National and State-by-State Energy Savings and Pollutant Reductions: Making the Case for Stronger Appliance and Equipment Efficiency Standards

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ABSTRACT

National appliance and equipment efficiency standards have been an important tool in securing energy savings. Standards adopted to date will save an estimated 1.2 quadrillion Btu—including 88 TWh of electricity savings—by 2000 and account for carbon emissions reductions of 29 million metric tons in 2000. Due to delays in the standards setting process, existing standards have not been upgraded to account for developments in appliance and equipment technology.

This paper summarizes the results of a quantitative analysis of the energy savings and pollutant reductions achievable with adoption of stronger efficiency standards. The goal of the analysis is to provide effective information for use in building broad-based support for updated standards. In addition to total national savings, state-by-state savings are provided to inform state governments, utilities, consumers, and other interested parties on state-level impacts. Using emissions factors for each regional power pool, state-by-state benefits in terms of CO_2, NO_x, SO_2, and particulate (PM_{10}) reductions are calculated. Other benefits of standards, such as improved reliability and positive impacts on low-income consumers, manufacturers, and the manufacturing workforce, are also discussed.

Introduction

Appliance and equipment efficiency standards have proven to be one of the most successful strategies for improving energy efficiency in the United States. Federal standards already in effect will save an estimated 1.2 quadrillion British thermal units (Btus) or "quads" in 2000—equivalent to the annual energy use of about 6.5 million American households (Nadel and Pye 1996). By 2015, annual savings from already existing standards are projected to grow to 3.1 quads, the annual consumption of more than 16 million households (Geller and Goldstein 1998). These savings benefit consumers by lowering utility bills, improving air quality, and reducing emissions of carbon dioxide, a leading contributor to global warming. Current efficiency standards will cut U.S. carbon emissions by 29 million metric tons (MMT) in 2000—equivalent to removing more than 23 million cars from our roads (EPA 1993; Geller and Goldstein 1998). Standards also contribute to reductions in sulfur dioxide, nitrogen oxides, and particulates, thereby helping to alleviate widespread public health problems, including asthma and other respiratory diseases, and environmental degradation from smog, acid rain, and haze.

The National Appliance Energy Conservation Act (NAECA) instructs the U.S. Department of Energy (DOE) to periodically review existing standards and to upgrade standards where "technically feasible and economically justified." Despite this requirement, the standards setting process has fallen terribly behind schedule. Since 1992 only two new standards rulemakings have been completed: refrigerators and freezers, to take effect in July 2001; and room air conditioners, to take effect in October 2000.[1] Recent developments in appliance technology have led to a new generation of products for which updated standards are appropriate.

In this paper, we demonstrate how much more can be achieved by further updating efficiency standards and illustrate how updated standards benefit the public in many ways at both the state and national level. Our analysis estimates the energy savings, utility bill savings, peak electricity reductions, water savings and pollutant emission reductions possible with adoption of new standards. We provide estimates for the United States as a whole and on a state-by-state basis. In addition, we discuss the positive impacts standards have on electric system reliability, low-income consumers, manufacturers, and workers.

Table 1 provides information on existing standards and proposed levels for updated standards and the dates these standards would go into effect. The proposed standard levels are our estimates of sensible improvements that meet the legislated criteria, based on DOE and national lab analyses for each product. The proposed effective dates assume that DOE makes progress based on its current schedule for ongoing standards rulemakings. We limit the analysis to products that DOE has designated as "high priority" in its appliance standards review process. Additional savings could be achieved by revising standards on other products such as dishwashers, residential furnaces and boilers, and freezers (Geller and Goldstein 1998).

Methodology

We conducted our analysis in two stages. First, we calculated the national impact of proposed new standards and then allocated the national totals on a state-by-state basis to determine impacts for each state.[2] We calculated both national and state impacts for the years 2010 and 2020. Each stage of the analysis involved multiple steps as described below.

We obtained national energy savings from proposed new standards by multiplying annual sales figures for each appliance by per-unit energy savings. We calculated electricity and natural gas savings separately, adjusted for electric generation losses, and then summed to obtain total primary energy savings. To calculate peak generation savings, we multiplied electric generation savings by a peak factor (kilowatt per kilowatt-hour [kW/kWh]). The peak factor for each appliance is the average coincident power demand of the appliance during peak periods divided by the annual energy consumption of the appliance. We determined the financial savings by multiplying forecasted electricity and natural gas rates by the energy savings, while we calculated financial costs by multiplying the per-unit incremental cost for each product by the number of units sold. We derived emission reductions by multiplying emission factors (in pounds/kWh) to the total primary energy savings. For cumulative costs and savings, we discounted to1999 using a 6 percent real discount rate. Cumulative costs and savings are from the effective date of the standard to 2010 and 2020. The net present value of savings also includes savings after 2020 for equipment sold prior to 2020.

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[1] In October 1998, DOE completed a rule for electric ovens and ranges, leaving the previous standard unchanged.

[2] Data for our calculations came from many sources. For a detailed discussion of sources and methodology, see Thorne, Kubo, and Nadel (2000).

Table 1: Proposed New Standards for Targeted Appliances

Appliance	Old Standard	New Standard	Avg. Percent Improvement	Effective Date	Notes
Clothes washers	0.82 MEF	1.36 MEF	40%	2006	Assumes 5-year phase-in; includes dryer savings. New efficiency level can be achieved by most horizontal-axis machines as well as highly advanced vertical-axis units.
Fluorescent lamp ballasts	Energy Efficient Magnetic	Electronic	15%	2006	Analysis does not take credit for current electronic ballast sales. Effective date is weighted average.
Central A/C & heat pumps	10 SEER 6.8 HSPF	13 SEER 8.0 HSPF	23% 15%	2006	SEER 13 units typically feature improved compressors and heat exchangers relative to conventional models.
Water heaters	0.86 EF (elec.) 0.54 EF (gas)	0.91 EF (elec.) 0.61 EF (gas)	5% 11%	2004	These efficiencies can be achieved by high-efficiency models with conventional technologies.
Transformers (dry-type)	81 kWh/yr losses	65 kWh/yr losses	20%	2005	NEMA TP-1 assumed as new standard. This standard based on a 3-year simple payback.
Transformers (liquid-type)	29 kWh/yr losses	24 kWh/yr losses	17%	2007	Old standard based on typical equipment being sold; no old standard in effect. New standard based on average losses of the 3 products with lowest life cycle costs.
Commercial packaged A/C & heat pumps (1st phase) (2nd phase)	8.9 EER 10.3 EER	10.3 EER 11.0 EER	14% 6%	2002 2007	Assumes compromise on a 2-phase standard. First tier from ASHRAE 90.1-1999. Second tier from Consortium for Energy Efficiency.
Commercial furnaces & boilers	0.78 CE	0.82 CE	5%	2005	Based on minimum life cycle cost point in analysis for DOE.

Notes: MEF = modified energy factor; SEER = seasonal energy efficiency ratio; HSPF = heating season performance factor; EF = energy factor; EER = energy efficiency ratio; CE = combustion efficiency.

To calculate state-by-state impacts, we prorated the national numbers using a number of allocation factors. For residential products, we allocated impacts according to each state's portion of national households. For commercial products, we used each state's portion of sectoral energy consumption. We then adjusted these figures to reflect the saturation and usage rate of each appliance by census region and division (climate zone was used where appropriate for Alaska and Hawaii). We adjusted financial savings based on utility rates in each state. We also adjusted emission reductions to account for the differences in fuel generation mix used by different regions.

Findings

DOE is required to upgrade appliance efficiency standards when product innovations make efficiency improvements affordable to manufacturers and consumers. Standards for each product are scheduled for review every 5 years. These reviews generally lead to an upgrade unless a change is not warranted due to economic or technical considerations. However, due to delays in the standards-setting process, many cost-effective product improvements have not been incorporated into the standards.

Our analysis demonstrates the cost-effectiveness of new standards: for each dollar of increased purchase price, consumers save more than two dollars on their utility bills. Table 2 summarizes the costs and benefits associated with the proposed new standards. Overall, the benefit cost ratio of these standards would be 2.33:1. Cumulative net savings from updated standards—utility bill savings less increased costs—will approach $19 billion in 2010 and grow to more than $41 billion in 2020.

Table 2: Cost-Effectiveness of Proposed Standards

Products	Cost (million $)	Benefit (million $)	Benefit-Cost Ratio	Net Savings (million $)
Clothes washers	5,430	26,015	4.79	20,585
Fluorescent lamp ballasts	1,598	4,317	2.70	2,719
Central A/C & heat pumps	16,656	21,034	1.26	4,378
Water heaters	2,604	8,729	3.35	6,125
Transformers	1,333	2,856	2.14	1,522
Commercial packaged A/C & heat pumps	1,406	5,802	4.13	4,397
Commercial furnaces & boilers	2,319	4,212	1.82	1,894
TOTAL	31,347	72,965	2.33	41,619

Notes:

1. Costs are cumulative for units sold from the effective date of each standard through 2020 (based on standards listed in Table 1). Benefits are cumulative for the lifetime of units sold through 2020.

2. Dollar figures expressed as net present value assuming 6 percent real discount rate. Costs and savings discounted to 1999 and expressed in terms of 1997$.

Energy Savings

Primary energy savings. Overall, new efficiency standards (as outlined in Table 1) would produce estimated primary energy savings of 0.7 quads in 2010 and 1.8 quads in 2020, approximately 1.8 percent and 4.6 percent of projected U.S. residential and commercial energy use in 2010 and 2020, respectively (EIA 1999b). To put these numbers in perspective, one quad is equivalent to the annual energy usage of more than five million American households. Figure 1 summarizes the annual primary energy savings for each product included in our analysis. Total savings include electricity reductions of more than 50 billion kWh in 2010, increasing to 142 billion kWh in 2020. This electricity would provide enough power to light 40 million homes in 2010 and more than 113 million homes in 2020. Natural gas savings amount to 171 billion cubic feet in 2010 and 373 billion cubic feet in 2020—enough gas to heat 2.6 million homes in 2010 and 5.7 million homes in 2020.

In general, new standards will produce the greatest savings in the most populous states. Energy savings in 2010 are projected to be greatest in Texas (71.3 trillion Btus), Florida (59.2 trillion Btus), California (46.9 Btus), Illinois (28.6 trillion Btus), and Ohio (27.1 trillion Btus). Ten trillion Btus equals the annual consumption of approximately 50,000 households. Projected

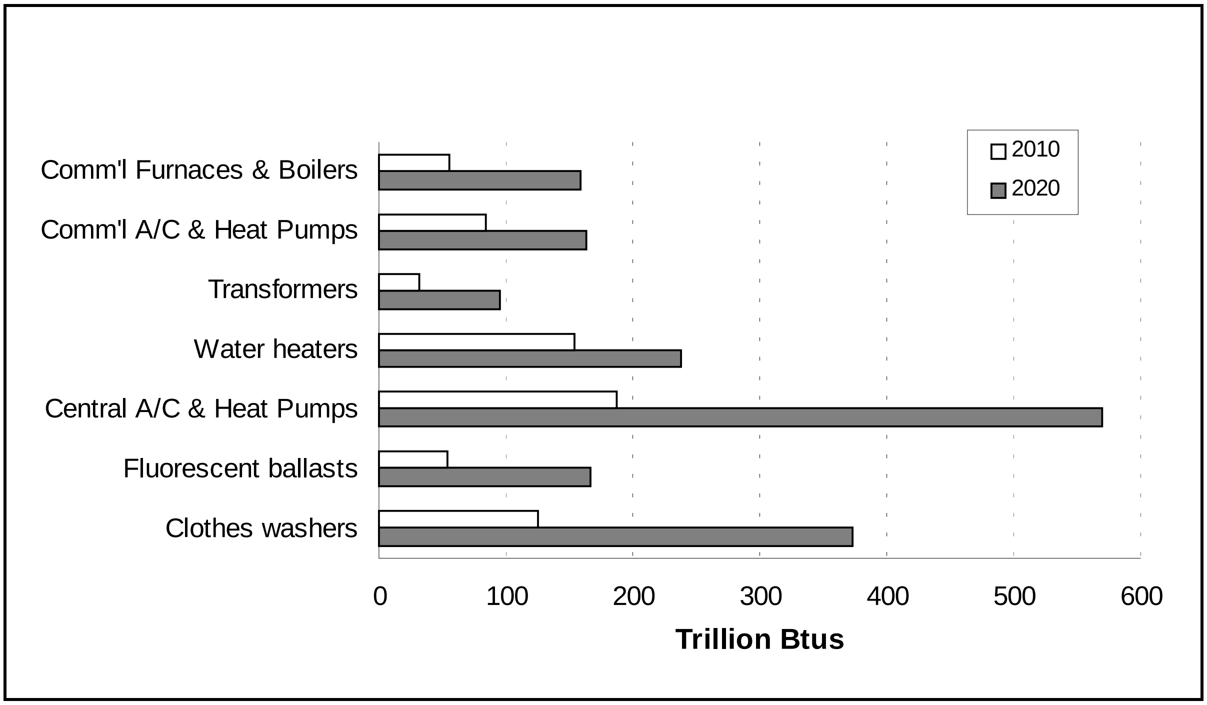

Figure 1. National Primary Energy Savings from Updated Standards

savings in New York and Pennsylvania, the third and fifth most populous states, are large (25.7 trillion Btu and 19.5 trillion Btu, respectively), but do not rank in the top five because of the products targeted in this analysis. For example, central air conditioners and heat pumps will generate the greatest energy savings of any product included and these products are less prevalent in New York and Pennsylvania due to their cooler climate and greater reliance on gas and oil heating. While total energy savings are greatest in Texas, Florida will realize the greatest electricity savings (5,600 gigawatt-hours [GWh] in 2010) due to its hot climate (and, therefore, high electric cooling load) and the limited use of natural gas. Gas savings will be greatest in California (21.5 trillion Btus in 2010) due to the large population and the predominance of gas water heating and space heating. Table 3 summarizes energy savings by state in 2010 and 2020.

Peak reductions. New standards would eliminate the need for almost 32,000 megawatts (MW) of summer peak generating capacity in 2010, growing to more than 91,000 MW of peak capacity in 2020. Figure 2 summarizes the peak reduction estimates for each product in our analysis. Air conditioners offer the greatest opportunity to cut peak electricity demand because they are used most intensively during peak demand periods. Fluorescent ballasts are another important source of peak savings—fluorescent lighting is used throughout the day in offices and other commercial buildings, thereby contributing to peak electricity demands.

At the state level, reductions in peak generation in 2010 are greatest in Texas (3.6 gigawatts [GW]), Florida (3.3 GW), California (1.8 GW), Illinois (1.4 GW), and Ohio (1.3 GW)—states with large peak electric loads due to climate and population. Peak reductions in these states will grow substantially by 2020 as follows: 11.0 GW in Texas, 10.2 GW in Florida, 5.6 GW in California, 3.8 GW in Illinois, and 3.6 GW in Ohio. Table 3 provides a state-by-state breakdown of peak reductions in 2010 and 2020.

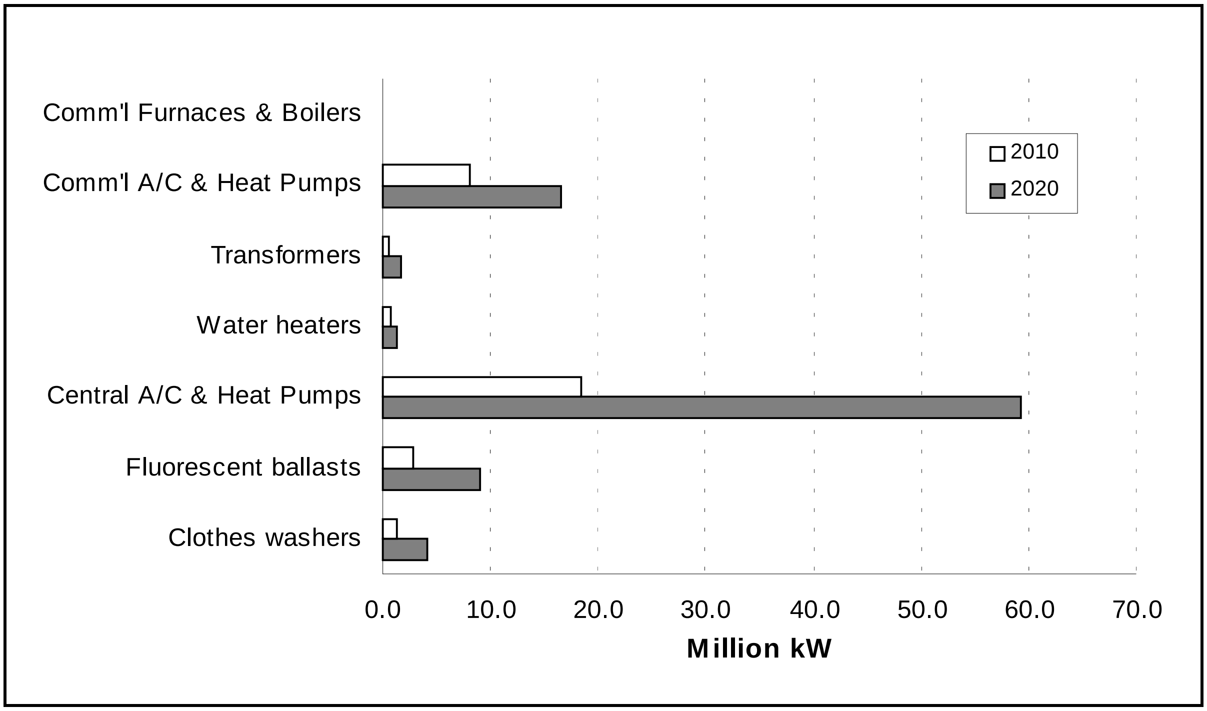

Figure 2. National Summer Peak Demand Reductions from Updated Standards
Note: Commercial furnaces and boilers are gas- or oil-fired and, thus, generate no peak savings.

By reducing peak demand, standards—in particular those on air conditioning equipment that can account for more than half of household energy consumption in the summer months—can help to offset the need for additional peak generating capacity. The new standards proposed here would eliminate the need for at least 64 large (i.e., 500 MW) power plants in 2010 and more than 180 large plants in 2020 (or their equivalent). Cutting peak demand also improves the reliability of the generating system, decreasing the likelihood of blackouts and power shortages, which have become a growing problem in many parts of the country. Recent summer power outages in Chicago, for example, disrupted business operations and contributed to heat-related deaths and associated health problems spurring regulatory investigations and lawsuits filed by elected officials. Reducing energy use and peak electricity demand through efficiency standards is a less expensive strategy than building additional power plants to serve growing energy needs.

Water Savings

The energy savings from a new clothes washer standard result largely from the substantial reduction in water required by more efficient clothes washer designs. Less water in the wash cycle translates to lower water heater energy demands. Front-loading washers (also referred to as horizontal-axis or h-axis washers) and some advanced top-loading designs use 40 percent less water than the traditional top-loading (or vertical-axis) machines. Clothes washers are responsible for over 20 percent of average household indoor water use, therefore the new standard could eliminate close to 10 percent of household indoor water demand (Osann and Young 1998).

Savings of this magnitude are particularly important in parts of the country that are facing droughts or chronic water shortages or seeking ways to reduce water use as a means of meeting other environmental goals. In the Pacific Northwest, for example, water conservation plays a vital role in the protection of salmon habitat and in the continued viability of hydroelectric power services, which makes up 85 percent of regional electricity generation (EIA 1999a). Faced with a growing population and limited supplies, Denver's water service area hopes to meet increased water demand with conservation. A new washer standard would help the Denver area meet nearly 30 percent of its goal (Denver Board of Water 1997).

Even in places without water shortages, water conservation is important. Saving water helps avoid or delay the construction of new or expanded drinking water and wastewater treatment facilities. According to the American Water Works Association, the nation faces about $325 billion in drinking water infrastructure investments to meet increased demand and requirements to improve drinking water quality (AWWA 1999). More demanding requirements to improve wastewater treatment will require additional investments. Table 3 summarizes water savings in each state from an updated clothes washer standard.

Consumer Utility Bill Savings

As a result of the efficiency gains from stronger appliance standards, consumer utility bills—including energy, water, and sewer bills—would be reduced by $5.3 billion in 2010 and $14.6 billion in 2020. Energy bill savings amount to $4.4 billion or approximately 1.7 percent of projected residential and commercial energy expenditures in 2010 and $11 billion or 4.1 percent of expenditures in 2020 (EIA 1999b). Although water savings are associated with only one product in our analysis, the dollar savings are impressive: water and sewer bill savings from an updated clothes washer standard total $825 million in 2010 and almost $3.6 billion in 2020. Consumer water and sewer savings from new clothes washer standards alone account for 16 percent of total utility bill savings in 2010 and 25 percent in 2020. These numbers reflect the upward trend in water and sewer costs, which are expected to increase at a rate of 3 percent per year (DOE 1999). Energy bill savings may be even greater as time-of-use rates become more common, because these standards will disproportionately cut costly peak demand. Figure 3 shows consumer utility bill savings for each product included in our analysis.

At the state level, the dollar savings from appliance standards depend on overall energy, water, and sewer savings as well as utility prices in the state. Projected utility bill savings in 2010 are largest in California ($465 million), Florida ($463 million), Texas ($442 million), New York ($279 million), and Illinois ($231 million). Average electricity prices in these states vary from a high of 11.1¢/kWh in New York to a low of 6.2¢/kWh in Texas, while average gas prices range from $5.50 per thousand cubic feet (55.0¢/therm) in New York to $2.24 per thousand cubic feet (22.4¢/therm) in Texas. Water and sewer savings, calculated using national average water and sewer costs, account for approximately 16 percent of total utility bill savings in 2010.

Cumulative net savings are largest in the most populous states. By 2010, consumer savings are projected to be greatest in California ($1.9 billion), Florida ($1.4 billion), New York ($1.3 billion), Texas ($1.1 billion), and Illinois ($930 million). Net savings will more than double by 2020 as the oldest appliances are replaced with new units that meet the upgraded standards. Projected savings by 2020 will be: California ($4.3 billion), Florida ($3.2 billion),

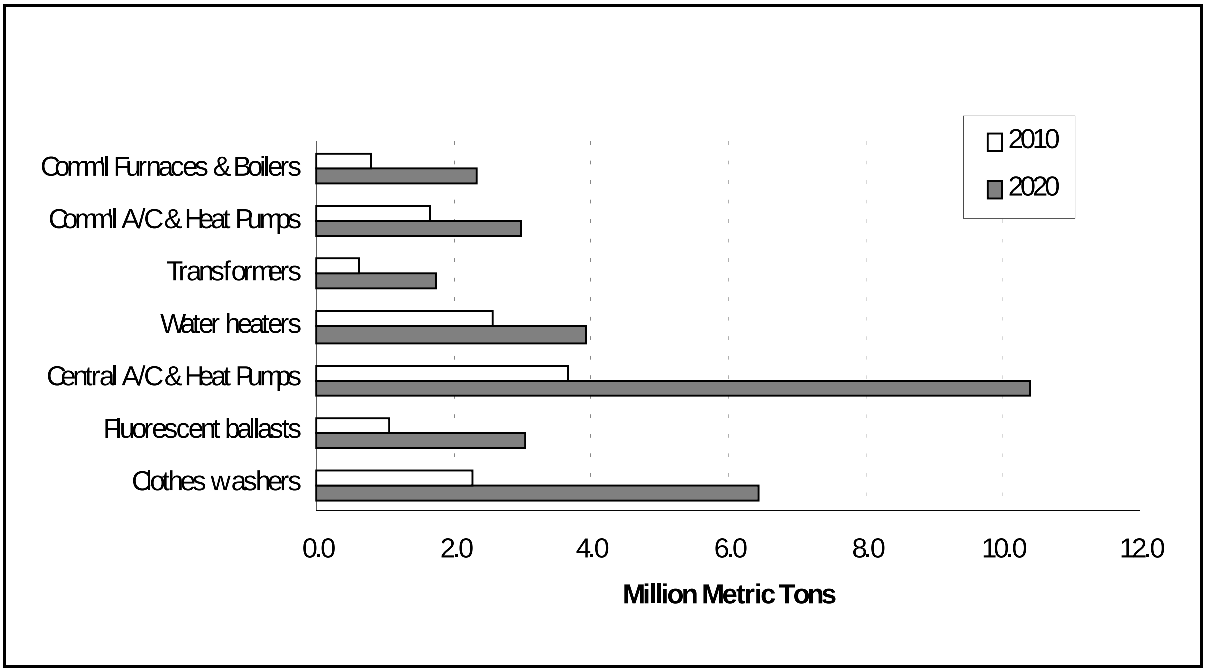

Figure 3. National Carbon Emissions Reductions from Updated Standards

New York ($2.7 billion), Texas ($2.4 billion), and Illinois ($2.0 billion). Table 4 summarizes state utility bill savings and net cumulative savings in 2010 and 2020.

Pollutant Reductions

Along with the energy and utility bill savings from new standards, reduced electricity generation will yield significant reductions in air pollutant emissions and, therefore, public health and environmental benefits. While this analysis does not attempt to quantify health and environmental benefits, reductions in carbon, sulfur dioxide, nitrogen oxides, and particulate matter (PM_{10}) in 2010 and 2020 are estimated.

Carbon emissions. Electricity generation is responsible for one-third of all U.S. emissions of carbon dioxide, the primary greenhouse gas. By cutting electricity demand and, therefore carbon emissions, appliance standards can play an important part in U.S. efforts to meet the carbon emissions reduction targets set out in the Kyoto Protocol, an international agreement reached in December 1997. The agreement sets greenhouse gas emissions reduction targets for industrialized nations. Under the Protocol, which the Congress has yet to ratify, the United States needs to cut its carbon emissions by almost 530 MMT during the budget period of 2008 to 2012 (7 percent below 1990 emissions) (EIA 1999b; Geller, Bernow, and Dougherty 1999). Current standards will reduce carbon emissions by 65 MMT in 2010 and upgraded standards could raise the reduction by almost 13 MMT (Geller, Bernow, and Dougherty 1999). In other words, carbon emissions from efficiency standards are equal to 15 percent of the U.S. carbon emissions reduction target for 2010. In 2020, standards will be a much bigger contributor to carbon reductions as savings from upgraded standards could approach 31 MMT. Figure 4 provides carbon reduction estimates.

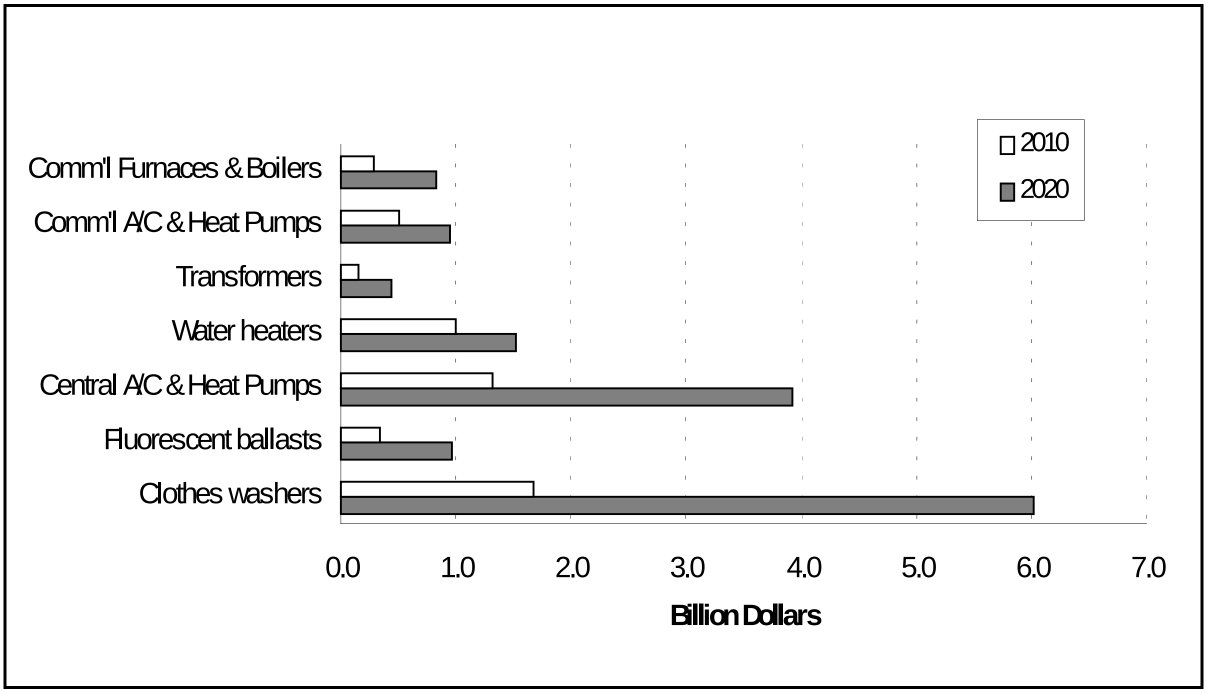

Figure 4. National Utility Bill Savings from Updated Standards

In general, carbon emissions are closely related to overall energy consumption—states with the largest energy use have the highest carbon emissions and will experience the greatest carbon reductions as a result of upgraded appliance standards. Carbon emissions reductions in 2010 will be greatest in Texas (1,273 MMT), Florida (1,119 MMT), California (951 MMT), Illinois (531 MMT), and New York (485 MMT). Table 5 provides state-by-state carbon emissions reductions.

Nitrogen oxides, sulfur dioxides, and particulate matter. Electric power generation is a leading source of air pollutants that pose threats to human health and the environment. Power plants are the largest source of sulfur dioxide (64 percent of total sulfur dioxide emissions) and mercury (33 percent) emissions, the second largest source of smog-forming nitrogen oxides (26 percent), and the fifth largest source of particulates (9 percent) (EPA 1998). Direct combustion of natural gas and fuel oil in homes and commercial buildings contributes an additional 4 percent of nitrogen oxide and 3 percent of sulfur dioxide emissions (EPA 1998).

Emissions of nitrogen oxides, sulfur dioxide, and particulates are closely related to the fuel mix used to generate electricity. Coal- and oil-burning power plants produce a disproportionate share of carbon, mercury, and particulate emissions. Coal-fired plants are responsible for more than 90 percent of nitrogen oxides and 95 percent of sulfur dioxide from electricity generation (EIA 1999b). As a result, pollutant reductions from upgraded appliance standards will be largest in states that rely more on coal and oil and less on cleaner burning natural gas. Table 5 provides a detailed breakdown of state pollutant emissions reductions.

While updated standards alone cannot cure the nation's air pollution problems, they can be an important part of the solution. Updated standards will reduce nitrogen oxide emissions by 40,000 metric tons (MT) in 2010 and almost 89,000 MT in 2020. Sulfur dioxide emissions will be cut by 154,000 MT in 2010 and more than 348,000 MT in 2020.[3] Particulate emissions will be reduced by over 2,000 MT in 2010, increasing to more than 5,000 MT in 2020. Thus, updated standards can help to alleviate environmental problems (e.g., crop losses related to smog damage, acid rain, and reduced visibility from haze) and illnesses (e.g., asthma and other respiratory and cardiopulmonary diseases) related to air pollution.

Air pollution reduction is an important issue at the state level, where many environmental laws are implemented. In addition to the broad environmental and public health concerns associated with carbon and other pollutant emissions, air quality figures into a number of political and economic issues facing the states. For example, Northeastern states have been engaged in long-standing disputes with many Midwestern states over cross-boundary transport of pollutants from coal-burning power plants in the Midwest. The Northeastern states argue that these emissions contribute to smog and acid rain throughout their region. Emissions reductions from new standards could also improve state compliance with federal Clean Air Act regulations.

The U.S. Environmental Protection Agency recently set a goal for 22 Eastern and Midwestern states to collectively cut smog-forming nitrogen oxide emissions by 25 percent.[4] While most states will need to rely on pollution control technologies and switching from coal to less polluting energy sources to meet their nitrogen oxide reduction targets, improved appliance efficiency may help avoid the need for some more expensive or intrusive steps. For most states required to reduce sulfur dioxide emissions to help fight acid rain, appliance standards would reduce emissions by about 3 to 10 percent of their allowable emissions. Because EPA regulates sulfur dioxide by a cap and trade system, the reductions may be simply traded away by utility companies, allowing others to increase their sulfur dioxide pollution. While efficiency may not lead to any net reductions in the short term, it does reduce the cost of compliance with current caps and makes tighter caps possible in the future.

Other Benefits

Direct energy savings and pollutant reductions are not the only benefits from upgraded appliance efficiency standards. Demonstration and discussion of the additional benefits that standards provide can help build a broader base of support for standards. For example, appliance standards act to distribute the benefits of technology advances to all users. While new technologies, including those that improve appliance efficiency, are usually introduced into high-end products first, standards force manufacturers to incorporate technical advances throughout their product lines. Saving energy is particularly important for low-income households that suffer from a high energy burden. Energy expenditures represent between 12% and 26% of total low-income household spending, while only 4% of median-income household spending (Pye 1996). For the 60% of low-income households that rent, standards address the split-incentive inherent when the property owner purchases appliances and the renter pays the utility bills.

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[3] Standards will cut power plant operations and direct emissions, but the overall level of sulfur dioxide emissions nationwide may not drop since they fall under the cap and trade system established by the Clean Air Amendments of 1990.

[4] As of the drafting of this paper, the nitrogen oxide reduction rule has been delayed by legal action.

Updated appliance standards can also reduce the likelihood of future blackouts and power outages by cutting electricity consumption overall, and peak demand in particular. DOE recently accelerated the schedule for new standards for central air conditioners and heat pumps in response to the growing incidence of power shortages. In announcing the proposed new standard, Energy Secretary Bill Richardson stated, “By increasing the efficiency of central air conditioning, we will help minimize the impact of future heat waves on the power grid and help consumers and business save money and energy” (Hamilton 1999). Power system planners are calling for extensive construction of new capacity in the next few years as a way to avoid future shortages. Significant price increases could be required to pay for added generating capacity, which is needed only during brief intervals of high peak demand. Updated standards can reduce these peak demands much more cost-effectively than new capacity construction.

Finally, appliance standards benefit U.S. manufacturers and workers by increasing demand for energy-saving products and lowering consumer utility bills. The growing demand for leading edge, energy-efficient technologies leads business to add jobs for highly skilled American workers. Lower utility bills free up household funds, increasing disposable income to be spent on other goods and services. Money spent on alternate goods—including food, housing, and entertainment—supports jobs in other sectors of the economy, which are more labor-intensive than electricity generation and transmission. Upgraded standards will save consumers more than $40 billion over the next 20 years, leading to thousands of new jobs as these dollars are spent. In fact, DOE predicts that standards on clothes washers, water heaters, and fluorescent ballasts alone will generate more than 120,000 new jobs by 2020.

Conclusion

Appliance efficiency standards have been enormously successful in reducing energy consumption and cutting air pollution. Updated standards hold the promise of much greater savings as the latest product innovations become the norm with adoption of new standards. By upgrading the existing standards, DOE will save consumers money and enhance environmental protection. Furthermore, improved standards will reduce the burden on overtaxed electric systems, create additional manufacturing jobs, and help alleviate the public health problems associated with air pollution. The benefits of upgraded appliance standards will be realized throughout the economy and in every region of the country.

Table 3: State-by-State Annual Energy and Water Savings

State	Total Primary Energy Savings (Trillion Btus)		Summer Peak Generation Savings (MW)		Water (Million gallons)	
	2010	2020	2010	2020	2010	2020
Alabama	15.9	42.3	726	2,147	3,808	12,271
Alaska	3.9	10.4	46	116	426	1,374
Arizona	11.0	26.4	576	1,518	3,362	10,832
Arkansas	8.5	22.8	443	1,374	2,230	7,186
California	46.9	111.1	1,847	5,594	22,122	71,280
Colorado	9.8	23.8	508	1,380	2,993	9,644
Connecticut	5.0	11.7	144	350	2,679	8,631
Delaware	2.5	6.7	108	322	647	2,085
Dist.ofColumbia	2.8	7.6	143	407	542	1,745
Florida	59.2	164.5	3,325	10,151	13,244	42,675
Georgia	24.4	66.1	1,067	3,188	6,385	20,575
Hawaii	1.9	4.8	131	415	775	2,498
Idaho	3.3	7.9	174	460	857	2,761
Illinois	28.6	67.0	1,438	3,778	9,831	31,679
Indiana	14.3	33.9	660	1,774	4,990	16,079
Iowa	8.0	19.8	430	1,201	2,492	8,029
Kansas	8.4	20.7	454	1,221	2,218	7,148
Kentucky	14.2	37.9	658	1,949	3,466	11,168
Louisiana	17.5	47.5	779	2,397	3,686	11,878
Maine	1.9	4.5	46	113	1,051	3,387
Maryland	17.0	45.8	756	2,250	4,387	14,137
Massachusetts	9.6	22.6	264	643	5,053	16,281
Michigan	23.0	54.2	1,104	2,941	8,078	26,030
Minnesota	11.5	28.5	627	1,792	3,983	12,833
Mississippi	9.6	25.4	442	1,303	2,296	7,397
Missouri	15.0	36.1	925	2,499	4,636	14,937
Montana	2.3	5.6	116	316	680	2,190
Nebraska	5.1	12.5	296	794	1,425	4,593
Nevada	4.0	9.8	194	519	1,234	3,975
NewHampshire	1.6	3.9	44	109	955	3,078
NewJersey	13.6	32.4	491	1,349	6,286	20,256
NewMexico	4.4	10.8	200	533	1,234	3,975
NewYork	25.7	59.7	831	2,197	14,660	47,237
NorthCarolina	25.1	68.0	1,106	3,304	6,556	21,126
NorthDakota	2.1	5.1	109	297	558	1,798
Ohio	27.1	63.8	1,339	3,558	9,623	31,009
Oklahoma	11.9	31.9	618	1,904	2,966	9,558
Oregon	7.5	19.0	223	641	2,489	8,020
Pennsylvania	19.5	46.3	692	1,935	9,997	32,211
RhodeIsland	1.5	3.5	37	92	823	2,650
SouthCarolina	12.4	33.6	538	1,610	3,227	10,397
SouthDakota	1.9	4.7	112	309	617	1,987
Tennessee	20.2	53.5	962	2,820	4,786	15,421
Texas	71.3	192.8	3,584	11,047	16,166	52,090
Utah	4.5	11.0	211	559	1,273	4,103
Vermont	0.9	2.0	23	57	494	1,592
Virginia	23.1	62.4	1,034	3,070	5,888	18,973
Washington	12.8	32.5	384	1,106	4,262	13,735
WestVirginia	6.2	16.8	259	781	1,674	5,395
Wisconsin	12.0	28.3	575	1,547	4,389	14,143
Wyoming	1.7	4.3	73	194	367	1,181
U.S.TOTAL	691.7	1,763.9	31,875	91,932	218,840	705,150

Table 4: State-by-State Consumer Dollar Savings

State	Annual Utility Bill (million$)		Cumulative Net Savings (million$)	
	2010	2020	2010	2020
Alabama	103	296	318	706
Alaska	22	59	73	150
Arizona	92	241	370	786
Arkansas	59	172	157	365
California	465	1,258	1,948	4,344
Colorado	69	186	246	536
Connecticut	56	142	276	567
Delaware	19	55	66	148
Dist. of Columbia	22	61	85	180
Florida	463	1,348	1,433	3,238
Georgia	187	537	635	1,415
Hawaii	31	77	136	292
Idaho	18	49	53	117
Illinois	231	606	930	1,994
Indiana	97	261	335	748
Iowa	56	151	191	420
Kansas	55	149	196	420
Kentucky	75	219	168	389
Louisiana	98	288	208	491
Maine	19	51	92	192
Maryland	136	390	487	1,078
Massachusetts	101	259	492	1,014
Michigan	178	471	686	1,492
Minnesota	77	215	249	562
Mississippi	64	184	205	455
Missouri	108	286	395	847
Montana	15	40	48	106
Nebraska	32	87	108	234
Nevada	29	77	102	222
New Hampshire	19	50	97	199
New Jersey	141	367	650	1,366
New Mexico	31	83	112	241
New York	279	707	1,314	2,731
North Carolina	191	549	646	1,440
North Dakota	13	36	45	97
Ohio	207	546	784	1,709
Oklahoma	74	216	172	401
Oregon	46	133	172	392
Pennsylvania	181	478	772	1,669
Rhode Island	16	40	75	156
South Carolina	83	243	249	564
South Dakota	14	37	49	107
Tennessee	126	361	377	835
Texas	442	1,292	1,059	2,464
Utah	27	75	89	195
Vermont	9	22	41	86
Virginia	168	484	555	1,236
Washington	72	212	255	594
West Virginia	41	119	115	264
Wisconsin	85	227	298	666
Wyoming	9	25	26	56
U.S. TOTAL	5,267	14,645	18,859	41,619

Table 5: State-by-State Pollutant Reductions

State	Carbon (Thousand Tons)		NOx (Tons)		PM_{10} (Tons)		SO_2 (Tons)	
	2010	2020	2010	2020	2010	2020	2010	2020
Alabama	278	690	828	2,169	26	89	5,279	12,653
Alaska	33	99	164	481	13	40	113	292
Arizona	164	361	434	91	2	14	1,097	2,409
Arkansas	148	373	395	330	12	45	1,522	3,858
California	951	2,408	1,110	1,738	121	465	2,026	4,544
Colorado	144	321	370	79	1	13	903	1,992
Connecticut	102	231	323	936	19	46	350	1,036
Delaware	52	128	185	557	12	24	540	1,385
Dist. of Columbia	59	144	214	633	13	27	634	1,603
Florida	1,119	2,535	5,245	3,264	261	349	12,338	33,542
Georgia	434	1,090	1,314	3,485	40	138	8,562	20,847
Hawaii	40	111	42	120	6	14	92	278
Idaho	57	139	201	192	9	30	246	450
Illinois	531	1,228	1,016	3,567	84	256	6,680	13,680
Indiana	240	557	1,208	3,040	36	105	4,024	7,581
Iowa	164	406	712	562	42	112	1,489	3,147
Kansas	140	326	349	265	12	42	1,228	2,723
Kentucky	263	663	1,433	3,895	35	110	6,314	12,895
Louisiana	294	756	737	624	24	96	2,681	6,778
Maine	37	87	115	341	7	18	119	357
Maryland	355	873	1,277	3,826	79	166	3,744	9,576
Massachusetts	193	442	605	1,762	37	89	645	1,912
Michigan	388	894	1,972	4,916	59	167	6,661	12,419
Minnesota	238	588	1,040	824	60	162	2,167	4,635
Mississippi	168	416	501	1,309	16	54	3,196	7,652
Missouri	256	581	673	503	20	72	2,498	5,553
Montana	40	98	139	134	7	21	165	306
Nebraska	107	259	472	365	27	70	1,032	2,134
Nevada	70	171	248	239	11	37	299	554
New Hampshire	33	76	105	306	6	15	113	336
New Jersey	264	589	907	2,476	65	123	2,189	5,099
New Mexico	64	145	161	34	1	6	384	846
New York	485	720	1,541	4,684	336	231	3,009	9,993
North Carolina	447	1,123	1,357	3,597	41	142	8,858	21,564
North Dakota	42	104	180	141	11	29	380	791
Ohio	461	1,058	2,369	5,894	69	196	8,140	15,218
Oklahoma	206	521	549	458	16	63	2,117	5,346
Oregon	138	343	509	495	21	69	714	1,328
Pennsylvania	378	842	1,302	3,573	93	176	3,094	7,294
Rhode Island	29	68	91	267	6	14	95	284
South Carolina	220	554	666	1,771	20	70	4,340	10,586
South Dakota	40	98	179	139	10	26	388	813
Tennessee	356	878	1,069	2,785	33	112	6,883	16,442
Texas	1,273	3,269	2,425	5,358	101	399	8,433	22,323
Utah	77	190	270	260	13	42	321	591
Vermont	17	39	55	159	3	8	59	175
Virginia	411	1,031	1,249	3,304	38	130	8,162	19,832
Washington	236	588	876	851	36	119	1,231	2,291
West Virginia	115	295	630	1,741	15	49	2,801	5,819
Wisconsin	221	516	420	1,489	35	109	2,678	5,560
Wyoming	24	56	57	13	0	2	131	289
U.S. TOTAL	12,668	30,923	40,326	88,602	2,198	5,136	153,781	348,859

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