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# Impacts of U.S. Appliance Standards to Date

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## INTRODUCTION

In 1975 the U.S. federal government established its role in improving appliance and lighting energy efficiency by setting voluntary labeling and efficiency guidelines for residential appliances and lighting products under the Energy Policy and Conservation Act (EPCA, P.L. 94-163). In 1987 EPCA and subsequent legislation was amended and updated by the National Appliance Energy Conservation Act (NAECA, P.L. 100-12). NAECA superceded requirements established by some individual states and set the first national energy efficiency standards for home appliances. A schedule for regular updates, currently specified to 2012, was also established. NAECA standards now influence appliances and equipment comprising about 80% of the source energy in the U.S. residential sector.

Most research during the past 20 years on appliance standards has involved prospective estimates of impacts. (Bertoldi *et al*. 1997, McMahon and Turiel 1997). This paper utilizes publicly available information to report the observed impacts over almost a decade of experience with the actual residential appliance standards that were adopted and implemented in the U.S. The energy savings, the energy cost savings, and the carbon emissions reductions that have already occurred in response to appliance standards in the U.S. are large and significant. In fact, in 1997 alone, appliance standards were responsible for reducing total U.S. residential energy consumption by approximately 2.5%, thus saving US$3.5 billion in annual energy costs to residential consumers, and reducing associated carbon emissions in the residential sector by 2.5%. Benefits to consumers, the economy, and the environment will continue to flow from these standards and their updates for years into the future.

## METHODOLOGY

Table 1 lists the appliances for which NAECA standards and updated standards have been adopted and the effective date for each standard. First updates for water heaters and central air conditioners and heat pumps and a second update for clothes washers are in process. Additional updates may occur in future.

As explained below, we gathered the responses to the imposition of NAECA standards over the past decade (and subsequent updates to some of those standards) from a variety of publicly available data sources. For example, Figure 1 shows the changes in energy consumption for new refrigerators. The average refrigerator in 1961 had approximately 12 cubic feet of capacity including freezer, used fiberglass insulation, and consumed 1015 kWh/annum. In 1972, when the first oil price shocks occurred, average energy consumption for new refrigerators was 1726 kWh/annum. In 1980, the average new refrigerator in the U.S. had 19.6 cubic feet, used CFC-blown insulation, and consumed 1278 kWh/annum. By 2001, after the 1990 standard established by NAECA and two updates (1993 and 2001), a typical new refrigerator in the U.S. is expected to have 20 cubic feet, have more features such as through-the-door services like ice and water, use

ozone-friendly foam insulation, and use about 63% less energy (476 kWh/annum) than the typical 1980 model

**Table 1. Effective Dates of U.S. Residential Appliance Standards**

| Appliance | Original Standard<br>Effective Date | First Update<br>Effective Date | Second Update<br>Effective Date |
|---|---|---|---|
| Refrigerators and Freezers | 1990 | 1993 | 2001 |
| Room Air Conditioners | 1990 | 2000 | Future |
| Central Air Conditioners | 1992 | In process | Future |
| Clothes Dryers | 1988 | 1994 | Future |
| Clothes Washers | 1988 | 1994 | In process 2004/2007 |
| Dishwashers | 1988 | 1994 | Future |
| Water Heaters | 1990 | Proposed 2003 | Future |
| Gas/Oil Furnaces | 1990 | Future | Future |
| Ranges and Ovens | 1990 | Electric (No update)<br>Gas (Future) | Future |
| Showerheads and Faucets | 1994 | Future | Future |

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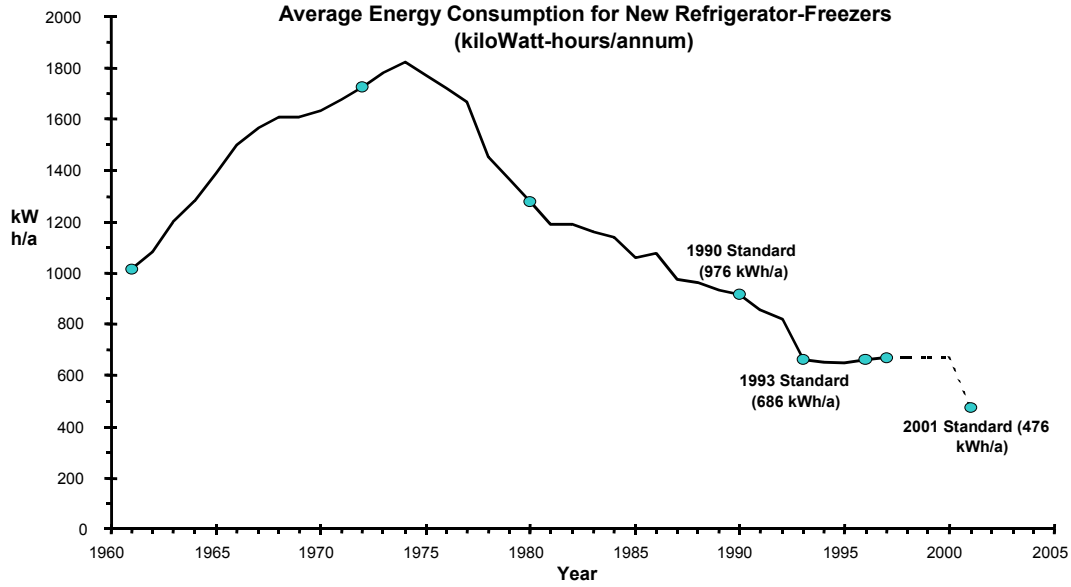


**Figure 1. Average Energy Consumption for New Refrigerator-Freezers**

The energy consumed each year by the nation's appliances is determined by the number of existing appliances, the product mix for each appliance, and their energy consumption per unit. Because the efficiency of units purchased generally increases over the years, the energy consumption per unit of stock varies according to vintage. The number of appliances is determined from historical data on annual shipments (from the industry trade associations), and the appliance lifetimes in years are calculated by applying a derived rate of retirement specific to each appliance. The total energy usage of the appliances in each year is calculated for two scenarios: with and without standards. In the latter case, the unit energy consumption is based upon historical (pre-standards) trends in unit energy consumption. Energy savings are calculated as the difference between the annual energy consumption in the base case and that of the standards case.

Energy cost savings are calculated based on the annual energy savings, multiplied by national average energy price in that year. A time series of energy prices is available from the U.S Department of Energy's (DOE) Energy Information Administration (U.S. DOE 1998).

Reductions in carbon emissions are calculated by multiplying the annual energy saved by carbon emissions coefficients for the various fuel types. DOE's Office of Building Technology, State and Community Programs provides these coefficients for source energy (U.S. DOE 1999).

## RESULTS – THE 1990-1997 EXPERIENCE

Using the inputs and the method described above, we designed spreadsheets that calculate and display energy savings, energy cost savings, and carbon emissions reductions for the years 1990-1997 based on the historic data. Figure 2 shows cumulative impacts from 1990 to 1997 (most recent data) of approximately 2 exajoules (EJ), US$22 billion (discounted present value at 7% to the year 2000), and 30 million metric tons of carbon.

Figure 2 graphically depicts the cumulative contribution (from 1990-1997) of the impacts of all of the appliance standards on energy savings, energy cost savings, and carbon emissions.

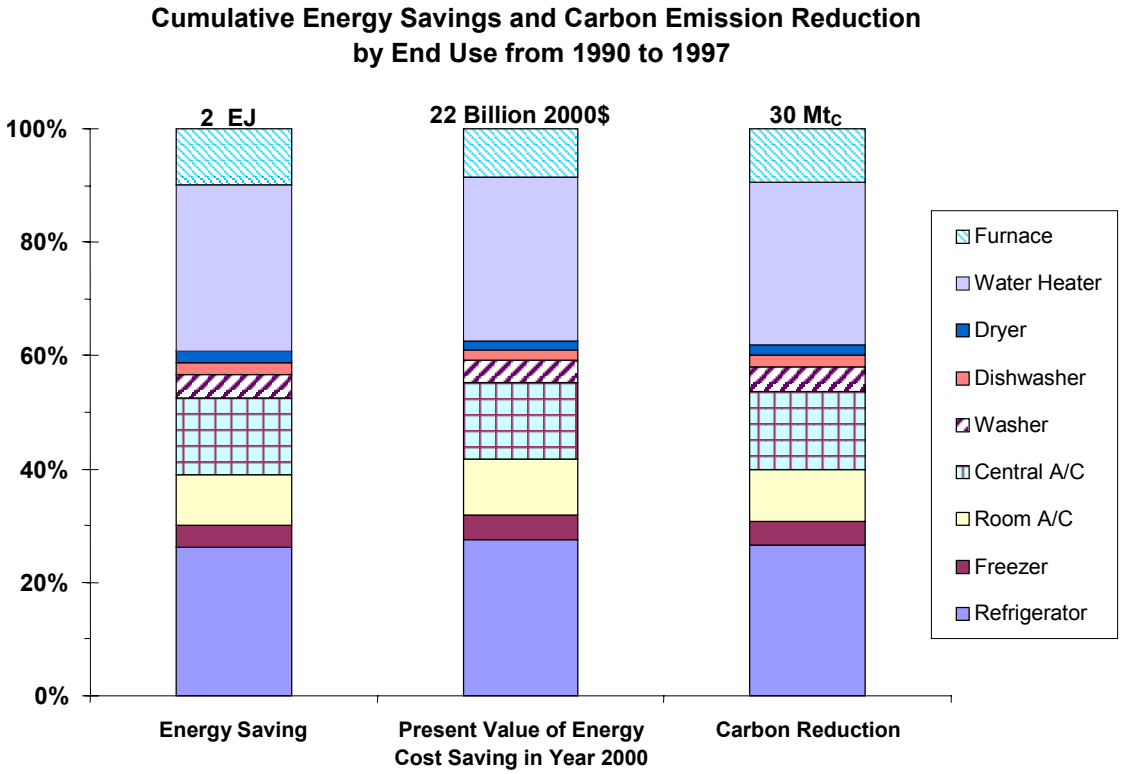


**Figure 2. Impacts of Standards, 1990-1997**

Tables 2, 3, and 4 show achieved and projected impacts. The standards data are first shown individually by appliance. Then, to assemble an aggregate estimate of the national energy savings, energy costs savings, and carbon emission reductions to date, the impacts of all of the standards are added together. Projections for future years are also shown.

**Table 2. Annual Source Energy Savings (in EJ)***

| | Refrigerator & Freezer | | | Room Air Conditioner | | Central A/C | Clothes Washer | Dish-Washer | Clothes Dryer | Water Heater | Gas/Oil Furnace | Total All Appliances | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NAECA | Update | | NAECA | Update | NAECA | Update | Update | Update | NAECA | NAECA | | | | Cumu- |
| | 1990 | 1993 | 2001 | 1990 | 2000 | 1992 | 1994 | 1994 | 1994 | 1990 | 1990 | NAECA | Updates | Total | lative |
| 1990 | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.06 | 0.00 | 0.06 | 0.1 |
| 1991 | 0.03 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.08 | 0.00 | 0.08 | 0.1 |
| 1992 | 0.04 | 0.00 | 0.00 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.06 | 0.01 | 0.13 | 0.00 | 0.13 | 0.3 |
| 1993 | 0.04 | 0.02 | 0.00 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.07 | 0.02 | 0.17 | 0.02 | 0.19 | 0.5 |
| 1994 | 0.05 | 0.04 | 0.00 | 0.02 | 0.00 | 0.04 | 0.01 | 0.00 | 0.00 | 0.08 | 0.03 | 0.22 | 0.06 | 0.28 | 0.7 |
| 1995 | 0.05 | 0.06 | 0.00 | 0.03 | 0.00 | 0.05 | 0.02 | 0.01 | 0.01 | 0.09 | 0.04 | 0.26 | 0.09 | 0.35 | 1.1 |
| 1996 | 0.05 | 0.07 | 0.00 | 0.03 | 0.00 | 0.07 | 0.03 | 0.01 | 0.01 | 0.11 | 0.05 | 0.31 | 0.13 | 0.43 | 1.5 |
| 1997 | 0.05 | 0.09 | 0.00 | 0.04 | 0.00 | 0.08 | 0.03 | 0.02 | 0.02 | 0.12 | 0.06 | 0.34 | 0.16 | 0.50 | **2.0** |
| 2000 | 0.06 | 0.15 | 0.00 | 0.05 | 0.00 | 0.11 | 0.05 | 0.03 | 0.03 | 0.13 | 0.07 | **0.41** | 0.26 | 0.68 | 3.9 |
| 2005 | 0.05 | 0.23 | 0.09 | 0.06 | 0.01 | 0.12 | 0.08 | 0.04 | 0.05 | 0.11 | 0.07 | 0.41 | 0.49 | 0.90 | 8.0 |
| 2010 | 0.03 | 0.27 | 0.18 | 0.05 | 0.02 | 0.07 | 0.06 | 0.05 | 0.06 | 0.07 | 0.05 | 0.28 | 0.65 | **0.92** | 12.7 |
| 2015 | 0.01 | 0.26 | 0.27 | 0.05 | 0.02 | 0.03 | 0.03 | 0.06 | 0.07 | 0.04 | 0.02 | 0.14 | 0.71 | 0.85 | 17.1 |
| 2020 | 0.00 | 0.24 | 0.33 | 0.04 | 0.02 | 0.00 | 0.01 | 0.06 | 0.07 | 0.01 | 0.00 | 0.06 | 0.74 | 0.80 | 21.2 |
| 2025 | 0.00 | 0.23 | 0.35 | 0.03 | 0.03 | 0.00 | 0.00 | 0.06 | 0.08 | 0.00 | 0.00 | 0.04 | 0.74 | 0.78 | 25.1 |
| 2030 | 0.00 | 0.23 | 0.36 | 0.03 | 0.03 | 0.00 | 0.00 | 0.06 | 0.08 | 0.00 | 0.00 | 0.03 | 0.75 | 0.78 | 29.0 |

*1 EJ = $10^{18}$ Joules. 1EJ = 0.9478 X $10^{15}$ Btu.

Includes electricity generation and transmission losses and household consumption of electricity, gas and oil.

**Table 3. Energy Cost Savings (in billion 2000 US$)**

| | Refrigerator & Freezer | | | Room Air Conditioner | | Central A/C | Clothes Washer | Dish-Washer | Clothes Dryer | Water Heater | Gas/Oil Furnace | Total All Appliances | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NAECA | Update | | NAECA | Update | NAECA | Update | Update | Update | NAECA | NAECA | | | | | |
| | 1990 | 1993 | 2001 | 1990 | 2000 | 1992 | 1994 | 1994 | 1994 | 1990 | 1990 | NAECA | Updates | Total | Cumu-lative | PV2000 @ 7% |
| 1990 | 0.18 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.00 | 0.51 | 0.00 | 0.51 | 0.5 | 1.0 |
| 1991 | 0.24 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.66 | 0.00 | 0.66 | 1.2 | 2.2 |
| 1992 | 0.29 | 0.00 | 0.00 | 0.13 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.40 | 0.06 | 0.98 | 0.00 | 0.98 | 2.2 | 3.9 |
| 1993 | 0.33 | 0.15 | 0.00 | 0.16 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.50 | 0.13 | 1.32 | 0.15 | 1.47 | 3.6 | 6.3 |
| 1994 | 0.37 | 0.30 | 0.00 | 0.19 | 0.00 | 0.31 | 0.07 | 0.03 | 0.03 | 0.60 | 0.20 | 1.68 | 0.43 | 2.11 | 5.7 | 9.4 |
| 1995 | 0.39 | 0.44 | 0.00 | 0.22 | 0.00 | 0.41 | 0.13 | 0.06 | 0.06 | 0.65 | 0.25 | 1.92 | 0.69 | 2.62 | 8.3 | 13 |
| 1996 | 0.40 | 0.59 | 0.00 | 0.26 | 0.00 | 0.52 | 0.19 | 0.09 | 0.09 | 0.74 | 0.31 | 2.23 | 0.96 | 3.19 | 11.5 | 17.3 |
| 1997 | 0.41 | 0.71 | 0.00 | 0.29 | 0.00 | 0.60 | 0.25 | 0.12 | 0.12 | 0.80 | 0.36 | 2.47 | 1.20 | 3.67 | 15.2 | 22 |
| 2000 | 0.41 | 1.10 | 0.00 | 0.36 | 0.01 | 0.82 | 0.38 | 0.20 | 0.20 | 0.82 | 0.42 | **2.84** | 1.88 | 4.72 | 28.4 | 36 |
| 2005 | 0.34 | 1.64 | 0.66 | 0.40 | 0.07 | 0.90 | 0.52 | 0.30 | 0.33 | 0.67 | 0.42 | 2.73 | 3.52 | 6.26 | 57.0 | 59 |
| 2010 | 0.19 | 1.95 | 1.32 | 0.38 | 0.13 | 0.54 | 0.42 | 0.36 | 0.43 | 0.43 | 0.30 | 1.84 | 4.61 | 6.45 | 89.3 | 78 |
| 2015 | 0.06 | 1.89 | 1.92 | 0.34 | 0.16 | 0.20 | 0.20 | 0.37 | 0.48 | 0.21 | 0.11 | 0.92 | 5.02 | **5.94** | 120.0 | 91 |
| 2020 | 0.01 | 1.71 | 2.38 | 0.30 | 0.17 | 0.04 | 0.06 | 0.39 | 0.52 | 0.06 | 0.03 | 0.43 | 5.23 | 5.66 | 148.8 | 99 |
| 2025 | 0.00 | 1.63 | 2.53 | 0.25 | 0.18 | 0.00 | 0.01 | 0.40 | 0.54 | 0.01 | 0.02 | 0.27 | 5.28 | 5.55 | 176.7 | 105 |
| 2030 | 0.00 | 1.63 | 2.56 | 0.19 | 0.19 | 0.00 | 0.00 | 0.41 | 0.55 | 0.00 | 0.02 | 0.21 | 5.34 | 5.55 | 204.5 | 110 |

The present value (discounted at 7% to 2000) of cumulative energy savings from 1990 to 1997 is US$22 billion. Savings from the original NAECA legislation have increased over time and are reaching their maximum (0.41 EJ and US$2.8 billion per annum) in year 2000. A decade of standards updates effective from 1993 to 2001 shifted the maximum for total expected savings from the existing standards to 2010 (0.92 EJ and US$6.45 billion per annum). Additional standards currently under development (not shown) are expected to add to these savings.

The pattern of savings in carbon emissions follows from energy savings. The cumulative reductions in carbon emissions are nearly 30 MtC by 1997. In 2000, the original standards are expected to reduce carbon emissions by about 6 MtC (million metric tons of carbon) per annum. The updates result in an expected maximum total savings of about 13 MtC per annum in 2010.

**Table 4. Carbon Emission Reductions (in MtC/a)**

| | Refrigerator & Freezer | | | Room Air Conditioner | | Central A/C | Clothes Washer | Dish-Washer | Clothes Dryer | Water Heater | Gas/Oil Furnace | Total All Appliances | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NAECA | Update | | NAECA | Update | NAECA | Update | Update | Update | NAECA | NAECA | | | | Cumu- |
| | 1990 | 1993 | 2001 | 1990 | 2000 | 1992 | 1994 | 1994 | 1994 | 1990 | 1990 | NAECA | Updates | Total | lative |
| 1990 | 0.32 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.44 | 0.00 | 0.92 | 0.00 | 0.9 | 0.9 |
| 1991 | 0.43 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 0.01 | 1.23 | 0.00 | 1.2 | 2.2 |
| 1992 | 0.53 | 0.00 | 0.00 | 0.24 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.78 | 0.13 | 1.85 | 0.00 | 1.9 | 4.0 |
| 1993 | 0.61 | 0.27 | 0.00 | 0.29 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.97 | 0.28 | 2.51 | 0.27 | 2.8 | 6.8 |
| 1994 | 0.70 | 0.56 | 0.00 | 0.36 | 0.00 | 0.58 | 0.13 | 0.06 | 0.06 | 1.17 | 0.42 | 3.22 | 0.81 | 4.0 | 10.8 |
| 1995 | 0.72 | 0.83 | 0.00 | 0.42 | 0.00 | 0.77 | 0.26 | 0.12 | 0.11 | 1.33 | 0.54 | 3.77 | 1.32 | 5.1 | 15.9 |
| 1996 | 0.76 | 1.11 | 0.00 | 0.50 | 0.00 | 0.99 | 0.38 | 0.18 | 0.17 | 1.50 | 0.66 | 4.42 | 1.86 | 6.3 | 22.2 |
| 1997 | 0.80 | 1.39 | 0.00 | 0.57 | 0.00 | 1.18 | 0.50 | 0.24 | 0.23 | 1.64 | 0.76 | 4.95 | 2.37 | 7.3 | **29.5** |
| 2000 | 0.83 | 2.23 | 0.00 | 0.73 | 0.01 | 1.66 | 0.79 | 0.42 | 0.41 | 1.79 | 0.97 | **5.99** | 3.86 | 9.8 | 56.7 |
| 2005 | 0.68 | 3.35 | 1.34 | 0.82 | 0.14 | 1.83 | 1.12 | 0.64 | 0.68 | 1.51 | 1.02 | 5.87 | 7.28 | 13.2 | 116.9 |
| 2010 | 0.39 | 4.00 | 2.71 | 0.79 | 0.27 | 1.10 | 0.91 | 0.77 | 0.89 | 1.00 | 0.74 | 4.01 | 9.55 | **13.6** | 184.9 |
| 2015 | 0.12 | 3.93 | 4.01 | 0.72 | 0.34 | 0.41 | 0.44 | 0.81 | 1.02 | 0.50 | 0.27 | 2.03 | 10.55 | 12.6 | 249.9 |
| 2020 | 0.01 | 3.56 | 4.96 | 0.63 | 0.36 | 0.07 | 0.14 | 0.84 | 1.10 | 0.15 | 0.06 | 0.93 | 10.95 | 11.9 | 310.5 |
| 2025 | 0.00 | 3.38 | 5.25 | 0.52 | 0.37 | 0.00 | 0.01 | 0.86 | 1.14 | 0.02 | 0.04 | 0.58 | 11.02 | 11.6 | 368.9 |
| 2030 | 0.00 | 3.39 | 5.31 | 0.40 | 0.39 | 0.00 | 0.00 | 0.88 | 1.17 | 0.00 | 0.04 | 0.44 | 11.14 | 11.6 | 426.8 |

Using refrigerators as an example, Figure 3 shows how the (undiscounted) energy cost savings and the increased equipment costs associated with new standards combine to yield positive net savings over time for the nation's consumers. For all products, the payback period required to offset increased equipment prices by energy bill savings averages 2 to 4 years, although individual consumers may experience a larger range reflecting the variability in equipment costs, energy prices, and consumer usage behaviors.

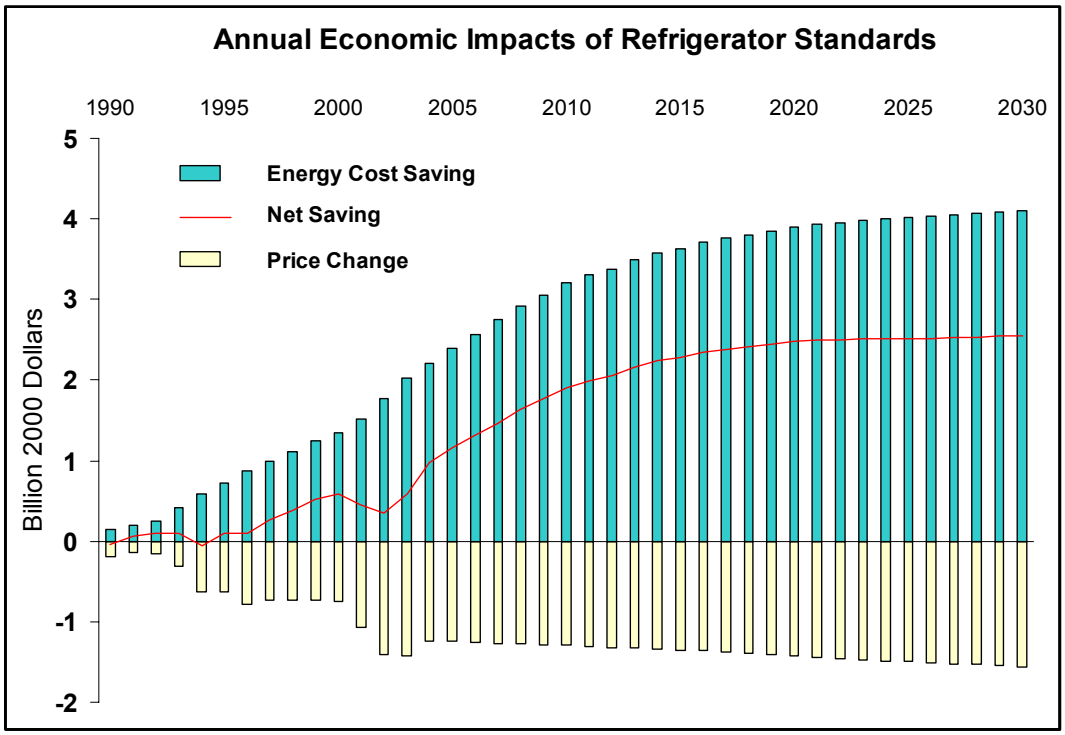


**Figure 3. Annual Economic Impacts of U.S. Refrigerator Standards**

Governmental administrative costs for the entire appliance, lighting, and equipment standards program represent an additional $5-10 million annually for developing test procedures, analyzing, and implementing regulations. This amount is too small to appear on the chart of national impacts.

## FUTURE IMPACTS OF ADOPTED STANDARDS

### Existing Standards

Because of the long useful lifetimes of appliances, up to 30 years, the existing standards will continue to provide net benefits many years into the future.

### Other Adopted Standards

Additional net benefits will accrue from updates to several NAECA standards that have either just taken effect (room air conditioners in 2000) or are scheduled to take effect in 2001 (refrigerators and freezers).

Table 5 shows a summary of the source energy savings (as per Table 2, but split into electricity and natural gas) associated with all of the existing residential appliance standards. The electricity savings are also converted to show that generation corresponding to about fourteen 500-megawatt (MW) power plants has been avoided by year 2000.

## Table 5. Energy Savings for Existing Residential Appliance Standards

| | Source Energy Savings (EJ) | | | | Electricity Savings (EJ Primary) | | | | | Natural Gas Savings (EJ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Annual Savings | | | Cumu- | Annual Savings | | | Cumu- | Power Plants | Annual Savings | | | Cumu- |
| Year | NAECA | Update | Total | lative | NAECA | Update | Total | lative | Avoided * | NAECA | Update | Total | lative |
| 1990 | 0.06 | 0.00 | 0.06 | 0.1 | 0.05 | 0.00 | 0.05 | 0.0 | 1 | 0.02 | 0.00 | 0.02 | 0.0 |
| 1991 | 0.08 | 0.00 | 0.08 | 0.1 | 0.06 | 0.00 | 0.06 | 0.1 | 2 | 0.02 | 0.00 | 0.02 | 0.0 |
| 1992 | 0.13 | 0.00 | 0.13 | 0.3 | 0.09 | 0.00 | 0.09 | 0.2 | 2 | 0.04 | 0.00 | 0.04 | 0.1 |
| 1993 | 0.17 | 0.02 | 0.19 | 0.5 | 0.11 | 0.02 | 0.13 | 0.3 | 4 | 0.06 | 0.00 | 0.06 | 0.1 |
| 1994 | 0.22 | 0.06 | 0.28 | 0.7 | 0.14 | 0.05 | 0.19 | 0.5 | 5 | 0.08 | 0.00 | 0.08 | 0.2 |
| 1995 | 0.26 | 0.09 | 0.35 | 1.1 | 0.17 | 0.08 | 0.25 | 0.8 | 7 | 0.09 | 0.01 | 0.10 | 0.3 |
| 1996 | 0.31 | 0.13 | 0.43 | 1.5 | 0.19 | 0.11 | 0.31 | 1.1 | 8 | 0.11 | 0.01 | 0.12 | 0.5 |
| 1997 | 0.34 | 0.16 | 0.50 | 2.0 | 0.22 | 0.14 | 0.36 | 1.4 | 10 | 0.12 | 0.02 | 0.14 | 0.6 |
| 2000 | 0.41 | 0.26 | 0.68 | 3.9 | 0.27 | 0.23 | 0.50 | 2.8 | **14** | 0.15 | 0.03 | 0.17 | 1.1 |
| 2005 | 0.41 | 0.49 | 0.90 | 8.0 | 0.26 | 0.45 | 0.71 | 6.0 | 19 | 0.14 | 0.04 | 0.18 | 2.0 |
| 2010 | 0.28 | 0.65 | 0.92 | 12.7 | 0.17 | 0.60 | 0.77 | 9.8 | 21 | 0.10 | 0.04 | 0.14 | 2.8 |
| 2015 | 0.14 | 0.71 | 0.85 | 17.1 | 0.09 | 0.68 | 0.77 | 13.6 | 21 | 0.05 | 0.03 | 0.08 | 3.4 |
| 2020 | 0.06 | 0.74 | 0.80 | 21.2 | 0.05 | 0.71 | 0.76 | 17.5 | 21 | 0.01 | 0.02 | 0.04 | 3.6 |
| 2025 | 0.04 | 0.74 | 0.78 | 25.1 | 0.03 | 0.72 | 0.75 | 21.2 | 20 | 0.00 | 0.02 | 0.02 | 3.7 |
| 2030 | 0.03 | 0.75 | 0.78 | 29.0 | 0.03 | 0.73 | 0.75 | 25.0 | 20 | 0.00 | 0.02 | 0.02 | 3.9 |

* 1 EJ of source energy (electricity) equals 27 coal-fired 500 MW power plant

Table 6 shows a summary of the total energy cost savings and carbon emissions reductions from existing residential appliance standards. By 1997, annual carbon emissions associated with the residential sector are reduced by about 3% of the 1990 residential sector emissions of 253 MtC per annum. By comparing the carbon emission reductions to typical carbon emissions from automobiles, the last column shows that in year 2010 the projected savings are equivalent to removing 10 million cars from the road.

## Table 6. Energy Cost Savings and Carbon Emission Reductions for Adopted Residential Appliance Standards

| | Energy Cost Savings (billion 2000$) | | | | Carbon Reduction (million metric tons) | | | |
|---|---|---|---|---|---|---|---|---|
| | Annual Savings | | | Cumu- | % of Residential | | | million cars |
| Year | NAECA | Update | Total | lative | Annual | Total in 1990 | Cumulative | off the road |
| 1990 | $0.5 | $0.0 | $0.5 | $0.5 | 0.9 | 0.4% | 0.9 | 0.7 |
| 1991 | $0.7 | $0.0 | $0.7 | $1.2 | 1.2 | 0.5% | 2.2 | 1.0 |
| 1992 | $1.0 | $0.0 | $1.0 | $2.2 | 1.9 | 0.7% | 4.0 | 1.4 |
| 1993 | $1.3 | $0.1 | $1.5 | $3.6 | 2.8 | 1.1% | 6.8 | 2.2 |
| 1994 | $1.7 | $0.4 | $2.1 | $5.7 | 4.0 | 1.6% | 10.8 | 3.1 |
| 1995 | $1.9 | $0.7 | $2.6 | $8.3 | 5.1 | 2.0% | 15.9 | 4.0 |
| 1996 | $2.2 | $1.0 | $3.2 | $11.5 | 6.3 | 2.5% | 22.2 | 4.9 |
| 1997 | $2.5 | $1.2 | $3.7 | $15.2 | 7.3 | **2.9%** | 29.5 | 5.7 |
| 2000 | $2.8 | $1.9 | $4.7 | $28.4 | 9.8 | 3.9% | 56.7 | 7.7 |
| 2005 | $2.7 | $3.5 | $6.3 | $57.0 | 13.2 | 5.2% | 116.9 | 10.2 |
| 2010 | $1.8 | $4.6 | $6.5 | $89.3 | 13.6 | 5.4% | 184.9 | **10.6** |
| 2015 | $0.9 | $5.0 | $5.9 | $120.0 | 12.6 | 5.0% | 249.9 | 9.8 |
| 2020 | $0.4 | $5.2 | $5.7 | $148.8 | 11.9 | 4.7% | 310.5 | 9.2 |
| 2025 | $0.3 | $5.3 | $5.6 | $176.7 | 11.6 | 4.6% | 368.9 | 9.0 |
| 2030 | $0.2 | $5.3 | $5.6 | $204.5 | 11.6 | 4.6% | 426.8 | 9.0 |

Carbon emission coefficient for electricity: 14.87 MtC/EJ

Carbon emission coefficient for natural gas: 13.65 MtC/EJ

Carbon emission from driving a car in a year: 1.28 metric ton of carbon

## STANDARDS CURRENTLY UNDER DEVELOPMENT

The U.S. Department of Energy is currently well along in its process to adopt updated standards for three residential appliances: water heaters, clothes washers, and central air conditioner and heat pumps. As with the previously adopted standards, these standards are expected to yield substantial savings to consumers.

Detailed results of the most current analyses of appliance standards under development in the U.S. are available from the Department of Energy's web site (U.S. DOE 2000). The current activities of the Energy Efficiency Standards Group at Lawrence Berkeley National Laboratory in support of the U.S. Department of Energy's work on appliance standards are available at the Group's web site (LBNL 2000).

## OTHER STANDARDS ACTIVITIES IN THE U.S.

In addition to the residential appliance standards mentioned in this paper, the U.S. has also adopted or is considering energy conservation standards for such diverse products as lighting equipment (e.g., fluorescent lamp ballasts); commercial heating, cooling, and water heating equipment; distribution transformers and water conservation standards for various plumbing products.

## CONCLUSIONS

Examining the actual impacts of U.S. appliance standards put in place during the past decade allows us to see the significant contribution they have already made in saving energy, lowering energy costs, and reducing emissions. These standards will continue to provide net benefits to U.S. consumers well into the future. In addition, the already-adopted standards that will soon take effect (for room air conditioners and refrigerators) are expected to yield substantial benefits. When the benefits from these already-adopted appliance standards are coupled with the benefits expected from standard rulemakings currently in progress and the benefits from already-adopted commercial sector standards, we can see that the U.S. has used appliance standards to reduce energy consumption, lower energy and total expenditures, and protect the environment.

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