The Efficiency Boom: Cashing In on the Savings from Appliance Standards

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About the Appliance Standards Awareness Project

The Appliance Standards Awareness Project (ASAP) is dedicated to increasing awareness of and support for appliance and equipment efficiency standards. Founded in 1999 by the American Council for an Energy-Efficient Economy (ACEEE), the Alliance to Save Energy, the Energy Foundation, and the Natural Resources Defense Council, ASAP is led by a steering committee that includes representatives from the environmental community, consumer groups, utilities, and state government.

ASAP's Steering Committee

Tim Ballo *Earthjustice*	Charlie Harak *National Consumer Law Center*
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About ACEEE

ACEEE is a nonprofit organization that acts as a catalyst to advance energy efficiency policies, programs, technologies, investments, and behaviors. For more information, see http://aceee.org. ACEEE fulfills its mission by:

- Conducting in-depth technical and policy assessments
- Advising policymakers and program managers
- Working collaboratively with businesses, public interest groups, and other organizations
- Organizing conferences and workshops
- Publishing books, conference proceedings, and reports
- Educating consumers and businesses

Projects are carried out by staff and selected energy efficiency experts from universities, national laboratories, and the private sector. Collaboration is key to ACEEE's success. We collaborate on projects and initiatives with dozens of organizations including federal and state agencies, utilities, research institutions, businesses, and public interest groups.

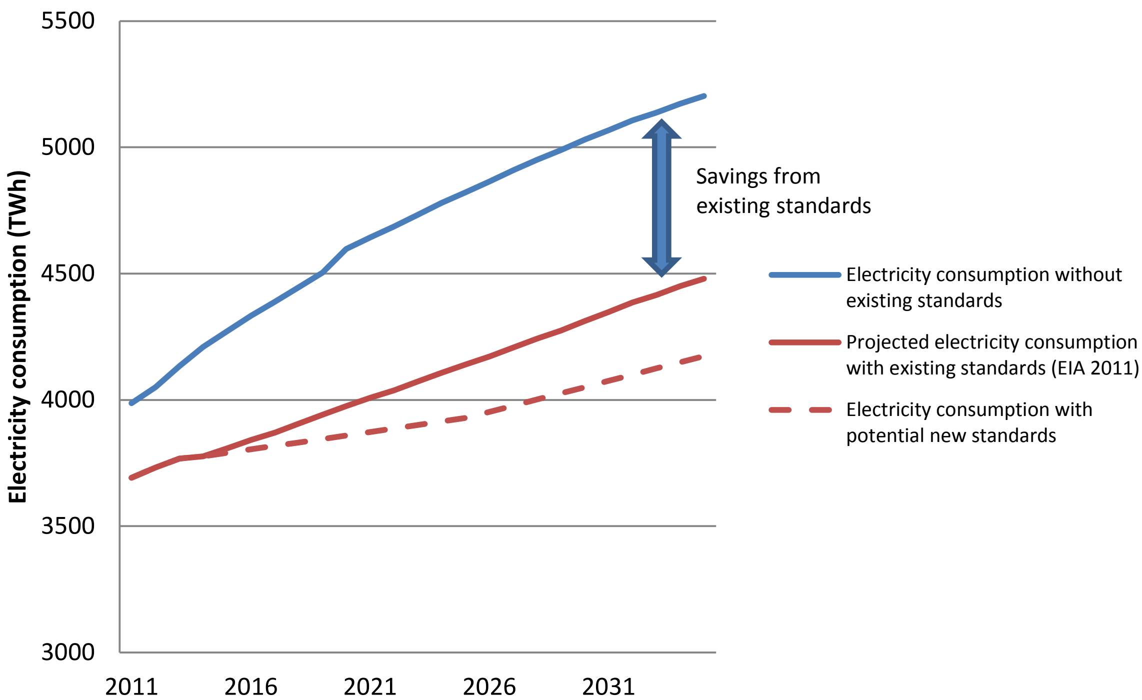
ACEEE is not a membership organization. Support for our work comes from a broad range of foundations, governmental organizations, research institutes, utilities, and corporations.

EXECUTIVE SUMMARY

Appliance, equipment, and lighting standards have been a cornerstone of U.S. energy policy since Congress enacted the first standards in the 1980s. They have significantly reduced U.S. energy consumption, providing large economic benefits for consumers and businesses. Taking into account products sold from the inception of each national standard through 2035, existing standards will net consumers and businesses more than $1.1 trillion in savings cumulatively. By 2035, cumulative energy savings will reach more than 200 quads, an amount equal to about two years of total U.S. energy consumption.

Standards have had a particularly large effect on electricity use. The top line in Figure ES-1 shows how much higher U.S. electricity consumption would be if existing product efficiency standards had never taken effect. On an annual basis, products meeting existing standards reduced U.S. electricity use in 2010 by about 280 terawatt-hours (TWh), a 7% reduction. The electricity savings will grow to about 680 TWh in 2025 and 720 TWh in 2035, reducing U.S. electricity consumption by about 14% in each of those years.

Figure ES-1. The Effect of Standards on Total U.S. Annual Electricity Consumption



Lower energy use has resulted in reduced emissions of greenhouse gases and other pollutants. Standards have also lowered peak electric demand levels, reducing strain on the electric grid and the need to build costly new power plants. Reduced energy consumption also puts downward pressure on overall energy prices, saving money for all energy consumers.

This report's key findings regarding the savings from products meeting existing standards are as follows:

- Annual electricity savings in 2035 of around 720 TWh, saving about 14% of what the projected electricity consumption in that year would have been without standards.
- Annual natural gas savings in 2035 of about 950 trillion British thermal units (TBtu), or enough to heat 32% of all natural-gas-heated U.S. homes.

- Peak demand savings in 2035 of about 240 gigawatt (GW), saving about 18% of what the total generating capacity projected for 2035 would have been without standards.
- Annual emissions reductions in 2035 of around 470 million metric tons of carbon dioxide (CO_2), an amount equal to the emissions of 118 coal-fired power plants.

For individual consumers, benefits have been very large and will grow as new and revised standards take effect. Based on a combination of existing and new standards, a typical household replacing its major appliances every 15 years will save over 180 megawatt-hour (MWh) of electricity and over 200,000 gallons of water between 1995 and 2040 simply by purchasing products that comply with minimum standards. Absent standards, this typical household's electricity use over this period would have been about 35% higher. The water savings, which do not include the savings from plumbing standards, would fill one-third of an Olympic-size swimming pool. Including the plumbing standards would increase these savings several-fold. Total bill savings over this 45-year period exceeds $30,000, or about enough to cover nearly two years of mortgage payments for an average U.S. household.

Since 2006, the U.S. Department of Energy (DOE), facing a series of court-ordered and statutory deadlines, has been setting a record pace for completing new and updated national standards: 17 new standards have been completed since January 2009 and another 11 are scheduled for completion by January 2013. After January 2013, the rate of statutorily required new standards drops off to a more typical level. However, many important standards are due between 2013 and 2015. In addition, DOE has begun work to cover new products not previously subject to national standards. Concurrently, the California Energy Commission (CEC) has initiated work to develop a new round of state-level standards. Historically, once California establishes new standards, other states follow suit. Therefore, during the 2013 to 2015 timeframe, standards for previously unregulated products may be established at either the national or state level.

This report evaluates potential new or updated standards for 34 product categories that could be adopted within the next four years. Due to federal preemption, many of these standards may only be adopted at the national level, but others may be adopted at the state level first. This substantial set of new and updated standards has the potential to generate enormous additional energy and economic savings. These new standards would increase the annual national electricity and peak demand savings from all national standards by nearly 50% by 2035. In Figure ES-1, the bottom line shows how potential new standards would reduce future electricity consumption.

Table ES-1. Potential Energy and Water Savings from New Standards

Product	Annual Savings in 2025				Annual Savings in 2035				Cumulative Quads
	Electricity (TWh)	Peak demand (GW)	Natural gas (Tbtu)	Water (billion gallons)	Electricity (TWh)	Peak demand (GW)	Natural gas (Tbtu)	Water (billion gallons)	
Residential:									
Air handlers	13.7	5.6	-	-	29.1	11.9	-	-	2.9
Battery chargers	6.3	0.9	-	-	6.3	0.9	-	-	1.3
Boilers (nat. gas)	-	-	14.1	-	-	-	39.8	-	0.3
Clothes washers	5.3	0.8	25.3	160.3	7.0	1.0	33.8	213.7	1.5
Computer equipment and components	11.8	1.6	-	-	11.8	1.6	-	-	1.7
Dishwashers	2.6	0.8	3.2	15.8	2.6	0.8	3.2	15.8	0.5
External power supplies	5.0	0.7	-		5.0	0.7	-		1.0
Faucets (residential lavatory)	1.3	0.2	8.9	23.6	2.7	0.4	18.2	48.4	0.5
Game consoles	7.9	1.1	-	-	7.9	1.1	-	-	1.1
Microwave ovens	2.3	0.3	-	-	2.3	0.3	-	-	0.4
Set-top boxes & digital communication equipment	14.7	2.0	-	-	14.7	2.0	-	-	2.3
Televisions	9.4	0.2	-	-	9.9	0.2	-	-	1.5
Toilets	-	-	-	44.6	-	-	-	91.5	-
Water heaters	18.2	2.5	-	-	43.0	5.9	-	-	4.1
Residential total	*98.5*	*16.8*	*51.6*	*244.3*	*142.3*	*27.0*	*95.0*	*369.5*	*19.0*
Commercial/Industrial:									
Air conditioners, air-cooled	5.5	5.5	-	-	9.7	9.6	-	-	1.1
Automatic ice makers	3.1	0.7	-	5.3	3.1	0.7	-	5.3	0.5
Clothes washers	0.2	0.1	2.4	15.6	0.2	0.1	3.4	22.2	0.1
Distribution transformers	10.9	1.5	-	-	22.4	3.1	-	-	2.3
Electric motors	9.0	1.4	-	-	18.6	2.9	-	-	1.9
Fans, blowers & ventilation equipment	3.1	0.5	-	-	8.5	1.4	-	-	0.7
Furnaces, commercial warm-air	-	-	4.2	-	-	-	7.7	-	0.1
Pre-rinse spray valve	0.8	0.1	9.5	14.9	0.8	0.1	9.5	14.9	0.3
Pumps	8.8	1.4	-	-	13.9	2.2	-	-	1.7
Refrigeration equipment	6.3	0.9	-	-	6.6	0.9	-	-	1.0
Walk-in coolers and freezers	14.7	3.4	-	-	14.7	3.4	-	-	2.4
Unit heaters	-	-	58.1	-	-	-	119.3	-	1.2
Urinals	-	-	-	6.6	-	-	-	13.6	-
Commercial total	*62.4*	*15.5*	*74.2*	*42.4*	*98.5*	*24.5*	*139.9*	*55.9*	*13.4*
Lighting:									
Candelabra & intermediate base incandescent lamps	8.0	0.2	-	-	8.0	5.7	-	-	1.3
General service fluorescent lamps	6.9	1.7	-	-	6.9	1.7	-	-	1.1
HID lamps	2.9	1.0	-	-	-	-	-	-	0.4
Incandescent reflector lamps	20.2	5.0	-	-	20.2	5.0	-	-	3.9
Luminaires (portable light fixtures)	0.2	0.0	-	-	-	-	-	-	0.0
Metal halide lamp fixtures	2.2	0.7	-	-	4.3	1.4	-	-	0.5
Outdoor lighting fixtures	10.3	0.7	-	-	26.1	1.8	-	-	2.3
Lighting total	*50.8*	*9.3*	-	-	*65.6*	*15.6*	-	-	*9.5*
TOTAL:	212	42	126	287	306	67	235	425	41.9

Table ES-1 shows the potential energy savings from the 34 new standards evaluated for this report. Key findings regarding energy savings and environmental benefits include:

- Annual electricity savings in 2035 would equal about 310 TWh, or about 7% of projected electricity consumption in that year.
- Annual natural gas savings would reach about 240 TBtu in 2035, or enough to heat 8% of all the natural-gas-heated U.S. homes.
- Annual water savings would reach about 430 billion gallons in 2035, or roughly enough to meet the needs of New York City.
- Peak electricity demand savings would reach about 67 GW in 2035, or about 6% of total U.S. generating capacity projected for 2035.
- Avoided CO_2 emissions in 2035 would equal around 200 million metric tons, an amount equal to the annual emissions of 49 coal-fired power plants. (The total estimated CO_2 savings in 2035 is more than the CO_2 reduction goal of New York.)

The potential savings from new standards are well-distributed between the residential, commercial and industrial sectors. The top ten products in terms of cumulative energy-saving potential are:

	Product	Cumulative Quads (through 2035)
1.	Residential electric water heaters	4.1
2.	Incandescent reflector lamps	3.9
3.	Residential air handlers	2.9
4.	Walk-in coolers and freezers	2.4
5.	Distribution transformers	2.3
6.	Outdoor light fixtures	2.3
7.	Set-top boxes	2.3
8.	Electric motors	1.9
9.	Computers and monitors	1.7
10.	Pumps	1.7

Other key findings about the relative savings of the evaluated standards include:

- Standards for seven products would deliver more than two quads of cumulative energy savings each. Together these seven categories comprise half of the total evaluated cumulative savings potential.
- Residential air handler standards would deliver the largest peak electric demand savings (about 12 GW in 2035), or roughly 18% of the total. Commercial air conditioners provide the second largest peak electric demand savings.
- Eight standards would achieve direct natural gas savings, with the largest potential gas savings deriving from commercial unit heaters.
- Residential clothes washer standards would provide the largest water savings, although another seven products also could contribute significant water savings.

Table ES-2. Potential Economic Savings from Future Standards

Product	Annual bill savings (million 2010$)		Purchases through 2035		
	in 2025	in 2035	Present value of costs (million 2010$)	Present value of savings (million 2010$)	Net present value (million 2010$)
Residential:					
Air handlers	$1,573	$3,331	$4,748	$18,740	$13,992
Battery chargers	$721	$721	$6,091	$7,061	$969
Boilers (nat. gas)	$158	$446	$1,245	$2,679	$1,434
Clothes washers	$2,010	$2,680	$3,355	$19,246	$15,891
Computer equipment and components	$1,348	$1,348	$0	$8,608	$8,608
Dishwashers	$445	$445	$1,076	$3,852	$2,777
External power supplies	$575	$575	$3,253	$5,558	$2,305
Faucets (residential lavatory)	$413	$847	$332	$5,692	$5,360
Game consoles	$910	$910	$0	$5,263	$5,263
Microwave ovens	$267	$267	$392	$2,145	$1,753
Set-top boxes & digital communication equipment	$1,679	$1,679	$0	$11,586	$11,586
Televisions	$1,082	$1,139	$0	$8,260	$8,260
Toilets	$312	$640	$0	$4,303	$4,303
Water heaters	$2,087	$4,933	$18,886	$23,807	$4,921
Residential total	*$13,580*	*$19,962*	*$39,379*	*$126,803*	*$87,424*
Commercial/Industrial:					
Air conditioners, air-cooled	$563	$993	$3,526	$5,953	$2,426
Automatic ice makers	$356	$356	$147	$2,675	$2,528
Clothes washers	$148	$210	$488	$1,277	$788
Distribution transformers	$1,112	$2,283	$6,366	$16,708	$10,342
Electric motors	$609	$1,251	$2,284	$8,405	$6,121
Fans, blowers & ventilation equipment	$211	$575	$592	$2,659	$2,067
Furnaces, commercial warm-air	$38	$70	$215	$434	$219
Pre-rinse spray valve	$274	$274	$0	$2,225	$2,225
Pumps	$593	$936	$5,020	$6,081	$1,061
Refrigeration equipment	$640	$674	$2,086	$4,886	$2,799
Walk-in coolers and freezers	$1,495	$1,495	$2,600	$11,727	$9,127
Unit heaters	$533	$1,094	$5,512	$6,846	$1,334
Urinals	$46	$95	$0	$637	$637
Commercial total	*$6,618*	*$10,306*	*$28,838*	*$70,514*	*$41,676*
Lighting:					
Candelabra & intermediate base incandescent lamps	$917	$917	$629	$5,888	$5,259
General service fluorescent lamps	$709	$709	$2,995	$5,285	$2,290
HID lamps	$299	$0	$1,666	$4,193	$2,527
Incandescent reflector lamps	$2,314	$2,314	$8,936	$20,204	$11,267
Luminaires (portable light fixtures)	$27	$0	$21	$134	$114
Metal halide lamp fixtures	$224	$438	$709	$2,894	$2,185
Outdoor lighting fixtures	$1,179	$2,993	$2,005	$16,283	$14,278
Lighting total	*$5,669*	*$7,371*	*$16,960*	*$54,881*	*$37,920*
TOTAL:	$25,868	$37,639	$85,177	$252,197	$167,020

Table ES-2 shows the economic impacts of the evaluated standards. Key economic impact findings include:

- Consumers of the affected products would save around $170 billion on a net present value basis.
- Twelve standards will each reduce consumer and business energy bills by at least a billion dollars a year by 2035.
- The largest net present value savings would come from clothes washers ($16 billion), outdoor lighting ($14 billion), air handlers ($14 billion), set-top boxes ($12 billion), and incandescent reflector lamps ($11 billion). These five products would deliver 40% of the potential net present value benefits of new standards.

- The average simple payback of the evaluated standards is 3.3 years. Simple paybacks range from less than one year to around 10 years for some long-lived products.
- The average benefit-cost ratio for the evaluated standards is 4:1. That is, the present value of product lifetime savings is, on average, more than four times larger than the upfront incremental costs for efficiency improvements.

In sum, already existing appliance, equipment, and lighting standards have delivered enormous energy savings plus economic and environmental benefits. New and updated standards that can be completed within the next few years have the power to cost-effectively add even more energy savings while saving money for the consumers and businesses that buy and use the affected products. New standards can also make significant contributions toward environmental objectives by reducing energy-related emissions. Ultimately, standards can contribute towards bringing U.S. energy supply and demand into better balance, thereby improving the long-term reliability of our electric grid and helping to moderate long-term energy prices. These large potential benefits make a strong case for timely updates to existing national standards and development of standards for previously unregulated products at both the state and national levels.

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INTRODUCTION

Appliance, equipment, and lighting standards have delivered more energy savings for the United States than almost any other policy. Along with these energy savings have come enormous net dollar savings for consumers and businesses and reductions in environmentally-harmful emissions. By cutting the rate of growth in electric demand, standards have eliminated the need for dozens of new power plants. Reduced demand levels in turn have put downward pressure on energy prices, saving money for all energy consumers. From improved incandescent light bulbs, to better refrigerators, to more efficient industrial motors and beyond, standards have driven innovations affecting most of the major energy-using products in U.S. homes and workplaces.

This report is the latest in a series by ACEEE and ASAP initiated in 1999 that estimate impacts from completed standards and potential savings from prospective standards. Since then, the U.S. Department of Energy (DOE) has completed many important new and updated standards. This report shows that very large energy, economic, and environmental savings from the next round of new standards can be achieved.

In this report, Sections 1 and 2 provide an updated estimate of the impacts to date for national standards, including standards completed through December 2011. Section 3 estimates the potential impacts of future standards, covering both very near term opportunities (i.e., national standards scheduled for completion by January 2013) as well as standards that are more likely to be completed after January 2013, either at the state or national level. We provide both national and state-level impact estimates for each potential standard. The state-level impacts are available at http://www.appliance-standards.org/map/benefits-from-federal.

Section 4 provides individual consumer impact estimates, including incremental upfront costs, per-unit savings, and paybacks (i.e., how quickly the estimated additional cost of improved efficiency is paid back in lower utility bills). A separate discussion estimates the impact of a set of existing and future standards for a typical household. Section 5 compares the results of this study to other recent assessments: the results of this study are consistent with other recent work. In Section 6, we provide short discussions for each product evaluated. These include key background information and assumptions for future standards.

Previous reports in this series have focused on either national or state standards opportunities. In this report, we take a somewhat different approach. We analyze the potential impacts for standards that can be adopted within the next four years, irrespective of whether they are more likely to be adopted nationally or at a state level. For products already subject to national standards, state standards are precluded except for certain narrow exceptions. Thus, for those products, updated national standards are the most likely avenue for improvements. However, we also analyze products that are outside the scope of current national standards. Standards for these products may be adopted either nationally or at the state level. This report also differs from previous iterations in that we assess the potential water and energy savings for updates to several plumbing product standards. For plumbing products, there are existing national standards, but federal preemption of state standards has expired, so updates may be adopted at either the state or national level.

In previous reports we have also treated related topics, such as the history of standards in the U.S., standards' effects on product features and prices, employment impacts related to standards, and market barriers to efficiency. We have updated this work in a set of short appendices included with this report. We also include an appendix on public and stakeholder attitudes about standards, which summarizes recent research and views from diverse interests. These appendices provide background and context, which will be familiar to some readers but useful as reference material.

SECTION 1. SAVINGS ACHIEVED BY EXISTING STANDARDS

California's Warren-Alquist Act, signed into law by Governor Ronald Reagan in 1974, authorized the first appliance standards in the United States and resulted in initial state-level standards for major home appliances by the mid-1970s. Congress authorized national standards in the Energy Policy and Conservation Act of 1975, but federal progress in developing specific standards proved slow. By the late 1980s, DOE had still not issued initial national standards and, faced with inadequate federal progress, several other states had joined California in enacting state-level standards. Starting in 1987, Congress enacted a series of laws on a broadly bipartisan basis that generally took a new approach: the laws enacted specific standards in statute and then charged DOE with updating them periodically if technologically feasible and economically justified. These laws were signed by Presidents Reagan (National Appliance Energy Conservation Acts of 1987 and 1988 or NAECA[1]), George Bush (Energy Policy Act of 1992 or EPAct 1992[2]) and George W. Bush (Energy Policy Act of 2005 or EPACT 2005[3]) and Energy Independence and Security Act of 2007 or EISA[4]). In total, national standards cover approximately 55 categories of products. Since 1990, DOE has completed about 30 rulemakings resulting in strengthened or initial standards for many of the covered products. (See Appendix B for a more detailed history of U.S. standards.)

We derived savings estimates for NAECA 1987 & 1988, EPAct 1992, and DOE rulemakings through 1997 based on Geller and Goldstein (1999). We used previous ACEEE/ASAP analyses and information from DOE analyses to estimate savings from EPAct 2005, EISA 2007, and DOE rulemakings from 2000 to 2011. In some instances, we have

A Kilo-*what?*

Visualizing units of energy can be difficult, even for energy experts. Here are a few energy equivalencies, to help make sense of the sometimes astronomical-sounding quantities of energy discussed in this report.

Electricity
- 11,480 kWh = annual use of an average U.S. home
- 1,275 TWh = annual use of all U.S. homes.

Natural gas
- 670 therms = annual use of an average U.S. home
- 4,655 TBtu = annual use of all U.S. homes.

Quads
- A quad = a quadrillion Btu
- 98 quads = annual U.S. energy consumption
- In this report, total quads refers to the sum of natural gas and source electricity.

CO_2 emissions
- 4 million metric tons = average annual emissions of a coal-fired power plant
- There are 464 coal-fired power plants in the U.S.

Water
- 146,000 gallons = annual use of a family of four
- 6.5 billion gallons = amount of water that flows over Niagara Falls every day

* Energy data from EIA's Residential Energy Consumption Survey; water and emissions data from EPA.

[1] U.S. Congress (1987)
[2] U.S. Congress (1992)
[3] U.S. Congress (2005)
[4] U.S. Congress (2007)

revised savings estimates when new information indicates that initial estimates were too high or low. For simplicity given the wide range of products covered in this report, we assume that, for (1) total sales volume and (2) the portion of sales that would meet a standard level absent the standard's adoption, neither would grow over time. We present an alternate scenario in Section 2 below that incorporates an assumption that at some point the efficiency gains achieved by standards would have happened even if the standard had not been adopted. The savings happening in the real world are the same in both scenarios: the first presented below attributes the total savings to standards and the alternate scenario attributes a declining share of the savings over time to standards.

Table 1 shows the cumulative energy and economic impacts from products meeting existing standards, broken out for each of the four major laws that established specific national standards. Each administration since 1989 has updated multiple standards through DOE rulemakings. The table also shows the collective impacts of DOE rulemakings completed to date. DOE significantly ramped up its work on new and updated standards starting in 2006 in response to Congressional concern about and litigation over missed deadlines. In addition, the 2005 and 2007 laws set new review deadlines for many products. As a result, many updates are being completed during the 2009–2013 period. Savings from standards completed since January 2009 show the most recent progress. Seventeen have been completed since then and another 11 are scheduled for completion by January 2013. Table 1 shows cumulative energy savings of existing standards through 2035, and the net present value (NPV) of existing standards based on purchases through 2035. The NPV is the difference between the present value of savings and the present value of costs. We discounted future costs and savings to 2010 assuming a real discount rate of 5%, and inflated past costs and savings to 2010 using a real interest rate of 5%.

Table 1. Energy Savings and Net Present Value from Existing Standards

	Groups of standards	Cumulative Energy Savings Through 2035 (quads)	NPV of Purchases Through 2035 (billion 2010$)
Legislation	NAECA 1987 & 1988	29.3	$ 215
	EPAct 1992	49.8	$ 340
	EPAct 2005	19.3	$ 123
	EISA 2007	28.5	$ 141
DOE rules	1989 - 2008	49.0	$ 213
	2009 - 2011	27.5	$ 77
	TOTAL	203.6	$ 1,109

In 2010, existing standards saved 3.4 quads of energy, which is equivalent to about 3.5% of total U.S. annual energy consumption. Existing standards will save more than **200 quads** of energy cumulatively through 2035, which is equivalent to about two years of total U.S. energy consumption. The NPV of existing standards is about **$1.1 trillion**.[5] About 40% of the cumulative energy savings are due to DOE rulemakings with a large portion completed within the last few years. The first two standards laws (NAECA 1997 & 1988 and EPAct 1992) contribute half of the total NPV. The standards in these two laws have been accruing savings for more than 15 years and are continuing to accrue savings.

Our estimate of NPV likely underestimates the economic benefits of existing standards because we have assumed that the incremental cost of more efficient products remains constant over time. In reality, historical data show that the real cost of appliances and equipment tends to decrease over

[5] The NPV calculation does not include the savings from the plumbing product standards in EPAct 1992, nor does it incorporate the value of lower energy prices as a result of reductions in energy demand.

time.[6] Recent DOE analyses for products including refrigerators, clothes dryers, room air conditioners, furnaces, and central air conditioners and heat pumps have applied learning rates to forecast product prices.

Table 2 shows the annual benefits from existing standards for the years 2025 and 2035. Each of the major appliance standards laws makes a significant contribution to annual savings. About 42% of the year 2025 energy savings totals are due to DOE rulemakings, increasing to about 44% by 2035, due to the many updates completed by DOE recently.

Table 2. Annual Energy Savings from Existing Standards

		Annual savings in 2025			Annual savings in 2035		
	Groups of standards	Electricity (TWh)	Natural gas (TBtu)	Total Quads	Electricity (TWh)	Natural gas (TBtu)	Total Quads
Legislation	NAECA 1987 & 1988	70.4	107.1	0.8	70.4	107.1	0.8
	EPAct 1992	121.9	268.1	1.5	121.9	268.1	1.5
	EPAct 2005	66.3	153.5	0.8	69.6	168.6	0.9
	EISA 2007	133.4	22.1	1.4	138.8	38.8	1.5
DOE rules	1989 - 2008	164.0	156.6	1.9	175.6	175.3	2.0
	2009 - 2011	126.2	128.9	1.4	146.8	195.5	1.7
	TOTAL	682.2	836.3	8.0	723.2	953.3	8.4

Note: Electricity and natural gas savings are site energy; total quads are combined primary energy savings.

Figure 1 shows how existing standards are reducing U.S. electricity consumption. Products meeting existing standards reduced U.S. electricity use by about 278 TWh in 2010, or by about 7% compared to electricity use absent existing standards. By 2025, savings will grow to 682 TWh, resulting in 14% lower electricity use than without standards. Projected savings increase to 723 TWh in 2035 (which is still about a 14% reduction due to projected growth in demand). Standards completed since January 2009 comprise a significant portion of total savings: 126 TWh in 2025 and 147 TWh in 2035.

Figure 2 shows net annual economic savings for consumers and businesses from existing standards in 2010, 2025, and 2035. Net economic savings are the difference between annual utility bill savings and annual investment costs for purchasing higher-efficiency products. Net savings from existing standards were about $27 billion in 2010 and will increase to about $61 billion in 2025 and $67 billion in 2035 (in 2010$). As noted above, our estimate of net economic savings likely underestimates the economic benefit of existing standards since we have not incorporated learning rates to account for observed declines in real prices over time. In 2010, the standards established by NAECA 1987 & 1988 and EPAct 1992 contributed about three-quarters of the total net savings. By 2025, the standards in EISA 2007 and the standards set through DOE rulemakings make up more than half of the total net savings. The majority of the net savings from EISA 2007 are due to the light bulb standards.

[6] See, for example, Dale et al. (2009).

Figure 1. Projected U.S. Electricity Consumption with and without Existing Standards

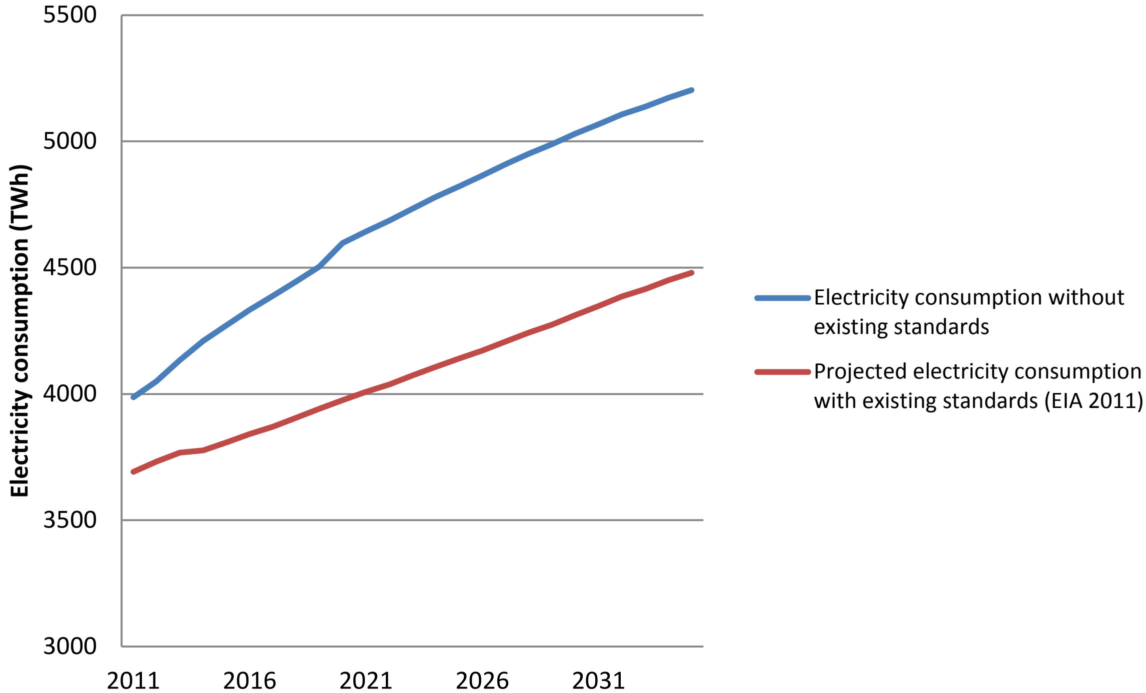


Figure 2. Net Economic Savings from Existing Standards

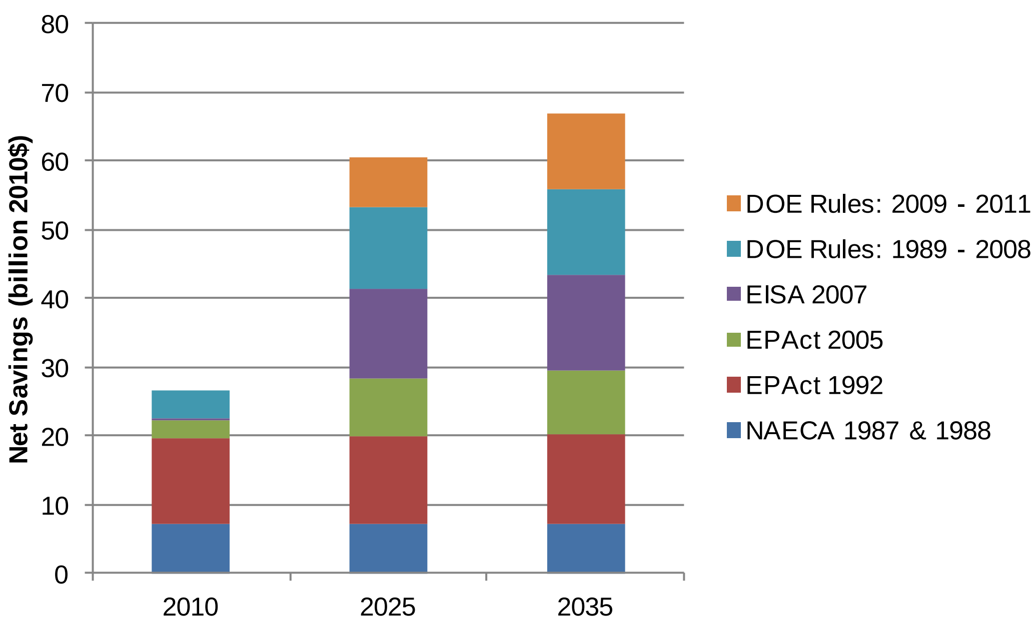
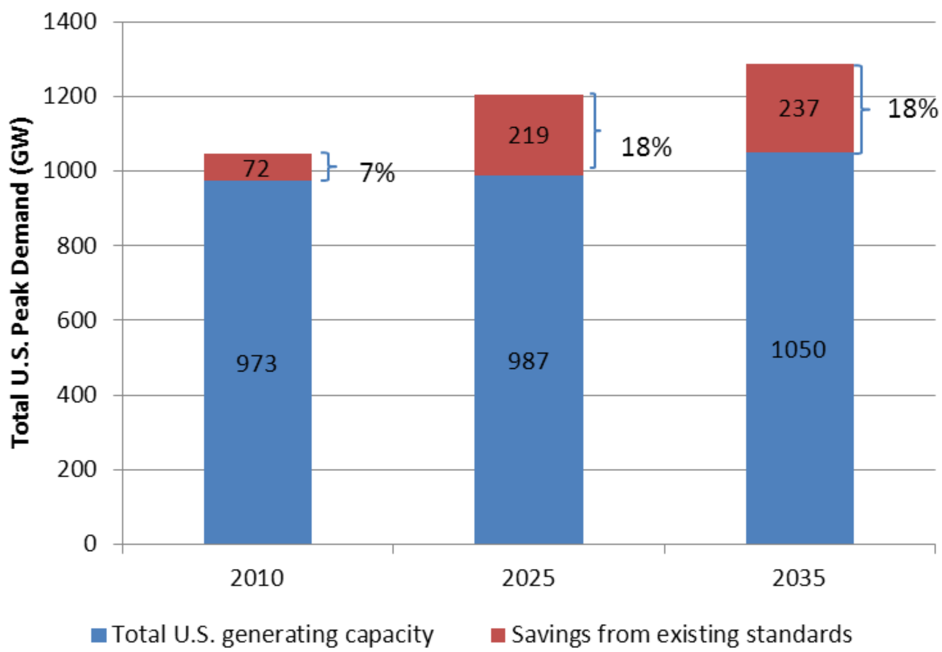


Figure 3 shows peak demand savings from existing standards as compared to actual or projected U.S. electricity consumption and demand for 2010, 2025, and 2035 (EIA 2011).[7] Peak demand

[7] We calculated peak demand savings based on estimates of electricity savings and product-specific coincident peak factors.

savings are driven in large measure by air conditioning standards. The 2001 residential central air conditioning standards alone will reduce 2025 peak demand by about 33 GW. New standards for commercial air conditioners took effect in 2010. Peak savings grow from 219 GW in 2025 to 237 GW in 2035, reducing peak demand by about 18% in those years. 42 GW and 52 GW of 2025 and 2035 savings, respectively, are attributed to standards completed since January 2009.

Figure 3. Peak Demand Savings from Existing Standards (GW)



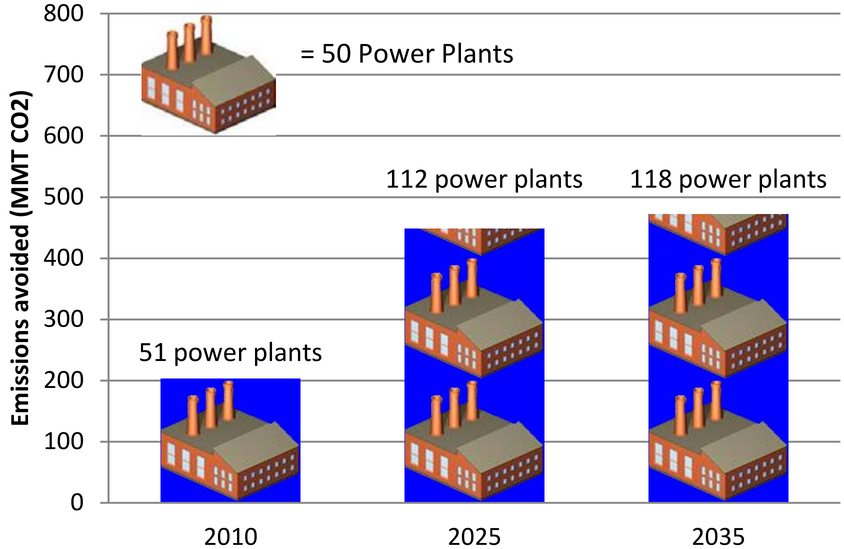
Natural gas savings from existing standards grow from 836 TBtu in 2025 to 953 TBtu in 2035, enough to heat 17 and 19 million typical gas-heated U.S. homes, respectively. For natural gas, the increase from 2025 is driven by recent new standards for residential water heaters and furnaces.

Figure 4 shows CO_2 savings from existing standards. The CO_2 savings from existing standards in 2010 were 203 million metric tons, an amount equal to the CO_2 emitted by 51 coal-fired power plants. By 2025, the CO_2 savings grow to 448 milion metric tons, an amount equal to the emissions of 112 average-sized coal-fired power plants. By 2035, savings increase to 472 million metric tons, the equivalent of 118 coal plant's CO_2 output. CO_2 savings can also be compared to the emissions of typical passenger vehicles: 2025 savings will be equal to the emissions of 88 million vehicles and 2035 savings equal to that of 93 million vehicles.

Standards have also reduced emissions of other power sector pollutants including nitrogen oxides, sulfur dioxide, and mercury, which helps states meet air quality goals at a reduced cost. Sulfur dioxide (SO_2) reductions due to existing standards will increase from about 410,000 metric tons in 2010 to 529,000 metric tons in 2025 and 490,000 metric tons in 2035. Year 2010 nitrogen oxides (NO_x) reductions reached 200,000 metric tons and will increase to 352,000 and 359,000 metric tons in 2025 and 2035 respectively.[8]

[8] We use average emissions factors from *Annual Energy Outlook 2011* (EIA 2011a) to approximate SO_2 and NOx emissions reductions. EIA forecasts a decrease in average SO_2 and NOx emissions factors over time.

Figure 4. CO_2 Reductions from Existing Standards in Equivalent Number of Coal Plants



In addition to these energy and economic savings and emissions reductions, existing standards have also bolstered the economy and employment. According to an ACEEE and ASAP study published in January 2011, existing standards increased U.S. employment levels by 340,000 jobs in 2010 (Gold 2011). Standards increase employment as consumers and businesses save or spend utility bill savings, resulting in increased economic activity. Therefore, as annual bill savings grow from existing and new standards, employment levels will be higher than would otherwise be the case.

In sum, standards have delivered enormous benefits for consumers, the environment, and the economy. This track record of success helps explain why Congress has repeatedly expanded the scope of the national standards to cover additional products over the past 25 years. The initial group of 13 covered products enacted in 1987 has been expanded to about 55. Each successive administration has updated existing standards and, in some cases, sought to add products as warranted to enhance this track record.

Section 2. Savings Achieved by Existing Standards: Alternate Scenario

The benefits presented in Section 1 result from products meeting efficiency performance levels required by standards. These estimates do not attempt to disaggregate the portion of incremental savings that result from standards and those savings that would have happened even if standards had never existed. All of the savings described in Section 1 happen, but it is difficult to assess what portion of those savings would have happened if the standards policy had never been adopted.
For many products, even absent standards, market forces and programs such as ENERGY STAR and utility-based incentives and promotions would increase efficiency for many products over time. This efficiency improvement is likely to be most significant for products where market drivers for efficiency and programs are strongest (e.g., furnaces, commercial lighting) and weakest where the barriers to efficiency were especially strong (e.g., transformers, reflector lamps). But, even for products where market forces and programs drive significant efficiency improvement, each iteration of a standard raises the base case. In other words, when new standards have gone into effect for a product, the market and programs shift focus to a new, higher level of efficiency that would not have been possible absent the standard. Therefore, there is significant uncertainty about whether the savings attributed to standards should erode over time and, if so, by how much. This analytical challenge is especially prevalent for a study like this one that examines dozens of different standards and technologies each with different technical and market characteristics.

In order to develop a conservative estimate of the impact of the standards policy, we analyzed an alternate scenario in which savings attributed to standards decline over time. This assumption takes the form of a "decay" rate. Savings for the first 15 years are calculated the same as in the scenario above. However, in the "decay" rate scenario, in the 16th year, 5% of sales of more efficient products are no longer attributed to the standards policy. In each subsequent year, another 5% are assumed to meet the standard even if the standard had never existed, so that after a total of 35 years, the scenario would show that the standard has no new impact.

Tables 3 and 4 reproduce Tables 1 and 2 above but with the decay rate assumption. With the decay rate, cumulative savings drops to about 162 quads and net present value benefits decline to $913 billion. As shown in Table 4, the annual savings *decline* between 2025 and 2035. This decline occurs because by 2035 the large savings achieved by some of the original standards laws will have been significantly reduced by the decay rate. **To be clear, these savings have not gone away, they just are no longer attributed to the standards policy in this scenario.**

Table 3. Cumulative Energy Savings and Net Present Value from Existing Standards, Decayed

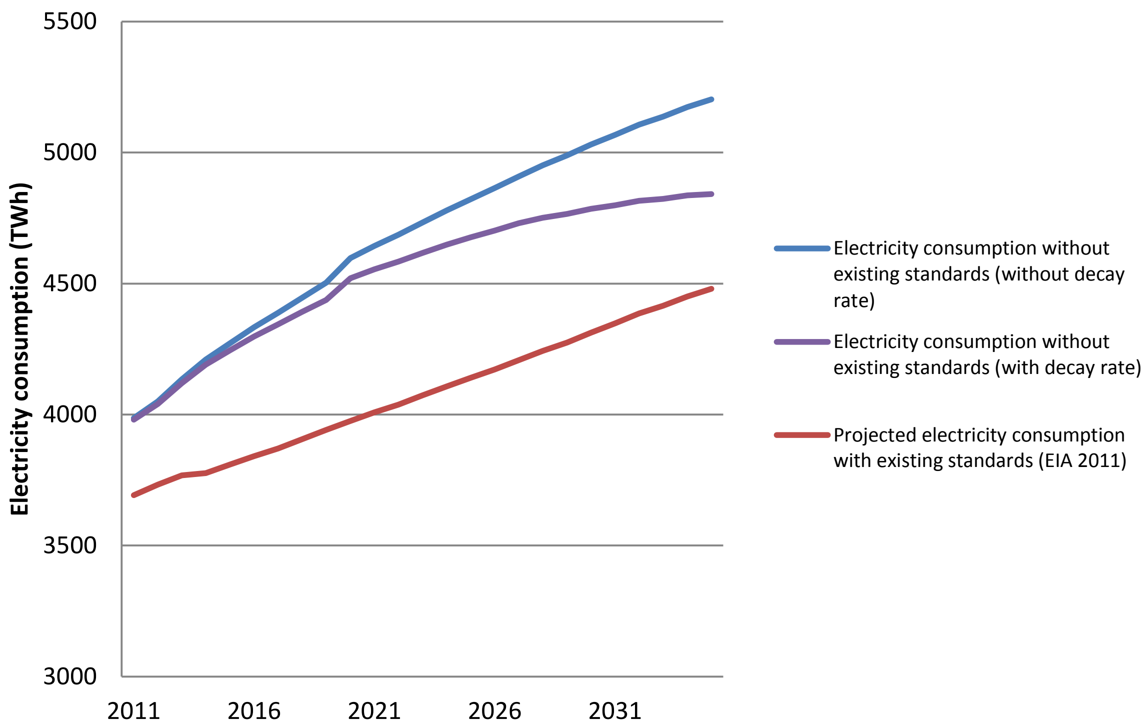
	Groups of Standards	Cumulative Energy Savings Through 2035 (quads)	NPV of Purchases Through 2035 (billion 2010$)
Legislation	NAECA 1987 & 1988	18.0	$159
	EPAct 1992	33.2	$262
	EPAct 2005	17.4	$107
	EISA 2007	26.9	$133
DOE Rules	1989 - 2008	40.1	$178
	2009-2011	26.6	$73
	TOTAL	162.2	$913

Table 4. Energy Savings from Existing Standards, Decayed

	Groups of Standards	Annual savings in 2025			Annual savings in 2035		
		Electricity (TWh)	Natural Gas (TBtu)	Total Quads	Electricity (TWh)	Natural Gas (TBtu)	Total Quads
Legislation	NAECA 1987 & 1988	24.6	37.5	0.3	2.3	3.6	0.0
	EPAct 1992	55.6	174.2	0.8	6.6	49.1	0.1
	EPAct 2005	63.3	144.4	0.8	43.6	106.9	0.6
	EISA 2007	132.9	22.1	1.4	102.7	35.5	1.1
DOE Rules	1989 - 2008	133.4	135.5	1.5	82.8	74.2	0.9
	2009-2011	126.2	128.9	1.4	123.7	178.6	1.5
	TOTAL	535.9	642.6	6.2	361.7	447.9	4.2

Figure 5 adds a line to Figure 1 to represent the electricity savings from standards with the decay rate. The figure shows how much higher U.S. electricity consumption would be if existing standards had never been adopted. U.S. electricity use will be 14% lower in 2025 and 2035 than it would have been absent any standards assuming no decay rate. Based on the scenario with the decay rate, the savings attributed to the standards policy is adjusted to 11% in 2025 and 7% in 2035.

Figure 5. Projected U.S. Electricity Consumption Compared to Projections without Existing Standards



Appendix G reproduces the other figures from Section 1, but with the decay rate assumption.

SECTION 3. SAVINGS AHEAD: 2012–2015

The savings from new and updated standards that could be completed within the next four years would add considerably to standards' record of achievement. Although DOE has completed 17 new standards since January 2009, as required by Congress or court decisions, another 11 are scheduled for completion by January 2013. After January 2013, the rate of statutorily required new standards or updates drops off to a more typical level. DOE is required to review and update, if warranted, more than a dozen standards between January 2013 and December 2015. DOE also has begun work to cover new products not previously subject to national standards. DOE last initiated work to cover previously unregulated products in 2002. However, Congress enacted consensus standards for each of these products before the DOE regulatory process could be completed. Starting in 2010, DOE initiated work on several new product categories including set-top boxes and network equipment, fans and blowers, and pumps.

In addition, the California Energy Commission (CEC) initiated a rulemaking process in August 2011 to consider new state-level standards. Several of the products we evaluate in this report (e.g., outdoor lighting, game consoles, and computers) have been recommended by various stakeholders for consideration in that process. In the past, when California adopted a standard for a given product, other states subsequently adopted identical or similar standards.

For this study, we first developed a list of more than 100 technologies for which standards could conceivably be developed. We then narrowed that list by focusing on products that would deliver significant savings and for which standards could be adopted within the next four years at either the national or state level. These include the 11 new national standards scheduled for completion by January 2013 and 16 standards legally required to be reviewed by DOE between 2013 and 2015. We also evaluated each of the currently "uncovered" product categories for which DOE has initiated work (i.e., computer equipment and components, set-top boxes, non-general purpose electric motors, fans and blowers, and pumps). Finally, we evaluated several products for which state standards have already preceded or are likely to precede national standards. These include some of the same products for which DOE has initiated work plus several others (e.g., portable light fixtures and outdoor lighting fixtures).

We generally did not include standards due for DOE review that afford relatively small potential savings (e.g., packaged terminal air conditioners and exit signs) or for which we lacked data to complete an adequate analysis (e.g., ceiling fans and commercial water heaters). We also did not include all of the products proposed for consideration in the pending CEC rulemaking because some were proposed too late for inclusion in this report.

Table 5 shows the products evaluated for this report along with the potential adoption and effective dates for new national standards, and, where applicable, state standards. In general, national standards preempt state standards, so Table 5 shows no state dates for many products. But if no national standards exist for a product, states are free to set their own. For plumbing products, federal standards exist, but preemption of state standards has expired. Table 5 shows national adoption and effective dates required or allowed by federal law and state adoption and effective dates based on the authors' judgment of when states could adopt the evaluated standards. For the most part, states can act more quickly than DOE.[9]

Our general methodology is driven by sales of affected products. We estimated per-unit energy and water savings, the portion of sales that would comply absent a new standard, and incremental costs for compliant products. In general, we assumed that neither annual sales nor baseline efficiency increase over the analysis period. For some products for which efficiency improvement trends are strong, we diverged from our general approach. For example, we project a growing future market share for efficient TVs given the ENERGY STAR program's historic effectiveness in increasing efficiency levels. We analyzed savings through 2035, a point at which stock for most products would have turned over and product savings could consistently be measured against each other. Where available, we used DOE estimates for product-specific information. Otherwise, we gathered information from technology experts, industry literature, research reports, utility program evaluations, and ENERGY STAR program materials. For the national savings estimates, we have used the potential national standards effective dates shown in Table 5. For some products, states can adopt and implement standards sooner than the federal government. State-by-state benefits based on both potential state and federal effective dates can be viewed at http://www.appliance-standards.org/map/benefits-from-federal. Full details of the methodology are available in Appendix A.

[9] In general, a DOE rulemaking takes about three years. For most previously unregulated products, federal law requires a five-year lag between completion of a final rule establishing a standard and that standard's effective date. While DOE has indicated its intent to reduce the time needed for rulemaking, the five-year lag is a general legal requirement. Lag times shorter than statutory minimums have been achieved in the past in the case of consensus agreements, through either Congressional or regulatory adoption. Federal law includes numerous exceptions to the general rules. For example, televisions are not subject to the five-year lag between a final rule and effective date.

Table 5. Products Evaluated

	Federal standards		State standards	
Product	Adoption date	Effective date	Adoption date	Effective date
Residential:				
Air handlers	2013	2017		
Battery chargers	2012	2014	2011	2013
Boilers (nat. gas)	2015	2020		
Clothes washers	2012	2015		
Computer equipment and components	2014	2019	2013	2014
Dishwashers	2012	2013		
External power supplies	2012	2014		
Faucets (residential lavatory)	2013	2016	2013	2014
Game consoles	2015	2020	2013	2014
Microwave ovens	2012	2015		
Set-top boxes & digital communication equipment	2013	2018	2013	2014
Televisions	2013	2016	2013	2014
Toilets	2013	2016	2013	2014
Water heaters	2015	2020		
Commercial/Industrial:				
Air conditioners, air-cooled	2015	2017		
Automatic ice makers	2013	2016		
Clothes washers	2015	2018		
Distribution transformers	2012	2016		
Electric motors	2012	2016		
Fans, blowers & ventilation equipment	2015	2020	2014	2015
Furnaces, commercial warm-air	2013	2016		
Pre-rinse spray valve	2013	2016		
Pumps	2013	2016	2013	2014
Refrigeration equipment	2013	2016		
Walk-in coolers and freezers	2012	2015		
Unit heaters	2013	2016		
Urinals	2013	2016	2013	2014
Lighting:				
Candelabra & int. base incandescent lamps	2013	2020		
General service fluorescent lamps	2014	2017		
HID lamps	2014	2017		
Incandescent reflector lamps (previously exempted)	2012	2015		
Incandescent reflector lamps (all products)	2014	2017		
Luminaires (portable light fixtures)	2014	2019	2013	2014
Metal halide lamp fixtures	2012	2015		
Outdoor lighting fixtures	2014	2019	2013	2014

KEY FINDINGS

The total energy, economic, and environmental benefits from new and updated standards that can be adopted within the next few years are enormous. New and updated standards for the 34 product categories evaluated for this report would yield the following national benefits:

- Consumers of the affected products would save more than $165 billion on a net present value basis.

- Annual electricity savings in 2035 would equal about 310 TWh, or about 7% of projected electricity consumption in that year.
- Annual natural gas savings would reach about 235 trillion Btu (TBtu) in 2035, or enough to heat 8% of all the natural-gas-heated U.S. homes.
- Annual water savings of about 430 billion gallons in 2035, or roughly enough to meet the needs of New York City.
- Peak electricity demand savings would reach about 67 GW in 2035, or about 6% of total U.S. generating capacity projected for 2035.
- Avoided CO_2 emissions in 2035 would equal 200 million metric tons, an amount equal to the annual emissions of 49 coal-fired power plants. (The total estimated CO_2 savings in 2035 is more than the CO_2 reduction goal of New York.)

On a cumulative basis, savings due to new and updated national standards from products sold through 2035 would reach 42 quads of primary energy and 5,200 TWh of electricity. As a point of comparison, the entire U.S. economy uses about 100 quads per year. Cumulative water savings amount to 5.5 trillion gallons, a volume larger than the amount of water that flows over Niagara Falls over the course of 2.5 months.

These savings would make a huge addition to the benefits standards have already delivered for the U.S. For example, the 310 TWh in annual electricity savings achievable in 2035 from new and updated standards is 43% of the annual savings in 2035 from *all* national standards adopted to date, either by Congress or DOE (see Table 2).

Table 6. Total Potential Savings for Near- and Later-Term Standards

	Annual Savings in 2025				Annual Savings in 2035				Cumulative Quads
	Electricity (TWh)	Peak demand (GW)	Natural gas (TBtu)	Water (billion gallons)	Electricity (TWh)	Peak demand (GW)	Natural gas (TBtu)	Water (billion gallons)	
Mar. 2012 - Jan. 2013 standards	70	10	30	180	100	20	40	230	14
Feb. 2013 - Dec. 2015 standards	140	30	100	110	210	50	200	200	27
Total	210	40	130	290	310	70	230	430	42

Table 6 aggregates the estimated savings for the standards scheduled for DOE completion between January 2012 and January 2013 (i.e., during the remainder of the current presidential term) and savings for standards that could be adopted in the subsequent three years. The 11 standards due between early 2012 and early 2013 have the potential to increase the annual electricity savings by two-thirds compared to standards already issued during the current administration.

Figure 6 highlights the cumulative energy savings through 2035 in quadrillion Btus (quads) for the 11 products for which new standards are scheduled for completion by January 2013. For this set of standards, the largest savings come from commercial and industrial products, such as walk-in coolers and freezers, electric motors, and distribution transformers. However, the potential savings are well-distributed—all of the near-term standards make significant contributions to the period's total potential.

The potential savings from standards adopted after January 2013 includes updating existing national standards and creating new standards for previously unregulated products. DOE is required to establish or update many important standards during the 2013 to 2015 period, such as commercial air conditioners and residential air handlers. But several of the national standards under review during this period will result in relatively small savings (e.g., commercial clothes washers and commercial warm air furnaces). Some of the biggest savings opportunities evaluated for this period derive from products not currently regulated by DOE, including several categories of consumer electronics (set-top boxes and TVs) and commercial and industrial products (e.g., outdoor lighting and pumps).

Figure 6. Breakout of Standards due by January 2013 (Cumulative Quads by 2035)

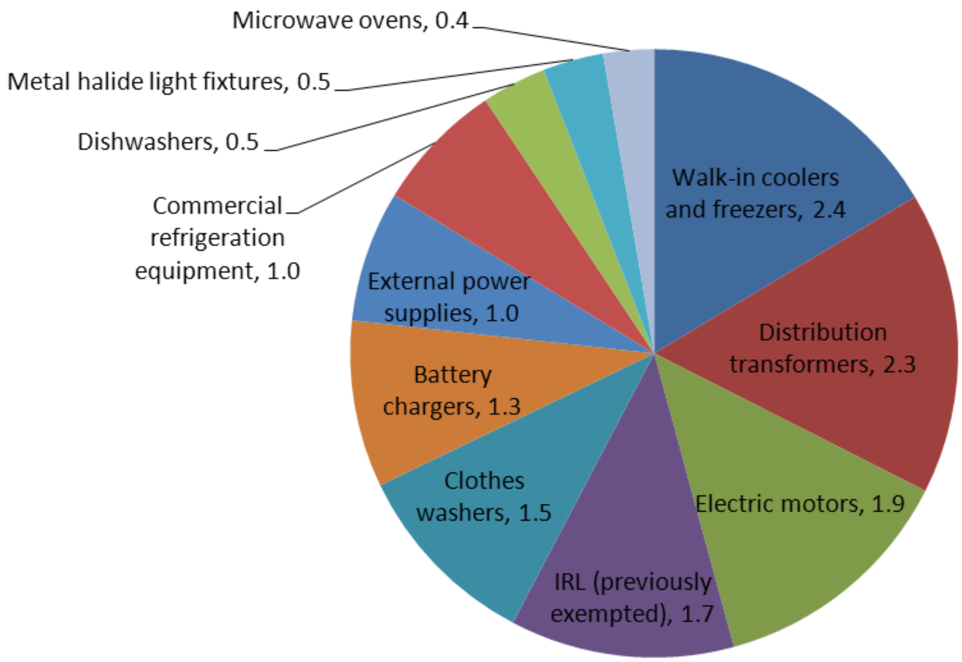


Table 7 shows the estimated savings for each individual product. Key results shown in Table 7 include:

- Potential savings are spread out among products used primarily in the residential, commercial, and industrial sectors.
- Seven different product classes have cumulative energy savings greater than two quads each. These include electric water heaters, incandescent reflector lamps, residential air handlers, walk-in coolers and freezers, distribution transformers, outdoor light fixtures, and set-top boxes. These seven categories comprise half of the total evaluated cumulative savings potential.
- Residential air handler standards would deliver the largest peak electric demand savings (about 12 GW in 2035), or roughly 18% of the total. Commercial air conditioners provide the second largest peak electric demand savings,
- Eight standards would achieve direct natural gas savings, with the largest potential gas savings deriving from commercial unit heaters.
- Residential clothes washer standards would provide the largest water savings, although another seven products also could contribute significant water savings.
- Eight standards would achieve direct natural gas savings, with the largest potential gas savings deriving from commercial unit heaters.

Table 7. Potential Energy and Water Savings by Product

Product	Annual Savings in 2025				Annual Savings in 2035				Cumulative Quads
	Electricity (TWh)	Peak demand (GW)	Natural gas (Tbtu)	Water (billion gallons)	Electricity (TWh)	Peak demand (GW)	Natural gas (Tbtu)	Water (billion gallons)	
Residential:									
Air handlers	13.7	5.6	-	-	29.1	11.9	-	-	2.9
Battery chargers	6.3	0.9	-	-	6.3	0.9	-	-	1.3
Boilers (nat. gas)	-	-	14.1	-	-	-	39.8	-	0.3
Clothes washers	5.3	0.8	25.3	160.3	7.0	1.0	33.8	213.7	1.5
Computer equipment and components	11.8	1.6	-	-	11.8	1.6	-	-	1.7
Dishwashers	2.6	0.8	3.2	15.8	2.6	0.8	3.2	15.8	0.5
External power supplies	5.0	0.7	-		5.0	0.7	-		1.0
Faucets (residential lavatory)	1.3	0.2	8.9	23.6	2.7	0.4	18.2	48.4	0.5
Game consoles	7.9	1.1	-	-	7.9	1.1	-	-	1.1
Microwave ovens	2.3	0.3	-	-	2.3	0.3	-	-	0.4
Set-top boxes & digital communication equipment	14.7	2.0	-	-	14.7	2.0	-	-	2.3
Televisions	9.4	0.2	-	-	9.9	0.2	-	-	1.5
Toilets	-	-	-	44.6	-	-	-	91.5	-
Water heaters	18.2	2.5	-	-	43.0	5.9	-	-	4.1
Residential total	*98.5*	*16.8*	*51.6*	*244.3*	*142.3*	*27.0*	*95.0*	*369.5*	*19.0*
Commercial/Industrial:									
Air conditioners, air-cooled	5.5	5.5	-	-	9.7	9.6	-	-	1.1
Automatic ice makers	3.1	0.7	-	5.3	3.1	0.7	-	5.3	0.5
Clothes washers	0.2	0.1	2.4	15.6	0.2	0.1	3.4	22.2	0.1
Distribution transformers	10.9	1.5	-	-	22.4	3.1	-	-	2.3
Electric motors	9.0	1.4	-	-	18.6	2.9	-	-	1.9
Fans, blowers & ventilation equipment	3.1	0.5	-	-	8.5	1.4	-	-	0.7
Furnaces, commercial warm-air	-	-	4.2	-	-	-	7.7	-	0.1
Pre-rinse spray valve	0.8	0.1	9.5	14.9	0.8	0.1	9.5	14.9	0.3
Pumps	8.8	1.4	-	-	13.9	2.2	-	-	1.7
Refrigeration equipment	6.3	0.9	-	-	6.6	0.9	-	-	1.0
Walk-in coolers and freezers	14.7	3.4	-	-	14.7	3.4	-	-	2.4
Unit heaters	-	-	58.1	-	-	-	119.3	-	1.2
Urinals	-	-	-	6.6	-	-	-	13.6	-
Commercial total	*62.4*	*15.5*	*74.2*	*42.4*	*98.5*	*24.5*	*139.9*	*55.9*	*13.4*
Lighting:									
Candelabra & intermediate base incandescent lamps	8.0	0.2	-	-	8.0	5.7	-	-	1.3
General service fluorescent lamps	6.9	1.7	-	-	6.9	1.7	-	-	1.1
HID lamps	2.9	1.0	-	-	-	-	-	-	0.4
Incandescent reflector lamps	20.2	5.0	-	-	20.2	5.0	-	-	3.9
Luminaires (portable light fixtures)	0.2	0.0	-	-	-	-	-	-	0.0
Metal halide lamp fixtures	2.2	0.7	-	-	4.3	1.4	-	-	0.5
Outdoor lighting fixtures	10.3	0.7	-	-	26.1	1.8	-	-	2.3
Lighting total	*50.8*	*9.3*	-	-	*65.6*	*15.6*	-	-	*9.5*
TOTAL:	212	42	126	287	306	67	235	425	41.9

Figure 7 illustrates how standards can help curb the growth of U.S. electricity consumption. By 2025, savings from the standards analyzed in this report would reduce projected U.S. electricity consumption by 5%. By 2035, the percentage climbs to 7%. Put another way, nearly half of the projected increase in electricity consumption between now and 2035 could be met by the savings from new standards. (The figure also reproduces the estimates of U.S. electricity consumption without existing standards presented in Figures 1 and 5.)

Figure 7. Projected U.S. Electricity Consumption Compared to Projections without Existing Standards and with Potential New Standards

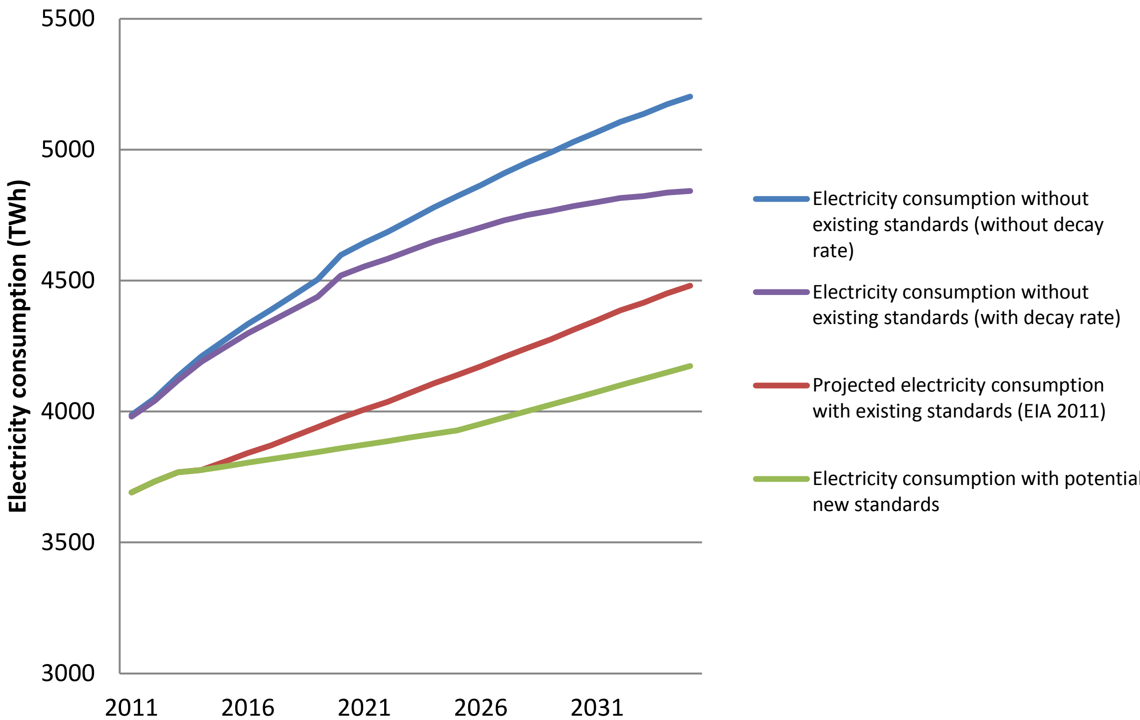


Table 8 shows the the estimated annual utility bill savings in 2025 and 2035 (i.e., savings in that year alone) for each individual product, as well as the cumulative present value of costs, savings, and net benefits. The present value of costs represents the cumulative incremental cost of more efficient products relative to baseline products, discounted to 2011. The present value of benefits represents consumer and business energy, water, and wastewater bill savings due to stronger standards for all products, also discounted to 2011. Net present value is the difference between the present value of benefits and costs. The analysis covers products purchased between the implementation date and the end of 2035. Our estimate of NPV likely underestimates the potential economic benefit of future standards since we have not incorporated learning rates to account for observed declines in real prices over time.

Key results shown in Table 8 include the following:

- Nearly one-third of the bill savings and NPV benefits shown in Table 8 are attributable to standards due for completion by January 2013—a total of $61 billion in NPV.
- Standards adopted by 2015 could reduce consumers' and businesses' annual utility bills by $26 billion in 2025, growing to $38 billion by 2035.
- Twelve standards will each reduce consumer and business energy bills by at least a billion dollars a year by 2035.
- The largest net present value savings would come from clothes washers ($16 billion), outdoor lighting ($14 billion), air handlers ($14 billion), set-top boxes ($12 billion), and incandescent reflector lamps ($11 billion). These five products would deliver 40% of the potential net present value benefits of new standards.

Table 8. Potential Economic Savings from Future Standards

Product	Annual bill savings (million 2010$)		Purchases through 2035		
	in 2025	in 2035	Present value of costs (million 2010$)	Present value of savings (million 2010$)	Net present value (million 2010$)
Residential:					
Air handlers	$1,573	$3,331	$4,748	$18,740	$13,992
Battery chargers	$721	$721	$6,091	$7,061	$969
Boilers (nat. gas)	$158	$446	$1,245	$2,679	$1,434
Clothes washers	$2,010	$2,680	$3,355	$19,246	$15,891
Computer equipment and components	$1,348	$1,348	$0	$8,608	$8,608
Dishwashers	$445	$445	$1,076	$3,852	$2,777
External power supplies	$575	$575	$3,253	$5,558	$2,305
Faucets (residential lavatory)	$413	$847	$332	$5,692	$5,360
Game consoles	$910	$910	$0	$5,263	$5,263
Microwave ovens	$267	$267	$392	$2,145	$1,753
Set-top boxes & digital communication equipment	$1,679	$1,679	$0	$11,586	$11,586
Televisions	$1,082	$1,139	$0	$8,260	$8,260
Toilets	$312	$640	$0	$4,303	$4,303
Water heaters	$2,087	$4,933	$18,886	$23,807	$4,921
Residential total	*$13,580*	*$19,962*	*$39,379*	*$126,803*	*$87,424*
Commercial/Industrial:					
Air conditioners, air-cooled	$563	$993	$3,526	$5,953	$2,426
Automatic ice makers	$356	$356	$147	$2,675	$2,528
Clothes washers	$148	$210	$488	$1,277	$788
Distribution transformers	$1,112	$2,283	$6,366	$16,708	$10,342
Electric motors	$609	$1,251	$2,284	$8,405	$6,121
Fans, blowers & ventilation equipment	$211	$575	$592	$2,659	$2,067
Furnaces, commercial warm-air	$38	$70	$215	$434	$219
Pre-rinse spray valve	$274	$274	$0	$2,225	$2,225
Pumps	$593	$936	$5,020	$6,081	$1,061
Refrigeration equipment	$640	$674	$2,086	$4,886	$2,799
Walk-in coolers and freezers	$1,495	$1,495	$2,600	$11,727	$9,127
Unit heaters	$533	$1,094	$5,512	$6,846	$1,334
Urinals	$46	$95	$0	$637	$637
Commercial total	*$6,618*	*$10,306*	*$28,838*	*$70,514*	*$41,676*
Lighting:					
Candelabra & intermediate base incandescent lamps	$917	$917	$629	$5,888	$5,259
General service fluorescent lamps	$709	$709	$2,995	$5,285	$2,290
HID lamps	$299	$0	$1,666	$4,193	$2,527
Incandescent reflector lamps	$2,314	$2,314	$8,936	$20,204	$11,267
Luminaires (portable light fixtures)	$27	$0	$21	$134	$114
Metal halide lamp fixtures	$224	$438	$709	$2,894	$2,185
Outdoor lighting fixtures	$1,179	$2,993	$2,005	$16,283	$14,278
Lighting total	*$5,669*	*$7,371*	*$16,960*	*$54,881*	*$37,920*
TOTAL:	$25,868	$37,639	$85,177	$252,197	$167,020

Table 9 shows the annual avoided emissions from new and updated standards in 2025 and 2035. The energy savings from standards result in fewer emissions from power plants and direct combustion of fossil fuels by appliances. Reductions in NO_x and SO_2 reduce the cost of meeting air quality goals designed to protect public health and the environment while reductions in CO_2 emissions help address climate change. Key results shown in Table 9 include the following:

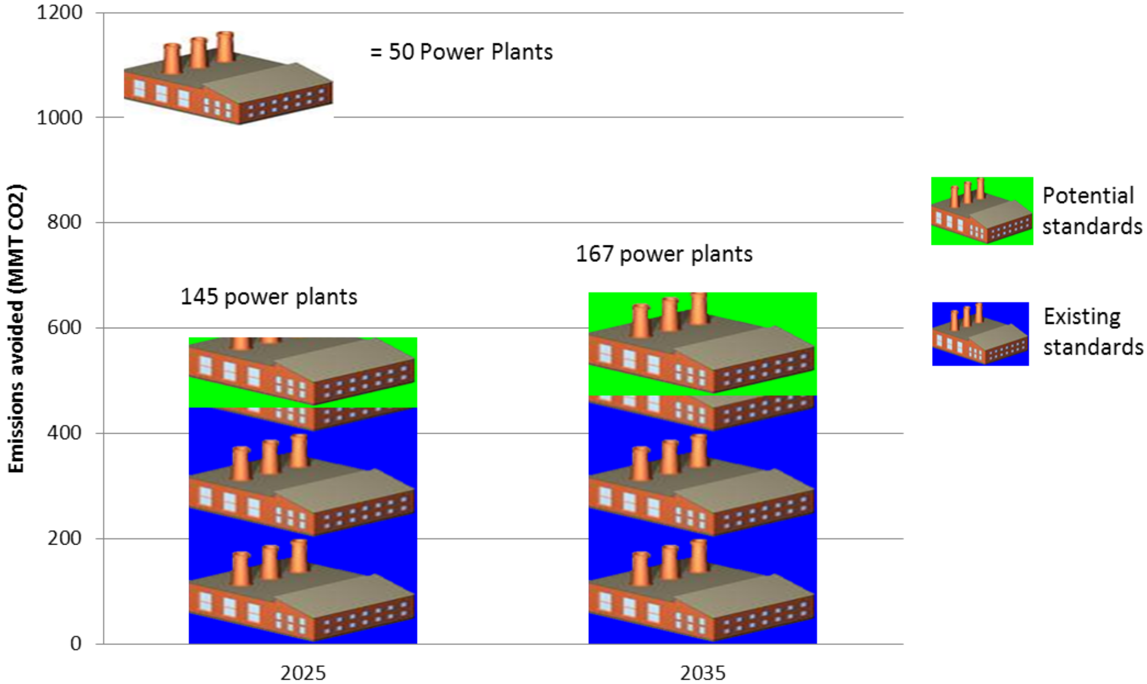
- The largest emissions reduction potential comes from standards delivering the largest electricity savings—electric water heaters, incandescent reflector lamps, outdoor lighting, distribution transformers, and air handlers. These five products would deliver more than one-third of the total CO_2 reductions in 2035.
- Six product standards would each generate at least 10 million metric tons of CO_2 savings annually by 2035.

Table 9. Potential Emissions Reductions from Future Standards

Product	Emissions Reductions in Year 2025			Emissions Reductions in Year 2035		
	CO_2 (MMT)	NOx (1000 MT)	SO_2 (1000 MT)	CO_2 (MMT)	NOx (1000 MT)	SO_2 (1000 MT)
Residential:						
Air handlers	8.3	6.3	13.0	17.4	12.8	24.6
Battery chargers	3.8	2.9	5.9	3.8	2.8	5.3
Boilers (nat. gas)	0.7	0.6	0.0	2.1	1.7	0.0
Clothes washers	4.5	3.5	5.0	6.0	4.5	6.0
Computer equipment and components	7.1	5.4	11.1	7.0	5.2	10.0
Dishwashers	1.7	1.3	2.5	1.7	1.3	2.2
External power supplies	3.0	2.3	4.7	3.0	2.2	4.2
Faucets (residential lavatory)	1.2	1.0	1.2	2.6	1.9	2.2
Game consoles	4.8	3.7	7.5	4.8	3.5	6.7
Microwave ovens	1.4	1.1	2.2	1.4	1.0	2.0
Set-top boxes & digital communication equipment	8.8	6.8	13.8	8.8	6.4	12.4
Televisions	5.7	4.4	8.9	6.0	4.4	8.4
Toilets	0.0	0.0	0.0	0.0	0.0	0.0
Water heaters	11.0	8.4	17.2	25.8	18.9	36.4
Residential total	*62.1*	*47.6*	*93.1*	*90.3*	*66.5*	*120.5*
Commercial/Industrial:						
Air conditioners, air-cooled	3.3	2.5	5.2	5.8	4.3	8.2
Automatic ice makers	1.9	1.4	3.0	1.9	1.4	2.6
Clothes washers	0.23	0.2	0.2	0.3	0.2	0.2
Distribution transformers	6.6	5.0	10.3	13.4	9.8	18.9
Electric motors	5.4	4.2	8.5	11.1	8.2	15.7
Fans, blowers & ventilation equipment	1.9	1.4	3.0	5.1	3.8	7.2
Furnaces, commercial warm-air	0.2	0.2	0.0	0.4	0.3	0.0
Pre-rinse spray valve	1.0	0.8	0.8	1.0	0.7	0.7
Pumps	5.3	4.1	8.3	8.3	6.1	11.7
Refrigeration equipment	3.8	2.9	5.9	4.0	2.9	5.6
Walk-in coolers and freezers	8.8	6.8	13.9	8.8	6.4	12.4
Unit heaters	3.1	2.4	0.02	6.3	5.0	0.03
Urinals	0.0	0.0	0.0	0.0	0.0	0.0
Commercial total	*41.5*	*31.9*	*59.0*	*66.4*	*49.1*	*83.4*
Lighting:						
Candelabra & intermediate base incandescent lamps	4.8	3.7	7.6	4.8	3.5	6.8
General service fluorescent lamps	4.2	3.2	6.6	4.2	3.1	5.9
HID lamps	1.8	1.4	2.8	0.0	0.0	0.0
Incandescent reflector lamps	12.2	9.3	19.1	12.1	8.9	17.1
Luminaires (portable light fixtures)	0.1	0.1	0.2	0.0	0.0	0.0
Metal halide lamp fixtures	1.3	1.0	2.1	2.6	1.9	3.6
Outdoor lighting fixtures	6.2	4.7	9.7	15.6	11.5	22.1
Lighting total	*30.6*	*23.4*	*48.0*	*39.3*	*28.8*	*55.5*
TOTAL:	134.2	103.0	200.2	196.0	144.5	259.3

Figure 8 converts the total potential CO_2 reductions into power plant equivalents. The CO_2 reductions in 2025 are roughly equal to the emissions of 34 average coal-fired power plants. Savings from new standards would grow to an amount equal to the emissions of 49 coal plants by 2035. As shown in the figure these savings would add considerably to the CO_2 reductions already achieved by existing standards.

Figure 8. CO_2 Reductions from Existing and Potential Standards in Equivalent Number of Coal-Fired Power Plants



Note: This figure assumes an average coal power plant as calculated by the EPA (see http://www.epa.gov/cleanenergy/energy-resources/efs.html#coalplant).

SECTION 4. CONSUMER IMPACTS

Above we have reported the national impacts for each of the products analyzed. This section illustrates the impacts for typical consumers and businesses. Table 10 provides key assumptions concerning the impact of new standards on a product's price (incremental cost) and the annual energy savings. These variables are the basis for determining the cost-effectiveness of new standards for typical purchasers. The last columns in Table 10 report the benefit-cost ratio and average simple payback period for each product.

Table 10. Consumer Economics

Product	Incremental cost	Annual Per-Unit Savings			B/C ratio	Payback period (years)
		Electricity	Gas	Water		
Residential:						
Air handlers	$150	$ 63.49			3.9	2.8
Battery chargers	$4	$ 1.35			1.2	2.8
Boilers (nat. gas)	$900		$ 145.17		2.2	6.2
Clothes washers	$57	$ 8.82	$ 4.15	$ 21.34	5.7	1.7
Computer equipment and components	$0	$ 7.30			no cost	-
Dishwashers	$20	$ 5.50	$ 0.67	$ 2.05	3.6	2.4
External power supplies	$1	$ 0.46			1.7	2.1
Faucets (residential lavatory)	$4	$ 1.83	$ 1.23	$ 2.04	17.1	0.8
Game consoles	$0	$ 8.84			no cost	-
Microwave ovens	$2	$ 1.82			5.5	1.3
Set-top boxes & digital communication equipment	$0	$ 9.51			no cost	-
Televisions	$0	$ 6.96			no cost	-
Toilets	$0			$ 5.57	no cost	-
Water heaters	$814	$ 114.26			1.3	7.1
Residential average					*3.1*	*3.3*
Commercial/Industrial:						
Air conditioners, air-cooled	$1,212	$ 205.22			1.7	5.9
Automatic ice makers	$70	$ 190.76		$ 41.70	18.2	0.3
Clothes washers	$351	$ 13.29	$ 17.59	$ 86.94	2.6	3.0
Distribution transformers	$588	$ 105.64			2.6	5.6
Electric motors	$207	$ 85.99			3.7	3.6
Fans, blowers & ventilation equipment	$1,410	$ 966.32			4.5	2.2
Furnaces, commercial warm-air	$300		$ 54.74		2.0	5.5
Pre-rinse spray valve	$0	$ 60.69	$ 64.80	$ 77.18	no cost	-
Pumps	$791	$ 145.25			1.2	8.2
Refrigeration equipment	$483	$ 152.29			2.3	3.2
Walk-in coolers and freezers	$725	$ 439.82			4.5	1.6
Unit heaters	$2,640		$ 262.26		1.2	10.1
Urinals	$0			$ 16.38	no cost	-
Commercial average					*4.1*	*4.5*
Lighting:						
Candelabra & intermediate base incandescent lamps	$0	$ 6.09			9.4	1.0
General service fluorescent lamps	$1	$ 0.34			1.8	2.5
HID lamps	$18	$ 53.52			2.5	0.4
Incandescent reflector lamps	$3	$ 4.17			2.3	0.7
Luminaires (portable light fixtures)	$2	$ 2.53			6.5	0.6
Metal halide lamp fixtures	$17	$ 6.20			4.1	3.1
Outdoor lighting fixtures	$40	$ 27.62			8.1	1.4
Lighting average					*5.4*	*1.5*
AVERAGE:					4.1	3.3

Key results from Table 10 include the following:

- For many products, the incremental cost to meet the potential standard level is very low or even zero. For other products, the incremental cost is significant. In all cases, however, the incremental cost is paid back through the savings well within the lifetime of the affected product. The potential standards for all the products are cost-effective, as indicated by a benefit/cost (B/C) ratio of 1 or higher.
- Overall, the savings from new standards outweigh the incremental upfront costs by a ratio of 4.1 to 1. Setting aside those products with no incremental cost, benefit cost ratios range from a low of 1.2 (unit heaters, battery chargers, and pumps) to a high of 18 (automatic ice makers).
- The average simple payback is 3.3 years—in other words, on average, the additional upfront cost is earned in lower utility bills in 3.3 years. Simple paybacks range from zero years (for standards with no incremental costs) to ten years for some long-lived products such as unit heaters.
- A few products (electric water heaters, boilers, unit heaters) have large incremental costs relative to the price of a baseline product. Although each of these standards is cost-effective as indicated by a benefit/cost ratio greater than 1, it may be difficult to advance these new standards if incremental costs do not fall because of the upfront cost impacts.

Consumer Impacts: A Household Example

Appliance standards have saved consumers significant amounts of money on their utility bills. To illustrate, we looked at a typical scenario of a household replacing its major appliances every 15 years,[10] and estimated the impacts of standards in terms of energy and water savings and utility bill savings.

For the purposes of this illustration, we envisioned a family buying a house that was built in 1980, including the appliances that had been in the house since it was built: a refrigerator, oven, clothes washer, dishwasher, incandescent light bulbs, gas furnace, electric water heater, and central air conditioning. In 1995 when the family moves in, they decide to replace all of those appliances—whether by choice or because some of the appliances reached the end of their life. The appliances were replaced again in 2010, and we'll expect them to get replaced one more time around 2025, by which point new standards for each product will have gone into effect. In each of those intervals, standards have been increased for most of these appliances, so they will be saving energy (and water in the case of clothes washers and dishwashers). This scenario approximates the real-life scenarios that most U.S. households experience, though more neatly categorized into precise replacement intervals. In order to estimate the impacts, we modeled the following products.

Refrigerators
The first national standards for refrigerators went into effect in 1990 and were revised in 1993. (California's standards went into effect much earlier and were voluntarily complied with nationally.) From 1980 to 1995, the average energy use of refrigerators dropped by nearly half. We assumed that a top-mount refrigerator (which has the freezer on top) would be purchased in 2025 since top-mounts make up the largest portion of sales (the previous replacements were modeled based on an average of all refrigerator models).

Ranges
Ranges received their first standards in 1990. The standard specified that gas ranges could no longer use a standing pilot light. This simple change alone resulted in a 30% decrease in energy

[10] A 15-year lifespan is about average for the appliances listed here. Some of the white goods (dishwasher, refrigerator) tend to have slightly shorter lifespans, while the HVAC equipment (furnaces, AC) have longer lifespans.

consumption. Although the standards have not been updated since then, a small change such as decreasing standby power to 1 W could save a bit more energy for the 2025 replacement.

Clothes washers
Clothes washers have undergone several standards updates since the first standards went into effect in 1988. We assumed that top-loading models would be purchased in 1980 and 1995, and front-loading models in 2010 and 2025. Front-loading models were a niche product in the U.S. before 2000, and tended to be expensive. Today's front-loaders have come down in price and offer increased amenity as well as significant energy and water savings.

Dishwashers
Dishwashers have seen major energy and water efficiency increases since the 1980s. The average dishwasher in the 1980s used an average of 8 to 14 gallons of water per cycle; the standard analyzed in this report would require that no more than 5 gallons per cycle be used. As with clothes washers, this reduction in water use translates to major energy savings; the less water used, the less water that needs to be heated.

Light bulbs
Although lighting technology has greatly advanced since the 1980s, 62% of all residential lights are still incandescent. Starting in 2014, the average 60 W bulb will be required to be about 28% more efficient, and 72% more efficient in 2020. We assumed that this household replaces its 22 incandescent bulbs (national average) with more efficient bulbs that just meet the standards.

Central air conditioners
The first central air conditioner standards went into effect in 1992. Today's air conditioners are nearly twice as efficient as units sold in the 1980s.

Water heaters
The first national standards for water heaters went into effect in 1990. We modeled an electric storage water heater, which we expect will be replaced by a heat pump water heater in 2025.

Furnaces
Furnace standards first went into effect in 1992. Furnaces that just meet today's standards are about 18% more efficient than an average furnace sold in 1980. We modeled a standard gas furnace and assumed it would be replaced by a condensing gas furnace in 2025.

For the purposes of this illustration, we have not estimated the incremental cost of the affected products. Net savings will be lower than the gross estimates below. However, as shown in Section 1, existing standards are very cost-effective for consumers. In some cases, real prices have declined even as new standards have taken effect.

FINDINGS

Water and energy savings per household
The water and energy savings over this 45-year period are substantial. This typical household would save over 180 MWh of electricity and over 200,000 gallons of water. Absent standards, this typical household's electricity use over this period would have been about 40% higher. The water savings would fill one-third of an Olympic-size swimming pool.

Table 11 shows the energy and water bill savings (as compared to the 1980 version of each product) through three replacement cycles, from 1995 through 2040.

Table 11. Water and Energy Bill Savings for an Example Household (2010$)

	1995 - 2010	2010 - 2025	2025 - 2040	Total
Fridge	$ 1,200	$ 1,500	$ 1,800	$ 4,400
Range (oven + cooktop)	$ 230	$ 230	$ 260	$ 720
Clothes washer	$ 180	$ 960	$ 1,500	$ 2,600
Dishwasher	$ 300	$ 490	$ 640	$ 1,400
Central air conditioner	$ 1,600	$ 3,100	$ 3,600	$ 8,200
Water heater	$ 90	$ 310	$ 2,100	$ 2,500
Furnace	$ 2,500	$ 2,300	$ 4,600	$ 9,500
Lighting	$ -	$ 460	$ 1,100	$ 1,500
Total	$ 6,000	$ 9,400	$ 15,500	$ 30,900

Over the course of three rounds of appliance replacements, the typical family saves more than $30,000, or more than enough to cover nearly two years of mortgage payments for an average U.S. household.[11] These savings are conservative because this example does not include many other energy- and water-using products that also have been or will be affected by standards such as plumbing products, and power supplies and battery chargers for consumer electronics. Including the plumbing standards would increase water savings several-fold.

SECTION 5. COMPARISONS TO OTHER STUDIES

In this report we present estimates of savings from both existing standards and standards that could be adopted within the next four years. Here we compare our findings to three other analyses estimating energy savings from either existing or future appliance standards. In general, our estimates of energy savings are similar to the results of other studies after accounting for differences in scope and analysis period.

Meyers et. al. (2011) estimated savings from standards adopted through 2010. Our estimates of annual energy savings in 2010 (3.4 quads) and net consumer savings in 2010 ($27 billion) from existing standards are very similar to the respective Meyers et. al. estimates of 3.0 quads and $27 billion. However, our estimate of cumulative energy savings from existing standards is significantly higher than the Meyers et. al. estimate. We estimate that cumulative savings will reach more than 200 quads by 2035, while Meyers et. al. estimate cumulative savings through 2070 of 157 quads. Much of this difference is due to differences in the number of years of shipments included in the analyses. We estimate savings due to shipments through 2035 for all existing standards while Meyers et. al. used 20–30 years of shipments for each group of standards. Meyers et. al. assumes an increasing base case efficiency, which corresponds to our "alternate scenario" where we apply a decay rate. We estimate cumulative energy savings through 2035 of 162 quads in our "alternate scenario."

An Institute for Electric Efficiency (IEE) white paper (IEE 2011) estimated potential electricity savings from new and updated appliance and equipment efficiency standards under both a "moderate" and an "aggressive" scenario. Our estimate of annual electricity savings in 2025 from potential standards (212 TWh) is similar to IEE's estimate under their "moderate" scenario (228 TWh). In the residential sector, IEE found that standards for consumer electronics represent the largest potential savings (64 TWh in 2025 under the "moderate" scenario). We also found significant savings potential for electronics—we estimate total potential savings of 55 TWh in 2025 from standards for TVs, set-top boxes, computers, game consoles, battery chargers, and external power supplies, which represent about half of the savings potential for the residential sector. The IEE white paper also found significant potential savings from updated lighting standards in both the residential and commercial

[11] Average U.S. mortgage (including taxes and insurance), according to the 2010 U.S. Census (U. S. Census Bureau 2011)..

sectors. Our estimate of electricity savings in 2025 from potential lighting standards represents nearly one-quarter of our total potential electricity savings estimate for 2025.

Finally, EIA's *Annual Energy Outlook 2011* (EIA 2011) included an "Expanded Standards" case that illustrates the impact of potential future appliance standards on residential and commercial energy consumption. EIA estimates that future appliance standards based on ENERGY STAR specifications and FEMP guidelines could save 12 quads of site energy cumulatively through 2035. Most of the potential energy savings correspond to reductions in electricity consumption, which means that the EIA savings estimate expressed in terms of primary (rather than site) energy savings would be about 36 quads. Our cumulative primary energy savings estimate of about 42 quads is higher than the EIA estimate. This difference is due in part to differences in the scope of the standards included in the analyses. Our savings estimate includes potential standards for distribution transformers and products primarily used in the industrial sector including electric motors, pumps, and fans, which are not included in the EIA analysis. We estimate cumulative savings from potential standards for these products to be 6 quads. Our savings estimate also includes potential standards for products for which there is currently no ENERGY STAR specification, including air handlers and outdoor lighting. However, the EIA analysis also includes products that are not included in our savings estimate including copiers, fax machines, and printers.

SECTION 6. PRODUCT DISCUSSIONS

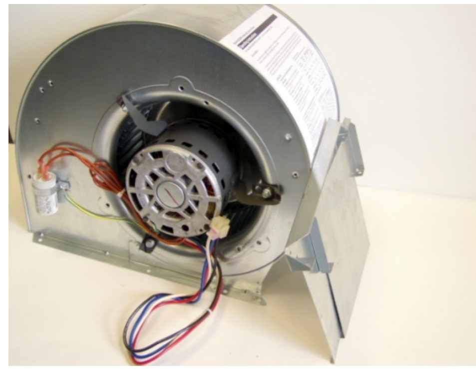
This section provides brief discussions for each of the products evaluated. We describe the product, current standards, key market data, the standard level evaluated and the potential national benefits from adopting the new standard. For products subject to existing national or state standards, we show the years the current standard was enacted or adopted and took effect. We also show the potential adoption and effective dates for new national standards. Appendix A lists more detailed assumptions for each product, as well as the general methodology used.

For products that are not subject to existing national standards (and, therefore, not subject to federal preemption), it is reasonably likely that one or more states will consider and potentially adopt standards prior to completion of national standards. State standards can be completed and made effective more quickly than national standards because state decision-making processes can often move more quickly and because the federal law which specifies relatively long lead times between a standard's publication and effective date does not apply. State-by-state benefits for each of the evaluated standards are available at http://www.appliance-standards.org/map/benefits-from-federal. This includes estimates based on both the potential federal effective dates and the earlier potential state effective dates. In the product discussions below, we only report potential national standards' benefits.

Residential

Air Handlers

<u>Product description:</u>
Air handlers are electrical devices that circulate air heated by the furnace or heat pump through a home's duct system into the living space. For homes with central air conditioning, the air handler also serves to circulate air during the cooling season. The terms "furnace fan" and "air handler" can be used interchangeably. An air handler consists of a fan and motor, housing, controls, and other necessary elements.



<u>Key statistics:</u>
- Annual shipments: 3.9 million
- Current standard: No national or state standards

<u>Potential standard:</u>
Most air handlers currently employ permanent split capacitor (PSC) motors. We analyzed a standard level based on the use of brushless permanent magnet (BPM) motors, also known as electronically-commutated motors (ECMs). BPM motors are able to achieve high efficiencies at multiple operating speeds. We estimate that a BPM motor can reduce the power consumption of an air handler by about 60% in heating mode and 35% in cooling mode.[12] For a typical household, the additional cost of a high efficiency air handler (about $150) would be paid back in lower utility bills within three years. There is some evidence to suggest that high static pressure in some homes' duct systems would erode the potential savings from high efficiency air handlers.
  - Status: DOE rulemaking underway; framework document published in June 2010.
  - Estimated DOE final rule: 2013
  - Estimated DOE effective date: 2017
- Annual savings in 2035: 29 TWh
- Net present value savings: $14 billion

Battery Chargers

<u>Product description:</u>
A battery charger is a device that charges batteries for consumer or non-consumer products, including battery chargers embedded in other products. Examples of consumer battery chargers include chargers for cordless phones, cellular phones, power tools and laptops. Non-consumer battery chargers include chargers for two-way radios, emergency backup lighting, and lift trucks. (This report does not include evaluation of potential standards for electric passenger vehicle battery chargers.)

<u>Key statistics:</u>
- Annual shipments: 310 million
- Current national standard level: none
- Current CEC standard: For small battery chargers, there are two requirements: (1) a limit for 24-hour

[12] Pigg 2003.

charge and maintenance energy based on battery capacity, and (2) a 1 W (plus an allowance for battery capacity) limit for the sum of maintenance and no-battery mode power; for industrial chargers, there are requirements for charge return factor, power conversion efficiency, power factor, maintenance mode power, and no-battery mode power

- Year CEC standard adopted/effective: 2012/2013 for consumer chargers; 2012/2014 for industrial chargers

Potential standard:
DOE has authority to set standards for consumer battery chargers. We analyzed the standard levels in the DOE preliminary analysis published in September 2010 for consumer battery chargers that represent the minimum life-cycle cost point. On average, the standard levels represent energy savings of about 60% relative to baseline products and can be achieved using switched-mode rather than linear power supplies, improved charge control circuitry, and limiting power when the battery is full or no battery is present. Lower electricity bills would cover the typical incremental cost for more efficient battery chargers (about $4) within three years. California completed state-level standards for both consumer and non-consumer battery chargers in January 2012 which will take effect in 2013 for consumer chargers and 2014 for industrial chargers. California standards for consumer chargers will be preempted once national standards go into effect, but state standards for non-consumer chargers will remain in effect. We have not analyzed standards for non-consumer battery chargers for this report. State standards for non-consumer chargers would achieve additional savings.

- Status: DOE rulemaking underway; preliminary analysis published in September 2010; California standards adopted January 2012 and effective February 2013 for consumer chargers and January 2014 for industrial chargers
  - Estimated DOE final rule: 2012
  - Estimated DOE effective date: 2014
- Annual energy savings in 2035: 6.3 TWh
- Net present value savings: $970 million

Boilers, Natural Gas

Product description:
Boilers heat water that is then used to heat a home using a hot water or steam distribution system. The technology used for steam boilers is the same as for hot-water boilers, except that circulating pumps are not used in steam boilers. Boiler capacities range greatly, but they tend to be higher than furnace capacities. The efficiency metric used to rate boilers is AFUE (annual fuel utilization efficiency), and refers to the rate at which fuel is converted to useful energy.

Key statistics:

- Annual shipments: 0.23 million
- Current national standard: 80% AFUE for steam; 82% AFUE for hot water plus prescriptive requirements
- Year current standard adopted/effective: 2007/2012

Potential standard:
We analyzed a standard level based on condensing boilers with advanced controls. Condensing technology is used to condense water out of flue gases to recoup heat to warm the home that would otherwise be vented up the chimney. We looked at a case study of several different commercial boiler retrofits that achieved around 50% savings at this standard level and extrapolated the savings potential to residential equipment. We estimate that approximately 20% savings can be achieved for this standard level.[13] The potential savings of switching to condensing technology are not fully captured in the current test procedure; it would indicate that condensing technology only results in

[13] In case studies, the smaller the application, the less savings were achieved.

approximately 11% savings, when in fact the ability to operate at much lower temperatures results in much greater savings. Based on high incremental upfront costs, we did not evaluate potential savings for circulating pumps. Lower gas bills would cover the typical incremental cost for more efficient boilers (about $900) within seven years.

- Status: DOE rulemaking not yet begun.
  - Estimated DOE final rule: 2015
  - Estimated DOE effective date: 2020
- Annual savings in 2035: 40 trillion Btu
- Net present value savings: $1.4 billion

Clothes Washers

<u>Product description:</u>
For the purposes of standards, clothes washers are defined by type: front-loading or top-loading; and by capacity: standard or compact.

<u>Key statistics:</u>

- Annual shipments: 9.5 million
- Current national standard: 1.26 modified energy factor (MEF); 9.5 water factor (WF)
- Year current standard adopted/effective: 2001/ 2007; water factor requirement added effective 2011

<u>Potential standard:</u>
We analyzed standard levels for top-loading and front-loading clothes washers based on the standard levels in a consensus agreement negotiated by manufacturers and efficiency proponents in 2010. The consensus agreement contains two tiers for top-loading washers: 1.72 MEF/8.0 WF effective in 2015 and 2.0 MEF/6.0 WF effective in 2018; and a single standard of 2.2 MEF/4.5 WF for front-loading washers effective in 2015. For top-loading washers, the tier 2 standards will yield 35% energy and water savings relative to a baseline washer. Front-loader savings will be 18% for energy and 40% for water. Key technologies for improved efficiency include improved fill and temperature controls, new drum designs and higher spin speeds. Lower utility bills would cover the typical incremental cost for more efficient clothes washers (about $57) within two years.

- Status: DOE rulemaking underway; analysis published in May 2010
  - Estimated DOE final rule: 2012
  - Estimated DOE effective date: 2015
- Annual savings in 2035:
  - Electricity: 7 TWh
  - Natural gas: 34 trillion Btu
  - Water: 214 billion gallons
- Net present value savings: $15.9 billion

Computer Equipment

Product description:
Computer equipment is a broad category that includes laptop computers, desktop computers, and desktop computer monitors.

Key statistics:
- Annual shipments: 27 million desktops, 66 million laptops, 43 million monitors
- Current standard level: No national or state standards

Potential standard:
Although there is not currently a national standard for computers and monitors, there are ENERGY STAR specifications for these products. We analyzed standard levels based on the ENERGY STAR version 5.0 specifications. Computers meeting ENERGY STAR 5.0 save up to 65% compared to the least efficient new products. Typical improvements to achieve these savings include improved power management and more efficient individual components. There are no known incremental costs associated with more efficient computers. A national standard is unlikely prior to 2019 due to lead times built into federal law. We did not evaluate standards for servers, which would add considerable savings.

- Status: DOE issued a request for information in early 2012; proposed by stakeholders for consideration in the next California Energy Commission docket.
    - Estimated CEC final rule: 2013
    - Estimated CEC effective date: 2014
    - Estimated DOE final rule: 2014
    - Estimated DOE effective date: 2019
- Annual savings in 2035: 11.8 TWh
- Net present value savings: $8.6 billion

Dishwashers

Product description:
Dishwashers are categorized as either standard capacity (most units sold) or compacts.

Key statistics:
- Annual shipments: 7.9 million
- Current national standard level: 355 kWh/year and 6.5 gallons/cycle
- Year current standard adopted/effective: 2007/ 2010

Potential standard:
We analyzed a standard level of 307 kWh/year and 5.0 gallons/cycle (222 kWh/yr; 3.5 gal/cycle for compact units) in accordance with a consensus agreement negotiated by manufacturers and efficiency proponents in 2010. This standard saves about 50 kWh per year (14%) compared to products just meeting the current standard. This improvement is possible through technological advances that allow for less water and energy use. Lower utility bills would cover the typical

incremental cost for more efficient dishwashers (about $20) in two years. For our analysis, we use the effective date of 2013 contained in the consensus agreement.

- Status: DOE rulemaking underway
  - Estimated DOE final rule: 2012
  - Estimated DOE effective date: 2013
- Annual savings in 2035:
  - Electricity: 2.6 TWh
  - Natural gas: 3.2 trillion Btu
  - Water: 16 billion gallons
- Net present value savings: $2.8 billion

External Power Supplies

<u>Product description:</u>
External power supplies are the small black boxes attached to the cord of many small or portable electronic devices such as cordless phones, cell phones, computer speakers, telephone answering machines, and laptop computers. Power supplies convert AC supply voltage (around 120 volts in the United States) to lower AC or DC voltages on which many electronic products operate.

<u>Key statistics:</u>

- Annual shipments: 300 million
- Current national standard level: Active mode minimum efficiency requirements based on nameplate output:
  - For <1 W, minimum efficiency = 0.5 x (nameplate output)
  - For 1–51 W, minimum efficiency = 0.09 x ln (nameplate output) + 0.5
  - For >51 W, minimum efficiency = 0.85
  - No-load mode maximum power consumption is 0.5 W
- Year current standard adopted/effective: 2007/2008

<u>Potential standard:</u>
We analyzed the standard levels in the DOE preliminary analysis published in September 2010 that represent the minimum life-cycle cost. On average, the standard levels represent energy savings of about 50% relative to the current standards. Technical improvements which can help meet this level include improved transformers, low-power integrated circuits, and low-loss transistors. Based on the DOE analysis, products meeting this level cost about $1 more and, based on national average energy prices, the additional cost will be paid back in lower energy bills in two years.

- Status: DOE rulemaking underway; preliminary analysis published in September 2010.
  - Estimated DOE final rule: 2012
  - Estimated DOE effective date: 2014
- Annual savings in 2035: 5 TWh
- Net present value savings: $2.3 billion

Faucets

<u>Product description:</u>
The residential faucets considered here include bathroom faucets and replacement aerators. A faucet controls and directs the flow of water.

<u>Key statistics:</u>

- Annual shipments: 17 million
- Current standard levels: 2.2 gallons per minute nationally; 1.5 gpm for Georgia
- Year current standard adopted/effective: 1992/1994 for the national standard; 2010/2012 for the Georgia standard.

<u>Potential standard:</u>
In December 2010, DOE waived federal preemption of the 2.2 gallon-per-minute (gpm) national standard enacted by Congress in 1992. This waiver of federal preemption allows states to set standards provided that they are stronger than the national standard. We analyzed the WaterSense efficiency level for residential faucets, which is 1.5 gallons per minute (gpm) (about 30% savings), and which is also the standard level adopted by Georgia. The potential energy savings include reduced water heater energy use for the portion of faucet use that is hot water. The savings listed here assume current water heater efficiencies. If the water heater standards analyzed in this report are adopted, this would reduce the energy savings from new faucet standard. The water savings, however, would not change. Lower utility bills would cover the typical incremental cost for more efficient faucets (about $4) within ten months.

- Status: DOE Request for Information (RFI) issued in September 2011; one state standard adopted
  - Estimated state final rule: 2013
  - Estimated state effective date: 2014
  - Estimated DOE final rule: 2013
  - Estimated DOE effective date: 2016
- Annual savings in 2035:
  - Electricity: 2.7 TWh
  - Natural gas: 18 trillion Btu
  - Water: 48 billion gallons
- Net present value savings: $5.4 billion

Game Consoles

<u>Product description:</u>
Video game consoles include set-top-box-style video game units, but exclude handheld video game devices. The three products that dominate the market are Sony Playstation, Microsoft Xbox, and Nintendo Wii.

<u>Key statistics:</u>

- Annual shipments: 21 million
- Current standard level: No national or state standards

Potential standard:
Although DOE currently has no plans to set standards for video game consoles, significant per-unit savings (around 80 kWh annually) could be achieved by implementing several simple measures outlined in a study conducted by NRDC. One of these measures ensuring that the game system enters a low-power mode when not in use—would achieve the substantial majority of the potential savings. There is no known incremental cost to meet this standard, so savings would be seen by consumers immediately. Status: DOE issued a request for information in early 2012; proposed by stakeholders for consideration in the next California Energy Commission docket.

- Status:
    - Estimated CEC final rule: 2013
    - Estimated CEC effective date: 2014
    - Estimated DOE final rule: 2015
    - Estimated DOE effective date: 2020
- Annual savings in 2035: 8 TWh
- Net present value savings: $5.3 billion

Microwaves

Product description:
Microwave ovens cook or heat food and beverages by converting electricity to microwave radiation to heat water molecules within the substance.

Key statistics:

- Annual shipments: 16 million
- Current standard level: No national or state standards

Potential standard:
We analyzed a standard setting a 1 watt limit on standby power consumption, which can be achieved by incorporating a zero-standby cooking sensor and using a switch mode power supply that incorporates solid-state relays. DOE's February 2012 proposed rule includes a 1W standby power requirement for most microwaves. This would save approximately 16 kWh/year. A final standard is due later in 2012. Lower electricity bills would cover the typical incremental cost (about $2) within fifteen months.

- Status: DOE proposed rule issued in February 2012.
    - Estimated DOE final rule: 2012
    - Estimated DOE effective date: 2015
- Annual savings in 2035: 2.3 TWh
- Net present value savings: $1.8 billion

Set-Top Boxes

Product description:
Set-top boxes is a category that, for the purposes of this report, is confined to cable and satellite boxes. These include digital cable boxes, multifunction DVRs, and satellite receivers. Recently there has been a trend toward products that combine multiple functions into one box. Most set-top boxes are placed into service by cable or satellite providers as part of their agreement with consumers.

Key statistics:

- Annual shipments: 35 million
- Current standard level: No national or state standards

Potential standard:
There are currently no standards for set-top boxes. DOE has initiated a rulemaking to develop standards. Potential savings of around 60% were identified in an NRDC study on set-top boxes, and included improving the efficiency of the internal power supply and implementing a low-power mode when not in use. There is not expected to be an incremental cost to achieve this standard.

- Status: DOE issued a Notice of Proposed Coverage Determination in June 2011 and a request for information in late 2011; stakeholders have proposed for consideration in the next California Energy Commission docket.
    - Estimated CEC final rule: 2013
    - Estimated CEC effective date: 2014
    - Estimated DOE final rule: 2013
    - Estimated DOE effective date: 2018
- Cumulative savings by 2035: 15 TWh
- Net present value savings: $12 billion

Televisions

Product description:
Televisions include products designed to receive and display audio-visual content from terrestrial, cable, satellite, Internet Protocol TV (IPTV), or other sources. TVs typically consist of a tuner or receiver and a display encased in a single enclosure. Traditional cathode-ray tubes (CRT) are, for the most part, no longer manufactured, having been replaced by flat panel technologies such as liquid crystal display (LCD) and plasma products.

Key statistics:

- Annual shipments: 41 million
- Current standard level: No national standard; CEC standard requires a maximum of 1 W standby power, and active mode power (W) less than or equal to 0.2 x (screen area) + 32 for televisions with a screen size smaller than 1,400 in^2.

Potential standard:
The ENERGY STAR version 5.3 standard for televisions was modeled as the potential standard. This standard uses a formula based on the screen size to determine how much energy a TV can use in active mode. It also includes a maximum cap on active mode energy use, regardless of size. However, we eliminated the cap for the purposes of a mandatory standard (and simply extended the formula used for larger televisions). This standard results in nearly 30% savings. There is not expected to be any incremental cost associated with this standard level.

- Status:
    - Estimated DOE final rule: 2013
    - Estimated DOE effective date: 2016
- Annual savings in 2035: 10 TWh
- Net present value savings: $8.3 billion

Toilets (residential)

Product description:
According to EPA, toilets (also known as water closets) are one of the primary users of water in the home, accounting for 30% of an average home's indoor water usage. In the U.S., there are an average of 1.9 toilets per home. This category covers tank-type toilets that are either gravity or pressure assist and either single- or dual-flush.

Key statistics:

- Annual shipments: 8.7 million
- Current standard levels: 1.6 gallons per flush (gpf) national; 1.28 gpf in some states
- Year current standard adopted/effective: 1992/1994 for the national standard; 2007-2010/2012-2014 for state standards.

Potential standard:
In December 2010, DOE waived federal preemption of the 1.6 gallon-per-flush (gpf) national standard enacted by Congress in 1992. This waiver of federal preemption allows states to set standards provided that they are more stringent than the national standard. Georgia, California, and Texas have adopted toilet efficiency standards that require products to use no more than 1.28 gpf. We analyzed toilet standards based on this 1.28 gpf level. Products meeting the 1.28 gpf level currently meet the qualifications for the EPA WaterSense[14] program. An update to the national standard would potentially have a later effective date. More efficient toilets are not expected to cost any more than toilets meeting the current standard.

- Status: DOE Request for Information (RFI) issued in September 2011; 3 states have adopted standards
    - Estimated state final rule: 2013
    - Estimated state effective date: 2014
    - Estimated DOE final rule: 2013
    - Estimated DOE effective date: 2016
- Annual savings in 2035: 92 billion gallons of water
- Net present value savings: $4.3 billion

[14] WaterSense is a program of the U.S. Environmental Protection Agency designed to encourage water efficiency through the use of a special label on consumer products. WaterSense is similar to ENERGY STAR; the former encourages water efficiency, the latter energy efficiency.

Water Heaters, Residential

Product description:
Residential water heaters are used primarily to provide hot water to residences for consumer use, appliances, and other functions. Water can be heated by electricity or gas. There are two main types of water heaters: typical heater/storage units and instantaneous water heaters.

Key statistics:

- Annual shipments: 3.5 million (electric water heaters only)
- Current national standard level: 0.90 EF for a typical 50-gallon electric storage water heater
- Year most recent standard adopted/effective: 2010/2015.

Potential standard:
DOE published a final rule in 2010 establishing new standards for residential water heaters that will go into effect in 2015. The standards in the 2010 final rule effectively require heat pump technology for large electric storage water heaters (>55 gallons). We analyzed standard levels that would effectively require heat pump technology for water heaters with storage volumes at or above 40 gallons. This standard would result in approximately 43% energy savings. Lower electricity bills would cover typical incremental cost for more efficient water heaters (about $800) in seven years. We did not analyze an increase in the gas water heater standard for this report, because, based on current information, condensing gas water heaters are not cost-effective for consumers. Tankless water heaters were not analyzed due to a lack of data available to verify savings.

- Status: DOE rulemaking not yet begun
  - Estimated DOE final rule: 2015
  - Estimated DOE effective date: 2020
- Annual savings in 2035: 43 TWh
- Net present value savings: $4.9 billion

Commercial

Air Conditioners and Heat Pumps (Air-Cooled)

Product description:
Commercial air-cooled central air conditioners (CACs) and heat pumps (HPs) reject heat to the atmosphere by blowing outside air over the condenser coil. Commercial CACs and HPs can either be "single package" systems, where the evaporator coil and the condensing unit are combined into a single physical unit, or "split systems," where the condensing unit is typically placed outdoors while the evaporator is indoors. Commercial CACs and HPs are often called roof-top units (RTUs) and are typically used for small- to mid-sized commercial buildings. RTUs may also contain a heating section.

Key statistics:

- Annual shipments: 0.5 million
- Current national standard level: Varies from 9.7 to 11.7 EER based on capacity and type of heating section

- Year current standard adopted/effective: 2005/2010

Potential standard:
The current standards for commercial air-cooled CACs and HPs are based on EER (energy efficiency ratio), which reflects full-load efficiency. We analyzed CEE's Tier 2 standard, which represents energy savings of about 9%. The incremental cost of $1,200 for an average-sized unit would have a payback period of less than 6 years.

- Status: DOE rulemaking not yet begun
    - Estimated DOE final rule: 2015
    - Estimated DOE effective date: 2017
- Annual savings in 2035: 9.7 TWh
- Net present value savings: $2.4 billion

Automatic Ice Makers

Product description:
Automatic commercial ice makers make and harvest ice and may include a means for storing and dispensing ice. They have a condensing unit and ice-making section operating as an integrated unit, and the condenser can either be air-cooled or water-cooled. Ice makers can be divided into two categories: batch type and continuous type. Batch-type ice-makers operate with alternate freezing and harvesting periods and include cube-type and tube-type machines. Continuous-type ice-makers continually freeze and harvest ice at the same time and primarily produce flake or nugget ice. Automatic commercial ice makers are typically found in hotels, restaurants, health care facilities, and educational settings.

Key statistics:

- Annual shipments (2015 projection): 0.25 million
- Current national standard level: Maximum energy use (kWh per 100 pounds of ice) varies based on equipment type, type of cooling, and harvest rate
- Year current standard adopted/effective: 2005/2010

Potential standard:
We analyzed standard levels based on the Consortium for Energy Efficiency's (CEE) Tier 2 standard. The CEE Tier 2 standard require that automatic ice makers use 10% less energy than an average unit. Lower utility bills would cover the typical incremental cost for more efficient ice makers (about $70) within four months.

- Status: DOE rulemaking underway; framework document published in November 2010.
    - Estimated DOE final rule: 2013
    - Estimated DOE effective date: 2016
- Annual savings in 2035:
    - Electricity: 3.1 TWh
    - Water: 5.3 billion gallons
- Net present value savings: $2.5 billion

Commercial Clothes Washers

Product description:
Commercial clothes washers (CCWs) are defined in EPAct 2005 as soft-mount, front-loading or soft-mount, top-loading washers, and have a clothes container compartment that is not more than 3.5 cubic feet for horizontal-axis clothes washers and not more than 4.0 cubic feet for vertical-axis clothes washers. EPAct 2005 also defines CCWs as products designed for applications in which the occupants of more than one household will be using the clothes washer, such as multi-family housing common areas, coin laundries, or other commercial applications.

Key statistics:

- Annual shipments: 0.18 million
- Current national standard level: Top-loading washers- 1.60 MEF / 8.5 WF
Front-loading washers- 2.00 MEF / 5.5 WF
- Year current standard adopted/effective: 2010/2013

Potential standard:
We analyzed a standard level of 2.20 MEF / 4.5 WF for all models (i.e., top- and front-loading washers) which corresponds to the standard level for residential front-loading clothes washers which will take effect in 2015. This would result in average savings of 27%, and the incremental cost of approximately $350 would be recouped within three years. Potential technology options for achieving this standard could include adaptive control systems, automatic fill controls, increased motor efficiency, spray rinsing, and improved remaining water extraction.

- Status: DOE rulemaking not yet begun
  - Estimated DOE final rule: 2015
  - Estimated DOE effective date: 2018
- Annual savings in 2035:
  - Electricity: 0.2 TWh
  - Natural gas: 3.4 trillion Btu
  - Water: 22 billion gallons
- Net present value savings: $780 million

Distribution Transformers

Product description:
Distribution transformers include the metal boxes found in subdivisions and the pole-mounted cylinders that reduce voltage from the high-voltage power lines to the voltages used by homes and businesses for lights, appliances and equipment. There are three types of distribution transformers that are covered here: liquid-immersed transformers, low-voltage dry-type transformers, and medium voltage dry-type transformers. Liquid-immersed distribution transformers use oil as a coolant and are generally installed outdoors, unlike dry-type transformers which are generally installed indoors. In general, utilities purchase most liquid-immersed distribution transformers for their systems whereas most dry-type transformers are purchased for buildings and owned by a building owner.

Key statistics:

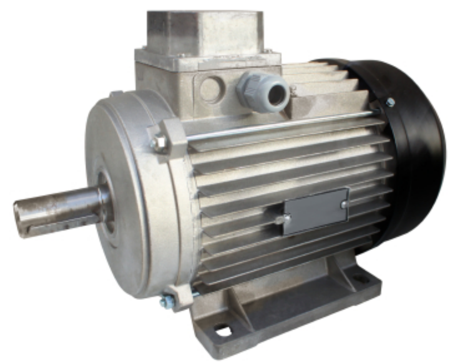
- Annual shipments: 1.1 million
- Current national standard level: Efficiency minimums vary by product class and size

- Year current standard adopted/effective: 2005/2007 for low-voltage dry-type; 2007/2010 for medium voltage dry-type, and liquid-immersed.

Potential standard:
We analyzed the standard levels that represent average energy savings (i.e., reduction in losses) of about 15% for liquid-immersed (the most cost effective level that can cost-competitively be met by a variety of core steel manufacturers), 42% for low-voltage dry-type (the most cost effective level using silicon steel core material and conventionally available manufacturing techniques), and 20% for medium-voltage dry-type (the level negotiated among stakeholders).These savings can be achieved through technology options such as using lower-loss core and conductor materials. The incremental cost for more efficient transformers varies based on transformer size. Incremental cost is generally recovered in lower operating cost within six to twelve years while transformers last 30 years or longer.

- Status: DOE rulemaking underway; proposed rule published in February 2012.
  - Estimated DOE final rule: 2012
  - Estimated DOE effective date: 2016
- Annual savings in 2035: 22 TWh
- Net present value savings: $10.3 billion

Electric Motors



Product description:
Electric motors convert electrical energy into mechanical energy. The motors covered here include 1-500 horsepower motors, including both the products that previously have been covered by standards, and currently non-covered motors. Typical applications of motors include fans, blowers, pumps, and compressors.

Key statistics:

- Annual shipments: 1.6 million
- Current national standard level: Most currently covered motors must meet NEMA Premium efficiency levels. Many motor types do not currently have standards.
- Year current standard was enacted: 2007

Potential standard:
The potential standard includes an increase to the NEMA Premium levels for most of the few categories of currently covered motors subject to lower standards. However, most benefits derive from an expanded scope of coverage to include products not previously subject to standards. The average estimated per-unit savings are 2%, with an incremental cost which varies based on motor size. Typical payback periods are about 4 years. Technology options for meeting this standard include improved bearings, a more efficient cooling system, improved grades of electrical steel, and using thinner steel laminations.

- Status:
  - Estimated DOE final rule: 2012
  - Estimated DOE effective date: 2016
- Annual savings in 2035: 19 TWh
- Net present value savings: $6.1 billion

Fans and Blowers

Product description:

A fan is an electrically powered device which provides a continuous flow of a gas, typically air, for ventilation or circulation. Fans are usually classified as axial or centrifugal. A blower is a centrifugal fan having a higher ratio of discharge pressure to suction pressure than a fan.

Key statistics:

- Annual shipments: 53,000
- Current standard level: No national standard

Potential standard:

We assumed that cost-effective energy savings of 10% were possible for centrifugal fans, and 56% for axial fans. Efficient axial fans carry a much higher premium than efficient centrifugal fans, but the large savings makes them cost-effective. The incremental cost, on average, is $1,400, with a 2.2 year payback. Increased efficiency can be achieved through options like including improved blade orientation, reduced friction losses, and improved design.

- Status:
  - Estimated DOE final rule: 2015
  - Estimated DOE effective date: 2020
- Annual savings in 2035: 8.5 TWh
- Net present value savings: $2 billion

Furnaces, Commercial Warm Air

Product description:

Commercial warm air furnaces are defined as units with capacities of at least 225,000 Btu/hr (British Thermal Units per hour). They are designed to supply heated air through a duct system. In practice, commercial furnaces are gas or propane heating sections of packaged roof-top units (RTUs) used for small- to mid-sized commercial buildings. RTUs are essentially air conditioners that may also contain a heating section.

Key statistics:

- Annual shipments: 0.15 million
- Current national standard level: 80% thermal efficiency
- Year current standard adopted/effective: 2001/2003

Potential standard:

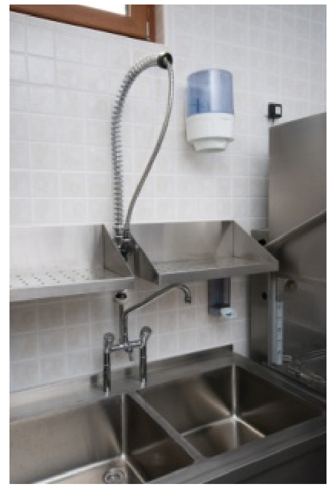
The current thermal efficiency standard is equivalent to the thermal efficiency requirement in ASHRAE 90.1, which is a commercial building energy code. However, ASHRAE 90.1 also contains additional prescriptive requirements for commercial warm air furnaces that are not included in the national standard. We analyzed a standard level based on adopting the additional prescriptive requirements in ASHRAE 90.1, which require that units include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. The average savings are around approximately 60 therms/year with an incremental cost of $300; this results in a 5.5 year payback.

- Status: DOE rulemaking not yet begun.
  - Estimated DOE final rule: 2013

    - Estimated DOE effective date: 2016
- Annual savings in 2035: 7.7 trillion Btu
- Net present value savings: $220 million

Pre-Rinse Spray Valves

Product description:
Pre-rinse spray valves are handheld devices that spray pressurized water to remove food waste from dishes prior to washing. They are commonly found in restaurants. According to the EPA, there are an estimated 1.35 million pre-rinse spray valves in the U.S. and up to 50% of them may be less efficient than federal standards requirements.



Key statistics:
- Annual shipments: 0.27 million
- Current national standard level: 1.6 gallons per minute
- Year current standard adopted/effective: 2005/2006

Potential standard:
The Federal Energy Management Program (FEMP) standard for pre-rinse spray valves is 1.25 gallons per minute (gpm). The EPA WaterSense program conducted a study of pre-rinse spray valve performance and energy savings at different efficiency levels. As part of the study, they concluded that there was less user satisfaction for products with a flow rate less than 1.0 gpm. However, the FEMP-level products resulted in equal or greater satisfaction than the less-efficient baseline products. Therefore, we analyzed the FEMP standard of 1.25 gpm. This standard level results in 22% energy and water savings. There is no known incremental cost to achieve this standard.

- Status: DOE rulemaking not yet begun.
    - Estimated DOE final rule: 2013
    - Estimated DOE effective date: 2016
- Annual savings in 2035:
    - Electricity: 0.8 TWh
    - Natural gas: 9.5 trillion Btu
    - Water: 15 billion gallons
- Net present value savings: $2.2 billion

Pumps, Commercial and Industrial

Product description:
There are two main categories of industrial pumps. Process pumps are responsible for mixing, and transporting materials in manufacturing processes. These are the pumps we focus on in this analysis. Ancillary or support pumps make up the rest of pumps. The paper, chemical, and petroleum and coal products manufacturing sectors have the highest pump energy use.

Key statistics:
- Annual shipments: 0.65 million
- Current standard level: No national or state

standards

Potential standard:
DOE estimates that cost-effective energy savings of 10% are possible for pumps. The pump energy data we used was from DOE's Request for Information, and includes commercial and industrial pumps. It represents an order of magnitude estimate of energy use. However, discussions regarding the scope of a pump standard are ongoing, and while we believe the best opportunity for standards may be with catalogue (commodity, or non-engineered/non-specialized pumps), clean water pumps, the scope of those products has yet to be determined, let alone any associated energy use estimates. We believe that for the purposes of estimating savings, the numbers from DOE are a reasonable starting point. Pump efficiency can be improved through design considerations such as curve shape, seal losses, and surface roughness.

- Status: DOE published a Request for Information in June 2011.
    - Estimated DOE final rule: 2013
    - Estimated DOE effective date: 2016
- Annual savings in 2035: 14 TWh
- Net present value savings: $1 billion

Refrigeration Equipment

Product description:
Commercial refrigeration equipment includes refrigerators and freezers used in supermarkets, convenience stores, and food service establishments. Commercial refrigeration equipment can either be "self-contained," where the refrigerated case and the complete refrigeration system are combined into a single physical unit, or "remote condensing," where the condensing unit is located remotely (typically outdoors) from the refrigerated case.

Key statistics:

- Annual shipments: 0.6 million
- Current national standard level: Maximum energy use (kWh/day) varies by equipment class and size
- Year current standard adopted/effective: 2005 or 2009/2010 or 2012 depending on product class

Potential standard:
We analyzed potential standards based on the levels in the DOE preliminary analysis published in March 2011 that represent the maximum cost-effective energy savings. On average, the standard levels represent savings of about 35% relative to the current standards. The average incremental cost of $480 results in a 3 year payback. Energy use of commercial refrigeration equipment can be reduced using a wide range of technology options including higher efficiency compressors, fan motors and fan blades; increased insulation; higher efficiency lighting; and increased evaporator and condenser surface area. Some of these technology options only apply to self-contained equipment, while others apply to both self-contained and remote condensing equipment.

- Status: DOE rulemaking underway; preliminary analysis published in March 2011.
    - Estimated DOE final rule: 2013
    - Estimated DOE effective date: 2016
- Annual savings in 2035: 6.6 TWh
- Net present value savings: $2.8 billion

Walk-In Coolers and Freezers

Product description:

Walk-in coolers and freezers (walk-ins) are large, insulated refrigerated spaces with access door(s) large enough for people to enter. Walk-ins are used to temporarily store refrigerated or frozen food or other perishable items. The equipment is composed of an envelope and refrigeration system, and there are three different refrigeration designs: (1) a packaged system where the evaporator and condensing unit are integrated into a single piece of equipment; (2) a dedicated remote condensing system where the condensing unit (which only serves the walk-in) is located remotely from the evaporator; and (3) a remote system where the evaporator is connected to a multiplex condensing system (a "rack" unit) that serves multiple pieces of refrigeration equipment. Walk-ins are primarily used in supermarkets, convenience stores and food service establishments.

Key statistics:

- Annual shipments: 0.34 million
- Current standard level: The current national standards are prescriptive requirements including specified insulation levels, automatic door closer requirements, and motor and lighting efficiency requirements.
- Year current standard adopted/effective: 2007/2009

Potential standard:

We analyzed standards based on a set of efficiency measures for walk-in cooler and freezer refrigeration systems including floating head pressure control, evaporator fan control, and high-efficiency compressors, fan blades, and fan motors. The specific measures applicable to a given type of walk-in depend on whether the walk-in is located indoors or outdoors and whether it has a dedicated condensing unit or is connected to a remote rack system. On average, the standards represent energy savings of about 20% relative to the current standards. The average incremental cost of $725 results in a 20 month payback period.

- Status: DOE rulemaking underway; preliminary analysis published in April 2010.
  - o Estimated DOE final rule: 2012
  - o Estimated DOE effective date: 2015
- Annual savings in 2035: 15 TWh
- Net present value savings: $9.1 billion

Unit Heaters

Product description:

Unit heaters are self-contained, fan-type heaters designed to be installed within the heated space. They are used to heat open commercial spaces such as factories, warehouses, and garages, and are typically hung from ceilings.

Key statistics:

- Annual shipments: 0.22 million
- Current standard level: The current national standards are prescriptive requirements
- Year current national standard was adopted/effective: 2005/2008

Potential standard:
The current national standards require that unit heaters include an interrupted or intermittent ignition device and have either power venting or an automatic flue damper. Most gravity and power vented unit heaters have a thermal efficiency of 80%. We analyzed a standard level of 90% thermal efficiency, which represents condensing technology. This standard level has an incremental cost of $2,640 and a 10 year payback period.

- Status: DOE rulemaking not yet begun.
  - Estimated DOE final rule: 2013
  - Estimated DOE effective date: 2016
- Annual savings in 2035: 120 trillion Btu
- Net present value savings: $1.3 billion

Urinals

Product description:
Urinals are most commonly found in commercial and institutional restrooms. Though the national standard of 1.0 gallons per flush became effective in 1994, the EPA WaterSense program estimates that 65% of urinals in use today exceed the maximum allowable flush volume.

Key statistics:

- Annual shipments: 0.3 million
- Current standard levels: 1.0 gallon per flush (gpf) national; 0.5 gpf in some states
- Year current standard adopted/effective: 1992/1994 for the national standard; 2007-2010/2012-2014 for state standards.

Potential standard:
In December 2010, DOE waived federal preemption of the 1.0 gallon-per-flush (gpf) national standard enacted by Congress in 1992. This waiver of federal preemption allows states to set standards provided that they are more stringent than the national standard. The voluntary WaterSense program has set criteria for flushing urinals at no more than 0.5 gallons per flush (gpf). California, Texas, and Georgia have adopted state standards at 0.5 gpf. We analyzed urinal standards based on this 0.5 gpf level. There is no known incremental cost associated with efficient urinals.

- Status: DOE Request for Information (RFI) issued in September 2011; 3 states have adopted standards
  - Estimated state final rule: 2013
  - Estimated state effective date: 2014
  - Estimated DOE final rule: 2013
  - Estimated DOE effective date: 2016
- Annual savings in 2035: 13.6 billion gallons of water
- Net present value savings: $640 million

Lighting:

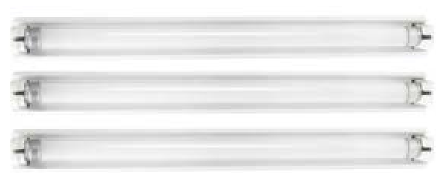
Candelabra and Intermediate Base Lamps

Product description:
General service candelabra base lamps use a screw base commonly designated as E11 or E12 according to ANSI designation. The designation refers to the diameter of the base, in millimeters. Candelabra bases are smaller than conventional A-lamps which use a medium base (E26 or E27). Candelabra base lamps are frequently used in chandeliers, ceiling fans, and small table lamps. Intermediate base lamps, E17, are far less common than candelabra and can be found in small table lamps, novelty fixtures, and ceiling fans.

Key statistics:
- Annual shipments: 280 million (candelabra); 29 million (intermediate)
- Current national standard level: 60W maximum (candelabra); 40W maximum (intermediate)
- Year current standard was adopted/effective: 2007/2012

Potential standard:
The standard is based on CFL or LED technology levels. Since current standards establish different baselines for the two lamp types, the standard levels for each differ. We analyzed potential standards of 14W for both lamp types corresponding to common wattages currently available and, in the case of candelabra, CFLs with a similar lumen output to 60W incandescent lamps. Incremental cost is $1.80[15], and results in an eleven month payback period.
- Status:
  - Estimated DOE final rule: 2013
  - Estimated DOE effective date: 2020
- Annual savings in 2035: 8 TWh
- Net present value savings: $5.3 billion

General Service Fluorescent Lamps (Linear Fluorescent Lamps)



Product description:
Fluorescent lamps have a low pressure mercury electric-discharge source in which a fluorescing coating transforms some of the ultraviolet energy generated by the mercury discharge into light. Linear fluorescent lamps are manufactured in a variety of shapes (straight- or U-shaped) and types (rapid start and instant start). General service fluorescent lamps are those lamps that satisfy the majority of fluorescent applications, except for some specialty lighting applications, such as lamps used in horticulture, cold temperature installations, and others. Common fluorescent lamps include T12 lamps (T12 lamps have a 1.5-inch diameter), T8 lamps (1-inch diameter) and T5 lamps (5/8-inch diameter).

Key statistics:
- Annual shipments: 640 million

[15] The actual incremental cost of a CFL or LED is higher, but the net annualized incremental cost takes into account the much longer lifetime of CFLs and LEDs. During the lifetimes of these products an incandescent product would need to be replaced several times.

- Current national standard level: 89 lumens per watt (4-foot, medium begin, ≤4500K); varies for other types)
- Year most recent standard adopted/effective: 2009/2012

Potential standard:
Current standards for general service fluorescent lamps set to take effect in 2012 correspond to Trial Standard Level 4 (TSL 4) in DOE's 2009 analysis of standards options. We analyzed standard levels based on TSL 5 from the same DOE analysis. For the most common lamp type—4-foot medium bipin, ≤4500K—the potential standard is 93 lumens per watt. Across covered product classes, the potential standard represents savings of approximately 3.5% on a sales-weighted basis. DOE's analysis showed that TSL 5 was technically feasible and yielded economic benefits for the vast majority of consumers. The average incremental cost is $0.75, and results in a 2.5 year payback period.

- Status: DOE rulemaking underway; framework document published in September 2011
  - Estimated DOE final rule: 2014
  - Estimated DOE effective date: 2017
- Annual savings in 2035: 6.9 TWh
- Net present value savings: $2.3 billion

HID Lamps

Product description:
High intensity discharge (HID) lamps include mercury vapor, metal halide, and high-pressure sodium lamps. These lamps are commonly used outdoors in parking areas and on roadways. Metal halide lamps are also used indoors in high ceiling applications such as factories, gymnasiums and big-box retail stores. Some types of metal halide lamps are also used in low ceiling applications.

Key statistics:

- Annual shipments: 7 million
- Current national standard level: No national or state standards

Potential standard:
We analyzed standards based on the standards case presented in DOE's positive determination regarding HID lamps published in July 2010. In the determination, DOE noted that a potential standard level that eliminates inefficient probe-start lamps (with a savings of approximately 15%) would likely prove technically-feasible, cost-effective and would yield significant savings. However, because fixtures that use probe-start lamps are essentially banned starting in 2020, we took into consideration the drastically reduced shipments of probe-start lamps that will result. The $18 incremental cost results in a 5 month payback.

- Status: DOE rulemaking underway
  - Estimated DOE final rule: 2014
  - Estimated DOE effective date: 2017
- Annual savings in 2035: 0 TWh (no savings from new shipments after 2020)
- Net present value savings: $2.5 billion

Incandescent Reflector Lamps

Product description:
Incandescent reflector lamps (IRLs) are the very common cone-shaped light bulbs most typically used in track lighting and "recessed can" light fixtures (light fixtures that mount flush with the ceiling such that the socket and bulb are recessed into the ceiling). The cone is lined with a reflective coating to direct the light. PAR lamps are the most common type of IRL; other common IRLs include "blown" PAR (BPAR) lamps, which are designed to be a low cost substitute for widely used PAR lamps, and "bulged" reflector (BR) lamps. Use of BR lamps has ballooned over the past 15 years as manufacturers have taken advantage of a loophole that exempted them from national standards.

Key statistics:

- Annual shipments: 240 million
- Current national standard level: Approximately 18 lumens per watt (65W, <125 V, standard spectrum)
- Year current standard adopted/effective: 2009/2012 (standards for previously exempted BR, ER, and other IRLs are expected to take effect in 2015)[16]

Potential standard:
We analyzed an average 26 lumen per watt standard level based on research by Ecos[17] on improved halogen infrared (HIR) technology. Our analysis includes savings from standards covering all major classes of IRLs including those ER, BR, and other IRLs previously exempted from standards.

- Status: DOE rulemaking underway; framework document published in September 2011
    - Estimated DOE final rule: 2014 (2012 for previously exempted products)
    - Estimated DOE effective date: 2017 (2015 for previously exempted products)
- Annual savings in 2035: 20 TWh
- Net present value savings: $11 billion

Luminaires (Portable Light Fixtures)

Product description:
Portable lighting fixtures are moveable lights such as floor, table and desk lamps that use a plug-in power cord. Portable fixtures are typically controlled with a switch located on the fixture itself, as opposed to hard-wired fixtures which are connected directly to the home's electrical system and typically operated exclusively by a wall switch.

Key statistics:

- Annual shipments: 43 million

[16] EPACT 1992, and later EISA 2007 exempted certain ER, BR and other IRL's from standards. However, DOE later concluded that it has the authority to set standards for these products. A rulemaking was initiated in 2010 to set standards for these products.
[17] Ecos (2011)

- Current standard level: No national standard; California standard requires use of efficient lamps

Potential standard:
California adopted a standard for portable light fixtures in 2008; the standard took effect in 2010. Our analysis is based on the California standard and standards included in Federal legislation drafted in 2010. The standard would require fixtures to meet the ENERGY STAR specifications for dedicated CFL fixtures and LED fixtures or to ship with screw-based CFLs or LED lamps. Average savings amount to 22 kWh/year, with an incremental cost of $1.50 and a payback period of seven months. We did not count any savings occurring after 2020, since an equivalent national standard for general service lamps will be in effect starting in 2020.

- Status: No DOE activity; one state standard in effect
  - Estimated DOE final rule:2014
  - Estimated DOE effective date: 2019
  - Estimated CEC final rule: 2013
  - Estimated CEC effective date: 2014
- Annual savings in 2035: 0 TWh (no new savings for shipments after 2020)
- Net present value savings: $110 million

Metal Halide Lamp Fixtures

Product description:
Metal halide lamp fixtures are commonly used in industrial buildings and high-ceiling commercial applications such as gymnasiums and big-box retail stores. Metal halide lamps are also used in some low-ceiling applications and in street lights and other high-light-output applications.

Key statistics:

- Annual shipments: 3.9 million
- Current national standard level: 88% ballast efficiency for 150-500 W fixtures
- Year current standard adopted/effective: 2007/ 2009

Potential standard:
The current standards apply to fixtures designed to operate lamps with wattages between 150 W and 500 W. We analyzed amended standards for these fixtures and new standards for fixtures designed to operate 50-150 W lamps and fixtures designed to operate lamps with wattages greater than 500 W. We analyzed the standard levels in the DOE preliminary analysis published in April 2011 that represent the maximum cost-effective energy savings. For 150-500 W fixtures, the standards represent savings of about 4% relative to the current standards. The incremental cost of $17 results in a payback period of just over 3 years. Potential technological improvements that could be used to meet the new standard include improved core steel, electronic ballasts, improved components and improved circuit design.

- Status: DOE rulemaking underway; preliminary analysis published in April 2011.
  - Estimated DOE final rule: 2012
  - Estimated DOE effective date: 2015
- Annual savings in 2035: 4.3 TWh
- Net present value savings: $2.2 billion

Outdoor Light Fixtures (Pole-Mounted)

Product description:

Outdoor light fixtures (or outdoor luminaires) are light fixtures intended for outdoor use and suitable for wet locations. Pole-mounted outdoor light fixtures are designed to be mounted on an outdoor pole and include area luminaires (for parking lots and other general areas), roadway and high-mast luminaires, decorative post-top luminaires, and dusk-to-dawn luminaires.

Key statistics:

- Annual shipments: 6.6 million
- Current standard level: No national or state standards

Potential standard:

We analyzed standards for pole-mounted outdoor light fixtures equivalent to a fixture efficiency of 80 lumens per watt. This would result in 18% savings. The incremental cost is $40, with an 18 month payback period.

- Status: No DOE rulemaking underway; proposed for consideration in the current California Energy Commission docket by stakeholders.
  - Estimated DOE final rule: 2014
  - Estimated DOE effective date: 2019
  - Estimated CEC final rule: 2013
  - Estimated CEC effective date: 2014
- Annual savings in 2035: 26 TWh
- Net present value savings: $14 billion

SECTION 7. CONCLUSION

Since their inception in the 1980s, appliance, equipment, and lighting standards have delivered enormous benefits for consumers, the environment, and the nation. By 2010, products complying with existing standards were responsible for 278 TWh of annual savings, reducing U.S. electricity consumption by about 7% in that year. Annual savings will grow to 682 TWh by 2025 and 723 TWh by 2035, reducing electricity consumption by about14% in each of those years. On a cumulative basis, taking into account products sold from the inception of each national standard through 2035, existing standards will net consumers and businesses more than $1.1 trillion in savings. By 2035, cumulative energy savings will reach more than 200 quads, an amount equal to about two years of total U.S. energy consumption. Not only have standards saved consumers and businesses money, they have reduced CO_2 emissions, in turn reducing the nation's contribution to climate change, as well as emissions of other pollutants.

Additional state and national standards could add considerably to these already substantial benefits. If all the standards proposed in this report are adopted nationally, total additional energy savings would reach 42 quads cumulatively by 2035 and additional net present value benefits for consumers and businesses would reach $170 billion. Annual electricity savings would reach 310 TWh by 2035. These cost-effective savings represent a significant energy saving opportunity for the nation that would deliver very large economic and environmental benefits.

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Appendix A. Methodology, Assumptions, and Sources

To calculate the potential energy and water savings of new standards for the products discussed in this report, we started with national estimates of equipment sales, per-unit energy and/or water use, potential energy and/or water savings, product lifetime, and incremental cost. The energy and water savings then drove the calculation of the economic savings and emissions reductions achieved nationally.

Economic savings were calculated on a consumer basis by multiplying energy and water savings by national average retail rates (residential, commercial, or industrial rates, as appropriate). For electricity and natural gas savings, we used retail rates from 2010 data compiled by the U.S. Energy Information Administration. Water rates include wastewater treatment, and are national averages as estimated by the American Water Works Association (AWWA). These rates are presented in Table A-3. We assumed retail rates remain constant through 2030. However, it is unlikely that retail electricity rates will remain static in the future; in fact, it is more likely that they will increase over time. Higher future retail rates will mean greater economic savings per unit of energy savings, and vice versa for lower retail rates.

We calculated costs by multiplying the per-unit incremental cost of each product by the annual sales volume. Cumulative costs and cumulative savings cover the period from the effective date of the standard to 2035, and we discounted them to 2011 using a 5% real discount rate.

Similarly, we derived emissions reductions by multiplying the electricity and natural gas savings by national average emissions factors for the U.S. We assumed that emissions factors remain constant over the analysis period.

Table A-1 lists some of the basic assumptions made in the analysis for each product. The individual product discussions in Section 6 contain additional detail about specific standard levels.

Table A-1. Assumed Standard, Equipment Life, and Incremental Cost

Product	Basis for Standard	Assumed Standard (max energy use or min efficiency)	Average Life of Equipment (years)	Incremental Equipment Costs
Residential:				
Air handlers	ACEEE analysis	0.17 W/cfm	18	$ 150.00
Battery chargers & external power supplies	Minimum LCC in preliminary TSD	Varies by product class		
Battery chargers			4	$ 3.72
External power supplies			4	$ 0.98
Boilers (nat. gas)	Condensing boilers	90 AFUE	25	$ 900.00
Clothes washers	Negotiated agreement	2.0 MEF for top loaders; 2.2 for front loaders	14	$ 57.00
Computer equipment and components	Energy Star v5.0	Varies	4	$ -
Dishwashers	INCAAA	307 kWh/yr; 5.0 gallons/year	12	$ 20.00
Faucets (residential lavatory)	WaterSense/Energy Star	1.5 gpm	25	$ 4.00
Game consoles	NRDC proposed Tier 2	Wattage cap on various active and standby modes	5	$ -
Microwave ovens	1 W standby	1 W standby	9	$ 2.28
Set-top boxes & digital communication equipment	NRDC savings estimate	Average potential energy use	5	$ -
Televisions	Energy Star v5.3 without a cap for large TV's	Varies by product size	10	$ -
Toilets	Various state standards	1.28 gallons per flush	25	$ -
Water heaters			13	
Electric storage	Heat pump water heater for products >40 gallons	2.0 EF		$ 814.00
Commercial/Industrial:				
Air conditioners, air-cooled	CEE Tier 2	Varies	15	$ 1,212.16
Automatic ice makers	CEE Tier 3	Varies	9	$ 70.00
Clothes washers	Negotiated front-loading level for residential	2.2 MEF; 4.5 WF	11	$ 351.21
Distribution transformers	Minimum LCC in preliminary TSD		30	
Liquid-immersed transformers		Varies		$ 503.00
Low-voltage dry type transformers		Varies		$ 760.00
Medium-voltage dry type transformers		Varies		$ 6,642.00
Electric motors	Consensus proposal for covered and some non-covered products	Varies	25	$ 207.18
Fans, blowers & ventilation equipment	ACEEE analysis	Varies	15	$ 1,410.00
Furnaces, commercial warm-air	ASHRAE 90.1-2010: reduced jacket losses	Varies	18	$ 300.00
Pre-rinse spray valve	FEMP standard	1.25 gpm	5	$ -
Pumps	ACEEE analysis	Varies	15	$ 791.00
Refrigeration equipment	Maximum cost-effective from DOE analysis	Varies	10	$ 483.00
Walk-in coolers and freezers	Navigant projected savings	Varies	10	$ 725.00
Unit heaters	Consdensing units	90% efficiency	21	$ 2,640.00
Urinals	ACEEE analysis	0.5 gallons per flush	25	$ -

Product	Basis for Standard	Assumed Standard (max energy use or min efficiency)	Average Life of Equipment (years)	Incremental Equipment Costs
Lighting:				
Candelabra & intermediate base incandescent lamps	CFL or LED-level	Varies	1	$ 2.00
GSFL lamps	TSL level 5 from 2009 rule	Varies	5	$ 0.76
HID lamps	Standard case presented by DOE in determination ruling	Varies	3	$ 18.05
IRL lamps	Anecdotal max tech HIR for covered and exempted IRLs	Average of 26 LPW	2	$ 3.00
Luminaires (portable light fixtures)	CFL in box, or Energy Star fixture	Varies	10	$ 1.50
Metal halide lamp fixtures	CEC Tier 2	Varies	22	$ 17.36
Outdoor lighting fixtures	ACEEE analysis	80 LPW	20	$ 40.00

Table A-2. Summary Table of the National Benefits of New National Efficiency Standards

Summary of Benefits by Product					2035					
Products	**Effective Date**	**Annual Svgs per Unit**	**Units**	**Incremental Cost per Unit**	**Energy & Water Savings**			**Summer Peak Capacity Reduction**	**B/C Ratio**	**Net Present Value[1]**
	Year			$	TWh	TBtu	Billion gallons water	GW		$Million (2010$)
Residential:										
Air handlers	2017	554	kWh	$ 150.00	29.1	303	-	11.9	3.9	$ 13,992
heating	2017	326	kWh	$ -	20.6	215	-	-	3.9	$ 13,279
cooling	2017	228	kWh	$ -	8.5	88	-	11.9	3.9	$ 5,460
Battery chargers & external power supplies	2014	-		$ 2.36	11.3	118	-	1.6	1.4	$ 3,275
Battery chargers	2014	12	kWh	$ 3.72	6.3	66	-	0.9	1.2	$ 969
External power supplies	2014	4	kWh	$ 0.98	5.0	52	-	0.7	1.7	$ 2,305
Boilers (nat. gas)	2020	130	therms	$ 900.00	-	40	-	-	2.2	$ 1,434
Clothes washers, residential	2015	77	kWh	$ 57.00	7.0	107	214	-	5.7	$ 15,891
electricity - machine & water heating	2015	77	kWh	$ -	7.0	73	-	1.0	5.7	$ 4,776
natural gas - water heating	2015	4	therms	$ -	-	34	-	-	5.7	$ 2,245
water	2015	3,048	gallons	$ -	-	-	214	-	5.7	$ 8,870
Computer equipment and components	2019	-		$ -	11.8	123	-	1.6	No cost	$ 8,608
desktops	2019	87	kWh	$ -	8.6	90	-	1.2	No cost	$ 6,264
laptops	2019	27	kWh	$ -	1.3	13	-	0.2	No cost	$ 966
monitors	2019	58	kWh	$ -	1.9	19	-	0.3	No cost	$ 1,378
Dishwashers, residential	2013	-		$ 20.00	2.6	30	16	-	3.6	$ 2,777
electricity - machine use & water heating	2013	48	kWh	$ -	2.6	27	-	0.8	3.6	$ 1,857
natural gas	2013	1	therms	$ -	-	3	-	-	3.6	$ 227
water	2013	293	gallons	$ -	-	-	16	-	3.6	$ 692
Faucets (residential lavatory)	2014	-		$ 4.00	2.7	46	48	-	17.1	$ 5,360
Water	2014	292	gallons	$ -	-	-	48	-	20.6	$ 2,166
Water heating - gas	2014	1	therms	$ -	-	18	-	-	12.4	$ 1,263
Water heating - electricity	2014	16	kWh	$ -	2.7	28	-	0.4	18.5	$ 1,932
Game consoles	2020	77	kWh	$ -	7.9	83	-	1.1	No cost	$ 5,263
Microwave ovens	2015	16	kWh	$ 2.28	2.3	24	-	0.3	5.5	$ 1,753
Set-top boxes & digital communication equipment	2018	83	kWh	$ -	14.7	153	-	2.0	No cost	$ 11,586
Televisions	2016	61	kWh	$ -	9.9	104	-	0.2	No cost	$ 8,260
Toilets (residential)	2016	795	gallons	$ -	-	-	91	-	No cost	$ 4,303
Water heaters, residential, electric	2020	997	kWh	$ 814.00	43.0	449	-	5.9	1.3	$ 4,921

Summary of Benefits by Product					**2035**					
Products	**Effective Date**	**Annual Svgs per Unit**	**Units**	**Incremental Cost per Unit**	**Energy & Water Savings**			**Summer Peak Capacity Reduction**	**B/C Ratio**	**Net Present Value[1]**
	Year			$	TWh	TBtu	Billion gallons water	GW		$Million (2010$)
Commercial/Industrial:										
Air conditioners, commercial (air-cooled)	2017	2,012	kWh	$ 1,212.16	9.7	101	-	9.6	1.7	$ 2,426
Automatic ice makers, commercial	2016	-		$ 70.00	3.1	33	-	-	18.2	$ 2,528
Electricity	2016	1,870	kWh	$ -	3.1	33	-	0.7	17.8	$ 2,263
Water	2016	5,957	gallons	$ -	-	-	5	-	21.7	$ 265
Clothes washers, commercial	2018	-		$ 351.21	0.2	6	22	-	2.6	$ 788
electricity	2018	130	kWh	$ -	0.2	2	-	0.1	2.6	$ 89
natural gas	2018	19	therms	$ -	-	3	-	-	2.6	$ 118
water	2018	12,420	gallons	$ -	-	-	22	-	2.6	$ 582
Distribution transformers	2016	-		$ 588.25	22.4	233	-	3.1	2.6	$ 10,342
Liquid-immersed transformers	2016	834	kWh	$ 503.00	13.7	143	-	1.9	2.5	$ 6,099
Low-voltage dry type transformers	2016	1,561	kWh	$ 760.00	7.9	83	-	1.1	3.1	$ 3,980
Medium-voltage dry type transformers	2016	8,473	kWh	$ 6,642.00	0.7	8	-	0.1	1.9	$ 263
Electric motors	2016	843	kWh	$ 207.18	18.6	193	-	2.9	3.7	$ 6,121
Fans, blowers & ventilation equipment	2020	9,474	kWh	$ 1,410.00	8.5	89	-	1.4	4.5	$ 2,067
Furnaces, commercial warm-air	2016	60	therms	$ 300.00	-	8	-	-	2.0	$ 219
Pre-rinse spray valve	2016	-		$ -	0.8	18	15	-	No cost	$ 2,225
Water	2016	11,026	gallons	$ -	-	-	15	-	No cost	$ 847
Water heating - gas	2016	71	therms	$ -	-	10	-	-	No cost	$ 711
Water heating - electricity	2016	595	kWh	$ -	0.8	8	-	0.1	No cost	$ 666
Pumps, commercial/industrial	2016	1,424	kWh	$ 791.00	13.9	145	-	2.2	1.2	$ 1,061
Refrigeration equipment, commercial	2016	1,493	kWh	$ 483.00	6.6	69	-	0.9	2.3	$ 2,799
Walk-in coolers and freezers	2015	4,312	kWh	$ 725.00	14.7	153	-	3.4	4.5	$ 9,127
Unit heaters	2016	286	therms	$ 2,640.00	-	119	-	-	1.2	$ 1,334
Urinals	2016	2,340	gallons	$ -	-	-	14	-	No cost	$ 637

Summary of Benefits by Product					**2035**					
Products	**Effective Date**	**Annual Svgs per Unit**	**Units**	**Incremental Cost per Unit**	**Energy & Water Savings**			**Summer Peak Capacity Reduction**	**B/C Ratio**	**Net Present Value[1]**
	Year			$	TWh	TBtu	Billion gallons water	GW		$Million (2010$)
Lighting:										
Candelabra & intermediate base incandescent lamps		-		$ 0.30	8.0	83	-	5.7	9.4	$ 5,259
Candelabra	2020	34	kWh	$ 0.30	7.6	79	-	1.9	9.8	$ 5,025
Intermediate base	2020	17	kWh	$ 0.30	0.4	4	-	0.1	4.9	$ 234
GSFL & IRL	2017	-		$ -	47.3	493	-	11.7	2.2	$ 24,825
General service fluorescent lamps	2017	3	kWh	$ 0.76	6.9	72	-	1.7	1.8	$ 2,290
Incandescent reflector lamps - covered (including pre	2017	30	kWh	$ 3.00	11.7	122	-	2.9	No cost	$ 4,733
Incandescent reflector lamps - previously exempted	2015	52	kWh	$ 2.70	8.4	88	-	2.1	No cost	$ 6,534
HID lamps	2017	467	kWh	$ 18.05	-	-	-	-	2.5	$ 2,527
Luminaires (portable light fixtures)	2019	22	kWh	$ 1.50	-	-	-	-	6.5	$ 114
Metal halide lamp fixtures	2015	54	kWh	$ 17.36	4.3	45	-	1.4	4.1	$ 2,185
Outdoor lighting fixtures	2019	241	kWh	$ 40.00	26.1	272	-	1.8	8.1	$ 14,278
TOTAL					306.4	235	425	67.1		$167,020

Notes:
[1] Net present value is the total monetary value of bill savings achieved by products purchased between the effective date of the standards and 2035 minus the total incremental product cost incurred by purchasers as a result of the standards over the same period expressed in 2010 dollars. Both costs and savings are discounted to 2011 using a 5% real discount rate.

Detailed Methodology

1) Calculation of national energy, water, and peak demand savings

We estimated national energy savings from potential new standards by multiplying annual national sales figures for each product by per-unit energy savings. Per-unit energy savings are the difference between the energy use of a product just meeting the potential standard and that of a product that just meets the current standard (or of a typical baseline product if no current standard exists). (We assume the distribution of efficiency levels above the current baseline and above a future standard are the same, except we assume zero savings for sales that currently meet the potential standards). The analysis is static and assumes that equipment sales remain at projected 2015 levels for all products. We also assumed that, in the absence of standards, efficiency levels remain at present levels. In actuality, both product sales and efficiency generally increase gradually, even in the absence of standards. Thus, we implicitly assumed that these factors counterbalance each other.

We used the following equation to calculate cumulative end-use electricity savings in 2025 and 2035:

> *End-use electricity savings = annual sales volume x per-unit electricity savings x (1 – current market share of new standard) x (years from effective date - 0.5)*

Similarly, we used the following equation to calculate end-use natural gas (NG) savings in 2025 and 2035:

> *NG savings = annual sales volume x per-unit NG savings x (1 – current market share of new standard) x (years from effective date - 0.5)*

We subtracted 0.5 from the number of effective years to account for sales throughout the purchase year, so the savings from units installed during the year will be equivalent to only half-year sales multiplied by the annual savings per unit.

To calculate primary energy savings from electricity savings (primary energy input required to generate a unit of electricity, in Btu/kWh), we use heat rates of 10,764 Btu/kWh for 2011, 10,424 Btu/kWh for 2025, and 10,056 for 2035. We use a 0.91 T&D loss factor—a 9% T&D loss (EIA 2008b). For natural gas savings, site energy savings and primary energy savings are assumed to be the same for the purposes of this analysis.

To calculate peak demand reductions, we multiplied electricity savings by a peak factor (kilowatt per kilowatt-hour) that quantifies the fraction of a product's annual hours of usage that occur during times of peak system demand. We also incorporate 9% losses for transmission and distribution and assume a 10% reserve margin. Historically, a reserve margin of 20% was typical, but utilities have cut down their margins during restructuring of the electric utility industry. Table A-5 provides the sources of the peak factors used in the analysis.

We calculated peak demand reductions as:

> *Peak demand reductions = end-use electricity savings ÷ T&D loss factor x peak factor x reserve factor*

To estimate national water savings, we considered direct water savings only. Direct water savings are water savings due to more-efficient water-using products such as commercial clothes washers and pre-rinse spray valves. These savings were calculated using the same methodology as for energy savings. Indirect water savings are water savings due to reduced water use at power plants for electricity generation (because of reduced electricity demand), and were not included in this analysis.

2) Calculation of economic costs and savings

We calculated annual utility bill savings using the following formula:

Annual utility bill savings = end-use electricity savings x national average electricity price + natural gas savings x national average natural gas price + water savings x national average water price

Table A-3 shows the electricity, natural gas, and water prices used for this analysis.

Table A-3. National Average Retail Energy and Water Prices

Electricity Prices, 2010 (cents per kWh)			Natural Gas Prices, 2010 ($/1000 cubic feet or $/10 therms)			Water & Wastewater Prices, 2010 (cents/gallon)
Res.	Comm.	Ind.	Res.	Comm.	Ind.	
11.46	10.2	6.74	11.21	9.17	5.4	0.7

We calculated annual investment costs using the following formula:

Annual investment costs = annual sales volume x per-unit incremental cost

We discounted annual utility bill savings and investment costs to 2011 assuming a 5% real discount rate. The present value (PV) of investment costs aggregates the present value of annual incremental costs from the effective date of each standard through 2035. The PV of savings aggregates the present value of energy and water bill savings from the effective date of the standard through the year in which products installed through 2035 reach the end of their lifetimes. Essentially, these two measures give the cumulative costs and benefits of standard-complying products installed through 2035. Subtracting the PV of investments from the PV of savings yields the net present value (NPV) of the potential standards.

3) Calculation of emission reductions

We calculated carbon dioxide, nitrogen oxide, and sulfur dioxide reductions for products using the following equation:

Emission Reductions = end-use electricity savings ÷ T&D loss factor x national average electricity emission factor + end-use natural gas savings x natural gas emission factor

For electricity savings, we used average emission factors for 2010, 2025, and 2035 based on AEO 2011. There is significant uncertainty as to the impact of appliance standards on emissions due to the complex impact of the resulting savings on electric load profile; variations in emissions levels for baseload, intermediate, and peak generation; and the interaction of standards with SO_2 and NOx environmental regulations for electric power generation combined with changes in utility fuel price projections. We therefore use average emissions factors to provide an approximation of emissions reductions due to standards. Emissions reductions for natural gas savings are based on data from the EPA Office of Air Quality Planning and Standards (EPA 1995). Specific national average emissions factors are summarized in Table A-4.

Table A-4. National Average Emissions Factors

	Electricity (metric tons/GWh)			Natural Gas (MMT/Quad)
	2010	2025	2035	
CO_2	581	548	545	53.1
NOx	0.59	0.42	0.40	0.0416
SO_2	1.35	0.86	0.77	0.00027

Table A.5. Sources for Key Assumptions

Product	Sales	Average Product Life	Current Standard or Baseline	New Standard or Average Use	Per Unit Incremental Cost	Coincident Peak Factor
Residential:						
Air handlers	AHRI 2011	DOE 2001	ACEEE Analysis	ACEEE Analysis based on Pigg 2003	ACEEE Estimate	ACEEE Estimate
Battery chargers	DOE 2010a	DOE 2010a	DOE 2010a	DOE 2010a	DOE 2010a	1/8760
Boilers (nat. gas)	DOE 2007a	DOE 2007a	EIA 2008	ACEEE Analysis based on correcting test procedure handling of condensing technology	ACEEE Estimate	N/A
Clothes washers	DOE 2010b	Osann 2009	DOE 2010b	DOE 2010b	DOE 2010b	ACEEE Estimate
Computer equipment and components	Delforge, 2011	Appliance Magazine 2009	EPA 2011a	EPA 2011a	ACEEE Estimate	1/8760
Dishwashers	DOE 2007b	DOE 2007b	DOE 2007b	DOE 2007b	ACEEE Estimate	ACEEE Estimate
Faucets (residential lavatory)	EPA 2007	Osann 2011	EPA 2007	EPA 2007	EPA 2007	1/8760
Game consoles	Gamasutra 2011	Peterson 2006	Delforge 2011	Delforge 2011	ACEEE Estimate	1/8760
Microwave ovens	DOE 2009a	DOE 2009a	DOE 2009a	ACEEE Analysis based on 1 W standby	DOE 2009a	1/8760
Set-top boxes & digital communication equipment	Horowitz 2011b	Hardy 2011	Horowitz 2011b	Horowitz 2011b	ACEEE Estimate	1/8760
Televisions	Patel 2010	ACEEE Estimate	Horowitz et al. 2005, EPA 2011b, and ACEEE Analysis	Horowitz et al. 2005, EPA 2011b, and ACEEE Analysis	ACEEE Estimate	ACEEE Estimate
Toilets	EIA 2008 & Quinn 2011	Quinn 2011	U.S. Census 2011, Quinn 2011, EIA 2008	U.S. Census 2011, Quinn 2011, EIA 2008	Quinn 2011	N/A
Water heaters	DOE 2010c	DOE 2010c	DOE 2010c	DOE 2010c	DOE 2010c	1/8760

Product	Sales	Average Product Life	Current Standard or Baseline	New Standard or Average Use	Per Unit Incremental Cost	Coincident Peak Factor
Commercial/Industrial:						
Air conditioners, air-cooled	DOE 2004a & PG&E 2008	PG&E 2008	DOE 2004a	CEE 2009	ACEEE Analysis & DOE 2004	ACEEE Estimate
Automatic ice makers	DOE 2010d	DOE 2010d	DOE 2010d	DOE 2010d	EPA 2011c	ACEEE Estimate
Clothes washers	DOE 2010e	DOE 2010f	DOE 2010f	DOE 2010f	DOE 2010f	ACEE Estimate
Distribution transformers	DOE 2011a	DOE 2011a	DOE 2011a	DOE 2011a	DOE 2011a	1/8760
Electric motors	ACEEE Analysis	ACEEE Estimate	ACEEE Analysis	ACEEE Analysis based on analysis submitted to DOE by a coalition of manufacturers	ACEEE Analysis	ACEEE Estimate
Fans, blowers & ventilation equipment	Elliott et al. 2002	Elliott et al. 2003	ACEEE Analysis & Elliott et al. 2002	ACEEE Analysis & Elliott et al. 2002	ACEEE Analysis	ACEEE Estimate
Furnaces, commercial warm-air	U.S. Census Bureau 2011	Hurley et al. 1986	ACEEE Analysis	Reduced jacket losses, to comply with ASHRAE 90.1-2010	ACEEE Analysis	N/A
Pre-rinse spray valve	EPA 2011d	DOE 2004b	EPA 2011d	EPA 2011d	ACEEE Estimate	1/8760
Pumps	DOE 1980 & ACEEE Analysis	Elliott et al. 2003	DOE 2011b	DOE 2011b	ACEEE Analysis	ACEEE Estimate
Refrigeration equipment	DOE 2011c	DOE 2011c	DOE 2011c	DOE 2011c	DOE 2011c	1/8760
Walk-in coolers and freezers	DOE 2010g	DOE 2010g	Navigant Consulting 2009	Navigant Consulting 2009	Navigant Consulting 2009	ACEEE Estimate
Unit heaters	Sachs 2003	DOE 2002	Sachs 2003	Sachs 2003	Sachs 2003	N/A
Urinals	EPA 2009	ACEEE Estimate	EPA 2009	EPA 2009	EPA 2009	N/A
Lighting:						
Candelabra & intermediate base incandescent lamps	Cadmus 2010 and Navigant Consulting 2002	Cadmus 2010 and Navigant Consulting 2002	U.S. Congress 2007 and ACEEE Analysis	ACEEE Analysis	Cadmus 2010	ACEEE Estimate
General service fluorescent lamps	DOE 2009b	DOE 2009b	DOE 2009b	DOE 2009b	DOE 2009b	ACEEE Estimate
HID lamps	DOE 2010h	DOE 2010h	DOE 2010h	DOE 2010h	DOE 2010h	ACEEE Estimate
Incandescent reflector lamps	DOE 2009b	DOE 2009b	DOE 2009b	30 LPW	DOE 2009b and Ecos 2011	ACEEE Estimate
Luminaires (portable light fixtures)	U.S. Census 2011 and PG&E 2008	PG&E 2008	PG&E 2008	Energy Star	ACEEE Estimate	ACEEE Estimate
Metal halide lamp fixtures	DOE 2011d	DOE 2011d	DOE 2011d	DOE 2011d	DOE 2011d	ACEEE Estimate
Outdoor lighting fixtures	ACEEE Analysis	ACEEE Analysis	ACEEE Analysis	ACEEE Analysis based on negotiated agreement with manufacturers	ACEEE Analysis	ACEEE Estimate

APPENDIX B. HISTORY OF STANDARDS IN THE UNITED STATES

Appliance standards have served as one of the nation's most effective policies for improving energy efficiency. The first standards were enacted at the state level in California in 1974, the first of many policy actions initiated that year when then-Governor Ronald Reagan signed the State Energy Resources Conservation and Development Act as part of the state's policy to "reduce wasteful, uneconomical, and unnecessary uses of energy" (CEC 1983). The two main rationales for standards were to save consumers money by lowering appliance operating costs and to help overcome the market barriers that inhibit the sale of efficient products.[18]

At a national level, the Energy Policy and Conservation Act (EPCA) was enacted in 1975. It established a federal program consisting of test procedures, labeling, and energy targets for consumer products. EPCA was amended in 1979 directing DOE to establish energy conservation standards for consumer products. In 1980, DOE proposed standards for nine appliances, but in 1983 issued a "no standard" standard. The 1983 finding was overturned in federal courts in 1985.

In the meantime, California's standards proved to be so successful that in 1986, with the development of additional state standards in California and in other states including New York, Florida, and Massachusetts underway, appliance manufacturers became increasingly concerned about the impact of differing state standards on their ability to do business on a national basis. To address these concerns, manufacturers negotiated with energy-efficiency advocates and states, reaching a consensus on national efficiency standards covering many major household appliances that would preempt the individual state standards. The resulting agreement formed the basis for a new federal law, the National Appliance Energy Conservation Act of 1987 (NAECA), enacted by Congress and signed by President Reagan (U.S. Congress 1987). States continued developing new standards for products not covered by NAECA, and in 1992 Congress enacted another round of standards. The Energy Policy Act (U.S. Congress 1992) added standards for many of the most common types of light bulbs, electric motors, commercial heating and cooling equipment, and plumbing fittings (U.S. Congress 1992). Each of these laws was based on consensus agreements between product manufacturers and efficiency advocates (Nadel and Pye 1996).

Since 2001, 13 states and the District of Columbia have adopted new state-level standards. As in the past, states' initiatives have continued to elicit a federal response. In 2005, the Energy Policy Act (EPAct 2005) set new standards for 16 products and directed DOE to set standards via rulemaking for another five (U.S. Congress 2005). In 2007, Congress passed the Energy Independence and Security Act (EISA 2007), enacting new or updated standards for 13 products, several of which had been first regulated at the state level. EISA created the first-ever U.S. standards for general service light bulbs, which will begin to phase out conventional incandescent light bulbs in 2012. EISA also included the first significant program reforms since NAECA in 1987, including specific authority for DOE to create regional standards for major residential heating and cooling products and a requirement that DOE review and improve all standards and their underlying test methods on a regular schedule.

In general, these laws set initial standards in statute and direct DOE to conduct scheduled reviews to update standards to determine if improved standards make sense. DOE must set new standards "to achieve the maximum improvement in energy efficiency […] which the Secretary determines is technologically feasible and economically justified" (42 U.S. Code 6295(o)). An economically justified standard is one for which the benefits exceed the costs, taking into consideration seven factors including impacts on consumers, impacts on manufacturers, and the nation's need to save energy.

Several standards were updated during President George H.W. Bush's term in office (e.g., refrigerators, clothes washers, and dishwashers), and another eight were updated under President Clinton (e.g., central air conditioners, room air conditioners, refrigerators [second update], clothes

[18] For more on market barriers, see Appendix E.

washers [second update], water heaters, and fluorescent lamp ballasts). During George W. Bush's administration, DOE updated two major standards (residential furnaces and distribution transformers), but both were subject to litigation that led to a requirement to conduct new rulemakings for each product. During this administration, DOE also issued the first standards for supermarket refrigeration products, which will become effective in 2012, and updated standards for packaged terminal air conditioners (PTAC) and packaged terminal heat pumps (PTHP).

Despite these various updates, by 2004 DOE had missed legal deadlines for the review of 22 different standards. These delays have been very costly: the U.S. Government Accountability Office estimated that delays for only four missed standards cost U.S. consumers $28 billion in foregone energy savings (GAO 2007). Part of this lapse could be traced to a Congressional moratorium on standards and resulting focus on process redevelopment at DOE in the mid-1990s. In response to concerns about whether they had sufficient resources to meet all the statutory deadlines, DOE instituted a prioritization approach whereby the agency would first tackle those overdue rulemakings with the biggest savings. However, DOE's pace of work on new rulemakings slowed to a crawl during President George W. Bush's first term. Much of the DOE's early efforts during this period were focused on rolling back the air conditioner standards set at the end of the Clinton presidency—a rollback that was ultimately declared illegal by the federal courts (Natural Resources Defense Council, et. al., v. Abraham, 355 F.3d 179 (2d Circuit 2004)).

For the three major high-priority rulemakings begun in 2001 (residential furnaces, commercial air conditioners and heat pumps, and distribution transformers), DOE did not release its preliminary analyses until July 2004. A process that should have been finalized by 2004 was still stuck in its early stages. Instead of catching up on missed deadlines, DOE was falling further and further behind, which led a coalition of states and efficiency advocates to file suit (New York, et. al. and Natural Resources Defense Council, et. al., v. Bodman. Nos 05 Civ. 7807 & 7808 (July 1, 2005 Southern District of New York)). Concurrently, Congress increased its scrutiny in budget hearings and enacted new reporting requirements. Legislation enacted in August 2005 required DOE to report on its missed deadlines, provide explanation, and develop a plan for catching up (EPAct 2005, Section 141). The law also requires DOE to provide status reports to Congress every six months.

DOE submitted its first report to Congress in January 2006, which included its plan for catching up on all missed deadlines (DOE 2006).[19] In November 2006, DOE signed a consent decree in the suit over the missed deadlines (U.S. District Court for the Southern District of New York 2006).[20] Under the new schedule, DOE committed to catch up on all missed legal deadlines by July 2011 as well as to meet new deadlines created by the 2005 law. DOE's schedule with respect to the missed deadlines is subject to ongoing court oversight.

In the wake of the Congressional report and consent decree, the pace of work at DOE increased noticeably and remains elevated to this day. Congress increased the program budget from $10.1 million in FY2005 to $35 million by FY 2010. By July 2011, DOE had met all but one of the deadlines required under the consent decree, requesting and being granted a 120-day extension to further analyze fluorescent lamp ballast data. DOE published new ballast standards in November 2011,

Even with the monumental task of catching up with the backlog and the consent decree requirements out of the way, DOE is still working at a busy pace. DOE's 2012 budget request includes a recommendation to broaden the scope and increase the effectiveness of appliance efficiency standards. As 2012 opens, DOE is updating standards for products as required by law, adopting new and updated test procedures, and pursuing standards for several new products (including set-top boxes, pumps, fans, blowers, and fume hoods) as authorized by earlier laws.

[19] See http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/congressional_report_013106.pdf.
[20] See http://www.ag.ca.gov/globalwarming/pdf/2-27-08consent_decree_NYvBodman.pdf.

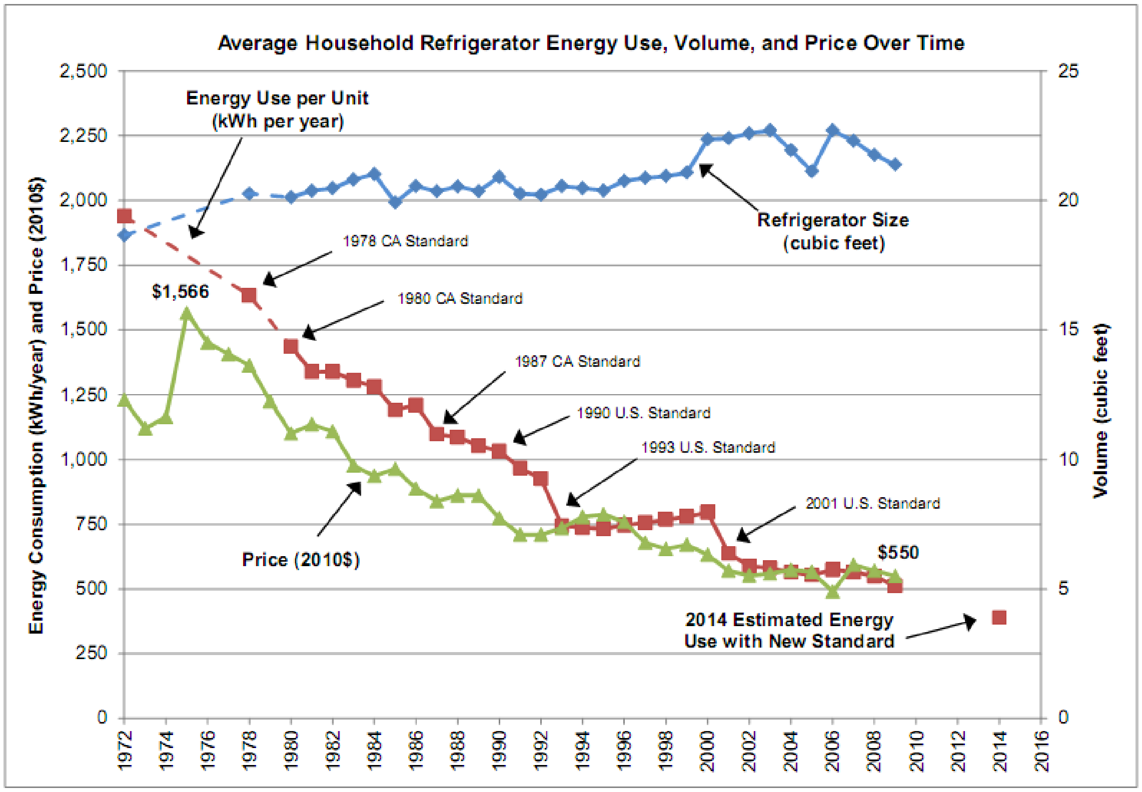
APPENDIX C. PRODUCT IMPACTS

By setting a minimum efficiency level, standards ensure that manufacturers incorporate efficiency improvements into all new products and thus provide all buyers a minimum level of efficiency performance. In many cases, without standards, manufacturers include efficiency improvements only in their premium products. Standards provide the impetus and the framework to allow these improvements to occur across the board.

Standards can help bring down costs for energy-efficient technologies due to economies of scale and also because standards encourage manufacturers to focus on how to achieve efficiency improvements at minimum cost as they compete for the most price-sensitive portion of the market. This result is obtained because the standards are usually based on energy performance (as measured by a test protocol promulgated by DOE) rather than on the use of specific technologies or design approaches.

As a result, higher-efficiency products become more affordable and widely available so that more consumers can benefit from advances in product performance and design. For example, due to standards, all new refrigerators today use high-efficiency motors and compressors, better insulation, and improved heat exchangers and, as a result, use 70% less energy than refrigerators manufactured in the 1970s, an improvement in efficiency of 225%. And while refrigerators became much more efficient during this period, they also began to feature other consumer amenities (e.g., they got bigger and auto-defrost became universal). During this period, the average per-unit value (wholesale price) of refrigerators actually **declined**. The latest round of standards, completed in August 2011, will reduce the energy use of the most common types of refrigerators by another 25% by 2014 (see Figure C-1).

Figure C-1. U.S. Refrigerator Use vs. Time



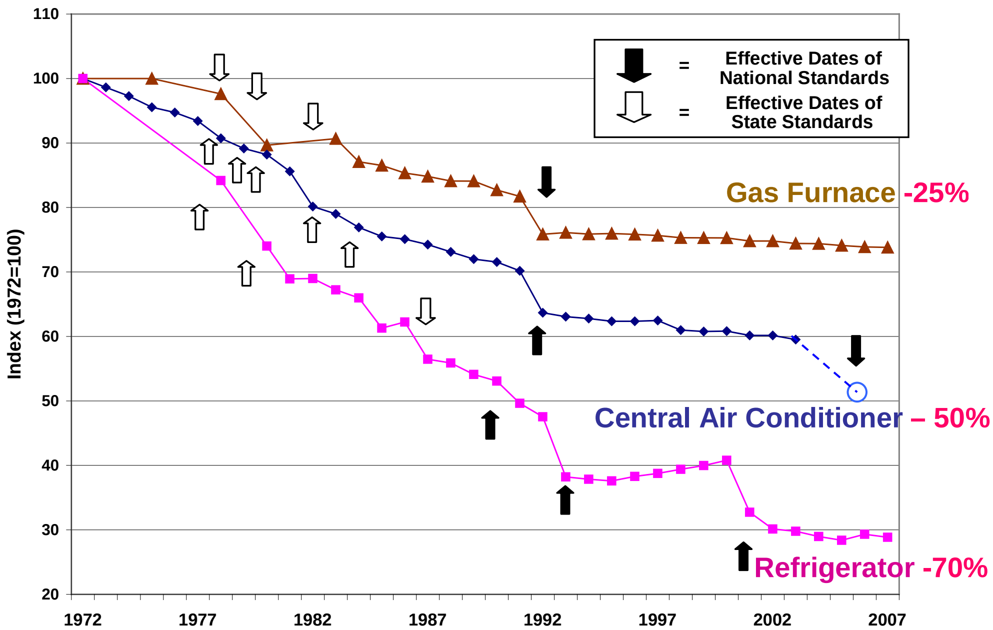
Sources: Association of Home Appliance Manufacturers (AHAM) for energy consumption and volume; U.S. Census Bureau for price

Notes: a. Data includes standard-size and compact refrigerators.
b. Energy consumption and volume reflect the DOE test procedure published in 2010.
c. Volume is adjusted volume, which is equal to the fresh food volume + 1.76 * freezer volume.
d. Prices represent the manufacturer selling price (e.g. excluding retailer markups) and reflect products manufactured in the U.S.

For manufacturers, new standards unleash intense market pressures to bring existing efficiency improvements to market at the lowest possible cost and to innovate further. Innovations that enable efficiency improvements at lower-than-expected costs can help manufacturers meet standards without raising prices or losing sales; innovations that take efficiency to new levels enable manufacturers to earn the larger margins sometimes associated with premium efficiency products. With innovation, manufacturer impacts are likely to vary from minimal to positive.

The energy savings and technological innovations spurred on by standards can be groundbreaking. Figure C-2 shows significant reduction in energy use for 3 products: gas furnaces, refrigerators, and central air conditioners over 35 years. In another example, the best clothes washers today reach water and energy efficiency performance levels unheard of when the 2007 clothes washer standard was announced in 2001. The best large Kenmore, GE, and Whirlpool clothes washers today use a fraction of the water and energy of models available in 2001. Even century-old technology like the incandescent light bulb is not immune: standards enacted by Congress in 2007 that take effect starting in 2012 have spurred dramatic innovation in products (already on the shelves today). Light bulb manufacturers asserted that they would never have invested in the incandescent light bulb innovation if not for the new lighting standards. Absent standards, consumers would still be throwing money away on inefficient incandescents. The disruption created by standards works both to generate large efficiency gains and to create opportunities for innovation.

Figure C-2. Index of U.S.-Average Energy Use per New Appliance Relative to 1972
Source: LBNL 2009



Minimum efficiency standards generally make sense when high-efficiency products are readily available or can be readily produced and are cost-effective, but due to a number of market barriers, many consumers and businesses are purchasing less efficient products. These barriers are deep and pervasive, and include demand and supply-side barriers, such as a lack of consumer awareness of efficiency options or benefits, limited stocking in retail stores, and split incentives between building owners and occupants. A greater discussion of this topic can be found in Appendix E.

Besides minimum efficiency standards, several other program and policy options help overcome these barriers, including education programs, rebate programs, and building code requirements. However, none of these options has the energy-saving impact of minimum efficiency standards because they do not affect all purchase decisions. The Environmental Protection Agency and DOE's ENERGY STAR labeling program offers manufacturers a way to increase the marketability of their most efficient products, but market share is commonly much less than 50%. Education programs generally only reach a small fraction of consumers. Likewise, utility incentive programs usually reach less than 50% of the eligible market. For education programs or incentive programs to reach larger portions of the market would be prohibitively expensive in nearly all cases; in fact, those few incentive programs that reach near-100% market share required 100% subsidization of all measures (Nadel, Pye, and Jordan 1994 . Building codes generally apply only to new or substantially renovated buildings, leaving the large number of existing buildings unaffected for decades. Also, building codes generally only cover products that are installed in buildings prior to occupancy (e.g., heating, cooling, and water-heating systems). These other programs and policy options deliver critical energy savings benefits and help pave the way for future standards, but they are by no means a replacement for efficiency standards as no single one of them would capture all of the potential benefits.

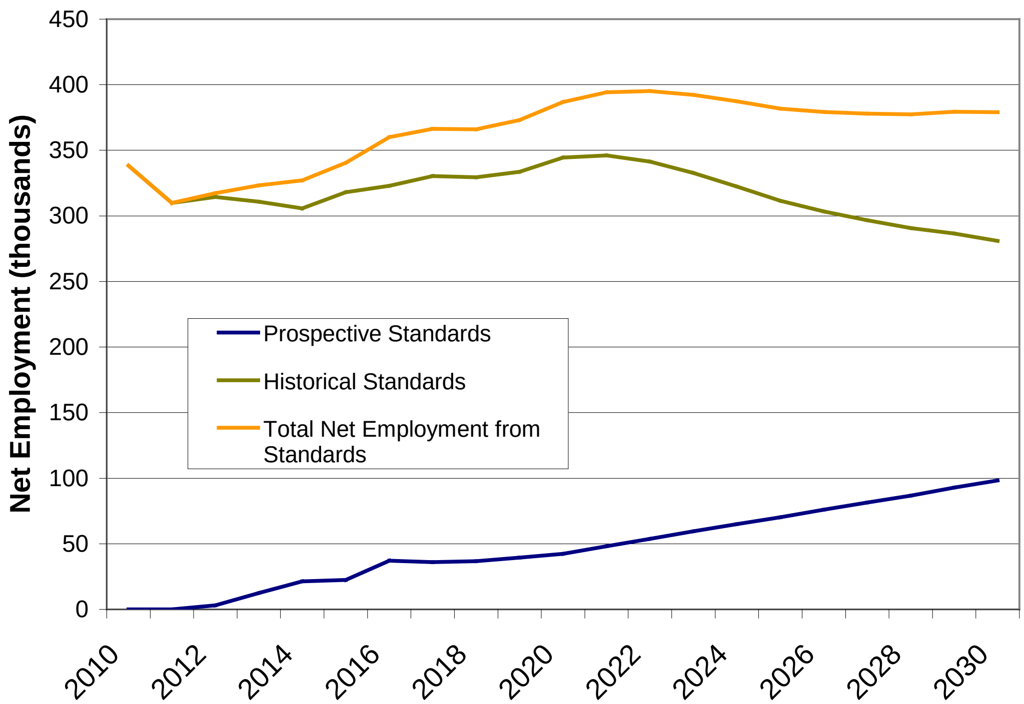
ENERGY STAR specifications should not be confused with federal standards. Federal appliance and equipment standards establish a minimum efficiency level that all products within a product class are legally obligated to meet. ENERGY STAR specifications are set higher than federal standards, so by qualifying for an ENERGY STAR label, manufacturers can increase the marketability of their efficient products due to the recognition that comes with the ENERGY STAR label.

Appendix D. Appliance Standards and Job Creation

National appliance, equipment, and lighting energy efficiency standards have a proven track record of creating jobs and strengthening the U.S. economy. Cost-effective standards contribute to job growth because when families and businesses save on utility bills, this moves spending from the utility sector, with relatively few jobs per dollar of revenue, to other sectors that have more jobs per dollar of revenue. As existing standards affect more product purchases, and as new standards take effect, the number of jobs generated will increase along with energy bill savings.

A 2011 ACEEE/ASAP report found that standards resulting from the four prior standards laws (signed by President Reagan and both Presidents Bush) and DOE rulemakings generated about 340,000 jobs in 2010, or 0.2% of the nation's jobs (Gold et al. 2011). The energy and related utility bill savings from standards will continue to contribute to a healthy economy over time, and in 2030, the number of jobs generated from existing and future standards will increase to about 380,000 jobs—an amount about equal to the number of jobs in Delaware in 2011. While the impact is small relative to total employment in the U.S. (i.e., less than one-half of 1%), the absolute total number of increased jobs is an important effect of appliance standards.

Figure D-1. Net Employment from Historical and Prospective Standards



Jobs created due to energy bill savings are generally called "indirect" jobs. Direct jobs are those in the manufacturing of the product subject to standards. In general, standards help drive innovation, which can contribute to job creation. When companies have to upgrade their products and retool their plants to comply with a new standard, they often come up with better products at lower than-expected-costs. For example, Phillips Lighting Company invested in its existing light bulb factory in St. Mary's, PA to produce new, energy-efficient incandescent light bulbs that comply with the national standards. On the other hand, GE chose to shutter its existing U.S. light bulb factory. For general service fluorescent lighting standards that take effect in 2012, GE chose to invest in an Ohio factory, consolidating some production that had been located in Canada. These examples demonstrate that manufacturers face choices about where to make their investments to make products complying with new standards. Just as with any manufacturing investment decision, manufacturers weigh both domestic investments and foreign investments. However, the level of efficiency required does not appear to be a factor in decisions about manufacturing location (Gold et al. 2011).

APPENDIX E. MARKET BARRIERS

Minimum-efficiency standards make sense when high-efficiency products are readily available or can be readily produced and are cost-effective, but due to a number of market barriers, many consumers and businesses are purchasing less-efficient products. These market barriers include the following demand- and supply-side barriers.

Demand-Side Barriers

- *Lack of awareness:* Many purchasers underestimate the amount of energy consumption and the associated environmental impacts of operating the equipment. Very often, they are not even aware that different models can consume significantly different amounts of energy and that buying more efficient products can lead to energy and utility bill savings.

- *Uninformed decision-makers/"panic purchases":* Even when the purchaser is aware of variations in energy efficiency, often they are too busy or rushed to research the cost-effectiveness of a decision, or information on high-efficiency products is not readily available. Many of these products are purchased once in a decade, so maintaining awareness to facilitate an occasional decision is not something most consumers can do. When purchases are made, often the buyer is in a rush (e.g., a broken-down furnace or refrigerator must be replaced quickly). In such "panic purchase" situations, efficiency performance gets little attention and choices are, at best, limited to what is in stock. In the commercial/industrial sector, many purchasing decisions are made by purchasing or maintenance staff that are unfamiliar with the relative efficiencies and operating costs of the equipment they purchase.

- *Third-party decision-makers ("split incentive"):* Many times the decision-maker (e.g., developer or landlord, purchasing department, etc.) is responsible for purchasing equipment but someone else (e.g., tenant, operating department, etc.) is responsible for paying the energy bills. In these instances, the purchaser tends to buy the least expensive equipment because he or she receives none of the benefits from improved equipment efficiency.

- *Financial procedures that overemphasize initial costs and de-emphasize operating costs:* In the commercial/industrial sector, accounting procedures often closely scrutinize capital costs, favoring purchase of inexpensive equipment, while operating costs are generally less scrutinized. Furthermore, when operating costs are reduced, the savings typically show up in a corporate-level account and are rarely passed on to the department that made the decision and the investment. This diversion of benefits discourages energy-saving investments (Nadel and Suozzo 1996).

- *Small per-unit savings:* While per-unit savings may seem significant to the individual consumer for some appliances and equipment types (e.g., heating and cooling equipment), for others the per-unit savings may be so small as to be inconsequential to the individual consumer. For example, an efficient external power supply for electronic equipment may save less than a dollar's worth of electricity a year, an amount unlikely to influence many consumers' purchase decisions. However, because 300 million or so of these devices are sold nationally each year, large energy savings are at stake for the nation as a whole.

Supply-Side Barriers

- *Limited stocking of efficient products:* Equipment distributors generally have limited storage space and therefore only stock equipment that is in high demand. This creates a "Catch-22" situation: users purchase inefficient equipment so distributors only stock inefficient equipment. Purchasing efficient equipment thus may require a special order, which takes more time. Most equipment that fails needs to be replaced immediately. Thus, if efficient equipment is not in stock, even customers who want efficient equipment are often stuck purchasing standard equipment (Nadel and Suozzo 1996).

- *Efficiency bundled into premium products only:* Often manufacturers will produce commodity-grade and value-added product lines. The commodity-grade line just meets efficiency standards and includes only basic features. The value-added line includes improved efficiency and other extra non-energy features at a significantly higher cost than commodity-grade products. A portion of the extra cost is for the improved efficiency but much of the extra cost is for the added "bells and whistles." Consumers desiring improved efficiency without the extra features are out of luck.

- *Manufacturer price competition:* Since manufacturers are competing for market share, if a manufacturer voluntarily increases efficiency in a commodity product line, they may find it impossible to pass on even small product cost increases to consumers without risking loss of market share. In contrast, mandatory standards ensure a level playing field for all manufacturers.

Appendix F. Public and Stakeholder Support for Appliance Standards

Long under the radar, appliance standards have gained attention over the past several years as large energy and cost savings have been reported in the media and touted by administration officials. Steven Chu, Secretary of Energy, has repeatedly mentioned appliance standards as a cost-effective policy for achieving energy savings and an integral part of U.S. energy policy. In a White House blog in 2011, he noted: "The Department of Energy is improving and enforcing appliance standards to drive innovation and make appliances more energy efficient. This is a great way to save energy—and save consumers money." In addition, there is a growing awareness by consumers that appliance standards are saving them money and reducing air pollution and greenhouse gas emissions. Highlighted below are three recent public opinion polls and examples of support for appliance standards.

Survey: Consumer Federation of America (CFA)

In January 2011, CFA conducted a nationwide survey to gauge the public's knowledge and opinions about appliance energy efficiency. The study concluded that: "The public overwhelmingly believes that improving appliance energy efficiency is beneficial and strongly supports appliance efficiency standards."

The data revealed that 95% of Americans believe that it is "beneficial for appliances like refrigerators, clothes washers, and air conditioners to become more energy efficient," with 78% believing this increased efficiency to be "very beneficial."

Nearly all Americans (96%) think improved appliance efficiency is important for personal financial reasons—"lowering your electric bills". Large majorities also believe improved appliance efficiency to be important for environmental reasons—because it reduces the nation's consumption of electricity "to reduce air pollution" (92% important, 77% very important) and "to reduce greenhouse gas emissions" (84% important, 66% very important).

Nearly three-quarters of Americans (72%) support "the government setting minimum energy efficiency standards for appliances," with strong support from 28%.

Source: Consumer Federation of America

Survey: EcoAlign

In February 2011, EcoAlign, a strategic marketing agency, conducted a survey of 1000 Americans nationwide examining customer perceptions of more energy efficient lighting options compared with traditional incandescent lighting. Jamie Wimberly, CEO of EcoAlign, noted: "Americans have fully embraced more energy efficient lighting options such as CFLs and LEDs. Moreover, a large majority of Americans clearly support higher efficiency standards."

The survey showed that a majority of Americans have installed some type of energy efficient lighting in their homes. Nearly two-thirds gave CFLs the highest satisfaction rating whereas more than half gave the highest rating to LEDs. Younger Americans especially favor LEDs.

When asked to rate the best reasons for using energy efficient lighting, respondents named the ability to "save energy" and "save money."

Source: EcoAlign: Lighting the Path Forward For Energy Efficiency

Survey: USA Today

A USA Today survey published in February of 2011 showed that public support of the new general service incandescent lighting standards is largely favorable. The standards, which will be phased in beginning in 2012, require that incandescent light bulbs be 25-30% more efficient than the traditional incandescents on the market today. The standards impact the most common bulbs (100, 75, 60, and 40-watt) and contain exceptions for specialty bulbs. Despite several months of outspoken criticism of the new lighting standards from certain talk radio hosts and a few prominent members of Congress, USA Today found that 61% of Americans support the standard, while only 31% oppose it.

Source: USA Today

Paper: U.S. Chamber of Commerce

In spring 2010, the US Chamber of Commerce's Institute for 21st Century Energy published a paper entitled: Increasing American's Energy Efficiency: A Key Pillar for Ensuring America's Energy Future. In the paper, they review the key steps to improve energy efficiency and secure America's energy security. New and updated appliance standards, with estimated savings of $250 billion over 30 years, figure large in the Chamber's proposals. In the first of seven recommendations, the Chamber recommends that the "U.S. Department of Energy (DOE) should move expeditiously to promulgate the appliance standards as required by both the Energy Policy Act of 2005 (EPACT 2005) and the Energy Independence and Security Act of 2007 (EISA 2007)." They recommend that "DOE make accelerating its pace on finalizing these efficiency rules a higher priority" and encourage DOE to "accelerate completion of standards that offer the greatest potential savings."

Source: U.S. Chamber of Commerce's Institute for 21st Century Energy – Increasing America's Energy Efficiency: A Key Pillar for Ensuring American's Energy Future

Resolutions

Several national organizations have passed resolutions stating their support for appliance standards. The National Association of Regulatory Utility Commissioners (NARUC), continuing a long tradition, passed resolutions in 2009 and 2011 in support of standards and backed an education campaign for the new lighting standards. These resolutions follow resolutions passed in 1996, 1997, 1999, 2000 and 2004. The National Association of State Utility Consumer Advocates (NASUCA) passed similar resolutions in 2008, 2009 and 2011, and the U.S. Conference of Mayors passed an appliance standards resolution in 2011.

APPENDIX G. SAVINGS FROM EXISTING STANDARDS—WITH DECAY RATE

Figure G-1. Net Economic Savings from Existing Standards, Decayed

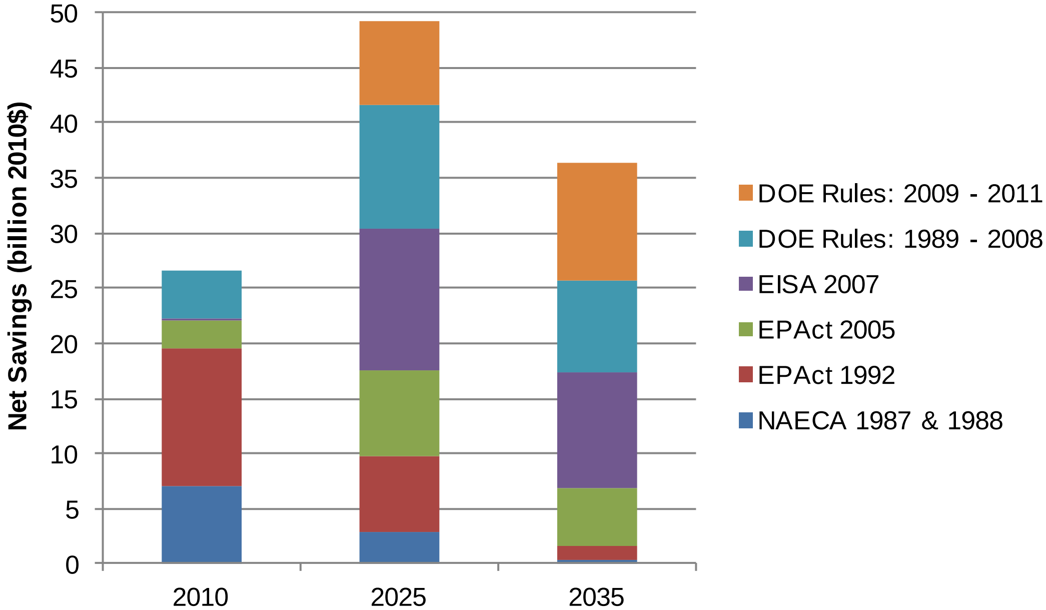


Figure G-2. Peak Capacity Reductions from Existing Standards (GW), Decayed

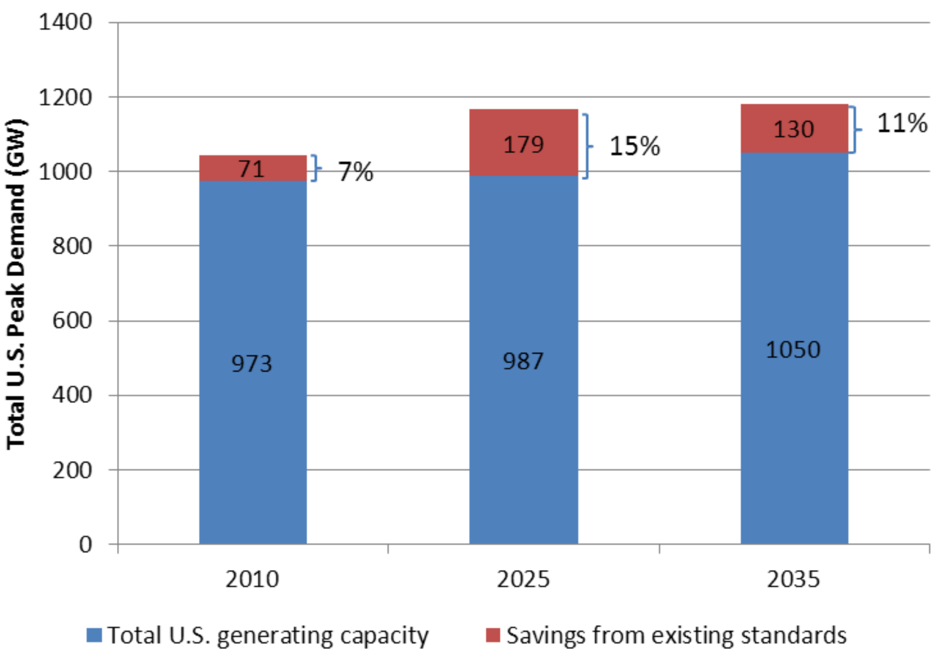


Figure G-3. CO_2 Reductions from Existing Standards in Equivalent Number of Coal Plants, Decayed