)

4.3 HEATING, VENTILATION, AND AIR CONDITIONING

The heating, ventilation, and air-conditioning sector (HVAC) accounts for over 46% of commercial electricity consumption and 26% of residential use. The overwhelming majority of natural gas use in commercial buildings was used for heating. Due to its long lifetimes and high operating costs, energy efficient HVAC equipment has large potential for efficiency improvements and significant resultant savings.

Regulations banning the production of CFC refrigerants are helping to spur the replacement market for unitary (single package) air conditioning units which utilize ozone-depleting substances.

Markets For Energy Efficient HVAC Equipment

The value of the efficient HVAC equipment market is expected to enjoy strong growth through 2001, as presented in the following table:

TABLE 4.42
VALUE OF EFFICIENT HVAC MARKET
($1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Air Source Heat Pumps	626,306	614,181	686,641	778,375	790,146	839,005	1,132,529	6.1
Water Source Heat Pumps	102,424	101,621	111,513	105,771	120,378	125,678	155,890	4.0
Chillers	603,786	651,581	671,520	938,820	1,124,708	1,323,164	2,981,853	17.6
Unitary AC units	2,430,088	2,521,397	2,735,413	3,283,130	3,386,488	3,693,335	5,720,254	
Room AC Units	707,157	728,735	717,053	978,234	1,114,613	1,258,994	2,314,844	12.9
Gas Furnaces	842,717	1,058,111	1,134,210	1,212,129	1,325,184	1,487,348	2,649,075	12.2
Electric Fans	409,604	473,113	494,066	552,292	527,951	563,999	784,696	6.8
TOTAL	**5,722,082**	**6,148,739**	**6,550,416**	**7,848,751**	**8,389,468**	**9,291,523**	**15,739,141**	10.6

source: US Department of Commerce, Bureau of the Census, Author

The following types of efficient HVAC equipment will be covered in this report:

- AIR SOURCE HEAT PUMPS
- WATER SOURCE HEAT PUMPS
- GROUND SOURCE HEAT PUMPS
- CHILLERS
- AIR CONDITIONING SYSTEMS
- FURNACES
- FANS

QUALITY INDICATORS

The performance of HVAC equipment is measured by several different indicators. Air conditioning systems are measured by their Energy Efficiency Ratio (EER) or Seasonally adjusted Energy Efficiency Ratio (SEER). The efficiency of large chiller packages is measured by the kWh/ton used. Heating systems are typically measured by a Heating Seasonal Performance Factor (HSPF).

UNITARY SHIPMENTS

For the air conditioning industry, 1995 was the best year on record. Shipments of unitary products topped 5 million units for the first time. These high growth rates have been driven by three key factors: low interest rates, the increasing replacement market, and hotter than average weather.

Unitary units include heat pumps, chillers, and fan coil units.

4.3.1 HEAT PUMPS

Heat pumps offer the most energy efficient way to provide heating, cooling, and water heating in many applications. Heat pumps are basically air conditioners in which the flow of refrigerant can be reversed to provide heating or cooling. They extract useful heat from the air or ground to transfer heat to the refrigerant. A typical heat pump will use 100 kWh of power to produce 300 kWh of useful heat (IEA). Heat pumps make up 25 percent of the market for unitary HVAC systems.

The technical and economic performance of a heat pump is closely related to the characteristics of the heat source. If the fuel used by conventional boilers were redirected to supply power for electric heat pumps, approximately 35 percent less fuel would be needed.

Air Source Heat Pumps

The most common type of heat pump is the air source heat pump. These units are suited for any well insulated structure, and work best in moderate climates. Ambient air heat pumps rapidly lose their efficiency benefits in the presence of decreasing outdoor temperatures (usually between 18 and 32 degrees F) due to the use of auxiliary heating systems,. Due to their relatively low up front cost, the typical pay back period for air source heat pumps is 4-7 years.

TABLE 4.43
SHIPMENTS OF AIR-SOURCE HEAT PUMPS
(quantity in #, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	825,160	794,992	875,899	1,022,908	1,036,767	1,100,668	1,484,570	**6.1**
value	626,306	614,181	686,641	778,375	790,146	839,005	1,132,529	**6.1**

source: US Department of Commerce, Bureau of the Census, Author

Water Source Heat Pumps

Water source heat pumps extract heat from water from a well, deep lake, river, or a closed-loop system buried in the ground. Water source heat pumps are slightly more efficient than air source units, due to the more stable seasonal temperature of the water. Their efficiency depends of the available groundwater source, flow rate, chemical makeup, and the temperature of the water. Water source heat pumps are better suited for larger applications. In general, the pay back period for installing an efficient water source heat pump will be less than 3-5 years.

TABLE 4.44
SHIPMENTS OF WATER SOURCE HEAT PUMPS
(quantity in #, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	111,745	99,236	105,159	99,321	109,326	109,133	108,176	**-.1**
value	102,424	101,621	111,513	105,771	120,378	125,678	155,890	**4.0**

source: US Department of Commerce, Bureau of the Census, Author

Ground Source Heat Pumps

Ground source heat pumps ("GHP") use the heat stored in the earth, and typically do not require back up heating systems. Depending on the location, GHPs can reduce electricity use by 23-44% compared to standard air source heat pumps. Even though they are the most efficient systems, ground source or geothermal heat pumps have annual sales under 40,000 units, representing less than 1 percent of unitary shipments. Most of the sales growth has been achieved through cooperative efforts of the heat pump industry and a limited number of electric utility companies. Due to their higher up-front costs and lack of consumer awareness, these types of heat pumps will not likely emerge as a mainstream HVAC option.

TABLE 4.45
COMPARISON OF SPACE CONDITIONING EQUIPMENT
(Seasonal Performance Factor*)

Equipment Type:	End Use Efficiency: Heat	Cool	Water Heating
Emerging Ground Source Heat Pump	3.86	5.48	2.25
Advanced GHP	3.48	4.93	1.31
Standard GHP	2.95	3.43	1.29
Advanced Air Source Heat Pump	2.26	4.33	2.30
High Efficiency Air Source Heat Pump	1.96	3.06	.90
Standard Air Source Heat Pump	1.74	2.57	.90
Electric Resistance/ Standard AC	1.00	2.57	.90
Gas Fired Heat Pump	.99	1.28	.81

TABLE 4.45 (cont.)

Advanced Gas Furnace/ High Efficiency AC	.87	3.11	.60
Standard Furnace/ Standard AC	.67	2.57	.60

* The Seasonal Performance Factor is calculated by dividing the number of BTU's demanded for space heating, cooling and water heating by the number of BTUs of energy input the equipment requires to meet the load. The larger the SPF, the more efficient the equipment.
source: L'Ecuyer, Zoi, Hoffman, 1993

The following table presents the energy savings from the use of heat pumps.

TABLE 4.46
ESTIMATED ENERGY SAVINGS BY THE USE OF HEAT PUMPS
(million kWh/year)

	1991	1992	1993	1994	1995	1996	2001
savings	2,159	4,220	6,482	9,068	11,710	14,499	30,986

source: US Department of Commerce, Bureau of the Census, DOE, Author

Climate Change Action No. 26:
Renewable Energy Commercialization-ENERGY STAR Geothermal Heat Pumps

As part of the US Climate Change Action plan, a consortium of GHP manufacturers, electric utilities, trade groups, environmental organizations, DOE and EPA entered into a collaborative agreement to demonstrate and market efficient GHPs. In some areas, ENERGY STAR labeled heat pumps can now be financed with ENERGY STAR loans from banks. These loans have special interest rates, longer repayment periods, or both. This industry-led, cost-shared program consists of interrelated tasks and projects designed to increase GHP unit sales to 400,000 by the year 2000, leading to a reduction in greenhouse gas emissions by 1.5 million metric tons of carbon equivalent annually.

4.3.2 CHILLERS

Chillers are a combination of chilled-water and -condenser heat exchangers and compressors. They compress large volumes of refrigerant gas which is circulated through a condenser to cool water. Air is circulated over coils containing the chilled water to provide cool air. They are used almost universally for cooling large commercial buildings. Chillers typically operate 2,000-6,000 hours per year, and have a mean service life of 24 years. Typical improvements in the energy efficiency of chiller systems include:

- Reducing the load
- Installing efficient water cooling coils and fan systems
- Installing high efficiency heat rejection devices including cooling towers and evaporative condensers
- Improve air distribution system efficiency
- Install energy efficient chillers.

Energy efficient chillers can provide the same comfort level while using up to 30 percent less energy.

Chiller replacement affords facilities the opportunity to upgrade the cooling system's performance and reliability, as well as save significant energy and CFC-based refrigerant supply costs. Chiller replacements also allow the opportunity to match the chiller capacity to the actual building air-conditioning load, not an estimated load. By more accurately matching building load and chiller capacity, higher operating efficiencies and better system performance can be achieved.

There are approximately 80,000 CFC-using centrifugal chillers in operation in the US (ARI 2), which will need to be phased out and replaced with non-CFC using equipment. Production of ozone-depleting CFCs ending on January 1, 1996 under US law. ARI completed a survey which concluded that it would take building owners much longer than initially projected to phase out chillers which use CFCs. The survey estimates that 34,222 units will be converted or replaced by 1999, representing 43 percent of the current market.

When 44 percent are replaced, the savings will equal 7 billion kWh/year. By 1995, only 18 percent had been replaced (ARI 2).

Centrifugal, Rotary Screw, And Absorption Chillers

Centrifugal chillers have medium to high reliability, medium cost, and the highest efficiency at medium and high lift conditions. Rotary Screw chillers are most efficient at capacity below 200 tons. Absorption chillers have a wide variety of applications, with normal capacities ranging from 100 to 1,500 tons.

TABLE 4.47
SHIPMENTS OF CHILLERS
CENTRIFUGAL, ROTARY SCREW, AND ABSORPTION UNITS
(quantity in #)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	4,690	5,190	6,420	7,583	8,002	9,211	19,158	**14.6**

source: US Department of Commerce, Bureau of the Census, Author

Reciprocating Chillers

These chiller packages are typically installed in smaller buildings.

TABLE 4.48
SHIPMENTS OF RECIPROCATING CHILLERS
(quantity in #)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	10,400	11,500	12,000	13,100	14,000	15,083	21,897	**7.7**

source: US Department of Commerce, Bureau of the Census, Author

The following table present the value of US chiller shipments from 1991-1996.

TABLE 4.49
VALUE OF US CHILLER SHIPMENTS
(value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	603,786	651,581	671,520	938,820	1,124,708	1,323,164	2,981,853	**17.6**

source: US Department of Commerce, Bureau of the Census, Author

The potential savings from the use of efficient chillers is presented in the following table:

TABLE 4.50
ENERGY SAVINGS FROM USE OF ENERGY EFFICIENT CHILLERS
(millions kWh/yr.)

	1991	1992	1993	1994	1995	1996	2001
savings	3,078	6,491	10,258	14,488	18,988	23,457	51,854

source: US Department of Commerce, Bureau of the Census, DOE, Author

4.3.3 AIR CONDITIONING

Over 41 million US homes have central air conditioning systems. Unitary air conditioners consist of a condensing unit and an evaporator coil. If the coil is in the same casing as the condenser, it is referred to as a self-contained or single package unit. Split system units connect the evaporator and the condenser by tubing.

Room air conditioners are small units intended to cool a single room.

TABLE 4.51
SHIPMENTS OF ROOM FAN-COIL AIR CONDITIONING UNITS: VERTICAL, VERTICAL STACK, AND HORIZONTAL
(quantity in #, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	269,571	198,302	262,159	215,387	234,650	232,812	223,834	**-.7**
value	119,989	97,212	124,937	109,787	121,365	123,779	136,591	**1.9**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.52
SHIPMENTS OF SINGLE PACKAGE AIR CONDITIONERS
(quantity in #, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
single package	176,650	179,270	206,800	244,397	283,555	319,738	582,884	**12.7**
value	336,067	361,228	420,035	496,425	513,385	571,615	978,153	**11.3**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.53
SHIPMENTS OF YEAR ROUND AIR CONDITIONERS
(quantity in #, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
year round air conditioners	389,566	411,468	426,946	495,434	516,003	554,157	791,658	**7.4**
value	757,013	793,173	842,423	1,028,579	1,098,062	1,207,426	1,941,013	**9.9**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.54
SHIPMENTS OF SPLIT SYSTEM AIR-CONDITIONING CONDENSING UNITS
(quantity in #, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	2,455,692	2,440,397	2,623,039	3,385,357	3,432,989	3,753,378	5,863,704	**9.3**
value	1,217,019	1,269,784	1,348,018	1,648,339	1,653,676	1,790,515	2,664,497	**8.3**

source: US Department of Commerce, Bureau of the Census, Author

The following table presents data on the improvement of the average efficiency of air conditioner units shipped between 1980 and 1991.

TABLE 4.55
SHIPMENT-WEIGHTED SEASONAL ENERGY EFFICIENCY RATIOS OF AC UNITS
(under 65,000 BTU)

YEAR	UNITARY AIR CONDITIONERS	SPLIT SYSTEM CONDENSING UNITS
1980	7.55	7.51
1981	7.78	7.73
1982	8.31	8.30
1983	8.43	8.44
1984	8.66	8.70
1985	8.82	8.84
1986	8.87	8.87
1987	8.97	8.95
1988	9.11	9.11
1989	9.25	9.23
1990	9.31	9.29
1991	9.49	9.48
1992	10.46*	10.53
1993	10.56	10.58
1994	10.61	10.64
1995	10.68	10.71

* NAECA standards in effect for split system units
source: Air Conditioning and Refrigeration Institute, 1996

The following table presents the energy savings from the use of efficient air-conditioners.

TABLE 4.56
ENERGY SAVED BY THE USE OF EFFICIENT UNITARY AIR CONDITIONERS
(million kWh/year)

	1991	1992	1993	1994	1995	1996	2001
savings	160	966	1,832	2,929	4,055	5,284	15,544

source: US Department of Commerce, Bureau of the Census, DOE, Author

ROOM AIR CONDITIONERS

Room air conditioners are factory made assemblies designed as units for mounting in a window or through a wall for delivery of cool air without ducts for conditioned air supply or air return. They are installed in over 33 million households in the US.

TABLE 4.57
SHIPMENTS OF ROOM AIR CONDITIONERS
(quantity in 1000s, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	2,286	2,519	2,234	3,265	4,010	4,690	10,266	**16.9**
value	707,157	728,735	717,053	978,234	1,114,613	1,258,994	2,314,844	**12.9**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.58
EFFICIENCY AND ENERGY CONSUMPTION TRENDS
FOR ROOM AIR CONDITIONERS

YEAR	Energy Consumption/Unit (kWh/yr.) *	Efficiency EER
1991	925	8.80
1992	853	8.88
1993	851	9.05
1994	843	8.97
1995	838	9.03

* based on 750 hours of operation
Source: AHAM, 1996

The following table presents the energy savings form the use of efficient AC units for 1991-2001.

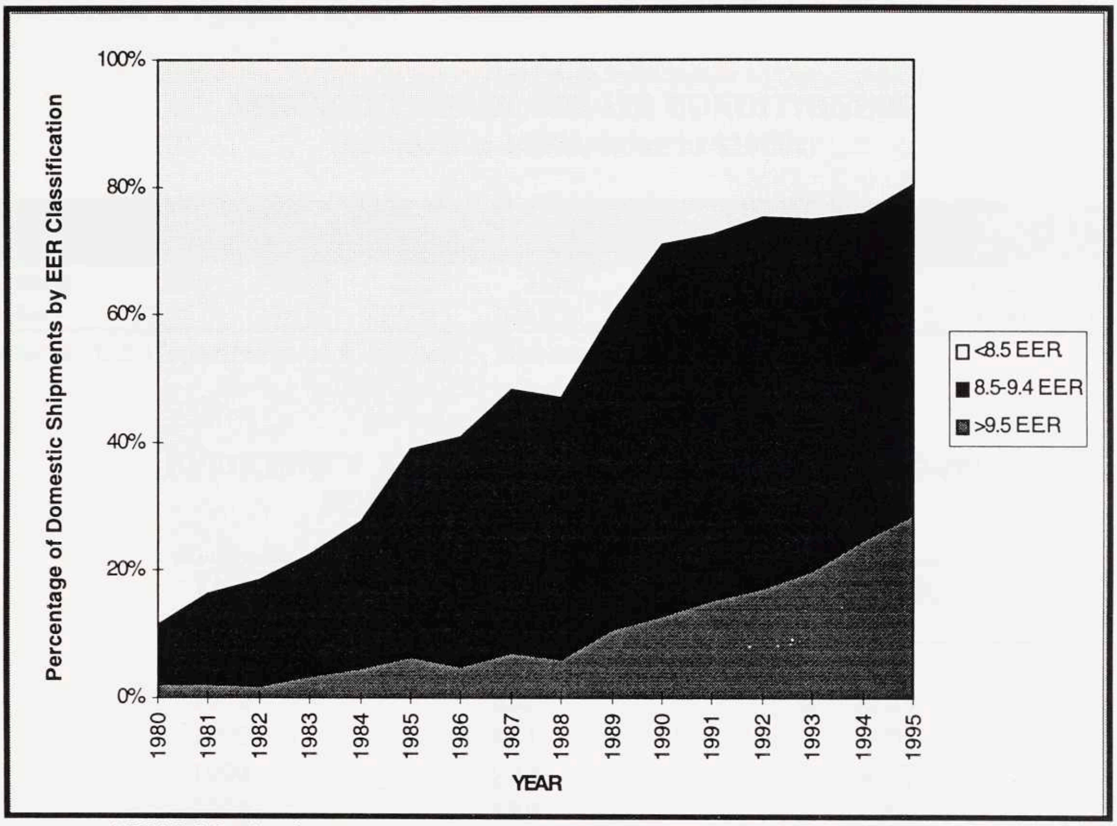
TABLE 4.59
ENERGY SAVINGS FROM THE USE OF EFFICIENT
ROOM AIR CONDITIONERS
(millions kWh/year)

	1991	1992	1993	1994	1995	1996	2001
savings	57	301	522	871	1,320	1,769	5,033

source: US Department of Commerce, Bureau of the Census, DOE, Author

The share of higher efficiency rated room air conditioning units has dramatically increased over time. The share of units less than 8.5 E.E.R. has decreased from over 88 percent in 1980 to 19 percent in 1995.

CHART 4.7
SHIPMENTS OF ROOM AIR CONDITIONER UNITS BY ENERGY EFFICIENCY RATING



source: AHAM 2, Author

STANDARDS

NAECA standards for room air conditioners went into effect on January 1, 1990. These standards set energy efficiency ratings for room air conditioners, which is the ratio of the cooling output divided by the power consumption.

The table shows the existing EER standards for room air conditioners

TABLE 4.60
NAECA ROOM AC STANDARDS

Product Class	Energy Efficiency Ratio
Without Reverse Cycle and with Louvered Sides	
<6,000 Btu	**8.0**
6,001-7,999 Btu	**8.5**

TABLE 4.60 (cont.)

8,000-13,999 Btu	**9.0**
14,000-19,999 Btu	**8.8**
>20,000 Btu	**8.2**
Without Reverse Cycle and without Louvered Sides	
<6,000 Btu	**8.0**
6,001-7,999 Btu	**8.5**
8,000-13,999 Btu	**8.5**
14,000-19,999 Btu	**8.5**
>20,000 Btu	**8.2**
With Reverse Cycle and with Louvered Sides	**8.5**
With Reverse Cycle and without Louvered Sides	**8.0**

source: EREC, 1997

The Department of Energy considers room air conditioners a high priority product for additional standards due to the moderate potential additional energy savings based on incremental technology. Additionally, interested parties and stakeholders recommended that room air conditioners be listed as a high priority product. Limited DOE resources would be needed to complete additional rulemaking.

CONSORTIUM FOR ENERGY EFFICIENCY
RESIDENTIAL CENTRAL AIR CONDITIONER AND HEAT PUMP PROGRAM

According to a 1992 survey, more than 200 electric utility companies offered incentives for the purchase of high efficiency residential central air conditioning systems. However, each utility set its own eligibility threshold, sending confusing signals to manufacturers as to what efficiency levels their products must meet. Additionally, high efficiency equipment may not be available in some service areas. In order to reduce confusion and to improve the availability of high-efficiency equipment, the CEE has developed a recommended set of thresholds for utility programs that can be used by utilities for their DSM programs. CEE has also developed a recommended program for proper AC and heat pump installation in order to insure optimal actual performance from high efficiency equipment.

These standards are set in a tiered system. The initial tier equipment is approximately 15 percent more efficient than the average equipment sold today. Higher tiers are set to provide a clear target for manufacturers to meet as they develop new equipment. Equipment is rated in terms of Seasonal Energy Efficiency Ratios (SEER), a measure of the average efficiency of a unit throughout the cooling season, giving weight to performance at different operating conditions. Peak Load performance is frequently measured by the Energy Efficiency Ratio (EER), which is calculated based on performance at an outdoor temperature of 95 degrees F. Heat Pumps are rated in terms of Heating Season Performance Factor (HSPF), a measure of the average efficiency throughout the heating season. Peak load is usually measured by the Coefficient of Performance (COP), typically calculated at 17 and 47 degrees.

The CEE program consists of four efficiency tiers for cooling and heating performance.

TABLE 4.61
CEE AC AND HEAT PUMP INITIATIVE EFFICIENCY TIERS

	COOLING PERFORMANCE		HEATING PERFORMANCE
TIER	SEER	EER	HSPF
1	12	10.5	7
2	13	11	8
3	14	12	8.5
Advanced	15 and above	12.5 and above	9 and above

In order for a utility to be considered a participant in the CEE initiative, it must offer incentives for Tier 1 or higher. Utilities are encouraged to adopt as many program tiers as appropriate. Each utility decides whether its program applies to central air conditioners, heat pumps, or both types of equipment. Utilities can offer incentive payments to consumers, dealers or manufacturers. Opinions vary as to the best mechanism for reducing equipment costs.

CEE is widely disseminating the program description and is recruiting additional participants. CEE will compile information about programs participants that it will present to manufacturers.

CONSORTIUM FOR ENERGY EFFICIENCY
HIGH EFFICIENCY COMMERCIAL AIR CONDITIONING
(HECAC) INITIATIVE

This group has been working together since early 1992 to develop technical efficiency specifications which utilities may incorporate into their DSM programs for unitary air conditioner equipment. The object of the specifications is to encourage the development and to increase the availability of high efficiency unitary air conditioners that utilities can promote through incentive and information based programs. The group decided to establish eligibility standards on the basis of cooling performance only. As of April 1996, utilities providing commercial electric service to approximately 15 percent of the nation are participating in the Initiative. CEE hopes to expand this percentage over the next several years.

The efficiency eligibility levels currently chosen by individual utilities vary widely. In some cases, a rebate is paid for a unit just meeting the eligibility level. Other utilities pay additional rebates for each EER improvement over the eligibility level. For a utility to participate, it must provide incentives (rebates or financing) for high efficiency commercial air conditioning equipment meeting at least Tier 1 efficiency levels or deploy a significant and focused educational or promotional program that identifies and promotes the equipment meeting Tier 1 standards.

The specifications of this initiative provide for two efficiency levels. Tier 1 for equipment that can be manufactured and promoted today, and Tier 2 for equipment that will be introduced to the market over the next few years. CEE has adopted newer, stricter eligibility standards effective January 1997 based on the new draft ASHRAE Standard 90.1R. CEE is interested in adopting a new Tier 2 standard that is based on the most efficient equipment now on the market and that generally results in 10 percent energy savings relative to Tier 1 efficiencies. CEE plans to work with ASHRAE and ARI to find mutually agreeable Tier 2 values.

TABLE 4.62
CEE HECAC INITIATIVE EFFICIENCY TIERS

EQUIPMENT TYPE	Size Category	Sub-Category	Tier 1 Efficiency	old Tier 2 Efficiency
Air Conditioners, Air Cooled	<65,000 Btu/hr	split system	12.0 SEER	14.0 SEER
	<65,000 Btu/hr	single package	11.0 SEER	14 .0 SEER
	65,000-134,999 Btu/hr	split system and single package	10.3 EER 10.6 IPLV	12.0 EER
	135,000-239,999 Btu/hr	split system and single package	9.7 EER 9.9 IPLV	12.0 EER 14.0 IPLV
	240,000-759,999 Btu/hr	split system and single package	9.5 EER 9.7 IPLV	12.0 EER 14.0 IPLV
	> 760,000 Btu/hr	split system and single package	9.2 EER 9.4 IPLV	12.0 EER 14.0 IPLV
Air Conditioners, water and evaporatively cooled	< 65,000 Btu/hr	split system and single package	12.1 EER 11.2 IPLV	14.0 EER 16.0 IPLV
	65,000-134,999 Btu/hr	split system and single package	11.5 EER 10.6 IPLV	15.0 EER 17.0 IPLV
	> 135,000 Btu/hr	split system and single package	11.0 EER 10.3 IPLV	15.0 EER 17.0 IPLV

source: CEE 3, 1996

4.3.4 FURNACES

There are 43 million oil and gas furnaces in US homes. Because of their extremely long lives (25 years or more), their exist significant potential savings from the use of efficient equipment. The following table presents the number of new, efficient units shipped per year.

TABLE 4.63
SHIPMENTS OF GAS FURNACES
(quantity in 1000s, value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	2,057	2,107	2,585	2,697	2,601	2,769	3,789	**6.5**
value	842,717	1,058,111	1,134,210	1,212,129	1,325,184	1,487,348	2,649,075	**12.2**

source: ARI, US Department of Commerce, Bureau of the Census, Author

The following table presents the savings from the use of efficient gas furnaces.

TABLE 4.64
SAVINGS FROM THE USE OF EFFICIENT GAS FURNACES
(billion Btu)

	1991	1992	1993	1994	1995	1996	2001
savings	41,140	83,280	134,980	188,920	240,940	296,330	631,870

source: US Department of Commerce, Bureau of the Census, DOE, Author

4.3.5 FANS

Electric fans can decrease energy costs by reducing air conditioning requirements. For each degree a thermostat on a cooling system is raised, there is a 3-5% energy savings. The comfort range for a cooled are can be raised 4-10 °F with modest air movement from the use of electric fans.

There are many types of fans which can achieve this function, including; louvers and roof ventilators, ceiling fans, and window fans. The following table presents the total shipments of electric fans for the years 1991 through 2001.

TABLE 4.65
SHIPMENTS OF ELECTRIC FANS
(quantity in 1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	18,549	21,269	20,857	24,263	23,738	25,334	35,075	**6.7**

source: US Department of Commerce, Bureau of the Census, Author

TABLE 4.66
VALUE OF US ELECTRIC FAN SHIPMENTS
($1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	409,604	473,113	494,066	552,292	527,951	563,999	784,696	**6.8**

source: US Department of Commerce, Bureau of the Census, Author

The following table was calculated based on 4 fans required to raise average comfort range 3°F.

TABLE 4.67
ENERGY SAVINGS FROM USE OF FANS
(Millions kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	973	2,090	3,185	4,459	5,705	6,061	8,116

source: US Department of Commerce, Bureau of the Census, DOE, Author

4.4 BUILDINGS SECTOR AND OTHER ENERGY SAVING DEVICES

There are numerous additional technologies which can improve end use efficiency. These other technologies represent a significant market and a significant opportunity for reducing energy use.

Markets For Other Energy Saving Technologies

The following table presents data on the value of the markets for building and other energy saving technologies. Because efficient motors have already been partially accounted for in the Appliance and HVAC section, they have been excluded from aggregate tables.

TABLE 4.68
VALUE OTHER ENERGY SAVING DEVICES AND EQUIPMENT
($ millions) (excluding motors)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Windows	4,105	4,191	4,276	4,362	4,447	4,526	4,947	**1.9**
Insulation	3,160	3,220	3,290	3,360	3,430	3,500	3,860	**2.0**
Low-flow Showerheads	14.9	16.9	19.1	21.3	23.8	26.6	46.0	**11.6**
Control Systems	18.3	21.4	25	29.2	34.2	40	68.9	**14.1**
TOTAL	**7,298**	**7,449**	**7,610**	**7,773**	**7,935**	**8,093**	**8,922**	**2.0**

source: US Department of Commerce, Bureau of the Census, CentainTeed, Lynch, Author

The following types of energy savings devices and programs will be covered in this section:

- WINDOWS
- INSULATION
- CONTROL SYSTEMS
- LOW-FLOW SHOWER HEADS
- MOTORS

Although complete data on sales, value, and energy savings are not available for all of these technologies, they represent significant areas of potential energy savings.

4.4.1 WINDOWS

Inefficient windows can waste up to 25% of the energy used for heating and cooling. Energy is wasted due to lack of insulation (measured by R-values) and emissivity (measured by E-value). The thermal performance of windows can be improved through the use of extra panes of glass. Typical single pane windows have R values of less than 1. Double pane windows have R values of 2. Inert gas between the panes provides increased R values. Windows can also be coated with reflective films which improve their E values. Low E windows control the amount of radiant heat that is admitted to the indoor area. They also prevent radiant heat from escaping the indoor area.

There are 1.2 billion windows in US housing units, a sizable market. Thirty six percent of these windows are efficient, with double or triple pane glass. Only 1.7% use some type of low E coating. Over sixty-one percent of all replacement windows use double or triple pane glass.

The dollar value of factory shipments of windows during the last decade has risen to over three percent of total US building materials shipments, and is estimated at nearly $7.5 billion in 1996.

There are more than 2,500 companies engaged in significant production of window and door related products; no single company dominates the market. This high degree of competition has forced companies to reduce costs of product lines to stay competitive.

TABLE 4.69
TOTAL US WINDOW SHIPMENTS
(quantity in millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	67.3	68.7	70.1	71.5	72.9	74.2	81.1	**1.9**

source: Window and Door Fabricator, Author

TABLE 4.70
VALUE US WINDOW SHIPMENTS
(value in $billions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	5.33	5.75	6.16	6.57	6.99	7.40	9.46	**5.9**

source: Window and Door Fabricator, Author

For the following table, energy efficient windows are defined as windows with double or triple paned glass. The growth rate of efficient windows is expected to remain relatively modest.

TABLE 4.71
SHIPMENTS OF EFFICIENT WINDOWS
(quantity in 1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	41,053	41,907	42,761	43,615	44,469	45,262	49,471	**1.9**

source: Window and Door Fabricator, Author

TABLE 4.72
VALUE ENERGY EFFICIENT WINDOW SHIPMENTS
(value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	4,105,300	4,190,700	4,276,100	4,361,500	4,446,900	4,526,200	4,947,100	**1.9**

source: Window and Door Fabricator, Author

Wooden frames are the dominant type of window frame, making up 46% of all frames in 1996. Their market share is expected to remain constant over the next five years. Vinyl frames, which are more efficient, have enjoyed a steady increase in market share at the expense of more inefficient aluminum frames. Sales of vinyl frames grew from 13% in 1987 to 26% in 1996. They are expected to represent over 31% of the window market by 2000. Metal window frames, which enjoy a price advantage, will have to add more expensive glazing to meet new energy codes. Sales of metal frames are expected to decline, losing market share from 46% in 1992 to 36% by 2000 (Window & Door Fabricator).

The following table presents the estimated energy savings from the use of efficient windows.

TABLE 4.73
ENERGY SAVINGS FROM THE USE OF EFFICIENT WINDOWS
(million kWh)

	1991	1992	1993	1994	1995	1996	2001
savings	7,184	14,518	22,001	29,633	37,415	45,336	87,256

source: US DOE, Window and Door Fabricator, Author

SUPERWINDOWS

This emerging technology yields impressive energy savings. Superwindows have a triple layer design coupled with two low-E coated surfaces. This design has a R-value of over 10. Super windows can reduce heating and cooling electricity use by 1,000 kWh/year more than standard efficient window savings. However, superwindows have high costs, up to $1000 more than standard efficient windows, leading to payback period of about 14 years (Jackson).

4.4.2 INSULATION

One of the most effective energy saving technologies available is insulation. Made from a variety of substances including fiberglass, mineral wood, foam and other materials, insulation reduces the transfer of heat through building structures. This allows consumers to significantly reduce heating and cooling energy use.

In the United States, 36 million homes are well insulated. 38.4 million are adequately insulated, while 22.5 million homes are poorly insulated. Because of home insulation, drastically less energy is needed to heat and cool homes in the US today when compared to the same homes without insulation. This difference has resulted in energy savings of 42 percent, or 11.91 quadrillion Btu per year. This is roughly equivalent to a reduction of 1.35 trillion lbs. of CO_2 (ECM).

If levels of insulation in all US buildings were improved to meet the Council of American Building Officials Model Energy Code, which specifies minimum efficiency standards, an additional 2.5 quadrillion BTUs would be saved, reducing CO_2 emissions by 285.3 billion lb./year (NAIMA).

Detailed figures on the sales of insulation shipments and energy savings were unavailable at this time, due to manufacturer's reluctance to release data.

The following table presents the estimated value of the US insulation market.

TABLE 4.74
ESTIMATED VALUE US SHIPMENTS OF THERMAL INSULATION
(value in $millions)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	3.16	3.22	3.29	3.36	3.43	3.50	3.86	2.0

source: CertainTeed, Author

4.4.3 CONTROL SYSTEMS

Control systems can optimize the lighting, heating, cooling and ventilation systems in residential and commercial buildings. Control systems can improve productivity, save energy, enhance comfort, increase safety, and reduce waste.

CLOCK SWITCHES
When usage patterns follow a defined pattern, clock switches may be the most cost-effective lighting control option. Clock switches turn lights on and off at preset times, regardless of occupancy. These devices are relatively inexpensive to install.

EMS CONTROLS
Energy Management systems (EMS) are more sophisticated versions of clock switches. A common EMS function is a sweep system that automatically cycles lights one floor at a time, signaling occupants that the lights will be shut off. (ESOURCE)

PHOTOCELL CONTROLS
Photocell controls sense natural light and adjust lighting based on the amount of natural daylight in the room.

OCCUPANCY SENSORS:
Occupancy Sensors can reduce a building's lighting energy by turning lights off in unoccupied spaces. There are numerous types of occupancy sensors on the market including; infrared sensors, ultrasonic sensors, and time-delay sensors.

CHART 4.8
TYPICAL SAVINGS FROM USE OF OCCUPANCY SENSORS

TYPE OF ROOM	ENERGY SAVINGS (%)
Private Office	13-50
Open Office	20-28
Classroom	40-46
Conference Room	22-65
Rest Room	30-90
Corridors	30-80
Storage Area/Closet	45-80

source: EPA 9, ESOURCE

Data on the specific number of occupancy sensors shipped is not available due to manufacturer's reluctance to release proprietary data. The following table presents the estimated value of shipments of occupancy sensors from 1991-2001.

TABLE 4.75
VALUE OF OCCUPANCY SENSOR MARKET
(value in $1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	18,276	21,375	25,001	29,241	34,200	40,000	68,934	**14.1**

source: Lynch, Author

STANDARDS

The EPACT of '92 mandates ASHRAE 90.1 as an acceptable standard for lighting design in new facilities. This allows discounting of allowed wattage to meet power density limits if the lighting is controlled by automatic devices such as timers and sensors. All state energy codes should include this provision or demonstrate how their alternative is comparable.

4.4.4 LOW-FLOW SHOWER HEADS

Approximately 37 percent of electric water heater energy and 22 percent of gas water heater energy is used to heat water for showers. By installing low-flow showerheads, consumers can realize both water and energy savings by reducing hot water usage during showering (Koomey). For this analysis, showerheads with flow rates at 2.5 gallons per minute or below are considered low-flow. There are several driving forces behind the markets for efficient showerheads. They are; new construction, remodeling, repair, and replacement.

There are several examples of electric utilities and water companies jointly promoting retrofit programs with low flow showerheads to realize significant energy and water savings.

There are inadequate data regarding the total sales of low flow showerheads. The Bureau of the Census only tracks plumbing fittings, and only at five year intervals. Additionally, the report has six separate categories which contain shower heads, as well as other products. Thus there is little official data on sales and value of shipments. However, a survey of manufacturers and distributors was undertaken in 1994 which provided a reliable estimate of the efficient showerhead market size.

TABLE 4.76
1993 RESIDENTIAL & COMMERCIAL LOW-FLOW SHOWERHEAD SALES

2.5 GPM OR LESS	2.5 GPM	2.0 GPM	1.5 GPM	**TOTAL**
2,300,000	4,978,895	325,000	40,000	**7,643,085**

Source: Corpening, et. al.

Based upon the survey and the historic growth rate of the plumbing fixtures markets, it is possible to estimate the current and future markets for low-flow showerheads.

TABLE 4.77
SHIPMENTS OF LOW-FLOW SHOWERHEADS
(quantity in 1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	5,972	6,756	7,643	8,529	9,519	10,623	18,389	**11.6**

source: US Department of Commerce, Bureau of the Census, Corpening, Author

The following table presents the value of the low flow showerhead market.

TABLE 4.78
VALUE OF LOW-FLOW SHOWERHEAD SHIPMENTS
($1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	14,931	16,891	19,107	21,324	23,797	26,558	45,974	**11.6**

source: US Department of Commerce, Bureau of the Census, Corpening, Author

The following table presents the estimated energy savings from the use of low-flow showerheads.

TABLE 4.79
ENERGY SAVINGS FROM THE USE OF EFFICIENT SHOWERHEADS
(millions kWh, trillion Btu)

	1991	1992	1993	1994	1995	1996	2001
electricity	707	1,508	2,414	3,424	4,552	5,812	14,666
gas	3,100	6,500	10,500	14,900	19,700	25,300	63,700

source: US Dept. of Commerce, Bureau of the Census, Corpening, Koomey, Author

STANDARDS

The Energy Policy Act of 1992 requires that low-flow showerheads be used in all new and most replacement situations. Showerheads must have a flow rate of less than 2.5 gallons per minute at 80 pounds per square inch.

4.4.5 MOTORS

Electric motors power much of the equipment used by consumers. Motor consume 44 percent of all residential electricity and 46 percent of all commercial electricity. Energy efficient motors can save large amounts of energy. However, specific energy savings from the use of efficient motors are not included in aggregate analysis due to the difficulties in avoiding double counting, unavoidable inclusion of industrial efficiency savings, and disaggregating difficulties.

Motor-driven appliances (such as refrigerators, washers, dryers, etc.) account for 69 percent of motor-driven residential applications. Air conditioning use represents 26 percent of motor electricity use. In the commercial, cooling is the primary motor load, accounting for 43 percent of sector motor use. Heating and ventilation accounts for 33 percent, and refrigeration and water supply account for 24 percent of commercial motor electricity use.

The energy efficiency of motors can be significantly improved by the use of adjustable speed drives, which use only as much power as is needed. Savings from the use of efficient motors can range from 10-40 percent of electricity use, leading to payback periods of six months to three years.

The following table presents the historical sales of energy efficient motors in the 1-200 horsepower range.

TABLE 4.80
SHIPMENTS OF EFFICIENT MOTORS
(quantity in 1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
quantity	253,848	221,020	241,945	311,509	339,712	368,877	556,846	**8.6**

source: US Department of Commerce, Bureau of the Census, Author

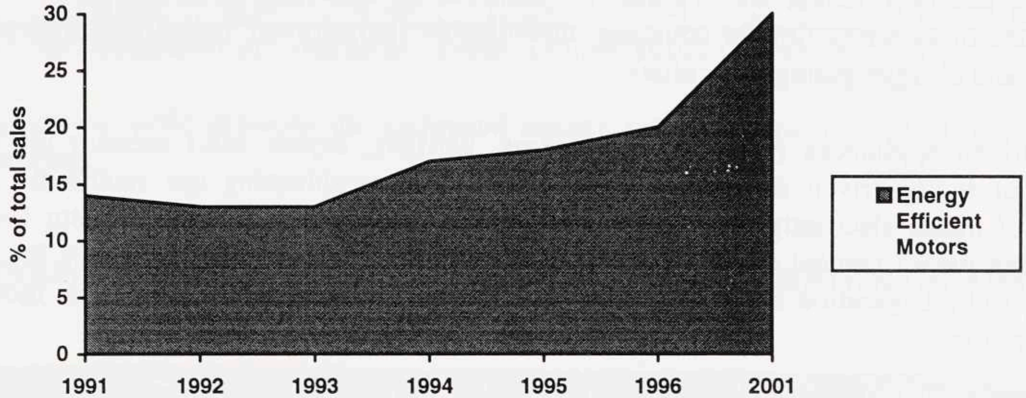
TABLE 4.81
VALUE OF EFFICIENT MOTORS MARKET
($1000s)

	1991	1992	1993	1994	1995	1996	2001	AAGR (%)
value	143,809	128,335	137,796	178,114	212,954	237,141	406,080	**11.3**

source: US Department of Commerce, Bureau of the Census, Author

As the following chart demonstrates, the market share of efficient motors is expected to top 30 percent by 2001.

CHART 4.9
MARKET SHARE OF EFFICIENT MOTORS



CHAPTER V

5. FUTURE TRENDS

There are several current and future developments which can potentially impact the markets for energy efficient end-use equipment. They are:

- The Future Costs of Energy
- Future US Policy regarding Efficiency
- Electric Utility Industry Restructuring and the Future of DSM
- The Role of Energy Service Companies
- The Global Markets for Energy Efficiency

These factors, while potentially significant, should not significantly decrease the markets for energy efficient end use equipment. In fact, future US policies and the actions of Energy Service Companies will continue to accelerate the penetration rates of energy efficient technologies, as will increased global demand for energy efficient equipment and services.

Despite the changes facing DSM spending on efficiency, the rise of energy service companies will continue to push the markets for energy efficiency. These companies, operating on profit motive alone, have implemented numerous efficiency retrofit projects, and expect to continue to do so. By capitalizing on the cost savings available from the installation of efficient end-use equipment, these companies have been able to overcome some of the market barriers and failures in the efficiency market, helping to close the efficiency gap.

Future events such as declining energy costs and electric utility industry restructuring will not adversely impact the markets for energy efficiency, while ESCOS and future governmental policies, will continue to increase the penetration rates of energy efficient end-use equipment in the near term. The global markets for energy efficiency will also undergo increased growth as developing nations will seek to meet energy needs in the face of capital and environmental constraints.

5.1 Future Costs of Energy

The future costs of energy are not likely to increase the penetration rates of energy efficient technologies. In fact, the predicted US electricity price is expected to decline over the next 25 years to a predicted price of 6.1 cents/kWh (EIA 10). This price decline can be attributable to low predicted natural gas prices and the impact of deregulation on the electricity generating industry. Despite the lack of rising price pressure, energy efficiency is expected to make significant inroads well into the next century due to the numerous other drivers acting on the markets for efficient equipment.

5.2 Future US Policy

The Clinton/Gore administration has stated its continued support for energy efficiency, and has supported numerous initiatives promoting this policy as discussed in Chapter III. This support can be expected to continue throughout Clinton's second term, as reflected in the increased levels of Federal funding for energy efficiency-related budget items and in the Administration's commitment to supporting new initiatives.

5.3 Electric Industry Restructuring and DSM

One of the most significant aspects of the EPACT of 1992 was the provision calling for electric utilities to open up their transmission lines, providing so-called "open access" based on non-discriminatory terms and conditions for wholesale electricity buyers and sellers. This provision, coupled with the regulatory structure of the electricity sectors in other countries (England and Wales), has led to a widespread shift towards deregulating the electric power sector, which may have a tremendous impact on electric utility spending on DSM and energy efficiency. Led by an initiative in California, numerous state utility commissions are examining proposals which would end utility companies traditional monopolies and open the retail electricity markets to all players.

Electric utility companies which operate in a competitive marketplace will have intense price pressures. Some analysis suggest that consumers will only be concerned about the short term cost of electricity. This has led utility companies to reduce their costs in an effort to reduce their price of electricity. Because the costs of DSM programs are recovered in the ratebase, the size of utility efficiency budgets have been questioned. Several utilities have announced that they will reduce their levels of DSM expenditures due to competitive pressures. Other utility companies have withdrawn their DSM plans altogether. Overall, the DSM industry will not likely enjoy the growth displayed in the early 1990s, but is projected to remain at current levels of spending. The benefits of DSM, namely reduced total costs, reduced environmental impact, societal benefits, as well as the favorable treatment of DSM by state regulators, and Climate Challenge commitments by several leading utility companies, should insure at least a constant level of DSM in the near-future, as discussed in Chapter III.

However, the long term future of DSM is highly dependent on the future structure of the electricity industry. Traditional electric utility companies will have a difficult time maintaining spending on efficiency programs in a completely deregulated environment. In such a case, consumers could participate in one DSM program, then switch to a different supplier who is not recovering the costs of DSM programs.

However, there are numerous potential scenarios in which DSM can continue its role as an important electricity planning option. DSM could be used by utilities as a marketing tool, offering efficiency services in exchange for long term service agreements. There are also proposals which would assess a "systems benefit charge" on all electricity users. The proceeds from this charge would then be used to fund socially beneficial activities like DSM, increased use of renewable energy technologies, and increased R&D spending. Some of the deregulation proposals being considered have offered the utility companies preferential treatment of their uneconomic assets in exchange for commitments of continued DSM funding.

While electric utility spending on DSM programs provided an early boost for energy efficiency, decreased funding will not destroy the markets for energy efficient end-use equipment. Many of the efficient technologies promoted through DSM have reached a mature development stage, and are being installed by independent parties (Energy Service Companies) who realize the arbitrage opportunity in ignored savings from energy efficiency.

5.4 Energy Service Companies

The past few years have seen a large rise in the number and market size of energy service companies (ESCOs). ESCOs offer customized efficiency services to customers, often designing and installing energy efficient equipment in exchange for a portion of the savings realized through reduced energy use. ESCOS identify cost-effective efficiency improvements, and in some cases provide financing and guaranteed performance. The term ESCO covers many types of companies, from those which provide complete turnkey energy systems to those that exclusively provide lighting upgrades.

The National Association of Energy Service Companies (NAESCO) lists 80 companies which provide complete services. They only consider companies which provide inclusive services, including lighting, HVAC, and control systems to consumers. In 1996, NAESCO members earned an estimated $1 billion, and expect the market to grow by 15 percent per year for the next five years (NAESCO).

The ESCO market has been aided by numerous government programs related to efficiency. One such program, the FEMP, solicits bids form ESCOS to complete efficiency upgrades at federal facilities. The FEMP lists 98 qualified energy service companies authorized to bid for Federal projects. Other federal programs, such as Green Lights and ENERGY STAR buildings, provide informational and technical assistance to participants-supporting the ESCO market. Overall, the ESCO market is expected to enjoy continued growth well into the next century, despite the uncertainty in future DSM funding levels.

5.5 The Export Market For Energy Efficiency

Energy efficient end-use equipment can expect to enjoy significant global growth over the next 20+ years. This growth rate can be attributed to several major factors;

- the expected global growth in energy demand
- the removal of traditional barriers to international trade

- the removal of energy subsidies in developing nations
- insufficient capital to meet rising demand for new electric generating capacity
- environmental concerns

5.5.1 The Global Markets For Energy Efficiency

Markets for energy efficiency have traditionally been centered on the industrialized (OECD) nations. There are, however, significant new opportunities in emerging markets in Latin America, Asia, Southern Africa, and Eastern Europe. These developing countries promise to be the largest markets for energy efficiency in the 21st century.

There is a great deal of uncertainty about the specific size of the current and future markets for energy efficiency. One study estimated that the global market for energy efficiency and services will rise from $40 billion in 1995 to over $125 billion in 2015. Another study found that the global market will rise to roughly $73 billion, with developing countries accounting for over 66% of the global market (IIEC).

While there is a wide range in estimates in the total future market for energy efficiency, there are two clear conclusions.

1. The market is large, and
2. It is expected to rapidly increase over the next 30 years.

5.5.2 Globilization Issues

The developing countries are experiencing large (3.7%) growth rates in the demand for electricity, currently more than double that of the OECD (IIEC). While the developing world has steadily improved its efficiency (measured by energy intensity), developing countries' energy intensity has significantly declined over the past 2 decades. This is partly attributable to rapid industrialization, but will significantly affect future competitiveness in an increasingly global marketplace.

Additionally, many traditional barriers to advanced western technology are being removed by the globilization efforts underway, including the General Agreement on Tariff and Trade (GATT).

5.5.3 International Developments In Electricity Sectors

Many of these developing countries are restructuring/privatizing their electricity sectors. In the late 1980s, consumers in developing countries paid an average of 60 percent of the real cost of the energy they received (OTA). These subsidies had a serious negative impact on the cost effectiveness of efficiency improvements. As governments privatize their energy sectors and more accurately price electricity, energy efficient equipment becomes more attractive and cost-effective.

5.5.4 Capital Shortages & Environmental Concerns

In addition to the cost-saving aspects of energy efficiency, developing nations have two additional reasons to encourage efficiency: capital shortages and environmental constraints.

To meet their projected high future levels of energy demand, the World Bank estimated that developing nations would need over $100 billion per year for the next thirty years to meet electricity needs alone. It is estimated that foreign exchange will be needed to pay for 40% of this total. Yet less than 10-12 % is expected to be available to support these electric power infrastructure projects (World Bank) (Phillips).

Energy efficiency can allow for reduced capital expenditures by displacing the need for new generating capacity. By controlling demand, fewer electricity generation plants will be needed to satisfy the demand for electricity.

This would allow developing countries to free up resources for other purposes. Despite the large potential for efficiency-related capital needs reductions, the availability of global capital will remain a concern for developing countries' energy infrastructures.

Increased fossil fuel consumption has had significant local and global environmental impacts. Local efforts to improve air quality and reduce water pollution related to energy production have spurred efficiency markets. Developing countries have recognized the obvious environmental benefits of reducing energy use. Some countries have incorporated efficiency programs in their national and local plans to reduce pollution. Additionally, the global response to the threat of climate change is creating an international framework which encourages the use of climate friendly technologies--including energy efficiency.

The Framework Convention on Climate Change explicitly allows signatory nations to meet their obligations "jointly with other parties." Projects which fall under this definition are known as "Activities Implemented Jointly" (AIJ). Joint Implementation provides the opportunity for industrialized nations to undertake efficiency projects which reduce greenhouse gases in developing countries, an additional driver for energy efficient equipment markets.

Multilateral development banks and bilateral aid agencies are also actively seeking to promote projects which will reduce carbon emissions. This makes the financing of large efficiency projects more likely.

5.5.5 Summary of International Aspects

The projected large increase in global electricity demand coupled with capital and environmental constraints will accelerate the growth in the international markets for energy efficient end-use equipment. The increase in the global demand for efficient products will influence to marketplace for efficient equipment by sending out powerful incentives for suppliers of energy efficient products. Suppliers will attempt to capitalize on the profitable opportunities for supplying energy efficient equipment, and for developing new technologies to reduce electricity use.

5.6 Overall Summary of Future Trends

The markets for energy efficient equipment will continue to grow over the short to medium term. The conjunction of the numerous forces acting on the markets will continue to accelerate the penetration rates of efficient equipment. The markets for energy efficient technologies have reached a maturity where subsidies from DSM are not necessary to maintain current sales. Consumers are increasingly accounting for energy expenditures when making products purchases, the numerous government programs discussed in Chapter III will continue to increase the acceptance of newer more efficient technologies, and independent third parties will continue to pursue cost-effective energy savings opportunities, increasing the rate of improvements in US energy efficiency. The growing international markets for energy efficient equipment will continue to influence suppliers of efficient equipment, and will represent an important outlet for products and services in the future.

CHAPTER VI

6. INTEGRATION OF RESULTS

The use of energy efficient end-use equipment has had a significant impact on US energy use. It will reduce consumers energy expenditures by over $37 billion per year by 2001, while reducing annual US carbon emissions by 82.7 million metric tons by 2001.

TABLE 6.1
BILL SAVINGS AND POLLUTION PREVENTION FROM ENERGY EFFICIENCY
(pollution reduction figures for electricity savings only)

	BILL SAVINGS ($billions)	*CO_2 Reduction (million metric tons)*	*SO_2 Reduction (metric tons)*	*NOx Reduction (metric tons)*
Year 2001	37	256	564,000	769,000

source: US EPA, US Department of Energy, Author

6.1 Aggregated Energy Savings

The following tables display the annual energy savings produced by each technology analyzed by end-use category.

TABLE 6.2
TOTAL ELECTRICITY SAVINGS FROM EFFICIENT LIGHTING
(millions kWh)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1992-2001 (%)
CFL	NA	3,344	6,795	10,429	14,651	16,187	36,643	**30.4**
Tungsten Halogen	122	172.3	212	190	189	197	282	**5.6**
Fluorescent Lighting	NA	2,632	5,730	9,502	11,635	14,560	36,412	**33.8**
HID	NA	15,934	34,063	55,806	66,644	65,802	95,644	**22.0**
Ballasts	266	692	1,488	2,276	3,324	4,269	15,443	**41.1**
TOTAL	**NA**	**22,774**	**48,288**	**78,203**	**96,443**	**101,016**	**184,424**	**26.1**

source: US Department of Commerce, Bureau of the Census, US DOE, Author

TABLE 6.3
TOTAL ELECTRICITY SAVINGS FROM THE USE OF EFFICIENT APPLIANCES
(millions kWh)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Dishwashers	23	62	257	968	1,771	2,626	7,777	**79.0**
Clothes Dryers	69.4	143.5	221.7	304.7	384.8	472.3	949.4	**29.8**
Clothes Washers	341	505	829	1,144	1,463	1,784	2,420	**21.6**
Kitchen Ranges and Ovens	101.1	202.3	311.0	426.9	543.6	664.7	1,340.0	**29.5**
Microwave Ovens	1,740	3,534	5,581	7,898	8,471	9,165	12,863	**22.1**
Refrigerators	2,264	5,355	10,145	15,318	20,916	27,079	68,585	**40.6**
Water Heaters	1,722	3,221	4,971	6,849	8,754	10,719	21,505	**28.7**
TOTAL	**6,260.5**	**13,022.8**	**22,315.7**	**32,908.6**	**42,303**	**52,510**	**115,439**	**33.8**

source: US Department of Commerce, Bureau of the Census, US DOE, Author

TABLE 6.4
TOTAL GAS SAVINGS FROM THE USE OF EFFICIENT APPLIANCES
(billion Btu)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Dryers	79	167	264	361	456	556	1,130	**30.5**
Kitchen Ranges and Ovens	123	267	418	585	748	924	2,017	**32.2**
Water Heaters	15,764	30,012	47,988	66,716	83,652	101,060	195,665	**28.6**
TOTAL	**15,966**	**30,446**	**48,670**	**67,662**	**84,856**	**102,540**	**198,812**	**28.7**

source: US Department of Commerce, Bureau of the Census, US DOE, Author

TABLE 6.5
TOTAL ELECTRICITY SAVINGS BY THE USE OF EFFICIENT HVAC EQUIPMENT
(million kWh/year)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Heat Pumps	2,159	4,220	6,482	9,068	11,710	14,499	30,986	**30.5**
Chillers	3,078	6,491	10,258	14,488	18,988	23,457	51,854	**32.6**
Unitary AC Units	160	966	1,832	2,929	4,055	5,284	15,544	**58.0**
Room AC Units	57	301	522	871	1,320	1,769	5,033	**56.5**
Electric Fans	973	2,090	3,185	4,459	5,705	6,061	8,116	**23.6**
TOTAL	**6,427**	**14,068**	**22,279**	**31,815**	**41,778**	**51,070**	**111,533**	**33.0**

source: US Department of Commerce, Bureau of the Census, US DOE, Author

TABLE 6.6
TOTAL GAS SAVINGS FROM THE USE OF EFFICIENT HVAC EQUIPMENT
(billion Btu)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Gas Furnaces	41,140	83,280	134,980	188,920	240,940	296,325	631,873	**31.4**

source: US Department of Commerce, Bureau of the Census, US DOE, Author

TABLE 6.7
TOTAL ELECTRICITY SAVINGS FROM THE USE OF OTHER ENERGY SAVING TECHNOLOGIES
(million kWh)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Windows	7,184	14,518	22,001	29,633	37,415	45,336	87,256	**28.4**
Low-Flow Showerheads	707	1,508	2,414	3,424	4,552	5,812	14,666	**35.4**
TOTAL	**7,891**	**16,026**	**24,415**	**33,057**	**41,967**	**51,148**	**101,922**	**29.1**

source: US Department of Commerce, Bureau of the Census, US DOE, Author

TABLE 6.8
TOTAL GAS SAVINGS FROM THE USE OF OTHER ENERGY SAVING TECHNOLOGIES
(billion Btu)

	1991	1992	1993	1994	1995	1996	2001	AAGR 1991-2001 (%)
Low-flow showerheads	3,100	6,500	10,500	14,900	19,700	25,300	63,700	**35.3**

source: US Dept. of Commerce, Bureau of the Census, US DOE, Corporing, Author

These savings will continue to persist through 2001. Energy-saving technologies will continue to be installed, helped by Energy Service Companies increasing pursuit of cost-effective retrofit projects. Federal standards will insure that savings from the installation of new appliances will continue as older units are replaced. The HVAC market will continue to yield large savings as older inefficient units are replaced with non-CFC using, energy efficient units. Because of their large per unit energy savings, HVAC systems will continue to be replaced before the end of their economic lives. While some additional energy saving technologies will continue to have modest growth, others will rapidly increase.

6.2 Energy Savings and US Greenhouse Gas Emissions

Despite the energy savings from the use of efficient end-use equipment, the US is not expected to meet the Climate Challenge goals of reducing emissions to 1990 levels. US emissions of Carbon from all sectors are expected to increase to 1558.7 million metric tons by 2001 (EIA 10). However, efficiency improvements in end-use consumption reduced emissions by over 5 percent of their projected levels in the absence of said efficiency improvements. Efficiency improvements are projected to avoid the emission of 82.7 million tons of Carbon per year by the year 2001.

TABLE 6.9
HISTORIC AND PROJECTED US CARBON EMISSIONS
(million metric tons)

	1990	1996	1997	1998	1999	2000	2001
emissions	1,340	1,444	1,467	1,497	1,524	1,543	1,559

source: EIA 10, 1996

The rise in emissions is due to high economic growth, higher overall energy consumption, lower renewable energy production, low energy prices, the retirement of several nuclear generating units, and increased transportation related emissions. Approximately 40% of the increased US carbon emissions were from the transportation sector. Partially due to improvements in energy efficiency, carbon emissions from the residential and commercial sectors show a small increase. Electricity and natural gas-related emissions from these sectors are projected to increase from 461 million metric tons in 1996 to 487 tons in 2001 (EIA 10), an increase of only 5 %. In the absence of gains in improved efficiency, emissions from the residential and commercial sectors would have risen over 23%. Improved efficiency, while not meeting US goals of Carbon emission stabilization, have significantly contributed to controlling greenhouse gas emissions.

CHAPTER VII

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Autonomous Improvements in Energy Efficiency

The US has experienced significant increases in the rates of energy efficiency improvements, as older inefficient technologies are replaced or retrofitted with new energy efficient end use equipment. This trend will continue, as more and more of the existing equipment stock turns over. Advances in technology will continue to improve the performance of new technologies, and the combination of new standards, regulations, and programs will continue to improve the performance of new technologies, continuously improving US energy efficiency in the future.

7.2 Review of Efficiency-Promoting Programs

The robustness of the markets for efficient end-use equipment illustrate the historical effectiveness of the numerous regulations and programs designed to increase penetration of efficient technologies. These programs succeeded because they addressed the market barriers and failures present in the efficiency marketplace. The programs can be grouped into several main categories:

- Information
- Market Demand Stimulation
- Supply Stimulation/Market Push
- Supply Stimulation/Market Pull
- Market Driven Partnerships/Collaborative Efforts

The combination of these programs has aided in the establishment of a thriving, growing market for energy efficient end use equipment that is self-sustaining. Once the market is established, then it can continue to grow without outside assistance.

7.2.1 Information Programs

These types of programs addressed consumers ignorance of efficient technologies. Labeling requirements allowed purchasers easy comparability of energy efficiency when making new equipment purchases. For more established technologies, information programs publicized and disseminated established results and performance. For newer technologies, informational programs publicized pilot and demonstration programs, aiding in product development.

7.2.2 Consumer-Oriented Efficiency Programs

Many programs successfully stimulated the demand for efficient technologies. The FEMP as well as DSM programs, specifically rebate and installation programs, created a predictable demand for certain types of equipment, reducing the risk for manufacturers of efficient equipment. By assuring manufacturers of a minimum specified demand for their products, the programs allowed economies of scale and learning curve effects to lower cost and increase manufacturer experience in producing efficient equipment.

7.2.3 Manufacturer-Oriented Efficiency Programs

The combination of market-push and market-pull programs has also had a significant effect on the markets for efficient equipment. Market push programs, such as minimum efficient standards, eliminated the worst performing equipment. While standards assure a minimum efficiency level, they do not encourage the development of equipment with higher efficiency. Market-pull programs, such as the SERP, the CEE Initiatives, and some of the ENERGY STAR programs, encourage the development of products that significantly exceed the minimum standards. By assisting in the commercialization of emerging highly efficient technologies, these programs actually transform markets for energy efficiency. The market-pull, or market transformation, programs can produce potentially large savings, especially once the technologies achieve wide-spread acceptance.

7.2.4 Partnerships

More recent efforts at increasing the penetration rates of efficient technologies have involved voluntary partnerships between government agencies, manufacturers, and other stakeholders. These programs allow participants to combine their efforts, effectively using their resources. For example, the government has provided technical support and assistance for the numerous energy star programs.

7.3 Market Evolution

These programs provide a wide range of drivers for the efficiency markets, all designed to establish and strengthen the industry. When new, unknown technologies have been introduced and demonstrated, consumer acceptance increases. When programs assure a minimum level of demand, then manufacturers receive the signal that the market is worth pursuing. By gaining experience with producing large quantities of efficient technologies, costs are reduced and performance increases, improving consumer acceptance and increasing demand. Once a technology has moved to the commercialization stage, the voluntary partnership programs continue to stimulate demand by offering publicity and advertising, further increasing acceptance. Technical support programs also provide initial assistance for fledgling markets and products. At this stage, independent players can accelerate the penetration rates of new technologies, capturing savings that consumers are not pursuing.

An excellent example of this is the transformation of the markets for efficient lighting. In its early stage, rebates for DSM programs were necessary to stimulate the demand for CFLs and efficient fluorescent lighting products. Once the demand for these products was established, manufacturers gradually lowered the cost and improved the performance of efficient lighting technologies. The market can now be considered as established, as demonstrated by the presence of third parties (the Energy Service Companies), who were initially aided by government partnership programs such as Greenlights, but are quite capable of operating without them to capture cost-effective energy savings from a pure profit motive.

7.4 Recommendations for Increasing the Rates of Autonomous Improvements in Energy Efficiency

Although the penetration rates of energy efficient technologies is increasing, there are several actions which can accelerate their diffusion. If US policy makers determine that improving the rate of efficiency improvements is necessary to reduce US carbon emissions, the following actions can increase the rate of AIEE, increasing the energy savings from the use of efficient and reducing the associated emissions.

1. Extend the FEMP to all government-owned facilities

Although many state and local governments are pursuing energy efficiency initiatives, the establishment of a coordinated Federal effort would improve their effectiveness. Establishing a national revolving energy efficiency fund of sufficient size (maintained through energy cost savings from completed projects) would increase the amount and effectiveness of governmental efficiency retrofit programs.

2. Increase Financing Availability for Efficiency Improvements

While investments in energy efficiency have high returns and relatively short pay back periods, many consumers do not have the resources to undertake all cost effective investments in energy efficiency, yet are too small to be noticed by energy service companies. Additional financing programs, similar to the energy efficient mortgage programs, should be developed. If such programs could induce small consumers to replace inefficient appliances and HVAC equipment before the end of their useful lives, significant savings could be achieved.

3. Launch Additional Partnering/Market Transformation Efforts

The newer collaborative efforts between government, industry and stakeholders has been an effective way to utilize resources. The government is well suited to provide technical support and assistance, and should continue to do so. Additional commercialization efforts should be undertaken as emerging technologies evolve beyond the demonstration and pilot stages. Coordinated action to stimulate demand and send the correct signals to manufacturers has proven to be an effective means of strengthening the markets for new products, and can continue to do so for newly developed energy efficient end use equipment.

4. Ensure The Restructured Electric Utility Industry Maintains Proper Incentives for Efficiency

While no longer a critical driver for energy efficient technologies, DSM programs continue to support the efficiency market. Actions to ensure that DSM has a role in the new electric utility sector should be undertaken at the federal and state level.

These programs will continue to address the market barriers and failures present in the efficient end-use industry. They will aid in the maturation of efficiency markets, to the point where they become truly self-sustaining. The above recommendations will increase the penetration rates of emerging efficient technologies, saving significant amounts of energy and reducing associated emissions. The conjunction of the numerous forces will continue to improve aggregate energy efficiency, saving US consumers millions of dollars in avoided energy expenses while preventing the release of significant quantities of pollution.

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9. APPENDIX: DETAILED SALES AND SAVINGS CALCULATIONS

Compact Fluorescent Lamps
1994 data extrapolated from linear trend line of the form y=.714 x2 - 1.49x +24.8

1991	24	1995 data from World Watch Institute					
1992	25		24	24.8	0.8	0.033	**57.660**
1993	26		24.8	26	1.2	0.048	
1994	30.2		26	30.2	4.2	0.161	
1995	35		30.2	35	4.8	0.158	
			35			**0.1005**	

CFL savings

1991	23987	3343787.8	
1992	24759	6795192.4	
1993	26067	10428932.2	
1994	30290	14651358.2	
1995	35000	16186570.4	
1996	38675		
1997	42735.87		26068583.96
1998	47223.14		10574960.79
1999	52181.57		36643544.75
2000	57660.63	36643545	

CFL Value

				AAGRs	2001
1991	104545	112762	8217	0.078597733	271279
1992	112762	107448	-5314	-0.047125805	
1993	107448	131156	23708	0.220646266	
1994	131156	151550	20394	0.155494221	
1995	151550			**0.101903104**	

Tungsten Halogen

	quantity in millions					
1991	9.5	11.1	1.6	0.168421053	17.915	tung savings, 2001
1992	11.1	13.7	2.6	0.234234234		52741
1993	13.7	11.4	-2.3	-0.167883212		229312
1994	11.4			**0.078257358**		282053

tungston

1991	71773	80991	9218	0.128432698	111128
1992	80991	92598	11607	0.14331222	
1993	92598	82926	-9672	-0.1044515	
1994	82926			**0.055764472**	

Efficient Fluorescent

	savings		
U-shaped		40w replace 75w incandescent	**total savings** (million kwh)
1992	11889	1731038.4	**2632.3362**
1993	11857	3457417.6	**5730.2425**
1994	13715	5454321.6	**9502.0032**
1995	17463	6265896	**11635.1214**
1996	23101	7903022.4	**14560.3584**
1997	26519.94	9767422.829	**17931.89505**
1998	30444.90	11657587.51	**21649.1974**
1999	34950.74	13382910.46	**25712.55707**
2000	40123.45	15363581.21	**30578.36512**
2001	46061.72	17637391.23	**36412.43457**

T-8		32w replaces 40w
1992	27066	901297.8
1993	41187	2272824.9
1994	53299	4047681.6
1995	66752	5369225.4
1996	79869	6657336
1997	98558.346	8164472.222
1998	121620.999	9991609.887
1999	150080.312	12329646.6
2000	185199.105	15214783.91
2001	228535.696	18775043.34

HID

Mercury Vapor

1991	4689	4611	-78	-0.016634677	4777	4852
1992	4611	4783	172	0.037302104		
1993	4783	4745	-38	-0.007944805		
1994	4745	4759	14	0.002950474		
1995	4759			**0.003918274**		

Metal Halide

1991	5732	7101	1369	0.238834613	15034	32528
1992	7101	8668	1567	0.220673145		
1993	8668	10433	1765	0.20362252		
1994	10433	12396	1963	0.188152976		
1995	12396			**0.212820813**		

HPS

1991	9076	9761	685	0.075473777	22135	45489
1992	9761	11558	1797	0.18409999		
1993	11558	14467	2909	0.251687143		
1994	14467	18488	4021	0.277942905		
1995	18488			**0.197300954**		

total HID

					1996-
1991	17714	19497	1783	0.100654849	71964
1992	19497	21473	1976	0.101348925	
1993	21473	25009	3536	0.164671914	
1994	25009	29645	4636	0.185373266	
1995	29645	35643	5998	0.202327543	
1996	35643			**0.150875299**	

HID values calculated based on 11.92 average $/units

savings

5732	6075920				
7101	7527060	1992	15934271.2	HPS	Halide
8668	9188080	1993	34063729.4	22130	15036
10433	11058980	1994	55806109	26489	18239
12396	13139760	1995	66644873.2	31708	22124
		1996	65802569.4	37954	26836
		1997	49972743	45431	32552
9076	9858351.2	1998	31434496.54		
9761	10602398.2	1999	23524894.32		
11558	12554299.6	2000	43225256.34		
14467	15714055.4	2001	95644612.39		
18488	20081665.6				

Ballasts

total		ballast values calculated based on 8.85 average $/unit			
electric					2001
1991	8343	13292	4949	0.593191897	98235
1992	13292	24488	11196	0.842311165	
1993	24488	24606	118	0.004818687	
1994	24606	32738	8132	0.330488499	
1995	32738	37874	5136	0.156881911	
1996	37874			**0.385538432**	
magnetic-corrected					
1991	55467	55379	-88	-0.001586529	29073
1992	55379	54790	-589	-0.010635801	
1993	54790	55991	1201	0.021920058	
1994	55991	47597	-8394	-0.149916951	
1995	47597	42471	-5126	-0.107695863	
1996	42471			**-0.061582139**	
				note: magnetic ballast sales forecast based on post EPACT growth rates	
magnetic-uncorrected					
1991	24919	28363	3444	0.138207793	13337
1992	28363	28150	-213	-0.007509784	
1993	28150	27517	-633	-0.022486679	
1994	27517	24901	-2616	-0.095068503	
1995	24901	20236	-4665	-0.187341874	
1996	20236			**-0.07810171**	
total					
1992	88729	97034	8305	0.093599612	119180
1993	97034	107428	10394	0.107117093	
1994	107428	108114	686	0.006385672	
1995	108114	105236	-2878	-0.026620049	
1996	105236	105236	0	0	
1997	105236	105239	3	2.85074E-04	
1998	105239	105336	97	0.000921712	
1999	105336	105936	600	0.005696058	
2000	105936	106962	1026	0.009685093	
2001	106962			**0.021868189**	

	savings	ballasts	
	8W electronic replace 16W, operates 80 hours/week (EIA)		**5 year lamp life**
1991	8343	266976	
1992	13292	692320	
1993	24888	1488736	
1994	24606	2276128	
1995	32738	3323744	
1996	37874	4268736	
1997	50372.42	5455309.44	
1998	66995.31	6802743.63	
1999	89103.77	8866672.39	
2000	118508.01	11611313.01	
2001	157615.64	15443046.3	

% of energy efficient ballasts

	Electronic	**Magnetic-uncorrected**	**Magnetic-corrected**
1991	9	28	63
1992	14	29	57
1993	23	26	51
1994	23	25	52
1995	31	24	45
1996	38	20	42
2001	79	7	15

total value of lamps calculations based on average $/lamp of .83

APPLIANCES

dishwashers

1991	4015	4641	626	0.155915318	5281	7181
1992	4641	5662	1021	0.219995691		
1993	5662	4952	-710	-0.125397386		
1994	4952	4967	15	0.003029079		
1995	4967			**0.063385675**		
	value					
1991	764	810	46	0.060209424	1103.484 442	1635.296 201
1992	810	1041	231	0.285185185		
1993	1041	1081	40	0.038424592		
1994	1081	1020	-61	-0.056429232		
1995	1020			**0.081847492**		

dishwashers			**savings**				
		new vrs. average 700 kWh/year			**10 year lifetime**		
	1991	4015	23287				
	1992	4641	62271.4				
	1993	5662	257044.2				
	1994	4952	968151.4				
	1995	4967	1771812				
	1996	5281	2626277.8				
	1997	5613.703	3534574.945				
	1998	5967.3662	4500094.811				
	1999	6343.3103	5526442.428				
	2000	6742.9388	6617449.945				
	2001	7167.7440	7777190.936				
dryers		**gas**					
	1991	988	1105	117	0.118421053	1244.6	1578.0
	1992	1105	1207	102	0.092307692		
	1993	1207	1219	12	0.009942005		
	1994	1219	1187	-32	-0.026251025		
	1995	1187			**0.048604931**		
		savings:	Gas Dryers consume 4 MMBtu/year (Koomey), new dryers are 2% more efficient (AHAM)				
	1991	988	79.04	79			
	1992	1105	88.4	167.44			
	1993	1207	96.56	264			
	1994	1219	97.52	361.52			
	1995	1187	94.96	456.48			
	1996	1244	99.52	556			
	1997	1303.712	104.29696	660.29696			
	1998	1366.29017	109.3032141	769.6001741			
	1999	1431.87210	114.5497684	884.1499424			
	2000	1500.60196	120.0481572	1004.1981			
	2001	1572.63086	125.8104688	1130.008568			
		electric					
	1991	3476	3587	111	0.031933257	4000	4631
	1992	3587	4013	426	0.118762197		
	1993	4013	4023	10	0.002491901		
	1994	4023	3885	-138	-0.034302759		
	1995	3885			**0.029721149**		
		value					
	1991	910	974	64	0.07032967	1599.7	
	1992	974	1060	86	0.088295688		
	1993	1060	1186	126	0.118867925		
	1994	1186	1103	-83	-0.069983137		
	1995	1103	1224	121	0.109700816		
		1224			**0.063442192**		

electricity Savings-Dryers

875 annual kWh usage. assume increased efficiency of 21.875 kWh/year

assuming 10 year lifetime

1991	3,176	69.475	**total savings**
1992	3,387	74.090625	143.565625
1993	3,573	78.159375	221.725
1994	3,793	82.971875	304.696875
1995	3,665	80.171875	384.86875
1996	4,000	87.5	472.36875
1997	4,116	90.0375	562.40625
1998	4,235	92.6485875	655.0548375
1999	4,358	95.33539654	750.390234
2000	4,485	98.10012304	848.4903571
2001	4,615	100.9450266	949.4353837

Washers

1991	6403.7	6204.8	-198.9	-0.031060168	6662	6953
1992	6204.8	6499.7	294.9	0.04752772		
1993	6499.7	6819.3	319.6	0.0491715		
1994	6819.3	6605.9	-213.4	-0.031293535		
1995	6605.9			**0.008586379**		
	value					
1991	1839.5	1718	-121.5	-0.066050557	1844	1874
1992	1718	1804	86	0.050058207		
1993	1804	2015	211	0.116962306		
1994	2015	1838	-177	-0.087841191		
1995	1838			**0.003282191**		

savings
46 cycles/year, 10 year life time
base line usage of 150 kWh/year

1991	6403.7	173540.27	
1992	6204.8	167529.6	341069.87
1993	6499.7	164442.41	505512.28
1994	6819.3	323234.82	828747.1
1995	6605.9	315762.02	1144509.12
1996	6662	318443.6	1462952.72
1997	6715.296	320991.1488	1783943.869
1998	6769.018	323559.078	2107502.947
1999	6823.170	326147.550	2433650.497
2000	6877.75	328756.731	2762407.228
2001	6932.777	331386.784	2920253.743

Kitchen Ranges and Ovens

1991	8427	8433	6	0.000711997	10087	12100
1992	8433	9058	625	0.074113601		
1993	9058	9660	602	0.066460587		
1994	9660	9727	67	0.006935818		
1995	9727			**0.037055501**		

savings	600 kWh unit energy consumption (Koomey), new units are 2% more efficient		
1991	8427	101124	101.124
1992	8433	101196	202.32
1993	9058	108696	311.016
1994	9660	115920	426.936
1995	9727	116724	543.66
1996	10086.899	121042.788	664.7027
1997	10460.114	125521.371	790.2241
1998	10847.138	130165.661	920.3898
1999	11248.482	134981.791	1055.3716
2000	11664.676	139976.117	1195.347
2001	12096.26	145155.234	1340.5029

gas

1991	2465	2892	427	0.173225152	3504	5027
1992	2892	3022	130	0.044951591		
1993	3022	3341	319	0.105559232		
1994	3341	3260	-81	-0.024244238		
1995	3260			**0.074872934**		

gas savings	5 MMBtu/year, new units are 1% more efficient		
1991	2465	123.25	123.2
1992	2892	144.6	267.8
1993	3022	151.1	418.9
1994	3341	167.05	585.95
1995	3260	163	748.95
1996	3504	175.2	924.15
1997	3766.099	188.30496	1112.454
1998	4047.803	202.39017	1314.8451
1999	4350.579	217.52895	1532.3740
2000	4676.002	233.80012	1766.1742
2001	5025.767	251.28837	2017.4625

	value	**electric**				
1991	1615	1620	5	0.003095975	1818	2050
1992	1620	1731	111	0.068518519		
1993	1731	1791	60	0.034662045		
1994	1791	1775	-16	-0.008933557		
1995	1775			**0.024335746**		
	value-gas					
1991	609	600	-9	-0.014778325	673.	745
1992	600	621	21	0.035		
1993	621	649	28	0.045088567		
1994	649	660	11	0.016949153		
1995	660			**0.020564849**		

Microwave Ovens

1991	486	505	19	0.03909465	335	238
1992	505	511	6	0.011881188		
1993	511	478	-33	-0.064579256		
1994	478	359	-119	-0.248953975		
1995	359			**-0.065639348**		
	value					
1991	3459	3606	147	0.042497832	2568	1965
1992	3606	3855	249	0.069051581		
1993	3855	3431	-424	-0.10998703		
1994	3431	2710	-721	-0.210142816		
1995	2710			**-0.052145108**		
	total					
1991	7594	7827.5	233.5	0.030747959	10857	15627
1992	7827.5	8931	1103.5	0.140977324		
1993	8931	10106	1175	0.131564215		
1994	10106	10095	-11	-0.001088462		
1995	10095			**0.075550259**		

Refrigerators

1991	7599	9396	1797	0.236478484	12181.	19724.
1992	9396	9676	280	0.029799915		
1993	9676	10305	629	0.065006201		
1994	10305	11062	757	0.073459486		
1995	11062			**0.101186021**		
1991	3363	3941	578	0.171870354	5190	8068
1992	3941	3938	-3	-0.000761228		
1993	3938	4209	271	0.068816658		
1994	4209	4752	543	0.129009266		
1995	4752			**0.092233762**		

refrigerators savings

based on new unit replacing old unit using 1155/year

1991	7599	2264502
1992	9396	5355786
1993	9676	10145406
1994	10305	15318516
1995	11062	20915888
1996	12179.26	27078594.57
1997	13409.36	33863734.51
1998	14763.71	41334173.58
1999	16254.84	49559126.99
2000	17896.58	58614800.7
2001	19704.14	68585097.46

Water heaters

electric						
1991	3689	3211	-478	-0.12957441	4207	4908
1992	3211	3747	536	0.166926191		
1993	3747	4021	274	0.073125167		
1994	4021	4080	59	0.014672967		
1995	4080			**0.031287479**		
gas						
1991	3941	3562	-379	-0.096168485	4352	4994
1992	3562	4494	932	0.261650758		
1993	4494	4682	188	0.041833556		
1994	4682	4234	-448	-0.095685604		
1995	4234			**0.027907556**		
other						
1991	136	154	18	0.132352941	102	83
1992	154	114	-40	-0.25974026		
1993	114	130	16	0.140350877		
1994	130	107	-23	-0.176923077		
1995	107			**-0.04098988**		

	electricity savings		each new unit saves 467 kWh/year (Koomey2)			
1991	3689	1722.763	1722			
1992	3211	1499.537	3221.537			
1993	3747	1749.849	4971.386			
1994	4021	1877.807	6849.193			
1995	4080	1905.36	8754.553			
1996	4207.6	1964.959661	10719.51266			
1997	4339.2	2026.423599	12745.93626			
1998	4474.9	2089.810129	14835.74639			
1999	4614.9	2155.17939	16990.92578			
2000	4759.3	2222.593401	19213.51918			
2001	4908.1	2292.116123	21505.6353			
	gas savings	each new unit saves 4 MMBtu/year (Koomey)				
1991	3941	15764	15764			
1992	3562	14248	30012			
1993	4494	17976	47988			
1994	4682	18728	66716			
1995	4234	16936	83652			
1996	4352.1	17408.5144	101060.5144			
1997	4473.5	17894.21195	118954.7264			
1998	4598.3	18393.46047	137348.1868			
1999	4726.6	18906.63801	156254.8248			
2000	4858.5	19434.13321	175688.958			
2001	4994.0	19976.34553	195665.3036			
	value-electric					
1991	447	401	-46	-0.102908277	536	656
1992	401	473	72	0.179551122		
1993	473	516	43	0.090909091		
1994	516	515	-1	-0.001937984		
1995	515			**0.041403488**		
	other					
1991	616	586	-30	-0.048701299	1117	2087
1992	586	700	114	0.194539249		
1993	700	748	48	0.068571429		
1994	748	986	238	0.318181818		
1995	986			**0.133147799**		
	TOTAL VALUE					
1991	1063	987	-76	-0.071495767		
1992	987	1173	186	0.188449848		
1993	1173	1264	91	0.077578858		
1994	1264	1501	237	0.1875		
1995	1501	1653	152	0.101265823		
	1619		AAGR=	**0.096659752**		

HVAC

heat pump-air

1991	825160	794992	-30168	-0.036560182	1100682	1484456
1992	794992	875899	80907	0.101770835		
1993	875899	1022908	147009	0.167837844		
1994	1022908	1036767	13859	0.013548628		
1995	1036767			**0.061649281**		

value

1991	626306	614181	-12125	-0.019359546	839004	1132528
1992	614181	686641	72460	0.117978251		
1993	686641	778375	91734	0.133598198		
1994	778375	790146	11771	0.015122531		
1995	790146			**0.061834858**		

heat pump-water

1991	111745	99236	-12509	-0.111942369	109133	108176
1992	99236	105159	5923	0.059686001		
1993	105159	99321	-5838	-0.055515933		
1994	99321	109326	10005	0.100733984		
1995	109326			**-0.001759579**		

value

1991	102424	101621	-803	-0.007839959	125677	155890
1992	101621	111513	9892	0.097342085		
1993	111513	105771	-5742	-0.051491754		
1994	105771	120378	14607	0.138100235		
1995	120378			**0.044027652**		

HP savings Average Efficiency Heat Pump replaces Electric Furnace and Central AC

saves 2305 kWh/year (Koomey 2)

1991	825160	111745	2159.566	**2159.566**
1992	794992	99236	2061.195	**4220.761**
1993	875899	105159	2261.338	**6482.100**
1994	1022908	99321	2586.737	**9068.838**
1995	1036767	109326	2641.744	**11710.582**
1996	1100631.84	109249.47	2788.776	**14499.358**
1997	1168430.76	109172.99	2944.876	**17444.235**
1998	1240406.10	109096.57	3110.603	**20554.839**
1999	1316815.12	109020.20	3286.550	**23841.389**
2000	1397930.93	108943.89	3473.346	**27314.736**
2001	1484043.47	108867.63	3671.660	**30986.396**

chillers-rotary

1991	4500	4800	300	0.066666667	8543	16383
1992	4800	6000	1200	0.25		
1993	6000	7100	1100	0.183333333		
1994	7100	7500	400	0.056338028		
1995	7500			**0.139084507**		

chillers-absorbtion

1991	190	390	200	1.052631579	667	2775
1992	390	420	30	0.076923077	**9210.65**	**19158.**
1993	420	483	63	0.15		
1994	483	502	19	0.039337474		
1995	502			**0.329723032**		

reciprocating

1991	10400	11500	1100	0.105769231	15083	21897
1992	11500	12000	500	0.043478261		
1993	12000	13100	1100	0.091666667		
1994	13100	14000	900	0.06870229		
1995	14000			**0.077404112**		

	total AAGR					
1991	4690	5190	500	0.106609808		
1992	5190	6420	1230	0.23699422		
1993	6420	7583	1163	0.181152648		
1994	7583	8002	419	0.055255176		
1995	8002	9211	1209	0.151087228		
	9211			**0.146219816**		
	chiller values					
1991	603786	651581	47795	0.079158841	1323163	2981853
1992	651581	671520	19939	0.030600954		
1993	671520	938820	267300	0.39805218		
1994	938820	1124706	185886	0.197999617		
1995	1124706			**0.176452898**		

note: chiller values calculated for SIC product codes 35851 51-58 and 35851 91-97 only

savings:
each new chiller saves 204546 kwh/year (ARI 2)

Room AC-fan coil

1991	269571	198302	-71269	-0.264379329	232811	223833
1992	198302	262159	63857	0.322018941		
1993	262159	215387	-46772	-0.178410812		
1994	215387	234650	19263	0.089434367		
1995	234650			**-0.007834208**		
value						
1991	119989	97212	-22777	-0.189825734	123779	136590
1992	97212	124937	27725	0.285201415		
1993	124937	109787	-15150	-0.121261116		
1994	109787	121365	11578	0.105458752		
1995	121365			**0.019893329**		

Room AC units

1991	2286	2519	233	0.101924759	4690	10266
1992	2519	2234	-285	-0.113140135		
1993	2234	3265	1031	0.461504029		
1994	3265	4010	745	0.228177642		
1995	4010			**0.169616574**		
value						
1991	707157	728735	21578	0.030513733	1258994	2314843
1992	728735	717053	-11682	-0.016030519		
1993	717053	978234	261181	0.364242253		
1994	978234	1114613	136379	0.139413474		
1995	1114613			**0.129534735**		

Single Package AC units

1991	176,650	179,270	2,620	0.014831588	319738	582884
1992	179,270	206,800	27,530	0.153567245		
1993	206,800	244,397	37,597	0.181803675		
1994	244,397	283,555	39,158	0.160222916		
1995	283,555			**0.127606356**		

Year-Round air conditioners

1991	389,566	411,468	21,902	0.056221539	554157	791658
1992	411,468	426,946	15,478	0.037616534		
1993	426,946	495,434	68,488	0.160413729		
1994	495,434	516,003	20,569	0.041517134		
1995	516,003			**0.073942234**		
value		336,067	361,228	420,035	496,425	513,385
value		757,013	793,173	842,423	1,028,579	1,098,062

Split system air-conditioning condensing units

1991	2,455,692	2,440,397	-15,295	-0.006228387	3753378	5863704
1992	2,440,397	2,623,039	182,642	0.074841102		
1993	2,623,039	3,385,357	762,318	0.290623967		
1994	3,385,357	3,432,989	47,632	0.014070008		
1995	3,432,989			**0.093326672**		
value						
1991	1,217,019	1,269,784	52,765	0.043355938	1790514	2664497
1992	1,269,784	1,348,018	78,234	0.061612054		
1993	1,348,018	1,648,339	300,321	0.222787084		
1994	1,648,339	1,653,676	5,337	0.003237805		
1995	1,653,676			**0.08274822**		
AC units	**savings**					
12 % efficiency gain from NAECA						
2% for 91						
1991	3.02	160.966				
1992	3.03	966.946				
1993	3.255	1832.776				
1994	4.124	2929.76				
1995	4.231	4055.206				
1996	4.623	5284.924				
1997	5.062185	6631.46521				
1998	5.543092	8105.927835				
1999	6.069686	9720.464409				
2000	6.646306	11488.38196				
2001	7.277705	13424.25167				
	7.969087	15544.02901				
AC single package-value						
1991	336067	361228	25161	0.074868999	571615	978153
1992	361228	420035	58807	0.162797458		
1993	420035	496425	76390	0.181865797		
1994	496425	513385	16960	0.034164275		
1995	513385			0.113424132		
year round						
1991	757013	793173	36160	0.047766683	1207425.779	1941012.584
1992	793173	842423	49250	0.062092381		
1993	842423	1028579	186156	0.220976873		
1994	1028579	1098062	69483	0.067552419		
1995	1098062			0.099597089		

room ac-energy savings

new unit replaces inefficient unit-950 kWh/year
assume static efficiency gains after 1995, 7 year lifetime
1991 units-save 25 kwh/unit/year (AHAM)
1992 units save 97 (AHAM)

Furnaces	**shipments**						
1991	2057	2107	50	0.024307244	2769	3789
1992	2107	2585	478	0.226862838		
1993	2585	2697	112	0.043326886		
1994	2697	2601	-96	-0.035595106		
1995	2601			**0.064725465**		
	value					
1991	842,717	1,058,111	215394	0.255594701	1487347	2649075
1992	1,058,111	1,134,210	76099	0.071919676		
1993	1,134,210	1,212,129	77919	0.068698918		
1994	1,212,129	1,325,184	113055	0.093269776		
1995	1,325,184			**0.122370768**		

	Furnaces-savings	New Furnaces Save 20 MMBtu vrs existing Stock (Koomey2)	
1991	2057	41140000	41140000
1992	2107	42140000	83280000
1993	2585	51700000	134980000
1994	2697	53940000	188920000
1995	2601	52020000	240940000
1996	2769.284	55385694	296325694
1997	2948.457	58969148.4	355294842.4
1998	3139.222	62784452.3	418079294.7
1999	3342.330	66846606.37	484925901.1
2000	3558.579	71171581.8	556097482.9
2001	3788.819	75776383.14	631873866

savings
microwave — **assume 5 year lifetime**
25% faster cooking time, each unit saves 2,292 kWh/year

1991	7594	17405.448
1992	7828	35347.224
1993	8931	55817.076
1994	10106	78980.028
1995	10094	84710.028
1996	10,858	91654.788
1997	11672.35	97937.9622
1998	12547.77	103534.5134
1999	13488.85	111315.5313
2000	14500.523	119664.1961
2001	15588.062	128639.0108

Fans

1991	18549	21269	2720	0.146638633	25333	35075
1992	21269	20857	-412	-0.019370915		
1993	20857	24263	3406	0.163302488		
1994	24263	23738	-525	-0.021637885		
1995	23738			**0.06723308**		

value

1991	409604	473113	63509	0.155049755	563998	784695
1992	473113	494066	20953	0.044287517		
1993	494066	552292	58226	0.117850652		
1994	552292	527951	-24341	-0.044072701		
1995	527951			**0.068278806**		

fans-energy savings 4 fans increase comfort zone by 3 degrees, saves 210 kWh/year assume 5 year lifetime

1991	18549	973.8225	973.8225
1992	21269	1116.6225	2090.445
1993	20857	1094.9925	3185.4375
1994	24263	1273.8075	4459.245
1995	23738	1246.245	5705.49
1996	25333.193	1329.992664	6061.660164
1997	27035.584	1419.368171	6364.405835
1998	28852.375	1514.749712	6784.163047
1999	30791.255	1616.540893	7126.89644
2000	32860.427	1725.172441	7605.823881
2001	35068.648	1841.104029	8116.935245

Showerheads

Assume an AAGR of 11.6 % based on historic growth rate of plumbing fittings

shipments, 1991-2001

1991	5972711
1992	6756461
1993	7643055
1994	8529649.3
1995	9519088.7
1996	10623303
1997	11855606.1
1998	13230856.4
1999	14765635.8
2000	16478449.5
2001	18389949.7

value

A conservative estimate of $2.5 per unit was used to calculate value

1991	149317775
1992	168911525
1993	191076375
1994	213241234
1995	237977217
1996	265582575
1997	296390153
1998	330771411
1999	369140895
2000	411961239
2001	459748742

savings

Savings were calculated assuming a 20 year life time.

Savings are estimated at 227 kWh or 10.3 therms of natural gas (Proctor, et. al.)

It is assumed that 50% of the units were used for gas water heaters, and 50% used for electric units

	Gas Savings: per year		**Electric savings: per year**
1991	30759461.6 therms		707766253.5 kWh
1992	34795774.1		800640628.5
1993	39361733.2		905702017.5
1994	43927694.3		1010763452
1995	49023306.8		1128012012
1996	54710010.4		1258861405
1997	61056371.6		1404889328
1998	68138910.7		1567856490
1999	76043024.4		1749727843
2000	84864015.2		1952696273
2001	94708241.0		2179209041
	Cumulative savings		
1992	65555235.8		1508406882
1993	104916969.		2414108900
1994	148844663.		3424872351
1995	197867970.		4552884363
1996	252577980.		5811745768
2001	637388544	**2001**	14,666,124,744

Motors **shipments**

1991		253848	221020	-32828	-0.129321484	368877	556846
1992		221020	241945	20925	0.09467469		
1993		241945	311509	69564	0.287519891		
1994		311509	339712	28203	0.09053671		
1995		339712			**0.085852452**		
	value						
1991		143809	128335	-15474	-0.107601054	237141	406080
1992		128335	137796	9461	0.073721121		
1993		137796	178114	40318	0.292591948		
1994		178114	212954	34840	0.195605062		
1995		212954			**0.113579269**		
	total motors						
1991		1797454	1816067	18613	0.010355202	1822623	1854415
1992		1816067	1758658	-57409	-0.031611719		
1993		1758658	1879710	121052	0.06883203		
1994		1879710	1816331	-63379	-0.033717435		
1995		1816331	1885704		**0.003464519**		
		1885704					

Total Windows

forecast based on a linear trend line with data from 1992, 1996, and 2000 of the form y=1.9286x+66.6

1991	67.375	68.75	1.375	0.020408163
1992	68.75	70.125	1.375	0.02
1993	70.125	71.5	1.375	0.019607843
1994	71.5	72.875	1.375	0.019230769
1995	72.875	74.25	1.375	0.018867925
1996	74.25	75.625	1.375	0.018518519
1997	75.625	77	1.375	0.018181818
1998	77	78.375	1.375	0.017857143
1999	78.375	79.75	1.375	0.01754386
2000	79.75	81.125	1.375	0.017241379
2001	81.125			**0.018745742**

value

forecast using linear trend line of the form y=.4125x + 4.925

1991	5.3375	5.75	0.4125	0.077283372
1992	5.75	6.1625	0.4125	0.07173913
1993	6.1625	6.575	0.4125	0.06693712
1994	6.575	6.9875	0.4125	0.062737643
1995	6.9875	7.4	0.4125	0.059033989
1996	7.4	7.8125	0.4125	0.055743243
1997	7.8125	8.225	0.4125	0.0528
1998	8.225	8.6375	0.4125	0.050151976
1999	8.6375	9.05	0.4125	0.047756874
2000	9.05	9.4625	0.4125	0.04558011
2001	9.4625			**0.058976346**

Savings from Efficient Windows

Complete retrofit with efficient Windows will reduce heating load by 2,100 kWh/year

With 12 windows/home (EIA), each window saves 175 kWh/year

1991	41,053	7184.275	7184.275
1992	41,907	7333.725	14518
1993	42,761	7483.175	22001.175
1994	43,615	7632.625	29633.8
1995	44,469	7782.075	37415.875
1996	45,262	7920.85	45336.725
1997	46121.97	8071.34615	53408.07115
1998	46998.29	8224.701727	61632.77288
1999	47891.26	8380.97106	70013.74394
2000	48801.19	8540.20951	78553.95345
2001	49728.41	8702.47349	87256.42694

Control Systems **value**

growth rates of 14.5 % for 1991-1996, 11.5% to 2001 (Lynch)

1991	18.276	
1992	21.375	
1993	25.001	1.141969162
1994	29.241	
1995	34.2	
1996	40	
2001	68.934	

AGGREGATE ANALYSIS

Future prices of gas =5.6 $/MMBTU (EIA)

Future price of electricity = 6.3 cents/kWh (EIA)

Savings = $37 billion in 2001 (author)

Using average EPA emissions factors (EPA1), 1 kWh avoids 1.0 lbs. CO_2, 1.1 grams SO_2 and 1.5 grams NOx

CO2 reduction=256 million tons

SO2 reduction =564 kilograms

NOx reduction = 769 kilograms

Avoided Emissions:

:

1 quadrillion Btus of gas emit 14.47 million tons Carbon (EIA 11)

Gas savings avoids 12.9 million tons Carbon in 2001.

1 metric ton Carbon dioxide =.2727 tons Carbon

Electricity savings avoid 69.8 million tons Carbon