Assessing Federal Appliance and Lighting Performance Standards

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Appliance and lighting efficiency standards have been an important and successful part of federal energy policy. To date, existing appliance and lighting standards have saved roughly 3% of U.S. annual residential energy consumption. By 2015, cumulative energy savings are projected to exceed 46 EJ (44 Quads) primary energy, or more than twice the projected value for all residential energy consumption in that year. For the consumer, existing standards have an average benefit-to-cost ratio of over 3 to 1. Existing appliance standards will also avert over 250 million tons of carbon emissions in 2015. This paper assesses the economic, energy, and environmental costs and benefits of existing and proposed appliance and lighting efficiency standards under the National Appliance Energy Conservation Act (NAECA) of 1987, and the Energy Policy Act (EPAct) of 1992. Accrued and projected savings under these standards indicate that investing in federal efficiency performance requirements for appliance and lighting products remains an effective way to profit nationally from energy efficiency. In addition to focussing on national and consumer impacts, manufacturer impacts will receive special attention. Future research directions are also proposed, including disaggregating impacts on individual manufacturers and on consumer subgroups.

INTRODUCTION

In 1975 the 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 NAECA superseded existing state requirements and actually set the first national efficiency standards for home appliances, as well as a schedule for regular updates, currently specified to 2012.

Today, NAECA, its amendments (P.L. 100-357), and the Energy Policy Act of 1992 (EPAct, P.L. 102-486), are at the heart of energy efficiency advances in residential appliances and lighting. At a time of increased demand for quantitative assessments of the impacts of government regulation, analyses from the Lawrence Berkeley National Laboratory show federal appliance and lighting efficiency standards providing substantial net benefits, quantifiable at both national and consumer levels. Nationally, efficiency gains can be seen in cumulative primary energy savings, in aggregate net gains to the U.S. economy, and as environmental gains in terms of averted carbon and NO_x emissions. For the individual American consumer, benefits come in the form of lower utility bills and an overall reduction in product life-cycle cost (first cost plus fuel costs). Predictions of increases in product purchase price and restricted model choice are most frequently cited as the fundamental negative impacts of efficiency standards, but existing data shows that—even when forecast—these costs are not necessarily present.

This paper draws together and describes a series of technical analyses of federal appliance and lighting efficiency standards conducted primarily at the Lawrence Berkeley National Laboratory. These findings are presented in order to better assesses the economic, energy, and environmental costs and benefits of existing and proposed appliance and lighting performance requirements under the National Appliance Energy Conservation Act (NAECA) of 1987, and the Energy Policy Act (EPAct) of 1992. Products covered under these acts include: dishwashers, clothes washers, clothes dryers, refrigerators and freezers, central air conditioners and heat pumps, room air conditioners, water heaters, swimming pool heaters, direct heating equipment, furnaces (including mobile home furnaces), kitchen ranges and ovens, fluorescent lamp ballasts, fluorescent and incandescent lamps, small electric motors (i.e.: 1–200 horsepower)[1], showerheads, faucets, urinals, and toilets.

In addition to focusing on consumer and national impacts of standards, this paper will also address the issue of manufacturer impacts.

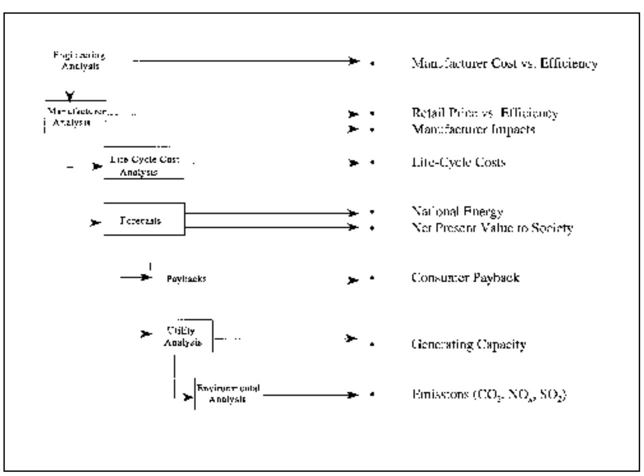
METHODOLOGY

A series of Technical Support Documents published by the U.S. Department of Energy (U.S. DOE 1988, 1989, 1990, 1993, 1995, and Atkinson et al. 1992) provides a detailed discussion of the analytic approach and methodology used in the assessment of federal appliance and lighting efficiency standards. As these documents explain, the impact of appliance efficiency standards is determined by comparing projections of a range of economic variables under existing legislation with projections under proposed standards. The differences between the projections of the energy consumption and economic variables in the base and standards cases provide quantitative estimates of the impacts of the standards. A sensitivity analysis is performed on key analytic parameters and assumptions in order to evaluate the significance and robustness of the differences.

The analysis is comprised of four major components: the Engineering Analysis, the Consumer Analysis (national and individual), the Manufacturer and Industrial Analyses, and the Utility/Environmental Analysis. Figure 1 illustrates the relationships among these components. The Engineering Analysis establishes appliance designs and related attributes such as efficiency and costs. Based on these costs, the Manufacturer Analysis predicts retail prices for use in the consumer analysis (the Life-Cycle Cost Analysis and Forecasts). Based on the relationship between the prices and efficiencies of design options, the consumer analysis forecasts sales and efficiencies for both new and replacement appliances. These data are used as inputs to the Manufacturer Analysis to determine financial impacts on typical firms within the industry. The Consumer Analysis also forecasts energy savings and consumer expenditures for the purchase and operation of the appliances. Consumer expenditures are used in the Life-Cycle Cost Analysis to determine consumer impacts. Changes in sales, revenues, investments, and marginal costs of utilities are calculated from the energy savings in the Utility/Environmental Analysis.

Three time frames are considered by the analysis. First, the analysis of consumer and utility impacts extends over a time

Figure 1. *Analytic Framework for the Appliance Standard Analysis*



frame consistent with the life of the products and includes the time required to approach market saturation. This time frame extends to 2030. Second, the Manufacturer Analysis is performed for two typical years—representing respectively short and long term perspectives—after the imposition of standards. Third, the Engineering Analysis examines the technical feasibility of improving the efficiency of appliances before the standards come into effect.

Quantitative estimates of the impacts of standards are calculated from the outputs of computer models. The model types utilized in the analysis are:

- Engineering Cost and Performance Models;
- Consumer Impact Models (COMMEND and LBL REM);
- Manufacturer Assessment Models (LBL MAM);
- Utility/Environmental Impact Model.

Model inputs are derived from an number of sources. Where possible industry sources are used. Shipment data, cost of purchased materials and parts, engineering and labor cost data, and information used to characterize baseline units are all taken or derived from manufacturer and industry trade association sources. Demographic inputs and residential market data are taken from government and industry surveys, including the Decennial Census, the Annual Energy Outlook, American Housing Surveys, and Residential Energy Consumption Surveys (McMahon et al. 1990).

In only two cases was the analysis of efficiency standards not conducted at LBL. In these cases—the 1988 ballast standard under NAECA, and the 1992 EPAct standards for products other than lamps—estimates of national economic and energy savings have been provided by the American Council for an Energy Efficient Economy (Geller 1995).

RESULTS

All results are reported as the difference between a projected ''base case,'' in which no new standards exist, and projected ''standards cases,'' in which appliance and lighting performance requirements are in effect.

Consumers

Federal appliance and lighting performance requirements are designed to reduce product life-cycle costs. As such, individual consumers purchasing new, energy efficient appliances save by reducing household energy expenditures. Summing for all existing standards, each dollar consumers pay in incremental equipment price will earn them 3.2 dollars (present value at 7% real discount rate) in reduced operating costs over the life of their equipment. Nationally, consumers will save over $60 billion for standards under the National Appliance Energy Conservation Act of 1987 (calculated to 2015), $72 billion for standards under the Energy Policy Act of 1992 (calculated to 2030), and reap a potential savings of as much as $56 billion for proposed standards (calculated to 2030). These figures are detailed in Table 1. For these savings, consumers can expect a simple payback period of, on average, two to three years, with the range of average payback periods for each product stretching from 0.8 to 8 years.

In an illustration of potential consumer savings at a household level, a 20% savings in annual operating costs is shown when comparing eight common household appliances with pre-NAECA efficiencies (represented by 1990 stock values) with a list of the same appliances meeting—but not yet exceeding—NAECA efficiency requirements (Turiel et al. 1995). At average national energy prices, savings to the consumer in this example are in excess of $200/year (see Table 2). Estimates of payback periods for the same list of appliances range from 4.3 years for standard dishwashers relying on gas water heating, to less than a year for standard clothes washers relying on electric water heaters.

Yet despite well defined consumer benefits, potential increases in equipment cost have raised concern about possible changes in consumer behavior. Such changes could include a reduction in the number of appliances purchased. In general, however, price increases have not been sufficient to cause significant changes in number of appliances purchased. Moreover, recent market survey data shows that for at least one major appliance, the top-mount, auto-defrost refrigerator freezer, average retail price dropped $46 in the six year period prior to and shortly after the first national refrigerator-freezer standards took effect (1987–1993). In

Table 1. *Net Present Value (NPV), and NPV as Benefits and Costs:*
(Values in billion $1990 discounted @ 7% real)

Standard	NPV =	(Benefit	–	Cost)
Existing (Forecast to 2015):				
NAECA ‘87	40.0	69.0		29.0
NAECA ‘88 (ballasts)	7.6	10.3		2.7
Refrigerator/freezer update ‘89	10.5	15.5		5.0
‘‘Clean Three’’ update ’91	2.5	4.0		1.5
TOTALS to 2015	60.6	98.8		38.2
Existing (Forecast to 2030):				
EPAct ‘92 (lamps only)	56.0	73.0		17.0
EPAct ‘92 (all other)	16.0	21.0		5.0
TOTALS to 2030:	72.0	94.0		22.0
Proposed (Forecast to 2030):				
Refrigerator/freezer consensus standard for ‘98	8.2	11.6		3.4
1994 NOPR for Water Heaters, Dir. Heating, Mobile Home Furns. and Pool Heaters	43.2	57.0		13.8
1996 Analyses for Room A/C, Cooking Products & Ballasts	4.8	6.7		1.9
PROPOSED TOTALS:	56.2	75.3		19.1

Source: All figures are taken or derived from DOE Technical Support Documents, EXCEPT for figures on ‘‘NAECA ‘88 (ballasts),’’ and ‘‘EPAct ‘92 (all other),’’ which were provided by Howard Geller, ACEEE.

Table 2. *Annual Energy Consumption and Cost Comparison*

Appliance	1990 Stock Average Annual Energy Use	1994 New Unit Annual Energy Use
Refrigerator-freezer	1220 kWh	670 kWh
Freezer	1010 kWh	500 kWh
Clothes washer[2]	890 kWh	670 kWh
Clothes dryer (electric)	930 kWh	830 kWh
Dishwasher	620 kWh	500 kWh
Room air conditioner	970 kWh	830 kWh
Gas water heater	300 therms	270 therms
Gas furnace	610 therms	530 therms
TOTAL ANNUAL ENERGY USE:	5640 kWh 910 therms	4000 kWh 800 therms
TOTAL ANNUAL COSTS: ($.082/kWh and $.69/therm)	$1,090	$880

Source: Derived from Turiel, et al. 1995.

addition, the number of models available, a common measure of degree of consumer choice, increased from 856 to 1005 over the same period (Elrick and Lavidge 1993). A more detailed analysis of affect of efficiency standards on refrigerator prices and amenity is presented in a companion paper (Greening et al. 1996).

Manufacturers

Manufacturer impact modeling indicates that reasonable energy efficiency standards will not have a large negative effect on the home appliance industry's bottom line: profitability as measured by return on equity (ROE). In none of the modeled cases was the stability of ROE threatened, either in the short or long term. In some cases—where price effects are stronger than shipment effects—ROE is actually expected to rise slightly with efficiency standards in place. ROE is especially stable for appliances which are relatively price inelastic, such as refrigerators, refrigerator-freezers and fluorescent and incandescent lamps.

These model results have been challenged by some manufacturers. For these manufacturers, opposition to appliance standards is rooted in the generally accepted fact that standards increase manufacturing costs while competition pressures may inhibit any corresponding rise in prices. A retrospective analysis for refrigerators (Greening et al. 1996) indicates that consumer prices have not risen as expected. One possible explanation is that the distribution channels have changed toward increasing market shares among power retailers and away from ‘‘mom-and-pop’’ appliance stores. Power retailers are chain stores which purchase appliances in large quantity lots, and so are in a position to hold down the price paid to manufacturers, independent of manufacturers' costs. The extent to which this has undercut manufacturer profits is not public knowledge as manufacturer's actual costs are not known. Determining the actual (as opposed to forecast) impacts of standards on manufacturers is a critically important area for future research.

Currently Lawrence Berkeley National Laboratory's Manufacturer Assessment Model (LBL MAM) assumes variable costs (costs which are proportional to output) can be passed on to consumers in the form of a price increase. Fixed costs, however, *cannot* be passed on in theory; these include the cost of plant and equipment. It is also assumed that if the markup over variable cost is not high enough to allow firms to cover these fixed costs, some firms will be forced out of the industry. It is to avoid this situation that manufacturer impacts are included in the analysis of proposed standards. (Predictions of adverse manufacturer impacts was a key reason a horizontal axis standard for clothes washers was rejected for 1994.) Further research into manufacturer impacts would benefit by the participation of the manufacturers themselves, since data on actual manufacturing costs, and the differences in cost structure among individual appliance divisions of different manufacturers, is not usually publicly available. Small manufacturers have argued that meeting the energy requirements is more burdensome on them than on larger manufacturers.

A review of company annual reports for manufacturers of refrigerators, fluorescent lamp ballasts, and water heaters for the period 1987–1993 found that energy efficiency regulations stimulated capital spending and often benefited firms.[3] Company reports by Natwest Securities Corporation (1994) and Smith Barney (1995) attribute growth in the appliance industry in part to discretionary replacement of old appliances driven by energy-efficiency improvements. No explicit mention was found either in company reports or in independent financial investment reports of adverse impacts caused by energy efficiency standards. Plant closures or job losses directly attributable to standards were not found.

While the United States may lead the world in energy efficiency standards, there is increasing interest among other countries in improving energy efficiency in appliances and lighting equipment (Somheil 1995). Most of the production of appliances is by international corporations, some of whom are interested in harmonization of standards. To the extent that products serve markets in multiple regions, manufacturers have an interest in minimizing the differences in requirements imposed on their products by different governmental jurisdictions in those markets. Manufacturer support for NAECA stemmed in part from the fact that federal standards under the Act supersede state standards. The extent to which U.S. manufacturers have benefited (or suffered) in the arena of international competition as a result of U.S. energy efficiency requirements is another interesting topic for further research. One theory holds that if the world is moving toward improved energy efficiency, then U.S. manufacturers are now well-positioned to profit from (or even propel) that movement. Another line of reasoning suggests that, if U.S. requirements are not normally met by products manufactured for overseas markets, then unique U.S. requirements may serve to protect the U.S. market for domestic manufacturers.

National Energy and Environmental Impacts

To date, appliance and lighting standards have saved roughly 3% of America's annual residential energy consumption. As older appliances are replaced, these same standards are projected to save over 46 EJ (44 Quads) primary energy by 2015, a savings equivalent to more than two years of current residential energy consumption. Proposed standards could save another 27 EJ (26 Quads) by 2015.

Environmentally, existing appliance standards are also predicted to avert over 250 million tons of carbon emissions in 2015, with proposed standards averting another 130 million. Appliance standards (existing and proposed) will also avert almost 800,000 tons of NO_x in 2015, and will make almost 850,000 tons of SO_2 available to be traded or banked under the Clean Air Act.

These aggregate national impacts are fully presented in Tables 3 and 4.

Table 3. *Annual Energy Savings in 2015*

Standard	Quads (primary) Saved	EJ (primary) Saved
NAECA '87	16.0	16.8
NAECA '88 (ballasts)	2.4	2.5
Refrigerator/freezer update '89	5.2	5.5
''Clean Three'' update '91	2.3	2.4
EPAct '92 (lamps only)[4]	14.5	15.2
EPAct '92 (all other)	4.2	4.4
SUBTOTAL:	44.6	46.8
Refrigerator/freezer consensus standard for '98	4.0	4.2
1994 NOPR for Water Heaters, Dir. Heating, Mobile Home Furns., and Pool Heaters	17.8	18.8
1996 Analyses for Room A/C, Cooking Products & Ballasts	20.4	21.5
SUBTOTAL:	25.9	27.4
TOTALS:	70.5	74.2

Source: All figures are taken or derived from DOE Technical Support Documents, EXCEPT for figures on ''NAECA '88 (ballasts),'' and ''EPAct '92 (all other),'' for which values have been estimated on the basis of information provided by Howard Geller, ACEEE.

Governmental Expenditure

From 1979 to 1994, department of Energy program expenditure on appliance and lighting standards amounted to about 1¢ to 10¢ per household per year. These funds were spent by the Department of Energy and its contractors to develop test procedures, conduct technological and economic analyses, hold public hearings, process and respond to public comments, and finalize regulations. Savings are about $10s to $100s per household per year—a return of about 1000 to 1 is provided to the national economy from the government expense. (Including consensus processes and legislation developed without costs to DOE, such as EPAct, the cumulative national savings are projected at about $130 billion.)

CONCLUSION

Federal appliance and lighting standards withstand careful cost-benefit analysis. The value of benefits outstrips costs

Table 4. *Emissions Reductions in 2000 and 2015*

Standard	CO_2 (10^6 tons) 2000	CO_2 (10^6 tons) 2015	NO_x (10^3 tons) 2000	NO_x (10^3 tons) 2015	SO_2 (10^3 tons) [traded or banked] 2000	SO_2 (10^3 tons) [traded or banked] 2015
NAECA '87	18.1	50.6	48.5	100.2	65.1	108.9
NAECA '88 (ballasts)	18.1	24.4	48.5	48.4	65.1	52.6
NAECA updates ('89 and '91)	19.9	39.3	53.1	77.8	71.4	84.5
EPAct '92 (lamps only)	34.6	90.8	92.4	179.7	124.1	195.3
EPAct '92 (all other)	16.4	48.0	43.9	95.0	59.0	103.3
SUBTOTAL:	107.1	253.1	286.4	501.1	384.7	544.6
Refrigerator/freezer consensus standard for '98	3.1	20.1	8.3	39.2	11.2	42.3
1994 NOPR for Water Heaters, Dir. Heating, Mobile Home Furns., and Pool Heaters	20.8	98.8	57.7	219.0	74.0	236.7
1996 Analyses for Room A/C, Cooking Products & Ballasts	1.9	12.1	5.2	23.7	7.0	25.5
SUBTOTAL:	25.8	131.0	71.2	281.9	92.2	304.5
TOTALS:	132.9	384.1	357.6	783.0	476.9	849.1

Sources: Emissions factors for this table were taken from estimates published originally as part of the 1991 National Energy Strategy (NES) and cited in the December 1992 Analysis of Federal Policy Options for Improving Lighting Energy Efficiency (LBL-31469, pp. 8/1–8/4). And in the November 1993 TSD covering the 8 product proposed rules (DOE/EE-0009 vol. 1, pp. 2–7). These estimates are designed to account for the impact of Title V of the 1990 Clean Air Act (HR 3030) on power plant emissions.

at the national level, and important reductions in operating costs are provided to individual consumers. The federal investment of about 1¢ to 10¢ per household per year has achieved national savings on the order of $10s to $100s per household per year, or a return of about 1000 to 1. Individual consumers achieve average returns in present value of reduced energy expenditures about 3 times the investment they make in incremental efficiency improvements. Additionally, major environmental savings are also present. These accrued and projected savings under efficiency standards indicate that investing in federal efficiency performance requirements for appliance and lighting products remains an effective way to profit nationally from energy efficiency.

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ENDNOTES

1. Smaller motors will be evaluated to determine if standards are needed and justified.

2. Includes electricity consumed in heating water in an electric water heater.

3. Memorandum of October 11, 1995 from Terry Chan and Carrie Webber, ''Retrospective on Appliance Standards.''

4. Excluding HVAC.

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