Appliance & equipment efficiency standards in the US: Accomplishments, next steps and lessons learned

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Abstract
Appliance and equipment efficiency standards are one of the most successful energy-saving policies adopted by the U.S. government. Standards began at the state level in the early 1980's and then expanded nationally with the passage of the National Appliance Energy Conservation Act of 1987. Subsequent legislation in 1988 and 1992 expanded the list of products, and a further expansion is likely in the fall of 2003 if now pending legislation is finalized. In addition, the U.S. Department of Energy periodically updates standards through a rulemaking process. As of 2000, appliance and equipment efficiency standards in the U.S. displaced the need for approximately 21 000 MW of electric generating capacity and reduced U.S. carbon emissions by about 25 million metric tons (MMT) annually. By 2020, due to standards already in place, these figures will grow to 120 000 MW and 73 MMT. The standards in the pending legislation and planned standards updates will increase these savings further.

This paper briefly summarizes the history and accomplishments of the U.S. standards program. Subsequent sections describe opportunities and activities to set new and updated standards in the U.S. and lessons learned from the U.S. standards programs (what has worked, what hasn't). The final section explores how these results and lessons may apply to other countries.

Introduction
Minimum efficiency standards are regulations that require products such as refrigerators, electric motors, and air conditioners to meet specific minimum efficiency requirements. Manufacturers are free to design their products any way they want, provided they meet or exceed specified efficiency levels.

History of Standards in the U.S.
Interest in standards goes back to the 1960s in the United States, with standards first being mentioned as a policy tool following a major multistate electrical blackout in the northeast section of the country in 1965. In the early 1970s, environmental concerns about power plant siting on the west coast led to a major analysis of energy policy options, including standards. The culmination was the adoption of the 1974 Warren-Alquist Act in California, which established the California Energy Commission with the authority to set appliance efficiency standards. California soon began to adopt standards via regulation, with the first standards taking effect in 1976. New York State also began to adopt standards, beginning in 1976 (Nadel and Goldstein 1996).

Activity at the state level combined with interest in reducing U.S. dependence on energy imports led to consideration of standards at the federal level. At first, the chosen federal option was voluntary targets for appliance efficiency, targeting on average a 20% reduction in new appliance energy use relative to then current levels. These goals were formalized in an executive order by President Ford and then in the adoption of the Energy Policy and Conservation Act of 1975. However, mandatory state standards began to take effect before the success of these voluntary targets

Table 1. U.S. equipment efficiency standards by product and initial effective date.

Year / Product	1988	89	90	91	92	93	94	~	2000	01	02	03	04	05	06	07	08	09	10
Refrigerators & freezers			X			X				X									
Clothes washers	X						X						X			X			
Clothes dryers	X						X												
Dishwashers	X						X												
Room air conditioners			X						X										
Residential central a/c					X										X				
Residential water heaters			X										X						
Fluorescent ballasts			X											X					X

could be assessed, and following a change in Presidents, the Carter Administration proposed mandatory federal standards. Extensive debate then ensued in Congress, leading ultimately to adoption of the National Energy Conservation and Policy Act of 1978. This Act included a provision directing the U.S. Department of Energy (DOE) to set mandatory minimum efficiency standards on appliances. DOE proceeded to develop new standards, but before they could be finalized, there was another change in Presidents. The new Reagan Administration was philosophically opposed to interventions in the market place and proposed "no standard" standards, meaning that no standards were set. This action was overturned by the federal courts in 1985 (Nadel and Goldstein 1996).

Concurrent with federal inaction on standards in the early 1980s, states increased their standard-setting activity, and by 1986, six states had adopted standards on one or more products. The growing number of state standards and concerns about future federal standards led appliance manufacturers to propose negotiations with energy efficiency advocates (e.g., the Natural Resources Defense Council, American Council for an Energy-Efficient Economy, state energy offices, and others). These discussions led to a consensus proposal that Congress adopt specific federal standards on many major appliances, with the provision that the federal standards would preempt state standards. This agreement was adopted by Congress and signed by President Reagan as the National Appliance Energy Conservation Act (NAECA) of 1987. Subsequent moves by states to adopt standards on commercial products not covered by NAECA led to further negotiations between manufacturers and efficiency advocates; ultimately these discussions led to passage of federal legislation in 1988 establishing efficiency standards for fluorescent lamp ballasts and in 1992 to passage of the Energy Policy Act (EPAct), which included standards on a variety of lamps, electric motors, and commercial heating, cooling, and plumbing products (Nadel and Goldstein 1996). The NAECA law also included a provision calling on DOE to periodically review and revise minimum efficiency standards. To date, DOE has revised standards on eleven products, including multiple revisions of refrigerator and clothes washer standards.

The United States has a large number of standards because successes with initial standards have led to interest in adopting standards on additional products. In the U.S., this activity has been led by several energy efficiency organizations (such as the American Council for an Energy-Efficient Economy and the Natural Resources Defense Council), and several legislators (including Representative Ed Markey and Senators Tim Wirth and Byron Dorgan). On two occasions when comprehensive energy legislation was moving forward, even political conservatives felt a need to support specific energy-efficiency provisions, such as standards, to make the legislation balanced.

The process for periodically updating and expanding standards is illustrated in Table 1, which shows the history of U.S. minimum efficiency standards by product and year (this table only includes federal standards that have gone through at least one revision process, and it does not include state standards).

Complementary Program Approaches

Standards are not the only approach for saving energy in the U.S. Other programs such as labeling, technology procurement, and incentive programs can save significant amounts of energy in their own right and also lay the groundwork for the adoption of new or revised standards. For example, in United States, the first step was to adopt a testing and labeling program. This program developed objective test procedures (often based on prior industry procedures) and collected data on all models sold in the country. Comparative energy use information were then put on "Energy Guide" labels on many types of appliances beginning in 1980. Unfortunately, recent evaluations of the U.S. information labeling program found that the label was not attention grabbing and was difficult for some consumers to understand. As a result, the current U.S. appliance label appears to be having little impact on sales and proposals to overhaul the program are now being discussed (Thorne and Egan 2002).

Another type of label in use in the U.S. is the *Energy Star* endorsement label run by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy. For many types of office and electronic equipment, this label is used to identify products with low standby energy use. EPA supports the Energy Star program through a public relations campaign and also allows manufacturers to advertise that specific products of theirs qualify for the Energy Star label. For the office and electronic products, owing to these marketing benefits and the fact that the cost of reducing standby power is generally low, manufacturers have rapidly introduced Energy Star products. As a result, an estimated 80% to 99% of personal computers, monitors, and printers sold in 1999 were Energy Star models (Brown, Webber and Koomey 2000). And 45%-95% of the TVs, VCRs and DVD players were Energy Star in 2002. On the other hand, the market share for Energy Star cable TV boxes and mini audio systems was only 14-15% in 2002 (McWhinney 2002), indicating that Energy Star is not able to influence the production decisions of all manufacturers. For other products, such as appliances, the Energy Star label is used to identify products whose energy efficiency is in the top 15-25% of products on the market. These programs are run by both EPA and DOE, often with substantial local marketing by utilities and states. In 2001, the market share for Energy Star dishwashers, room air conditioners and refrigerators ranged from 15-20%, depending on the product (USDOE 2002a). The lower market share is likely due to the higher cost of achieving Energy Star performance levels with these products (incremental costs are generally in the tens of dollars and sometimes more than $100).

Financial incentives for the purchase of high-efficiency equipment can increase the availability and sales of high-efficiency equipment. When properly structured and marketed, these programs have achieved participation rates as high as 60% for products that are typically 10% to 15% more efficient than average efficiency equipment on the market (Jordan, Nadel and Pye 1994). These programs are increasingly being used to lay the groundwork for new or revised standards. For example, the objective of several coordinated utility incentive and promotion programs in the United States has been to support the development of stronger efficiency standards on residential clothes washers and residential and commercial air conditioners (Suozzo and Thorne 1999).

Technology procurement represents another potential complement to standards. Technology procurement encourages manufacturers to commercialize new high-efficiency products, starting the market diffusion process that may ultimately lead to standards. For example, in the early 1990s, 24 U.S. electric utilities sponsored the Super Efficient Refrigerator Program (SERP), which offered a $30 million prize to the manufacturer who could produce approximately 250 000 refrigerators that were at least 25% more efficient than a unit just meeting the 1993 U.S. refrigerator standards. The winning bid was approximately 30% more efficient (Brodie et al. 1994), which helped lay the groundwork for the 2001 U.S. refrigerator standard that is reducing the energy use of the most common refrigerators by approximately 30% relative to the 1993 standard.

Finally, many U.S. states and municipalities have building codes that require certain safety and energy-saving features in new homes and buildings. The energy requirements in these codes frequently include minimum efficiency levels for heating and cooling equipment. These building code efficiency levels can be coordinated with equipment efficiency standards, regardless of whether the building is new or old. For example, in the United States, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) developed a model building code for commercial buildings that was adopted by many states. The equipment efficiency values in this code were the basis of mandatory efficiency standards adopted by the U.S. Congress in 1992. Under this legislation, revisions to the ASHRAE code trigger revisions to the federal equipment standards (U.S. Congress 1992).

Each of the approaches discussed above can and have resulted in significant energy savings. However, relative to standards, these other programs tend to have lower market share (if enforced, standards affect 100% of sales), lower savings (as discussed below, standards can help drive savings of 25% to 70%), and/or higher costs (standards don't require incentives or extensive marketing). There are exceptions, such as the high market share for the Energy Star office and consumer electronic equipment program. But in general, other program approaches should be considered complements – not alternatives – to standards.

Impacts of U.S. Standards

IMPACTS OF STANDARDS ON PRODUCT EFFICIENCY

Standards are often set at levels designed to eliminate a certain proportion of current products from the market. But the analyses that provide the basis for selecting the stringency level of the standard typically take place several years before standards take effect, and it is possible that similar levels of efficiency could be obtained if the market were left to function on its own. For the United States, annual data on the salesweighted average efficiency of many products are available going back to the 1970s, which allows us to track efficiency trends over time, and whether efficiency tends to increase steadily throughout the period, or whether efficiency improvements tend to be episodic and concentrated around the times that new efficiency standards take effect. These data are plotted for three products in Figure 1. For example, since 1972, average refrigerator energy use has decreased from 1 726 kWh to about 490 kWh. In several years (1981--82, 1985--86, and 1993--1999) there were little or no efficiency improvements. All of these years were periods in between new standards, meaning that these were years in which market forces prevailed, and there were no new standards to drive new efficiency improvements. Conversely, the periods with the most rapid improvements in refrigerator efficiency (1978--81, 1986--87, 1992--93 and 2000--2001) all corresponded with the effective dates of new standards.

Support for this view is provided in a 1997 journal article by staff at two major appliance manufacturers, who note that "standards have driven the development of high efficiency [refrigerator] components such as high EER compressors,

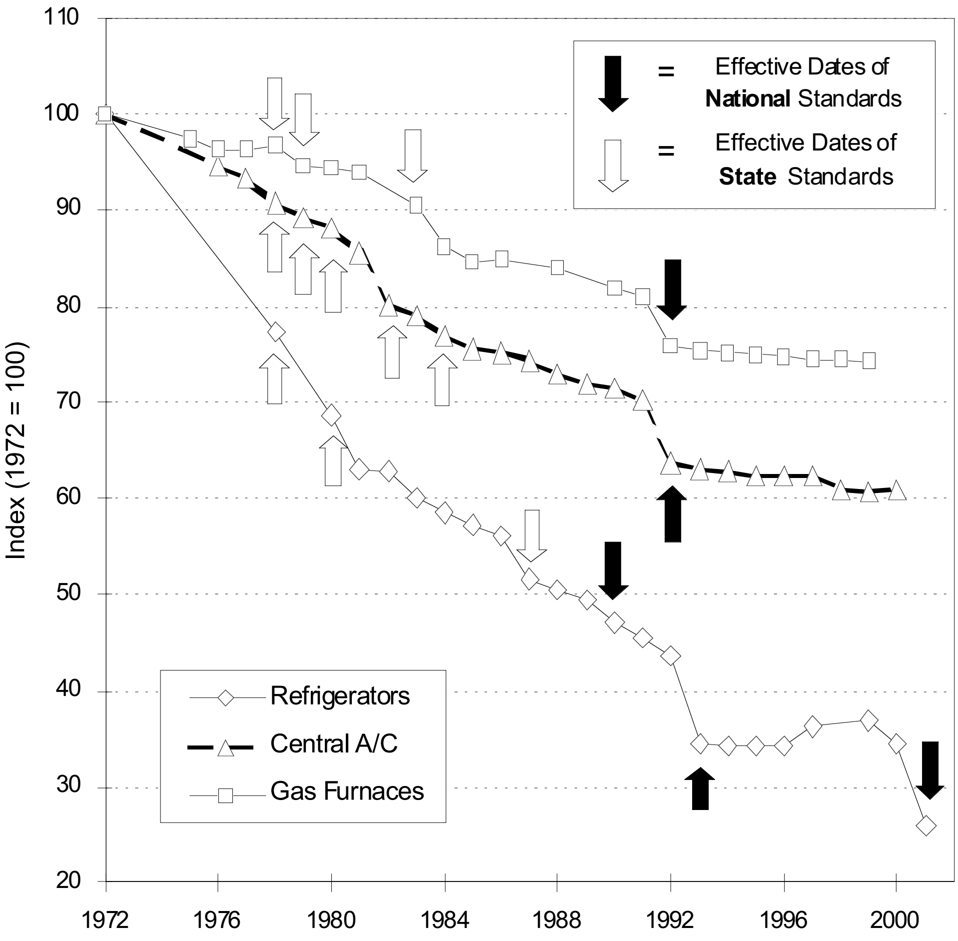

Figure 1. Energy intensity of U. S. refrigerators, central air conditioners, and gas furnaces. *This is from an analysis by the American Council for an Energy-Efficient Economy (ACEEE) based on data compiled by manufacturer trade associations. The index is based on energy use or energy efficiency per unit and does not account for modest changes in unit size over time. The 2001 value for refrigerators is based on the new 2001 federal efficiency standard.*

adaptive defrost controls, and low wattage fan motors that are currently used exclusively for the U.S. marketplace" (McInerney and Anderson 1997). Similar trends apply to other products, a point that is particularly obvious in Figure 1 in the period from 1993-2000 when no new efficiency standards went into effect. While other factors besides efficiency standards have contributed to these savings (e.g., rising electricity prices and utility rebate programs), the largest improvements in product efficiency have been in periods adjacent to the effective dates of new efficiency standards.

Skeptics may argue that standards merely accelerate efficiency improvements that would have happened anyway. While there is perhaps some truth to this argument for products that are steadily improving in efficiency, for other products, efficiency has been essentially flat in the absence of new standards (note the absence of efficiency improvements in the 1990s for the three products analyzed in Figure 1). Similar trends have occurred for passenger vehicles in the United States where the fuel economy of new cars and light trucks has been stagnant since efficiency standards were last changed in 1987 (Geller 2001).

ENERGY AND DEMAND SAVINGS

As part of the standards adoption process, DOE and Lawrence Berkeley National Laboratory (LBNL) have estimated the energy and demand savings from standards relative to projected trends in the absence of standards. These estimates have been summarized by the American Council for an Energy-Efficient Economy (ACEEE) and are reported in Table 2. These calculations allow for modest efficiency improvements in the absence of standards, based on historical data such as that shown in Figure 1. However, the estimates were made prior to the effective date of each standard and do not include any adjustments for post-implementation experience. Although such adjustments are not likely to be large (based on data in Figure 1 and similar data for other products), the calculations in Table 2 should be considered approximate and are subject to some uncertainty. Still, as an order-of-magnitude estimate, the savings are substantial. In 2000, relative to projected efficiencies in the absence of standards, U.S. federal efficiency standards reduced national electricity use by 88 TWh (a Terrawatt-hour [TWh] is a billion kWh), which was 2.5% of U.S. electricity use in 2000. In addition, natural gas and oil were saved, bringing total sav-

Table 2. Estimated savings from U.S. efficiency standards.

Enact Year	Standards	Electricity Savings (TWh/yr)			Primary Energy Savings (quads/yr)			Peak Load Reductions (GW)			Carbon Reductions (MMT)			Net Benefit ($billion)
		2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020	Thru 2030
1987	NAECA	8.0	40.9	45.2	0.21	0.55	0.61	1.4	14.9	16.5	3.7	10.0	10.1	46.3
1988	Ballasts	18.0	22.8	25.2	0.21	0.27	0.29	5.7	7.1	7.9	4.4	5.0	5.0	8.9
1989&91	NAECA updates	20.0	37.1	41.0	0.23	0.43	0.47	3.6	6.9	7.7	4.8	8.1	8.1	15.2
1992	EPAct (lamps, motors, etc.)	42.0	110.3	121.9	0.59	1.51	1.67	10.1	26.2	28.9	11.8	27.5	27.9	84.2
1997	Refrigerator/freezer update	0.0	13.3	28.0	0.00	0.13	0.28	0.0	1.7	3.6	0.0	2.9	5.5	5.9
1997	Room A/C update	0.0	1.3	2.1	0.00	0.01	0.02	0.0	1.0	1.6	0.0	0.3	0.4	0.6
2000	Ballasts update	0.0	6.2	13.7	0.00	0.06	0.13	0.0	1.8	3.0	0.0	1.3	2.7	2.6
2001	Clothes washer update	0.0	8.0	22.6	0.00	0.11	0.28	0.0	1.3	6.1	0.0	2.2	5.4	15.3
2001	Water heater update	0.0	2.5	4.9	0.00	0.08	0.13	0.0	1.5	3.6	0.0	1.4	2.2	2.0
2001	Central A/C&HP update	0.0	10.7	36.4	0.00	0.11	0.35	0.0	3.5	41.5	0.0	2.3	7.2	5.0
	TOTAL	**88**	**253**	**341**	**1.2**	**3.3**	**4.2**	**21**	**66**	**120**	**25**	**61**	**75**	**186**
	% of projected U.S. use	**2.5%**	**6.5%**	**7.8%**	**1.3%**	**2.9%**	**3.5%**	**2.8%**	**7.6%**	**12.6%**	**1.7%**	**3.4%**	**3.8%**	

Note: *This table includes an air-conditioner standard finalized in January 2001. In May 2002 DOE weakened this standard to a level that will provide about two-thirds of the savings shown here. This latter action is being challenged in court.*
Source: Geller, Nadel and Kubo 2001.

ings to 1.1 exojoules (1.2 quadrillion Btus), 1.3% of total U.S. energy use (EIA 2002). By way of comparison, relative to control groups of non-participants, utility energy-efficiency programs saved approximately 57 TWh nationwide in 2000 (2001 data are not yet available) (York 2002). Appliance standards are probably the most effective government policy for reducing electricity use and are one of the most effective policies for reducing energy use (from our review of the literature, only Corporate Average Fuel Economy Standards for passenger vehicles had greater total energy savings in the United States in 2000) (Friedman et al. 2001).

U.S. energy efficiency standards have also had a substantial impact on peak electricity demand. In 2000, standards displaced the need for approximately 21 000 MW of generating capacity, which is about 2.8% of the installed generating capacity in the United States in 2000 (see Table 2).

Furthermore, standards already enacted will substantially increase the savings in years ahead as existing appliances are replaced with new, more efficient products, particularly once standards set from 2000 to 2001 take effect later in the decade. According to the DOE/LBNL estimates (with a few adjustments in the case of the 2006 air conditioner standard), by 2020, standards already set will reduce electricity use by 341 TWh (7.8% of projected use), save 3.9 exojoules (4.2 quadrillion Btus) per year (3.5% of projected U.S. energy use), and reduce peak electric demand by 120 000 MW (more than a 10% reduction from current projections for demand in 2020) (Geller, Kubo and Nadel 2001).

Some economists have speculated that as efficiency standards and programs improve appliance efficiency, consumers will be encouraged to use these appliances more, because each hour of operation will be less costly (a circumstance labeled the *snapback* effect or *rebound* effect). Such snapback would reduce the energy savings achieved. A 1993 study examined the results of more than 40 evaluations of energy efficiency programs and found little evidence of snapback in practice. In most cases there was no change in appliance use with efficient products. The only cases of reported snapback relevant to standards were that purchasers of compact fluorescent lamps tended to use them for more hours than the incandescent lamps that were replaced, and in a few cases purchasers of air conditioners used them more often during periods of moderately hot weather. This study concluded that snapback "can occur, but it is not a widespread phenomenon. Instead, [snapback] is a localized phenomenon, largely limited to several specific end-uses" (Nadel 1993). It is also worth noting that where snapback does occur, it does provide benefits, but these benefits are in terms of increased consumer comfort or utility, and not in terms of energy savings.

Impact on Emissions of Air Pollutants

Many countries are using standards as part of their strategies to constrain growth in greenhouse gas emissions. Table 2 provides estimates of the reduction in carbon emissions – the major greenhouse gas – resulting from standards in the United States. In 2000, standards reduced U.S. carbon emissions by 25 million metric tons (MMT), which is 1.7% of U.S. emissions. (Note: These figures are just for carbon and differ from figures for carbon dioxide in that they do not include the weight of the oxygen atoms.) As savings from existing standards increase over time, these reductions are expected to increase to 75 MMT in 2020, which is 3.8% of projected U.S. emissions in that year. Any new standards set between now and 2020 will increase this figure. Under the Rio treaty, the United States (and other countries) pledged to stabilize carbon emissions at 1990 levels. To meet this commitment in 2020, the United States will need to reduce

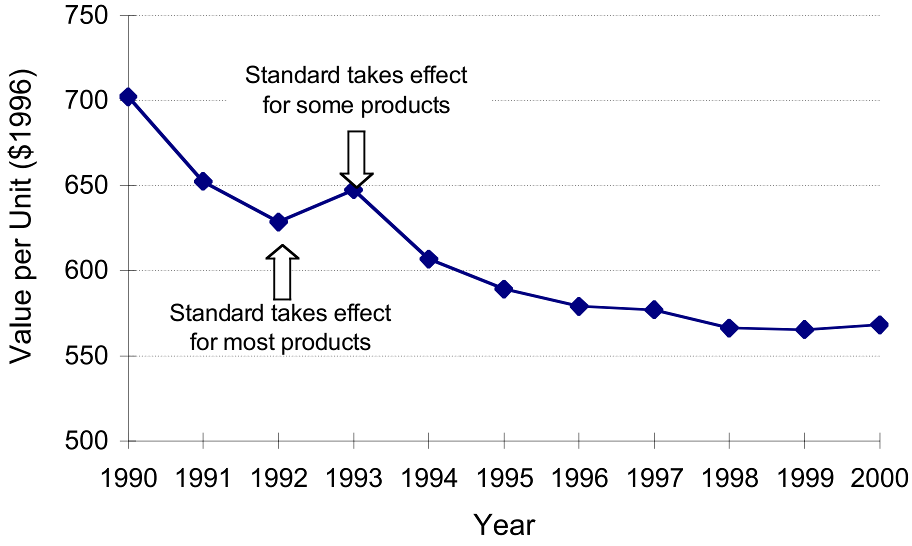

Figure 2. Average price paid to manufacturers of residential central air conditioners by year .
(ACEEE analysis based on data in US Census Bureau, various years)

projected emissions by 736 MMT (EIA 2002). Appliance standards set to date will account for approximately 10% of these reductions, making a significant contribution toward this overall goal.

Consumer Economics

Prior to adoption of standards, DOE, LBNL, and other analysts have examined the consumer economics of proposed standards. All of the standards adopted in the United States to date have had estimated benefit to cost ratios of more than one (benefits exceed costs), with an average benefit to cost ratio from these standards of about 3:1 (Geller 1995). Looked at another way, the discounted benefits to consumers of already enacted standards minus the discounted costs to consumers of standards are estimated to total approximately $180 billion (170 billion Euro)[1] for products purchased by 2030 (see Table 3). These net benefits amount to approximately $1 800 (1 700 Euro) per U.S. household (1997), spread over a 40-year period, an average of $45 (43 Euro) per household per year.

These figures are all based on incremental cost estimates made before the standards took effect. Several studies have examined actual changes in costs and prices once standards took effect and compared these impacts to estimates made during standard adoption processes. In general, standards have cost less in practice than was estimated when the standards were set.

The first thorough study on this issue was an examination by Greening et al. of the retail price of refrigerators before and after the 1990 and 1993 federal refrigerator efficiency standards. They found that the average real retail price did not change following the 1990 standard, and the price *decreased* 14% following the 1993 standard. Greening et al. also found that the interior volume of refrigerators declined slightly after the 1993 standard, and when they normalized refrigerator prices to hold interior volume constant, real prices decreased 8% after the 1993 standard (Greening et al. 1996). By comparison, when the 1993 standard was set, DOE estimated that the average refrigerator would increase in price by 7% (USDOE 1989).

Similarly, S. Nadel examined data from the Census of Manufacturers for central air conditioners and found that new efficiency standards that took effect in 1992/1993 had essentially no impact on long-term cost trends. Prior to the standards, manufacturer costs per air conditioner were declining modestly every year. With the exception of a one-year blip in 1993 (the year after most of the standard took effect), this trend continued (see Figure 2) (US Census Bureau, various years). Even the one-year blip was a modest $18 (17 Euro) per unit. Assuming a markup from manufacturer cost to consumer price of 2.42 (USDOE 2000), the $18 manufacturer cost increase works out to a retail price increase of $44 (42 Euro) per unit, far less than the price increase of $762 (726 Euro) predicted by manufacturers (CEC 1984) or the $349 (332 Euro) price increase predicted by DOE (USDOE 1982).

Another less vigorous data point is provided for the 2001 refrigerator standard. The DOE analysis during the rule-making process estimated that the new standard would increase the consumer cost of a new refrigerator by $58 (USDOE 1996). But in a presentation on energy-efficiency strategies, a spokesman for Sears, the largest appliance retailer in the United States, noted that they are able to buy refrigerators meeting the new standard for about the same price that they previously paid for units meeting the old standard (Schlenner 2000).

1. Based on the January 2003 exchange rate of $1.05 per Euro.

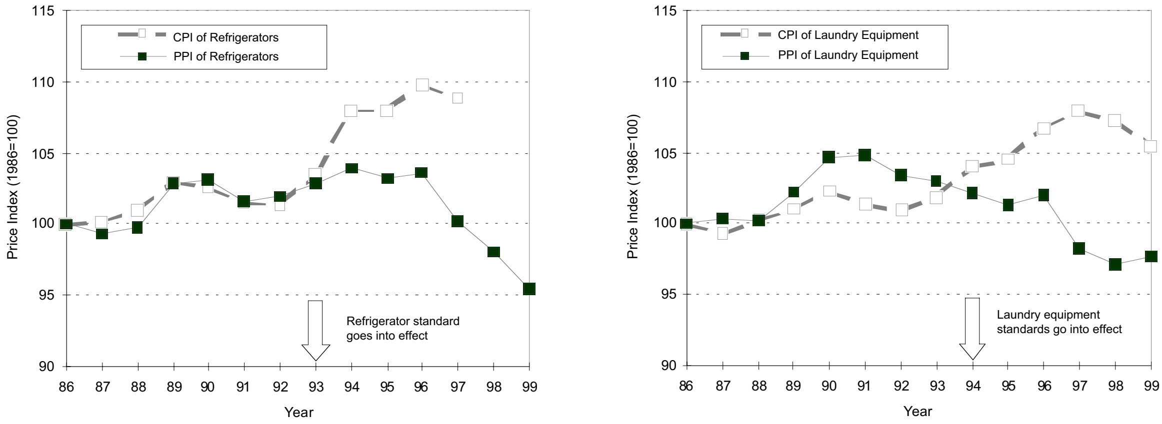

Figure 3. Consumer and Producer Price Indices and sales for refrigerators and clothes washers. *From U.S. Bureau of Labor Statistics Consumer and Producer Price Indices as reported in AHAM 2000.*

Finally, Dale et al. (2002) examined historic price data from *Consumer Reports* magazine and from the Sears Catalog and conducted a detailed regression analysis on price as a function of efficiency and other factors. They examined four products (room air conditioners, central air conditioners, refrigerators and clothes washers) and compared the price effects from their regression models with DOE estimates made as part of the standard-setting process. They found that price did increase on average as efficiency increased, but that actual price increase for more-efficient room air conditioners was 42% to about 90% less than DOE predicted, and the actual price increase for the other products was generally 20-25% less than DOE predicted. They concluded that their analysis "strongly suggests that the TSD overestimated the price to increase efficiency for every appliance considered in this paper."

Overall, while these studies cover only some of the U.S. efficiency standards, the trend is entirely one-sided, indicating that in all likelihood, the net benefits of standards are probably greater than the figures shown in Table 2.

There are probably several reasons why price increases following standards are less than previous predictions. First, as noted by senior staff for two appliance manufacturers, "in order to conserve capital resources, [manufacturers] typically combine improvements in energy efficiency with cost reductions, quality improvements, and new features. Each manufacturer's facility and tooling are typically revised at certain intervals to attain these other objectives due to improvements in technology and/or new marketplace demands." To the extent that efficiency improvements can be coordinated with these other investments, costs can be cut (McInerney and Anderson 1997). For example, they may find other cost reductions to offset the cost of efficiency improvements---cost reductions they might have made even without standards---but standards provided extra impetus. Second, in order to remain price competitive, manufacturers will often "sharpen their pencils" and seek ways to improve efficiency at the lowest possible cost. Third, broad technological changes are helping to lower the real price of appliances over time (Dale et al. 2002), a factor not considered in DOE's analyses. Fourth, manufacturers and distributors could reduce the markups changed to customers. Dale et al. (2002) did find some evidence that markups are declining, particularly markups on the incremental manufacturing cost to increase product efficiency.

Impact on Manufacturers

Appliance manufacturers are often concerned that meeting new standards requires significant investment, potentially drawing money away from other promising opportunities such as expansion in overseas markets. Manufacturers are also concerned that in today's highly competitive markets, increases in production costs cannot be passed on to consumers and that manufacturer profits will suffer (McInerney and Anderson 1997). In addition manufacturers sometimes worry that higher product prices could reduce demand for their products. Some data are available to assess these issues, but these data are limited and thus not definitive.

In the United States, as part of the standards-setting process, an analysis is conducted to estimate the impact of prospective standards on the profitability of manufacturers overall, and for defined subgroups of manufacturers. A review of many of these analyses concluded:

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. In none of the modeled cases was the stability of return on equity threatened. In some cases – where price effects are stronger than shipment effects – return on equity is actually expected to rise slightly with efficiency standards in place. Return on equity is especially stable for appliances which are relatively price inelastic, such as refrigerators, refrigerator-freezers and fluorescent and incandescent lamps (McMahon et al. 1996).

These findings cover appliance standards set as of 1996. Since then several additional standards have been set, including several with estimated impacts on manufacturers similar to those of the earlier studies. However for two recent standards – residential clothes washers and central air conditioners – significant adverse impacts on manufacturers were predicted. Both of these analyses estimate very high incremental prices for products at the new standard levels, price estimates that have been controversial (and in the case of clothes washers, DOE acknowledges that prices are likely to be lower). If incremental prices in fact prove to be lower, adverse impacts on manufacturers will probably be much less substantial.

Support for these analytic results is provided by a review of data on refrigerators and clothes washers following imposition of new standards in 1993 and 1994 (we use these findings because there is not yet sufficient data to assess the 2001 refrigerator standard). In the year these standards took effect, the consumer price indices for refrigerators and clothes washers increased more rapidly than the producers' price index for these products (see Figure 3). In addition, product sales increased in the year the standards took effect (AHAM 2000). The increase in product sales was probably largely due to a growing economy, but standards appear not to have hurt this trend.

Another line of evidence on the impacts of standards on manufacturers is to examine company annual reports and independent reports of financial analysts. Chan & Webber (1995) conducted such an analysis, analyzing 15 reports that covered the 1987 to1993 period. This review found several comments that standards were increasing sales revenues and profits. For example, a manufacturer of water heaters, Mor-Flo, noted in its 1990 annual report that standards have benefited the company in three ways: (*a*) "we no longer have to produce models to address the varying state energy efficiency standards;" (*b*) "price increases on ... minimum standard models have more than offset the corresponding cost increases resulting in an improved gross profit margin"; and (*c*) since the standards took effect, "the Company has been selling a larger number of 'step-up' models." None of the reports examined by Chan & Webber mentioned any adverse impacts of standards. More recently, Lennox, a major manufacturer of air conditioners, reported that "it is well positioned to comply with any new standards that may be promulgated by the Department of Energy and does not foresee any adverse material impact from a National Appliance Energy Conservation Act standard change"(Lennox 2000).

Another concern expressed by manufacturers is that standards may accelerate trends toward industry consolidation. Although industry consolidation is a long-term trend that began long before standards, there have been several allegations that standards affected this trend. First, as the 1990 U.S. room air conditioner standard took effect, one room air conditioner manufacturer stopped producing its own units and instead started buying units from other producers. Second, as the 1993 U.S. freezer standard took effect, a couple of manufacturers left the freezer industry, citing in part the cost of reconfiguring their products to meet the new standard. More recently, one medium-size manufacturer stopped making top-mounted refrigerator-freezers just as the new 2001 refrigerator standards took effect. In many of these cases, strategic corporate objectives were also served by exiting certain markets, but standards likely reinforced these trends.

Taken together, the available data indicate that standards do not appear to have caused significant adverse impacts on manufacturers, although they may have modestly contributed to industry consolidation trends. However, these data apply to situations in which the cost increases associated with the new standards proved to be modest in practice, despite early concerns that cost and price increases might be much larger (see the section above on Consumer Economics). If a future standard were in fact to result in a large cost increase, there is currently no empirical evidence to judge the impacts on manufacturers.

Impact on Product Utility

Another concern expressed by manufacturers is that standards could cause them to discontinue useful features that are valued by consumers or to not develop useful new features. These concerns have been expressed prior to the setting of standards, but we have seen no information indicating that such problems resulted once standards took effect. In the one study that directly examined these issues, Greening et al. (1996) analyzed data on refrigerator features before and after the 1990 and 1993 U.S. refrigerator standards took effect. They found that following the standards, "refrigerator features, such as size and amenities, were not diminished". However, this is not to say that such problems could not occur in the future, particularly with very stringent new standards.

Opportunities and Activities for New and Updated Standards

OPPORTUNITIES

In the United States, recent research has found that standards are probably technically feasible and economically justified for many products that are not currently subject to standards. In addition, revisions to many existing standards are also feasible. Table 3 summarises the results of a forthcoming ACEEE analysis estimating the energy, economic, and environmental savings from more than 20 new or updated standards. DOE has also examined many of these same opportunities and concluded that substantial energy can be saved from new or updated standards on most of these products (USDOE 2002b).

Activities

In response to these opportunities, action is now taking place at three levels in the U.S.: (1) DOE is conducting rulemakings to set standards on several products; (2) the U.S. Congress is considering legislation to add new products to the standards program; and (3) several states are setting or considering setting standards on products that are not currently subject to federal standards. Activities in these three jurisdictions are discussed in the sections below.

DOE Rulemakings

DOE is now in the middle of rulemakings to adopt updated standards for two products (residential furnaces/boilers, and commercial packaged air conditioners) and is developing initial standards for distribution transformers (both dry-type and liquid immersed). All three rulemakings are scheduled for completion in late 2004. DOE is also investigating opportunities for setting initial standards on several other products – high-intensity discharge lights, commercial refrigerators and freezers, refrigerated vending machines, res-

Table 3. Energy, economic and environmental savings possible from new and revised U.S. efficiency standards.

Product	National Energy Savings in 2020 (GWh)	(Bill. Btu)	NPV for Purchases Thru 2020 ($million)	Benefit-Cost Ratio	Peak Load Reduction in 2020 (MW)	Carbon Reduction in 2020 (1 000 MT)
Battery chargers	5 235	51 470	1 903	3	707	599
Beverage merchandisers	1 866	18 347	962	10	425	214
Boilers and furnaces	17 069	341 701	12 886	2	3 984	3 496
Ceiling fans (with lights)	19 932	195 954	8 034	3	6 392	2 282
Comm'l clothes washers	322	8 526	803	3	103	84
Comm'l packaged A/C&HP (<5 tons)	906	8 907	306	4	1 395	104
Comm'l packaged A/C&HP (5-20 tons)	11 462	112 684	4 034	4	11 738	1 312
Comm'l packaged A/C (over 20 tons)	1 575	15 486	503	3	1 613	180
Comm'l refrigerators & freezers	1 318	12 960	651	8	300	151
Compact fluorescent lamps	2 808	27 601	1 451	7	899	321
Dishwashers	1 771	29 382	1 317	3	567	309
Dry type transformers	4 562	44 847	2 567	5	616	522
Exit signs	1 933	18 999	1 124	9	261	221
External power supplies	12 544	123 325	6 533	4	1 694	1 436
Ice-makers	870	8 552	431	7	198	100
Liquid immersed transformers	4 861	47 788	2 148	3	897	557
Reflector lamps	21 361	210 004	3 409	2	6 840	2 446
Digital cable and satellite TV boxes	8 347	82 062	5 195	7	1 127	956
Digital TV converter boxes	11 338	111 462	7 056	7	1 531	1 298
Torchiere lamps	21 976	216 050	10 543	4	7 037	2 516
Traffic signals	1 290	12 686	400	2	174	148
Unit heaters (nat. gas)	NA	44 933	2 643	8	NA	398
Vending machines	2 907	28 581	1 379	7	662	333
TOTAL	156 254	1 772 308	76 280	3	49 159	19 982

Source: Forthcoming ACEEE analysis.

idential ceiling fans, residential torchiere lighting fixtures (floor lamps that bounce light off the ceiling), and several categories of currently unregulated incandescent reflector lamps. Research is scheduled to be completed around the end of 2003, and formal rulemakings for promising products could begin in 2004. In addition, DOE is completing revisions to the residential dishwasher test procedure in 2003, laying a foundation for a new standard for this product.

Congressional Action

In 2001 and 2002, the U.S. Congress considered comprehensive energy legislation, including a section addressing new efficiency standards. Legislation passed both houses of Congress and a House-Senate conference committee reached agreement on the standards provision in October 2002, based largely on a bill that passed the Senate in May 2002 (U.S. Senate 2002). However, the bill ultimately died due to controversies on other issues, but the legislation is being considered anew in 2003. As of this writing, a will is now working its way through Committees in both houses of Congress with a standards provision very similar to the House-Senate conference agreement reached in late 2002. Under the pending bill, specific standards will be established for six products – residential ceiling fans, torchiere lighting fixtures, traffic signals, exit signs, compact fluorescent lamps, and commercial unit heaters. These standards will take effect 1 $^1/_2$ - 3 years after the bill is enacted (varying by product). In addition, the bill directs DOE to set standards on five products within three or four years (varying by product), with the standards taking effect three years later. The five products are commercial refrigerators and freezers, refrigerated vending machines, residential ceiling fans, external power supplies and battery chargers for consumer electronics. Chances for passage of the bill are very good; most likely in the summer or fall of 2003.

State Standards

Given the large opportunities available and the fact that Washington has not yet acted, several states are also working on setting new state standards. In November 2002, the California Energy Commission set new or updated standards on 13 products. These are new standards on commercial reach-in refrigerators and freezers, refrigerated vending machines, refrigerated beverage merchandisers, commercial coin-operated clothes washers, torchiere lighting fixtures, exit signs, traffic signals, wine chillers, ground source heat pumps, computer room air conditioners, commercial packaged air conditioners, residential air conditioners, and residential water heaters. The new standards take effect over the 2003-2007 period, depending on the product (CEC 2002). The last two standards on this list are updates of existing state and federal standards, and before they can take effect, California must petition the federal government for exemption from federal preemption based on a compelling state interest, a process that will likely extend through 2003 and 2004.

Other states are also considering new standards, with proposed legislation pending in at least 10 states. Chances for enactment in 2003 are good in several states.

Lessons Learned

Overall, the U.S. standards program shows that standards can save a substantial amount of energy and money, reducing pollutant emissions (particularly carbon), without significant adverse impacts on product utility or manufacturers. Overall, appliance standards have already reduced U.S. energy use by more than 1%, and this figure will rise to about 3.5% by 2020, based only on standards that have already been adopted. For some product categories, standards have driven improvements in energy efficiency of as much as 70%.

A key foundation for standards is having test procedures in place to fairly measure energy use, and collecting test data on a wide array of products in order to determine which standard levels are reasonable. In the U.S., standards have generally been enacted at the state level first and then are adopted by the U.S. Congress based on existing state standards. Standards legislation in the U.S. has generally had the support of both major political parties, provided the key parties (manufacturers and efficiency advocates) can reach consensus first on standards all parties are comfortable with. Typically, in order to reach agreement, provisions are made to preempt state standards on products once the national standards take effect. Another common tool for reaching agreement has been to agree to strong standards, but to give manufacturers multiple years to prepare before standards take effect (typically three years, but in some cases as much as five years).

Due to technological change, most standards can be revised several times. For example, in the U.S. the federal refrigerator standard has been revised twice, and a third revision is likely at some point in the next decade. Rulemakings to decide on new standard levels are based on extensive analysis, but there is often much disagreement on key assumptions, leading to drawn-out rulemaking processes.

In a number of cases, negotiations among the key parties have resulted in consensus proposals, which have dramatically simplified the rulemaking process. However, for negotiations to work, both major parties (manufacturers and efficiency supporters) have to be willing to compromise. Compromise generally occurs when all parties perceive that action will be taken in the absence of a compromise and all parties perceive that a compromise is better than likely action if no compromises are made. In such negotiations, common compromises include delaying the effective date, setting a two tier standard (modest standard at first, stronger standard later), exempting niche products from new standards (either permanently or for an extended period of time), and coming up with creative solutions to tricky issues (solutions that are difficult to develop in an adversarial rulemaking). For example, in recent negotiations on new ballast standards, a key sticking point was whether and how to apply the new standards to the replacement of individual burned-out ballasts. A solution was crafted that allows such replacement sales for an extra five years but ultimately applies the same standard to all new ballasts. Another recent creative solution was an agreement by parties to the new clothes washer standards agreement to also support specific changes to the Energy Star program and to support federal tax credits for products that exceed the new Energy Star levels. However, negotiations do not always succeed – for example recent attempts to start negotiations on new residential air conditioner and water heater standards were unsuccessful.

Finally, other program approaches, such as labelling and promotion programs, incentive programs, and technology procurement can be a useful complement to standards. In a few cases, such as for some types of electronic equipment, labelling and promotion programs can be an alternative to standards. This is the case when efficiency specifications are easy to meet and manufacturers voluntarily switch the vast majority of their production to meet the new specifications. In most cases however, labelling and incentive programs can affect roughly one-quarter of sales, but these voluntary programs help get manufacturers used to producing more efficient products, making adoption of new standards less controversial.

Application to Other Countries

Clearly, standards have worked well in the U.S. But standards appear to also be effective in a number of other countries. For example, Canada and Mexico generally adopt the same standards as the U.S., allowing manufacturers to serve all three countries with the same products. But at times, Canada and Mexico have set standards on products not regulated in the U.S., sometimes laying the groundwork for subsequent U.S. standards (Nadel 1996). Australia has also had a good experience with standards, often adopting the most stringent standards in place among their trading partners (Holt 2001). Japan, South Korea and China have also used standards for many years. In Japan, the current approach is the so-called "top-runner" approach in which standards are set based on the most efficient products on the market (the "top-runners"), but manufacturers are given many years before the standards take effect (from 4-11 years, depending on the product) (Nagata 2001). In Korea, two standards are generally set at the same time, a mandatory standard and a voluntary standard. Several years later, the old voluntary standard becomes mandatory and a new voluntary standard is set. In this way manufacturers have advance warning about future standards and can prepare accordingly (Egan and duPont 1998). In China, in recent years standards on key products have been revised every few years, with modest increases in standard level taking place each time. However, China is also looking into approaches to set more stringent standards (so-called "reach" standards) but giving manufacturers more time before the standards take effect (Li 2003).

Experience in these and other countries has found many of the same lessons as shown by the U.S. experience. For example, the availability of test procedures and data is a critical first step before standards can be set. The availability of such data was essential for setting new standards in China and the lack of such data prevented Thailand from setting standards for many years. Labelling and incentive programs can partly transform a market and lay a foundation for standards. For example, in Thailand, a labelling and incentive program built a substantial market share for efficient refrigerators and air conditioners (ERM Siam 1999), making standards relatively uncontroversial. Reaching consensus with most manufacturers has also proven to be a key ingredient in setting new standards in China and Thailand. However, in some countries such as Brazil and the European Union, reaching consensus has been difficult, in part because manufacturers perceive that there is not a credible threat that standards will be set in the absence of an agreement (Menanteau 2001). Also, in the European Union, individual countries are prevented from setting standards, even when there is no Europe-wide standard. This is a very different situation from the U.S. where state standards are not preempted until national standards take effect, thereby allowing state standards to help drive the national standard-enactment process. If Europe and Brazil want to set standards, either legislators need to show more resolve to convince manufacturers that action will be taken, or states/individual countries should be empowered to set standards in the absence of collective action.

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