Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards

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EXECUTIVE SUMMARY

At both the state and national levels, energy-related problems are as severe in 2006 as they have ever been. Energy prices have increased sharply over the past several years, placing an ever greater burden on consumers and businesses. For example, natural gas prices have skyrocketed, with average residential prices reaching $13.30 per million Btu over the first 10 months of 2005, up 53% relative to the same period in 2002. Low- and middle-income families are especially hard hit. Meanwhile, energy-related environmental problems, most notably global warming, continue to dot the news headlines. From a national security perspective, observers of all political stripes raise concerns about U.S. dependence on imported energy—especially oil, but increasingly natural gas. The interconnectedness of energy markets means that price increases for any one resource often ripple through all energy markets. Power system reliability presents yet another challenge. The catastrophic Northeast blackout of August 2003 remains a fresh reminder of the economic costs imposed by electric grid reliability problems. Growing demand for power continues to strain electric systems in some parts of the country.

Given these energy-related problems, policymakers increasingly are turning to efforts to use energy resources more efficiently. This report describes sensible and up-to-date opportunities to advance one specific energy-saving policy: appliance and equipment efficiency standards. Efficiency standards stand out as one of the most effective and successful policies used by both state and federal government to save energy. These standards help reduce unnecessary energy waste by requiring that certain energy-consuming products meet minimum energy-savings performance levels. By saving energy, these standards save consumers and businesses significant amounts of money over the life of the affected equipment, reduce pollution, and improve electric system reliability.

In addition, by easing demand for energy, efficiency standards and other energy-saving policies can help lower natural gas and electricity prices. In 2005, ACEEE researchers found that natural gas markets are so tight that just a modest 2–4% reduction in national gas use can reduce natural gas prices by 20% or more. Such savings can be achieved with more efficient gas-fired appliances as well as through reduced electricity use, since in many regions of the United States, natural gas is the marginal fuel used for power generation.

State Appliance and Equipment Efficiency Standards

Individual states initiated the first efficiency standards for appliances and other equipment in the 1970s and 1980s. California adopted the first appliance standards law in 1974 and in the late 1970s and early to mid-1980s, other states (including Florida, Kansas, and New York) established state standards for various products. These state standards led to broad support for national standards, which Congress enacted in 1987, 1988, and 1992 and Presidents Reagan and George H.W. Bush signed into law to save energy and replace a patchwork of state standards. These initial efficiency standards covered major residential appliances (e.g., refrigerators, air conditioners, water heaters, washers and dryers, etc.) as well as the most common commercial equipment (e.g., fluorescent lamps, motors, furnaces, etc.). Their success has been well-documented. For example, as a result of several rounds of state and

federal standards, a typical new refrigerator today uses less than one-third as much energy as a typical one sold in the early 1970s. Overall, these existing standards will net consumers and businesses nearly $200 billion in savings by 2020.

Since 2001, states have again been turning to efficiency standards to help reduce energy waste. California adopted new standards for several products in 2001 and for more products in 2004. Maryland and Connecticut enacted state standards laws in 2004, followed by New Jersey, Arizona, Washington, Oregon, Rhode Island, New York, and Massachusetts in 2005. As in the 1980s and 1990s, this round of state standards prompted broad support for strong federal standards, resulting in Congress enacting 16 new standards as part of the Energy Policy Act of 2005, signed into law by President George W. Bush in August 2005. These latest national standards will save energy users another $50 billion net by 2020.

This report examines opportunities for new equipment and appliance standards beyond those enacted by Congress in 2005. We find that near-term standards make sense for 15 products evaluated in this report and that such standards would achieve considerable energy savings, economic benefits, and pollution reductions. These standards could be set at the national or state level, but, given the historical approach to efficiency standards, we recommend that states act first to set such standards. Details on each of these products, including recommended standards and information on product availability and economics, are provided in the body of the report.

Key Recommendation

The 15 products for which we recommend near-term state standards are:

- bottle-type water dispensers
- commercial boilers
- commercial hot food holding cabinets
- compact audio products
- DVD players and recorders
- liquid-immersed distribution transformers
- medium-voltage dry-type distribution transformers
- metal halide lamp fixtures
- pool heaters
- portable electric spas (hot tubs)
- residential furnaces and boilers
- residential pool pumps
- single-voltage external AC to DC power supplies
- state-regulated incandescent reflector lamps
- walk-in refrigerators and freezers

Most of these products are not currently covered by national standards and thus state standards are uninhibited by federal law. For three products included here (commercial boilers, pool heaters, and residential furnaces and boilers), national standards currently exist but they have become badly outdated. Under federal law, if a state wishes to enforce a standard tougher than federal minimums, it must first establish the standard and then petition the U.S. Department of Energy (DOE) for a waiver from federal preemption.

Key Findings

If adopted on a national basis, the recommended standards would:

- Save consumers and business $54 billion net for appliances and equipment purchased between 2008 and 2030.
- Save 52 terawatt-hours (TWh)[1] of electricity in 2020, an amount equal to nearly 2% of projected residential and commercial sector U.S. electricity use in that year.
- Save about 340 billion cubic feet (bcf) of direct natural gas in 2020 (100 bcf savings from reduced gas use for boilers, furnaces, and pool heaters and an additional 240 bcf savings in power plants), enough to meet the natural gas heating needs of about 6.3 million typical households.
- Cut national electricity demand levels by about 12 gigawatts (GW)[2] in the year 2020, an amount roughly equal to the generating capacity of 40 average power plants (i.e., 300 MW each).
- Save 9 billion gallons of water (used for generating steam) at power plants in the year 2020.
- Cut global warming carbon emissions by 12 million metric tons (MMT) in 2020, an amount equal to that emitted by 8 million average passenger cars annually.[3]
- Reduce significantly emissions of smog-forming nitrogen oxides (NOx), sulfur oxides (SOx—the main component of acid rain), fine particulate matter, and mercury.

Annual savings levels will continue to grow after 2020 as purchasers continue to install appliances that meet the standards (see Table ES.1 for 2030 savings levels). Overall, the recommended standards would have a benefit-cost ratio of 4.5 to 1; for every $1 consumers or businesses invest in improved efficiency, they'll save $4.50 on energy bills. Tables ES.1 and ES.2 summarize the energy, economic, and pollution savings potential from adopting national minimum-efficiency standards for the above 15 products.

Achieving the national benefits outlined here will require federal government action. However, as in the past, states can and should act first, both to gain the considerable benefits of state standards for themselves and, eventually, to prompt appropriately strong national standards. To assist states in considering such standards, we have estimated the benefits of adopting the recommended standards for each of the states. We make the state-by-state benefit data available in an online appendix consisting of a table for each state published at www.standardsASAP.org.

[1] One TWh is a billion kWh.
[2] 12 GW = 12,000 MW.
[3] A typical vehicle emits 12,000 lbs. of carbon dioxide each year (about 1,500 kg carbon), based on an average on-road fuel economy of 20 miles per gallon and average vehicle use of 12,000 miles per year.

Table ES.1. Estimated Energy Savings and Economics of Proposed New Standards

Products	Effective Date	National Energy Savings in 2020		National Energy Savings in 2030		Cumulative Savings for Products Purchased Thru 2030	NPV for Purchases Thru 2030	Benefit-Cost Ratio
	(year)	(TWh)	(tril. Btu)	(TWh)	(tril. Btu)	(quads)	($ billion)	
Bottle-type water dispensers	2008	0.3	3	0.3	3	0.1	0.2	12.9
Commercial boilers	2012	NA	5	0.0	10	0.1	0.5	2.8
Commercial hot food holding cabinets	2008	0.4	4	0.4	5	0.1	0.2	3.7
Compact audio products	2008	1.7	18	1.7	17	0.4	1.7	22.9
DVD players and recorders	2008	0.2	3	0.2	3	0.1	0.2	4.6
Liquid-immersed distribution transformers	2008	8.2	85	14.7	148	1.8	7.3	3.4
Medium-voltage dry-type transformers	2008	0.5	5	0.9	9	0.1	0.5	4.1
Metal halide lamp fixtures	2008	9.0	94	14.4	145	1.9	8.6	11.5
Pool heaters	2012	NA	8	NA	14	0.2	0.7	2.7
Portable electric spas (hot tubs)	2008	0.2	NA	0.2	2	0.0	0.1	2.0
Residential furnaces and residential boilers	2012	13.1	225	27.7	467	4.8	21.2	4.6
Residential pool pumps	2008	3.1	32	3.1	31	0.6	1.1	1.6
Single-voltage external AC to DC power supplies	2008	4.9	51	4.9	49	1.0	3.7	4.9
State-regulated incandescent reflector lamps	2008	5.8	60	5.8	58	1.4	4.9	6.8
Walk-in refrigerators and freezers	2008	4.7	49	4.7	47	0.8	3.0	6.8
Total		51.9	641	78.9	1007	13.2	54.0	4.5

Note: NPV is the value of energy savings due to standards minus the additional cost of more efficient products expressed in current dollars. A 5% real discount rate is used for these calculations.

Table ES.2. Estimated Summer Peak Load, and Water and Pollutant Reductions from New Standards

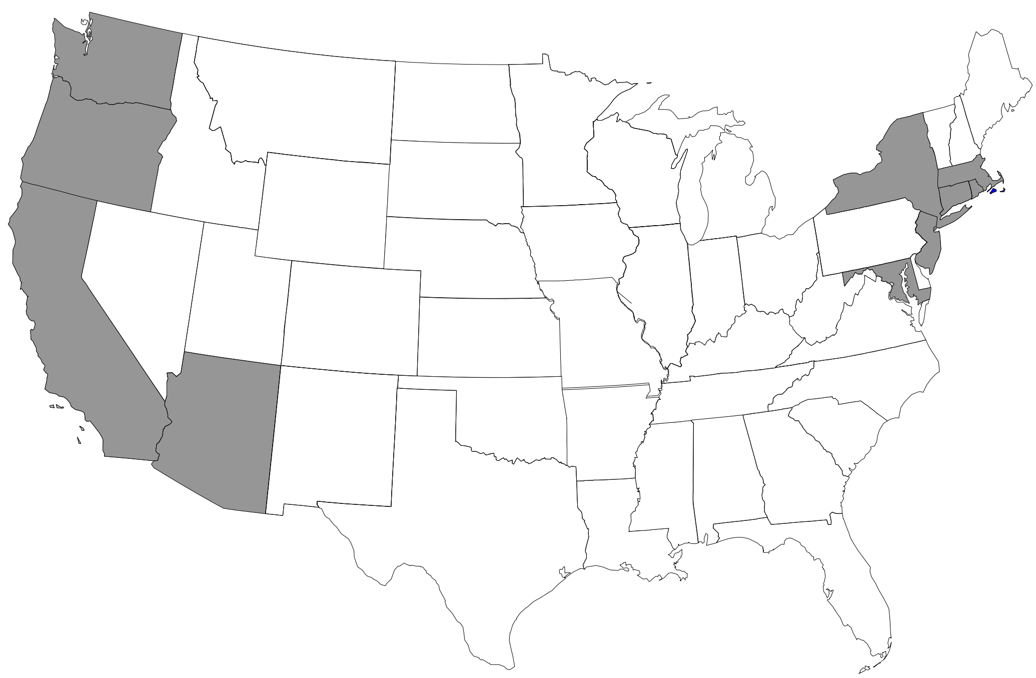
	Summer Peak Load Reduction		Water Savings	Pollutant Reductions in 2020			
	In 2020 (GW)	In 2030 (GW)	In 2020 (billion gal)	Carbon (MMT)	NOx (1000MT)	SOx (1000MT)	PM10 (1000MT)
Bottle-type water dispensers	0.04	0.04	0.02	0.1	0.1	0.6	0.0
Commercial boilers	NA	NA	NA	0.1	0.2	0.0	0.0
Commercial hot food holding cabinets	0.1	0.1	0.1	0.1	0.2	0.9	0.0
Compact audio products	0.2	0.2	0.1	0.3	1.0	4.1	0.1
DVD players and recorders	0.03	0.03	0.02	0.0	0.1	0.6	0.0
Liquid-immersed distribution transformers	1.1	2.0	1.0	1.6	4.7	19.6	0.3
Medium-voltage dry-type transformers	0.1	0.1	0.1	0.1	0.3	1.2	0.0
Metal halide lamp fixtures	2.9	4.7	2.4	1.7	5.1	21.3	0.3
Pool heaters	NA	NA	NA	0.1	0.3	0.0	0.0
Portable electric spas (hot tubs)	0.04	0.04	0.0	0.0	0.1	0.4	0.0
Residential furnaces and residential boilers	3.1	6.5	3.2	3.8	12.8	34.9	0.8
Residential pool pumps	0.7	0.7	0.4	0.6	2.8	7.3	0.1
Single-voltage external AC to DC power supplies	0.7	0.7	0.3	0.9	2.8	11.7	0.2
State-regulated incandescent reflector lamps	1.4	1.4	0.7	1.1	3.2	13.7	0.2
Walk-in refrigerators and freezers	1.1	1.1	0.5	0.9	2.6	11.2	0.1
Total	11.6	17.7	8.9	11.6	36.3	127.5	2.0

Note: Water savings include direct savings at the point of use as well as reductions in power plant water use.

1. INTRODUCTION

This report is an update of the 2005 ACEEE report of the same name. That report in turn was an update and expansion of a 2001 ACEEE report entitled *Opportunities for New Appliance and Equipment Efficiency Standards: Energy and Economic Savings Beyond Current Standards Programs* (Kubo, Sachs, and Nadel 2001). The 2001 report examined opportunities for state appliance and equipment efficiency standards for 14 products. The 2005 report included most of these products but also added information on promising standards for six additional products. Many states used the previous reports as they considered new appliance standards and regulations. Since 2001, legislation or regulations have been adopted in ten states (Arizona, California, Connecticut, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Washington) based in substantial part on recommendations in the earlier reports. In addition, in August 2005 the U.S. Congress passed the Energy Policy Act of 2005 that set standards for 16 products and directed the DOE to develop standards for five additional products. Many of these products were covered in the earlier reports. With these actions, it is time for an updated list of targets for state action, carrying over some items from the 2005 report, but adding ten new ones. We hope the current report is at least as useful, and provides the information that additional states need to adopt standards on the updated list of 15 products covered here.

Figure 1. States with Appliance and Equipment Efficiency Standards



2. BACKGROUND

2.1 History of Standards in the United States

Appliance efficiency standards were first enacted by the state of California in 1974 when then-Governor 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, thereby reducing the rate of growth of energy consumption, prudently conserving energy resources, and assuring statewide environmental, public safety, and land use goals" (CEC 1983). Other rationales for standards were to save consumers money by lowering appliance operating costs and helping to overcome market barriers that inhibit the sale of efficient products.

California's original standards applied to refrigerators, freezers, room air conditioners, and central air conditioners. California subsequently expanded the scope of its standards to include space heaters, water heaters, plumbing fittings, fluorescent ballasts, and large air conditioners (CEC 1983). In the early and mid-1980s, other states (including Florida, Kansas, and New York) began to adopt standards on central and room air conditioners (Geller 1983). In 1986, Massachusetts adopted standards on refrigerators, room air conditioners, water heaters, fluorescent ballasts, and showerheads (Nadel 1994).

In 1986, with the likely development of additional state standards, appliance manufacturers became increasingly concerned about the impact of differing state standards on manufacturers' ability to do business on a national basis. To address these concerns, they offered to negotiate with energy efficiency advocates and states in order to reach consensus on national efficiency standards that would largely preempt individual state standards. The resulting agreement was adopted by Congress and signed by President Reagan as the National Appliance Energy Conservation Act of 1987 (NAECA) (U.S. Congress 1987).

In the late 1980s and early 1990s, several states (e.g., Colorado, Connecticut, Delaware, Florida, Georgia, Massachusetts, New Jersey, New York, Rhode Island, Texas, Vermont, and Washington) adopted standards on fluorescent lamp ballasts, showerheads, and/or a variety of lamp types and began considering standards on other products. Based in significant part on these state actions, in 1988 Congress added fluorescent ballasts to NAECA (U.S. Congress 1988). And in 1992, Congress adopted and President George H.W. Bush signed the Energy Policy Act of 1992 (hereafter called "EPAct 1992"), which 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). The specific products covered by these different federal standards are summarized in Table 2.1.

Table 2.1. Products Subject to Existing Federal Appliance Efficiency Standards

Products Included in the National Appliance Energy Conservation Act of 1987	
Refrigerator-freezers	Clothes washers
Freezers	Clothes dryers
Room air conditioners	Dishwashers
Central air conditioners & heat pumps	Ranges & ovens
Furnaces & boilers	Pool heaters
Water heaters	Fluorescent lamp ballasts
Direct-fired space heaters	Televisions*
Products Added in the Energy Policy Act of 1992	
Fluorescent lamps	Showerheads
Incandescent reflector lamps	Faucets & aerators
Electric motors (1–200 hp)	Toilets
Commercial packaged air conditioners & heat pumps	Distribution transformers*
Commercial furnaces & boilers	Small electric motors (<1 hp)*
Commercial water heaters	High-intensity discharge lamps*

Source: Nadel and Pye (1996)

* Specific standards were not set in the legislation but instead DOE was instructed to investigate whether standards were technically feasible and economically justified and to set standards where these criteria were met.

Since the original NAECA and EPAct 1992 standards, DOE has updated several standards and these updates are yielding significant additional energy and economic savings. DOE was specifically instructed to update standards whenever "new available technology makes higher standard levels economically justifiable" (U.S. Congress 1987). These updates include new refrigerator, freezer, and room air conditioner standards published in 1997; new fluorescent ballast standards published in 2000; and new clothes washer, water heater, and central air conditioner and heat pump standards published in 2001 (in most cases, new standards take effect three years after final publication). Despite completing these important updates, DOE has missed legal deadlines for about 20 other updates (see below).

In 2005, after about five years of work, Congress adopted the Energy Policy Act of 2005 (U.S. Congress 2005a). This bill addressed many aspects of U.S. energy supply and use, including new efficiency standards. The bill set new efficiency standards for 16 products and directed DOE to set standards via rulemaking for five additional products (see Table 2.2). The standards in this bill were all based on consensus agreements between energy efficiency supporters and product manufacturers. These agreements were worked out through product-by-product negotiations over several years. Most of these agreements were based on standards adopted by states in recent years.

Table 2.2. Products with Standards Set in the Energy Policy Act of 2005

Residential
Ceiling fan light kits
Dehumidifiers
Compact fluorescent lamps
Torchiere lighting fixtures
Commercial and Industrial
Air conditioners and heat pumps (unitary equipment 240–760k Btu/hr)
Clothes washers
Distribution transformers (low voltage)
Exit signs
Fluorescent lamp ballasts (F34 and F96ES types)
Ice-makers (cube type, 50 to 2,500 lbs/day)
Mercury vapor lamp ballasts
Pedestrian traffic signals
Pre-rinse spray valves
Refrigerators and freezers (packaged)
Traffic signals
Unit heaters

Standards to Be Set by DOE Rulemaking

Battery chargers
Commercial refrigeration—supermarket refrigeration systems, ice-cream freezers, refrigerators without doors
External power supplies
Furnace fans
Refrigerated beverage vending machines

Note: In addition, some of the standards set in EPAct 2005 will be updated in DOE rulemakings.

As noted above, in recent years, ten states have adopted new appliance and equipment efficiency standards. In early 2002, California adopted new standards on ten products ranging from commercial clothes washers to traffic signal modules. In early 2004, the Maryland and Connecticut legislatures enacted efficiency standards on nine and eight products, respectively, drawing from the California energy standards, ENERGY STAR® specifications, and other widely used specifications. Similar legislation passed both houses of the New Jersey legislature in 2004 and was finalized in early 2005. In December 2004, the California Energy Commission adopted new standards on 19 additional products, including 15 products not previously regulated and four products that were already regulated but for which revisions were made (CEC 2004). In addition, California has standards on several products pending, with a decision scheduled for early 2006 (CEC 2005). In 2005, six states adopted efficiency standards legislation, generally for an expanded list of products relative to the 2004 laws. The additional products drew from the new California standards and other sources and were featured in the January 2005 version of this report. These states are Arizona, Massachusetts, New York, Oregon, Rhode Island, and Washington. Table 2.3 summarizes products now subject to state efficiency standards that are not preempted by federal standards and also includes standards now pending in California.

Table 2.3. Products Covered by Adopted and Pending State Standards

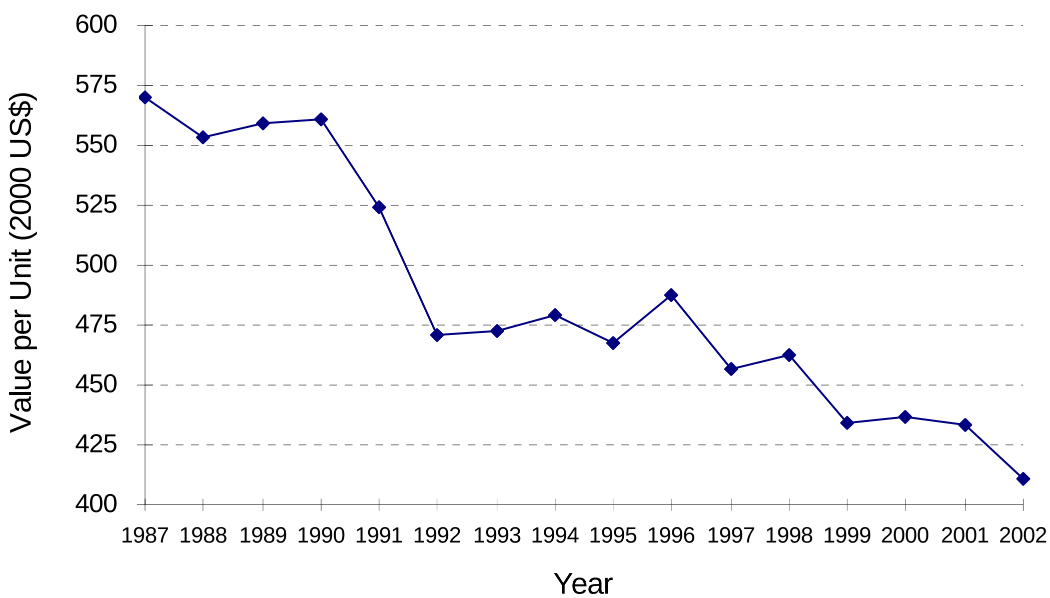
Product	California	Arizona	Massachusetts	New York	Oregon	Rhode Island	Washington
Boilers & central furnaces not covered by federal standards	X						
Commercial hot food holding cabinets	X						
Computer room air conditioners	X						
Consumer audio and video equipment	X			O			
Digital television adaptors	X			O			
Duct furnaces	X						
External power supplies	X	X	X	O	X	X	X
Freezers (residential, 30–39 cubic feet)	X						
General service incandescent lamps	XO						
Incandescent reflector lamps not federally regulated	O		X	O	X		X
Medium-voltage dry-type distribution transformers			X				
Metal halide lamp fixtures	XO	X	X	X	X	X	X
Pool heaters not covered by federal standards	X						
Pool pumps	X						
Refrigerated beverage vending machines	X						
Residential furnaces & boilers			X*				
Residential furnace fans			X				
Small water heaters not covered by federal standards	X						
Under-cabinet light fixture ballasts	X						
Walk-in refrigerators & freezers	X						
Water dispensers	X						
Water & ground water-source heat pumps	X						
Wine chillers	X						

Key: X = standard adopted, O = standard pending, XO = standard adopted and revised standard pending
* Will petition for exemption from federal preemption.
Note: Connecticut, Maryland, and New Jersey are not listed here as their standards are on products subsequently covered by federal legislation. Under the rules of federal preemption, these states may enforce their state standards until the federal standards for these products go into effect, but additional states may not enact standards for products with specific standards set in federal law. Also, the states listed in Table 2.3 have generally adopted standards on products not listed here that are now covered by federal standards.

2.2 Rationale for Standards

By setting a minimum-efficiency level, standards ensure that efficiency improvements are incorporated into all new products and thus ensure all buyers a minimum level of efficiency performance. Without standards, in many cases, only premium products include efficiency improvements. Standards can help bring down costs for energy-efficient technologies due to economies of scale and because standards encourage manufacturers to focus on how to achieve efficiency improvements at minimum cost as manufacturers compete for the most price-sensitive portion of the market. As a result, higher-efficiency products become more affordable and widely available and all consumers enjoy the benefits from advances in product performance and design. For example, due to standards, all new refrigerators use high-efficiency motors and compressors, better insulation, and improved heat exchangers and are three times more energy efficient than refrigerators were in the 1970s. During this period, the average per unit value (average manufacturer cost and profit) of refrigerators actually **declined** (see Figure 2.1).

Figure 2.1. Per Unit Value of Refrigerators, 1987–2002 (in 1996 dollars)



Note: New federal standards took effect in 1990, 1993, and 2001.
Source: Census (2003 and earlier years)

Clearly, appliance and equipment efficiency standards save energy—standards already in place will save 5.1 quads in 2020, equivalent to the annual energy use of 28 million U.S. households (further details provided below). In addition, efficiency standards also reduce pollutants, improve electric system reliability, and save consumers and business owners a significant amount of money during the life of the equipment from reduced energy bills. Due to these multiple benefits, it is important for the federal government, states, and utilities to include present and future standards in their energy use forecasts and plans and to take steps to ensure that state and federal appliance standards are regularly updated and expanded to cover additional products so that these many benefits can be realized.

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 he or she is 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. In the commercial/industrial sector, many purchasing decisions are made by purchasing or maintenance staff who 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 250 million or so of these devices are sold nationally each year, large energy savings are at stake for states or 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. A good example is beverage vending machines—the manufacturers agree in concept that energy savings could be achieved with very small incremental cost but they have been reluctant to participate in voluntary programs for improved efficiency since purchasers (e.g., beverage bottling companies) only look at first cost. In contrast, mandatory standards ensure a level playing field for all manufacturers.

Besides minimum-efficiency standards, a number of other program and policy options are available to overcome these barriers, including education programs, rebate programs, and building code requirements. However, none of these options have the energy-saving impact of minimum-efficiency standards because the options do not affect all purchase decisions. Education programs generally only reach a small fraction of decision-makers. For the products discussed in this report, there either is no EPA/DOE ENERGY STAR program or ENERGY STAR products generally have a market share of much less than 50% (Nadel et al. 2003).[4] Utility incentive programs likewise generally reach less than 50% of the eligible market (Nadel, Pye, and Jordan 1994). For education programs or incentive programs to reach larger portions of the market would be prohibitively expensive in nearly all cases. Building codes generally apply only to new or substantially renovated buildings, leaving the

[4] The only exception is DVD players where ENERGY STAR has about a 64% market share due to the very low incremental cost for meeting the ENERGY STAR specification.

large number of existing buildings unaffected. Also, building codes generally cover only products that are installed in buildings prior to occupancy (e.g., heating, cooling, and water-heating systems) and thus many products covered by standards are not covered by building codes. Thus, while these other programs and policy options have important benefits and complement efficiency standards (e.g., by encouraging higher-efficiency levels than can be mandated with efficiency standards), they are not a replacement for efficiency standards.

2.3 Savings from Current Standards

Several organizations have conducted studies on the impacts of efficiency standards to date on U.S. energy use. For example, both ACEEE and Lawrence Berkeley National Laboratory (LBNL) have periodically published estimates of the national impacts of specific federal efficiency standards (Atkinson et al. 1992; Geller 1987, 1995; Geller and Miller 1988; Geller and Nadel 1992; LBL 1990; McMahon et al. 1990). These studies generally compared the efficiencies of appliances with standards to what efficiencies would have been if pre-standard efficiency trends had continued. ACEEE has compiled a list of savings estimates including electricity savings, primary energy savings, peak load reductions, and carbon reductions in the years 2000, 2010, and 2020 from all standards adopted so far. This analysis is summarized in Table 2.4.

Table 2.4. Savings from Federal Appliance and Equipment Efficiency Standards

Enact Year	Standards	Electricity savings (TWh/yr)			Primary energy savings (Quads/yr)			Peak load reductions (GW)			Carbon Reductions (MMT)			Net Benefit ($Billion)
		2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020	Thru 2030
1987	NAECA	8.0	40.9	45.2	0.21	0.55	0.61	1.4	14.9	16.5	3.7	10.0	10.1	46.3
1988	Ballasts	18.0	22.8	25.2	0.21	0.27	0.29	5.7	7.1	7.9	4.4	5.0	5.0	8.9
1989&91	NAECA updates	20.0	37.1	41.0	0.23	0.43	0.47	3.6	6.9	7.7	4.8	8.1	8.1	15.2
1992	EPAct (lamps, motors, etc)	42.0	110.3	121.9	0.59	1.51	1.67	10.1	26.2	28.9	11.8	27.5	27.9	84.2
1997	Refrigerator/freezer update	0.0	13.3	28.0	0.00	0.13	0.28	0.0	1.7	3.6	0.0	2.9	5.5	5.9
1997	Room Air Conditioner update	0.0	1.3	2.1	0.00	0.01	0.02	0.0	1.0	1.6	0.0	0.3	0.4	0.6
2000	Ballasts update	0.0	6.2	13.7	0.00	0.06	0.13	0.0	1.8	3.0	0.0	1.3	2.7	2.6
2001	Clothes Washer Update	0.0	8.0	22.6	0.00	0.11	0.28	0.0	1.3	6.1	0.0	2.2	5.4	15.3
2001	Water heater update	0.0	2.5	4.9	0.00	0.08	0.13	0.0	1.5	3.6	0.0	1.4	2.2	2.0
2001	Central AC&HP update	0.0	10.7	36.4	0.00	0.11	0.35	0.0	3.5	41.5	0.0	2.3	7.2	5.0
2005	EPAct 2005	0.0	14.7	53.0	0.00	0.21	0.65	0.0	5.8	23.9	0.0	3.7	11.5	47.5
	TOTAL	**88**	**268**	**394**	**1.2**	**3.5**	**4.9**	**21**	**72**	**144**	**25**	**65**	**86**	**234**
	% of projected U.S. use	**2.5%**	**6.9%**	**9.1%**	**1.3%**	**3.1%**	**4.0%**	**2.8%**	**8.3%**	**15.1%**	**1.7%**	**3.6%**	**4.4%**	

Source: Geller, Kubo, and Nadel (2001); ACEEE analysis on EPAct (2005)

The overall savings from established appliance and equipment efficiency standards are enormous. As of 2000, appliance standards had already cut U.S. electricity use by 2.5% and U.S. carbon emissions from fossil fuel use by nearly 2%. The total electricity savings are projected to reach 268 and 394 trillion kilowatt-hours (kWh) per year, or 6.9% and 9.1% of the projected total U.S. electricity use in 2010 and 2020, respectively. The primary energy savings from these standards, including reductions in fuel use at power plants and in homes and businesses, should reach 4.9 quads in 2020—equivalent to the annual energy use of about 27 million American households. The peak load reduction is expected to reach 72,000 MW in 2010 and 144,000 MW in 2020, which is equivalent to the power produced by nearly

500 average (i.e., 300 MW) fossil fuel power plants. The standards also will reduce carbon emissions by 65 MMT in 2010 and 86 MMT in 2020 (including both power plant and end-use savings). The latter value is equivalent to the annual carbon emissions from approximately 58 million "average" passenger cars (EPA 1997). These savings will occur while simultaneously the standards will provide a cumulative net benefit through 2030 of about $230 billion to U.S. consumers, about $2,200/household (Geller, Kubo, and Nadel 2001; Nadel 2005a). These savings estimates are conservative because they only account for the savings resulting from federal standards and don't include the benefits from state standards that preceded the federal requirements. The economic benefit estimates also are conservative because energy prices have increased faster in recent years than was generally assumed in the analyses.

Of particular interest in Table 2.4 are the six updates to NAECA issued by the Clinton Administration in 1997, 2000, and early 2001. These standards include refrigerators and freezers, room air conditioners (A/C), fluorescent ballasts, clothes washers, water heaters, and central A/C and heat pumps. These six standards combined are expected to reduce electricity use by 107 billion kWh/yr and peak electric demand by 59,000 MW by 2020, while saving consumers and businesses over $31 billion net through 2030. These savings represent a significant portion of the overall savings from appliance and equipment standards to date and illustrate the importance of regularly updating standard levels whenever new technology proves both feasible and beneficial.

Furthermore, from the point of view of government expenditures, standards are incredibly cost-effective. A 1995 analysis compared the costs and benefits of the federal standards program as of 1995 and concluded that benefits are more than 2,500 times greater than program costs (Geller 1995). A 2001 study of more recent experience under the federal standards program found benefits were more than 2,000 times greater than the costs of recent DOE rulemakings (Kubo, Sachs, and Nadel 2001). Costs for states to develop and implement standards have proven to be much, much lower than federal costs, with benefit-cost ratios somewhat higher as a result. This issue is discussed further in Section 3.5.

2.4 Opportunities for New and Updated Standards

The efficiency standards established to date have provided significant energy and economic savings, yet the United States is experiencing overall growth in energy demand and an increasingly tight supply. Growth in electricity use is exceeding power plant construction in some regions and existing power surpluses could soon evaporate. Savings from new efficiency standards can improve system reliability by reducing the need for additional power plants and easing the electric load on already stressed transmission lines and transformers. Furthermore, natural gas prices skyrocketed in the past few years (e.g., $13.30 per thousand cubic feet was the average residential price in the first ten months of 2005, up 53% relative to the same period in 2002) (EIA 2006a).[5] ACEEE researchers discovered that markets are so tight that just a modest 2–4% reduction in national gas use could reduce natural gas prices by 20% or more (Elliott et al. 2003). Such savings could be achieved with the use of more

[5] In late 2005, wholesale natural gas prices rose even higher but have since returned to levels prevalent in the first ten months of 2005.

efficient gas-fired equipment as well as through reduced electricity use, since in many regions of the United States, natural gas is the marginal fuel used for power generation. Coal prices have also been rising in the past year, affecting electricity prices, which have been increasing because demand is up (due in part to high oil and natural gas prices) and supplies are tight. Appliance and equipment efficiency standards, along with other efficiency actions, can reduce demand, softening markets and reducing energy prices as a result.

When NAECA was passed in 1987 and the two Energy Policy Acts were passed in 1992 and 2005, Congress focused on many of the most common residential appliances and commercial equipment that had significant energy and economic savings potential. Despite Congress' enactment of 16 new standards in the summer of 2005, many products for which new standards make sense have not been addressed by the federal government. California has standards for about twenty products not covered by federal standards. Other states (including Arizona, Massachusetts, New York, Oregon, Rhode Island and Washington) have a few standards (see Table 2.3). In addition, increased market share for products meeting some of the ENERGY STAR specifications has paved the way for standards adoption. For other products, additional research on the energy savings potential, usage, cost, and availability (these developments are discussed in detail for specific products below) has become available, demonstrating the case for new state standards.

Policy support for updating existing standards and broadening the coverage of efficiency standards to additional products comes from many quarters. The Interlaboratory Working Group (2000), the National Petroleum Council (2003), the State Public Interest Research Groups (2001), and the Bush Administration's National Energy Policy Development Group (2001—i.e., the Administration's energy plan) have all stated support for new standards. New efficiency standards have also drawn bipartisan support in Congress. One of the least controversial elements of EPAct 2005 was the standards section.

The National Association of Regulatory Utility Commissioners (NARUC) has adopted resolutions in support of both upgraded national efficiency standards and expanded state efficiency standards. NARUC specifically urged DOE "to expeditiously promulgate and implement new national standards for commercial air conditioners and heat pumps; residential furnaces and boilers; and electric distribution transformers that achieve the greatest level of cost-effective energy savings" (NARUC 2004a). Separately, NARUC urged state policymakers to support "action where appropriate to establish State level energy efficiency standards that are cost effective for their respective states" and "to coordinate across State lines to the greatest extent practical in the development and implementation of such State standards" (NARUC 2004b). The Bush Administration's national energy plan, issued in 2001, noted that "standards will stimulate energy savings that benefit the consumer, and reduce fossil fuel consumption, thus reducing air emissions." The plan then recommended that the Secretary of Energy: (1) "support [the] appliance standards program for covered products, setting higher standards where technologically feasible and economically justified"; and (2) "expand the scope of the appliance standard program, setting standards for additional appliances where technologically feasible and economically justified." (National Energy Policy Development Group 2001). The following section briefly reviews key upgrades to existing federal standards that are due. The remainder of this report primarily focuses on recommendations for new state standards for 15 products, primarily ones not covered by current federal standards.

2.5 Savings from Updated Federal Standards

Several existing federal standards are now ready for updating. DOE is presently working on two products as high priorities—residential furnaces and boilers, and electric distribution transformers (the last is not currently subject to a federal standard but DOE was directed to set standards under EPAct 1992). For these products, DOE issued Advanced Notices of Proposed Rulemakings (ANOPRs) in August 2004 and DOE has said it will issue final rules by the fall of 2007. Additional information on these rulemakings can be found in a September 2004 report issued by the Appliance Standards Awareness Project (Nadel et al. 2004).

In addition, DOE is under heavy pressure to catch-up on a backlog of more than 20 rulemakings for updated standards for which Congressional deadlines have passed. Congress has asked DOE to report on steps it is taking to catch-up overdue standards and the Attorneys General of 15 states have sued DOE asking the courts to set a schedule for rapidly catching up on overdue rulemakings. Included in this list are products for which standards were set in the late-1980s and early 1990s that have yet to be revised, as well as products for which standards were updated in 1997–2001, but which will be ready for another round of revisions later this decade because of opportunities for significant additional cost-effective savings beyond the current standards. Products that are likely to fall into this category include residential refrigerators, residential gas-fired water heaters, and residential central air conditioners and heat pumps. In June 2004, a coalition of states, utilities, and energy efficiency groups formally petitioned DOE to begin a new rulemaking on residential refrigerators. DOE accepted this petition in April 2005 and said a schedule for this rulemaking would be issued later. Furthermore, as noted above, the Energy Policy Act of 2005 directs DOE to develop standards on five products and also to update standards on several products for which initial standards are set in EPAct 2005.

Given these demands, on January 31, 2006, DOE issued a proposed schedule for future rulemakings. The schedule proposes to complete new rulemakings mandated under NAECA and the two Energy Policy Acts by 2011. Rulemakings for two of the products with the largest savings (residential refrigerators and furnace fans) are not scheduled to begin until 2012 at the earliest as DOE argues that these rulemakings are optional (DOE 2006).

Energy savings from additional updated standards will be substantial. Table 2.5 lists products and possible standard levels for products subject to pending DOE rulemakings. Based on our estimates, these updates to current federal standards could yield over 180 TWh of electricity savings and 2.3 quads of primary energy savings annually by 2030.

Table 2.5. Potential Savings from DOE Rulemakings

Product	Annual Energy Use	Units	Estimated Savings (%)	Annual Savings Once Stock Turns Over: TWh	Annual Savings Once Stock Turns Over: TBtu
Residential:					
Battery chargers	6	TWh	34%	2	21
Central AC & HP	243	TWh	20%	49	510
Clothes dryers	100	TBtu	10%	NA	10
Clothes dryers	81	TWh	10%	8	84
Dehumidifiers	12	TWh	10%	1	13
Direct heaters	110	TBtu	8%	NA	9
Dishwashers	260	TBtu	11%	NA	28
External power supplies	67	TWh	7%	5	51
Freezers	19	TWh	10%	2	20
Furnaces & boiler effic.	4,907	TBtu	5%	NA	221
Furnace fans	56	TWh	49%	28	287
Pool heaters	82	TBtu	19%	NA	16
Ranges & ovens	287	TBtu	13%	NA	36
Refrigerators	85	TWh	25%	21	222
Room AC	27	TWh	9%	3	26
Water heaters	1,386	TBtu	4%	NA	54
Water heaters	116	TWh	2%	3	26
Commercial:					
Beverage vending machines	10	TWh	10%	1	11
Boilers	584	TBtu	3%	NA	18
Clothes washers	20	TBtu	21%	NA	4
Distribution transformers	75	TWh	27%	20	209
Fluorescent ballasts	227	TWh	7%	16	171
Fluorescent lamps	227	TWh	5%	11	118
Gen'l service incand. lamps	65	TWh	5%	3	34
Ice-makers	7	TWh	10%	1	8
Incand. reflector lamps	38	TWh	17%	6	66
Motors	403	TWh	2%	8	84
PTACs/PTHPs	13	TWh	13%	2	17
Reach-in refrig. & freezers	13	TWh	30%	4	40
Supermarket refrigeration	25	TWh	20%	5	51
TOTAL			Electricity	198	2,068
			Fuels		395
Grand total					**2,463**

Notes:
* Annual energy use for 2020 from EIA (2005) if available; otherwise used best available current year figures.
* Percentage savings from DOE and ACEEE analyses; these are very approximate preliminary estimates.

2.6 Possible New Federal Standards Legislation

No sooner had the ink dried on the Energy Policy Act of 2005 than rising energy prices, concerns about increasing reliance on imported oil, and other factors spurred members of Congress to start talking about new legislation. Many bills have been introduced, including one on oil refineries that passed the House of Representatives. While efficiency standards are not the main focus of these discussions, if legislation moves forward, there is a good chance that Congress could include some new efficiency standards. In general, Congress has shown itself willing to adopt new standards where industry and efficiency advocates have developed a consensus on how to proceed. Already, the National Electrical Manufacturers Association (NEMA) has agreed to support a negotiated national standard for incandescent reflector lamps identical to the standard established in some states. Discussions are underway about possible federal standards on several other products, spurred by standards that have recently been adopted or are now under consideration at the state level.

2.7 Need for State Action

While progress has been made at the federal level, states cannot count on the federal government by itself to set reasonably strong efficiency standards in a timely way. DOE's recent commitment to catch up on overdue required federal standard updates is a good start, but the agency's ability to meet a schedule for new standards remains unproven. Also, while Congress will consider new legislation, given that it took about five years to enact the last federal energy law, it remains far from certain that federal legislation will be enacted any time soon. States can and should enact standards on the products covered in this report in order to address the very real state needs to save energy, reduce energy bills for consumers, and cut pollution. State action will also make it more likely that DOE and Congress will eventually act, helping to spread the benefits to the nation as a whole. The rest of this report discusses opportunities for state standards in more detail.

3. Products Meriting Consideration for State Efficiency Standards

3.1 Introduction

We used four basic criteria for determining which products are ready for state-level efficiency standards:

1. A standard would achieve significant energy savings;
2. A standard is known to be very cost-effective for purchasers and users of the product;
3. Products meeting the recommended standards are readily available today; and
4. A state standard could be implemented at very low cost to the state.

The following sections first describe the products and standards (Section 3.2) and then detail how each of these basic criteria is met. Cost-effectiveness for the purchaser/user is addressed in Section 3.3. Using national average energy prices, most of the recommended standards have simple paybacks of less than 3 years, with many having even shorter payback periods. Section 3.4 shows the current availability of products meeting the standards. In Section 3.5, we discuss how existing standards and voluntary programs smooth the way for very low-cost implementation by additional states establishing their own standards. Section 4 summarizes the energy, environmental, and economic benefits for each of the recommended standards. An online appendix available at www.standardsASAP.org shows the energy, economic, and environmental benefits for each of the fifty states.

For most of the products listed, there are currently no federal standards and thus states are not subject to federal preemption with regard to setting efficiency standards for these products.[6] For a few products listed here, there are federal standards but DOE has been slow to update these standards. In these cases (i.e., residential furnaces and boilers, pool heaters, and commercial boilers), we recommend that states set standards and then petition DOE for a waiver from federal preemption. This waiver process is described further in Section 3.5.4 of this report.

3.2 Product and Standard Descriptions

We break the product and standard descriptions into three groups: products that are not federally regulated that are ready for state standards today in *all* states; products that are ready for state standards today in *some* states based on climate or other regional factors (including a few that are federally regulated); and products for which a little more work is needed over the next year or so before they are ready for state standards. Within each category, we list products in alphabetical order. Categories and products are summarized in Table 3.1.

Table 3.1. Products for State Standards by Category

Category	Products
Products that are not federally regulated that are recommended for state standards today in *all* states	Bottle-type water dispensers Commercial hot food holding cabinets Compact audio products DVD players and recorders Liquid-immersed distribution transformers* Medium-voltage dry-type distribution transformers* Metal halide lamp fixtures Single-voltage external power supplies State-regulated incandescent reflector lamps Walk-in refrigerators and freezers
Products recommended for state standards today in *some* states	Commercial boilers Pool heaters Portable electric spas (hot tubs) Residential pool pumps Residential furnaces, boilers, and furnace fans Other products covered by California standards**
Products needing some additional research before state standards can be adopted	Battery chargers Multi-function cable and satellite boxes

* DOE is currently conducting a rulemaking on these products but the rulemaking is many years behind schedule, and under EPAct 2005, preemption of state standards will not begin until either DOE issues a final rule (for states without standards on these products by then) or the DOE standard takes effect (for states that have adopted a standard prior to the DOE final rule).
** Products discussed but not analyzed in this report.

[6] Under federal law, when federal standards take effect, states are preempted from adopting state efficiency standards on the same products different than the federal standards, unless they demonstrate a compelling state interest to DOE. The department is required or authorized to establish standards for some products covered in this report, but it has either failed to meet its legal deadlines (as is the case with transformers) for setting standards or has failed to exercise its authority (as is the case with furnace fans.) Therefore, states have stepped in where DOE has moved very slowly or failed to act.

3.2.1 Products Not Federally Regulated that Are Recommended for State Standards Today in All States

States either have developed or are currently developing standards for a number of products not subject to any federal standard. In this section, we discuss ten of these products.

Bottle-Type Water Dispensers

THE PRODUCT: Bottled water dispensers are commonly used in both homes and offices to store and dispense drinking water. Designs include those that provide both hot and cold water and those that provide cold water only.

Source: Oasis

THE STANDARD: In 2000, the EPA issued a voluntary ENERGY STAR performance specification for standby energy of 1.2 kWh per day and 0.16 kWh per day for "hot and cold" dispensers and "cold only" dispensers, respectively. In December 2004, the California Energy Commission adopted the standard for "hot and cold" dispensers manufactured after January 1, 2006 and we recommend that other states follow its lead. PG&E (2004e) found that the "cold only" standard did not result in significantly decreased energy consumption and thus did not recommend including those products in the standard.

KEY FACTS: "Hot and cold" water dispensers tend to be much less efficient than "cold only" because they must maintain water tanks at two temperatures in a small space. The greatest factor determining energy efficiency is insulation of the water reservoirs. Older models of "hot and cold" dispensers often do not have insulated hot water tanks, which increases heat dissipation and standby energy waste. Adding insulation between the tanks and increasing existing insulation levels can reduce standby energy waste. PG&E (2004e) found that a reduction from the baseline "hot and cold" dispenser daily energy consumption of 1.93 kWh to the proposed 1.2 kWh would save nearly 38% of annual energy consumption. The slight cost (about $12) to improve a basic unit to meet the proposed standard would be earned back in lower energy costs within about 6 months at national average energy prices. In 2004, 41% of water dispensers on the market met ENERGY STAR specifications.

Commercial Hot Food Holding Cabinets

THE PRODUCT: Hot food holding cabinets are used in hospitals, schools. and other applications for storing and transporting food at a safe serving temperature. They are freestanding metal cabinets with internal pan supports for trays. Most are made of stainless steel and are insulated; however, there are some models that are non-insulated and are often made of aluminum. The main energy-using components include the heating element and the fan motor.

THE STANDARD: The ENERGY STAR specification sets a maximum idle energy rate issued for hot food holding cabinets of 40 W per cubic foot of measured interior volume. In December 2004, the California Energy Commission adopted this level as a statewide minimum standard, effective January 2006.

Source: Carter-Hoffmann

KEY FACTS: Appropriate insulation in hot food holding cabinets is the key mechanism to meet the proposed standard (PG&E 2004h). Insulated cabinets also have the advantage of quick preheat times, less susceptibility to ambient air temperatures, and a more uniform cabinet temperature. The incremental cost for insulation is roughly $450 (PG&E 2004h). Other features that reduce heat loss include automatic door closers, magnetic door gaskets, and Dutch doors (half-doors). The recommended maximum idle energy rate translates to a 78% annual energy savings of 1,856 kWh relative to a basic, inefficient model (PG&E 2004h). These energy savings cover the estimated additional cost of more efficient units within three years. There is significant uncertainty of the current ENERGY STAR market share of this equipment. EPA estimated a 2004 market share of 11% (EPA 2005). But other industry experts we consulted with estimate 40 to 75%. For this report, we chose a midpoint market share estimate of about 40%.

Compact Audio Products

THE PRODUCT: Compact audio products include integrated systems that have more than one of the following functions: radio tuner, tape player, CD player, and MP3 player. The proposed standard does not cover component audio systems (separate receiver, CD player, etc.) or systems powered by batteries.

Source: Sharp

THE STANDARD: A standby power level of 2 W for compact audio products is listed under ENERGY STAR specifications. In late 2004, this standard was adopted by the California Energy Commission to be effective January 2007 for audio products without a permanently illuminated clock display. For products with a permanently illuminated clock display, the standard is 4 W. In July 2005, New York State followed California’s lead, enacting the Appliance and Equipment Energy Efficiency Standards Act of 2005. The New York law requires a state agency to set a specific standard for compact audio products by June 30, 2006.

KEY FACTS: Compact audio products, similar to other personal electronic devices, function at three main power modes: on, standby, and off. Many products spend a large amount of time in standby mode—not “on” but energized so they can receive a signal from a remote control. Only 28% of compact audio systems manufactured in 2004 met ENERGY STAR specifications (PG&E 2004f). Efficiency measures to reduce standby power, however, are simple and inexpensive with an incremental cost of about $1, an amount earned back in lower energy bills within 3 months. Measures include flash memory, LCD displays, low power data receivers and tuners, and monolithic ICs that incorporate subsections such as tuners and decoders into one device (PG&E 2004f).

DVD Players and Recorders

Source: Panasonic

THE PRODUCT: DVD (Digital Versatile Disc) players are popular home electronics used to play DVDs storing audio-visual data such as movies. DVD recorders are devices used to record audio-visual signals onto a DVD.

THE STANDARD: In 2003, the EPA set an ENERGY STAR specification for a maximum standby energy level of 3 W during standby mode for DVD players and recorders. In 2004, the California Energy Commission adopted this standard to take effect beginning in January 2006. In July 2005, New York State followed California's lead by enacting legislation requiring an agency to set a standard for DVD players and DVD recorders by June 30, 2006.

KEY FACTS: According to a DOE (2002) report, the average standby energy use of DVD players is 26.5 kWh per year. Power supply design accounts for most excess energy use during standby mode, which can be lowered using low standby power development kits such as Power Integrations' TinySwitch-II IC (PG&E 2004f). Features that reduce energy use in both standby and active mode include flash memory, LCD displays, low power data receivers and tuners, and monolithic ICs. Simple changes to power supply design that reduces standby energy use costs about $1, an amount earned back in energy savings within one year. PG&E predicts that 64% of DVD players and recorders will meet ENERGY STAR standards in 2005 (PG&E 2004f).

Liquid-Immersed Distribution Transformers

Source: Federal Pacific

THE PRODUCT: Distribution transformers reduce electricity voltage from the high levels at which power is shipped over utility transmission and distribution lines to the lower levels required to power equipment and machinery. Utilities own and operate the transformers on their systems including those seen on utility poles and cement pads throughout utility systems. These utility-owned transformers are typically "liquid-immersed"-type equipment. Liquid-immersed distribution transformers use oil as coolant and are generally used outdoors, unlike the dry-type transformers discussed below that are generally used indoors.

THE STANDARD: Since utility deregulation, many utilities have reduced the efficiency of transformers they purchase, arguing that under deregulation they have no incentive to purchase efficient transformers (EEI 2004). To address this market failure and achieve significant energy savings, standards on liquid-immersed distribution transformers should be set. In the late 1990s, the National Electrical Manufacturers Association (the trade association for transformer manufacturers) developed a recommended standard (NEMA standard TP-1—NEMA 1996) for all types of distribution transformers, including liquid-immersed transformers. NEMA standard TP-1 specifies a set of voluntary efficiency minimums. Massachusetts, New York, Minnesota, and Oregon require TP-1 or better liquid-immersed transformers through state building codes. In addition, Massachusetts has a equipment efficiency standard that covers installations not affected by its building code. The federal Energy Policy Act of 1992 instructed DOE to develop federal standards for transformers, but it has not yet done so. Although DOE is working on this standard now, we recommend that states adopt their own state-level standards since the DOE process has proven to be very slow. Under federal law, for states that adopt standards prior to the issuance of DOE's final rule, state standards are not preempted until the federal standard takes effect. According to a 2005 DOE analysis for this rulemaking, efficiency levels above those in TP-1 are cost-effective for all transformer categories examined (DOE 2005). Specifically, DOE found that relative to TP-1, life-cycle cost savings are achieved in all liquid-immersed transformer categories at efficiency levels 0.20 efficiency points above TP-1 (e.g., if TP-1 calls for an efficiency of 99.0%, DOE found that a standard of 99.2% provides life-cycle cost savings). Based on this analysis, we recommend that states adopt a standard 0.20 efficiency points higher than TP-1.

Source: General Electric

Table 3.2. Recommended Standard for Liquid-Immersed Distribution Transformers

Single Phase		Three Phase	
Rated Power Output in kVa	Minimum Efficiency %	Rated Power Output in kVa	Minimum Efficiency %[7]
≥ 15 < 25	98.8	≥ 15 < 30	98.3
≥ 25 < 37.5	98.9	≥ 30 < 45	98.6
≥ 37.5 < 50	99.0	≥ 45 < 75	98.8
≥ 50 < 75	99.1	≥ 75 < 112.5	98.9
≥ 75 < 100	99.2	≥ 112.5 < 150	99.0
≥ 100 < 167	99.2	≥ 150 < 225	99.1
≥ 167 < 250	99.3	≥ 225 < 300	99.2
≥ 250 < 333	99.4	≥ 300 < 500	99.2
≥ 333 < 500	99.4	≥ 500 < 750	99.3
≥ 500 < 667	99.5	≥ 750 < 1000	99.4
≥ 667 < 883	99.6	≥ 1000 < 1500	99.4
883	99.6	≥ 1500 < 2000	99.5
		≥ 2000 < 2500	99.6
		2500	99.6

KEY FACTS: When TP-1 was first developed, the market share of complying transformers was approximately 90% for liquid-immersed transformers. Since then, the market share of

[7] The TP-1 standard provides for slightly more stringent standards for transformers with low Basic Impulse Insulation (BIL) levels. To keep our proposal simple, we ignored this distinction and used the less stringent standards for both high and low BIL products.

TP-1 compliant products has declined due to cost-cutting pressures and reduced use of life-cycle cost analysis at utilities and industrial firms (Thorne and Kubo 1999). While precise data are not available, it appears that TP-1 units now account for on the order of 75% of liquid-immersed sales. Most manufacturers of liquid-immersed transformer are very flexible and custom build products according to their customer's specifications. This manufacturing flexibility makes it relatively easy for manufacturers to meet the recommended standard. Transformers at our recommended levels likely account for less than half of liquid-immersed sales. Based on the DOE analysis, the additional cost of transformers meeting the standards recommended here pays back in saved energy within about 4.5 years while transformers typically last thirty years or longer (DOE 2005).

Medium-Voltage Dry-Type Distribution Transformers

THE PRODUCT: Large industrial and commercial enterprises typically buy power from utilities at higher voltages, and own and operate "medium-voltage dry-type" transformers to reduce voltages for their own use. Dry-type transformers are air-cooled (hence the name "dry type") and are generally not as efficient as liquid-immersed transformers. Dry-type transformers are primarily used indoors, where concerns about oil leakage make use of liquid-immersed transformers more difficult.

Source: MIDWEST

THE STANDARD: As with liquid-immersed transformers, NEMA's TP-1 standard is an industry-developed guideline for medium-voltage dry-type transformers. A little over half of medium-voltage dry-type transformers meet the NEMA standard. Oregon, New York, and Minnesota require newly installed transformers subject to the state building code to comply with NEMA standard TP-1. Recently, DOE published an analysis of medium-voltage dry-type distribution transformers indicating that efficiency levels 0.3 efficiency points higher than TP-1 are cost-effective for all product categories analyzed (DOE 2005). In 2005, Massachusetts adopted these levels as a state standard. We recommend that additional states adopt these levels. The specific standard is summarized in Table 3.3. Under federal law, for states that adopt standards prior to the issuance of DOE's final rule, state standards are not preempted until the federal standard takes effect.

KEY FACTS: Transformers waste as much as 3% of their energy input as dissipated heat as they reduce voltage to lower levels. By moving to better designs and higher quality materials (e.g., better steel cores), this energy waste can be cut. The proposed standard reduces the energy waste associated with this equipment by an average of about one-third, with the added cost of the more efficient equipment paid back in 3–5 years, which is very attractive considering that DOE estimates that this equipment has an average life of 32 years. Most makers of transformers have product lines that meet the proposed standard or can easily modify existing product lines to meet the standard.

Table 3.3. Recommended Standard for Medium-Voltage Dry-Type Distribution Transformers

Single Phase		Three Phase	
Rated Power Output in kVa	Minimum Efficiency %	Rated Power Output in kVa	Minimum Efficiency %[8]
≥ 15 < 25	97.9	≥ 15 < 30	97.1
≥ 25 < 37.5	98.2	≥ 30 < 45	97.6
≥ 37.5 < 50	98.4	≥ 45 < 75	97.9
≥ 50 < 75	98.5	≥ 75 < 112.5	98.2
≥ 75 < 100	98.7	≥ 112.5 < 150	98.4
≥ 100 < 167	98.8	≥ 150 < 225	98.5
≥ 167 < 250	99.0	≥ 225 < 300	98.7
≥ 250 < 333	99.1	≥ 300 < 500	98.8
≥ 333 < 500	99.2	≥ 500 < 750	99.0
≥ 500 < 667	99.3	≥ 750 < 1000	99.1
≥ 667 < 883	99.3	≥ 1000 < 1500	99.2
883	99.4	≥ 1500 < 2000	99.3
		≥ 2000 < 2500	99.3
		2500	99.4

Metal Halide Lamp Fixtures

THE PRODUCT: Metal halide light fixtures are commonly used in industrial buildings and high-ceiling commercial applications such as gymnasiums and big-box retail stores. Some street lights and other high-output outdoor applications also use these fixtures.

Source: Holophane

THE STANDARD: In recent years, a new type of metal halide lamp[9] called a "pulse start" lamp has been introduced that uses about 15% less energy than the older "probe start" lamp. Pulse start lamps use an igniter to start the lamp through a series of high-voltage pulses and do not need a starter electrode (or starting probe electrode) as in probe start lamps. In addition, highly efficient electronic ballasts for metal halide lamps recently have come down in price and improved in quality and are now ready for widespread adoption. To address these two opportunities for energy savings, the California Energy Commission has developed standards for new metal halide fixtures, which it is adopting in two steps. The first step, adopted by the CEC in December 2004, disallows the use of the most inefficient ballast types (probe start ballasts) in the most common fixture types (those which operate in a vertical, base-up position). By addressing the ballast only and not the lamp, the standard only requires existing fixtures to be upgraded when ballasts fail. The second step of the CEC standards will extend the initial standard to all fixtures, regardless of lamp position, including

[8] The TP-1 standard provides for slightly more stringent standards for transformers with low Basic Impulse Insulation (BIL) levels. To keep our proposal simple, we ignore this distinction and use the less stringent standards for both high and low BIL products.

[9] The lighting industry commonly uses the term "lamps" to refer to light bulbs, rather than light fixtures.

the less common horizontal, vertical base-down and "universal" positions, effective January 2008. California is also considering requiring use of electronic ballasts, effective 2009 or perhaps later. Electronic ballasts are generally more efficient than magnetic ballasts and also better maintain lamp lumen output as lamps age, allowing lower wattage lamps to be used.

We recommend that other states adopt a ban on new probe start ballasts in metal halide light fixtures. As of January 2006, seven states had established standards disallowing probe start ballasts for some types of metal halide light fixtures. Four states' standards apply to fixtures regardless of position, while the other three are limited to vertical position fixtures. Due to the limited current availability of high-efficiency, electronic ballasts for metal halide lamps, we recommend that all but the most ambitious states consider an electronic ballast requirement at a later date. For most states, it is probably simpler to specify that a standard disallowing probe start ballasts take effect in 2008 for all lamp positions, rather than pursue the standard in two steps.

KEY FACTS: Pulse start lamps and ballasts save an average of about 15% and high-efficiency electronic ballasts can cut electricity use by another 11%. Presently, about 20% of metal halide lamp fixture sales are pulse start, primarily in new construction. About 2% of metal halide ballast sales are electronic (PG&E 2004d). The additional cost of a pulse start lamp fixture is covered by lower energy bills within about 1 year and the electronic ballast efficiency requirements earn back their additional cost within about 2 years. All of the major lighting manufacturers and many small manufacturers make pulse start lamps. Nearly all of the ballast manufacturers make pulse start ballasts that can be used to comply with the initial standard. At least eleven ballast manufacturers make electronic ballasts for metal halide lamps (PG&E 2004d).

Single-Voltage External AC to DC Power Supplies

THE PRODUCT: External power supplies are the small black boxes typically attached to the power cord of many types of electronic products 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 the lower AC or DC voltages on which many electronic products operate. Typically the power supply plugs into an electric outlet and an electrical cord comes out of the power supply to bring power to the product.

Source: Ecos Consulting

THE STANDARD: The California Energy Commission recently developed initial standards for these products, which take effect January 1, 2007. As of January 2006, five additional states (Arizona, Massachusetts, Oregon, Rhode Island, and Washington) had enacted external power supply standards based on the initial CEC standards and a rulemaking was pending in New York. A second-phase, more stringent California standard, scheduled to be effective July 1, 2008, further reduces maximum no-load consumption for all output wattages to 0.5 W. EPA developed efficiency levels similar to the CEC's initial standard for a voluntary

ENERGY STAR labeling program, which began January 1, 2005. EPA plans to introduce a second-phase specification for power supplies effective July 1, 2006. The CEC's initial standard included approximately the top 25% most efficient products on the market. This initial standard is summarized in Table 3.5. Other states should follow the lead of the several states that have established this power supply standard. Ambitious states may want to consider adopting the more stringent, second-phase CEC standard.

Table 3.5. California Standards on External Power Supplies

Nameplate Output	Minimum Efficiency in Active Mode
< 1 Watt	0.49 * Nameplate Output
≥ 1 Watt and ≤ 49 Watts	0.09 * Ln(Nameplate Output) + 0.49
> 49 Watts	0.84
	Maximum Energy Consumption in No-Load Mode
≤ 10 Watts	0.5 Watts
> 10 Watts ≤ 250 Watts	0.75 Watts
Where Ln(Nameplate Output) is the natural logarithm of the nameplate output expressed in Watts.	

KEY FACTS: The typical, basic power supply is only 25 to 60% efficient (i.e., 40 to 75% of power is dissipated as heat). Power supplies also generally use several Watts of standby power, even when the device being powered is off. More efficient power supplies typically use electronic rather than magnetic components and can be 90% efficient in the active mode and have standby power levels of less than 1 W. PG&E (2004a) found that the more efficient power supplies have an incremental cost of less than $1. Energy bill savings recoup the minor additional cost for the consumer very quickly. Electronics manufacturers do not make their own power supplies, but rather source them from other companies. Nearly all power supplies are made in low-wage countries in Asia and are purchased primarily on the basis of first cost. There are many major manufacturers of efficient power supplies and several manufacturers of the key power supply components that these manufacturers rely on (PG&E 2004a).

State-Regulated Incandescent Reflector Lamps Reflector Lamps

THE PRODUCT: Reflector lamps are the very common cone-shaped light bulbs most typically used in "recessed can" light fixtures.[10] The cone is lined with a reflective coating to direct the light. "Bulged" reflector (BR) lamps are specific types of reflector lamps. "Blown" PAR (BPAR) are reflector lamps designed to be a low-cost substitute for widely used PAR lamps. Use of BR lamps has mushroomed in recent years as manufacturers have taken advantage of a loophole that exempts them from federal standards. BPAR lamp sales have also increased.

Source: GE Lighting

THE STANDARD: Under the federal Energy Policy Act of 1992, many reflector lamps need to meet specified efficacy

[10] Recessed cans are low-cost light fixtures that mount flush with a ceiling such that the socket and bulb are recessed into the ceiling. They are very common in residential and commercial construction.

requirements (i.e., lumens/Watt need to exceed specified minimum values). The federal law's intent was to substitute halogen and other more efficient lamp types for the most common type of inefficient reflector lamp known as "R lamps." Ellipsoidal reflector (ER) lamps were exempted because they have a special light distribution that allows lower wattage lamps to be used in recessed fixtures. BR lamps were exempted because one small manufacturer of these lamps said they were "just like" ER lamps and major manufacturers did not produce them. In fact, as we have since discovered, BR lamps have essentially the same light distribution as R lamps and the market share of these lamps has increased from less than 1% of reflector lamp sales prior to the federal law's passage to about 50% today. It is unclear whether BPAR lamps are covered by the federal law or not; we include them here just to be certain they are covered at either the federal or state level. R20 (2" diameter standard reflector lamps) were excluded from the standard since at the time there were no efficient substitutes (a situation that has since changed). We recommend that states close these loopholes by requiring that BR, BPAR, ER, and R20 lamps meet the same efficacy requirements as R lamps (see Table 3.6).[11] Specific types of lamps can be exempted from these requirements without significantly reducing energy savings (recommended exemptions are noted in Table 3.6). In 2005, Massachusetts, Oregon, and Washington enacted standards along these lines.[12] In early 2006, the California Energy Commission proposed a standard identical to Massachusetts' and expects to finalize this standard in the spring of 2006. New York law calls for a study on these products, followed by a rulemaking to set specific standards.

KEY FACTS: The halogen and other lamp types that substitute for BR lamps generally reduce energy use by more than 10%. The energy bill savings quickly cover the additional cost ($0.20 to $4.00) of the more efficient lamps. All major manufacturers and many smaller manufacturers make lamps that comply with the standards (PG&E 2004c). The proposed exemptions were a negotiated compromise in Massachusetts. NEMA, which represents the manufacturers, and ACEEE have agreed to ask Congress to adopt this standard with the negotiated exemptions as a federal standard. Since Congress is not presently considering energy legislation, it is unclear how many years this process will take.

Table 3.6. Proposed Standards on Many BR and ER Lamps Plus Some R Lamps

Wattage	Minimum Efficacy (lumens per Watt)
40–50	10.5
51–66	11.0
67–85	12.5
86–115	14.0
116–155	14.5
156–205	15.0

Recommended exemptions: BR30, BR40, ER30, and ER40 of less than or equal to 50 W; BR30, BR40 and ER40 of 65 W; R20 of equal to or greater than 45 W.

[11] DOE is now studying whether to subject BR lamps to the same standards as R lamps. However, DOE rulemakings generally take about five years, so the earliest a federal standard is likely is 2010, with the standard taking effect three years later.

[12] Oregon and Washington did not include all of the exemptions we recommend here.

Walk-In Refrigerators and Freezers

THE PRODUCT: Walk-in refrigerators and freezers are used in restaurants, hospitals, convenience stores, supermarkets and other locations where boxes of perishable food need to be stored. Walk-in units are essentially a small insulated room that is maintained either just above freezing (for a refrigerator) or significantly below freezing (for a freezer). They have a large door through which people can walk that is large enough to also accommodate a hand cart and a stack of boxes. The refrigeration system is located either on top of the walk-in or at a nearby location outdoors. In the latter case, the refrigeration system and the walk-in room are connected via pipes through which refrigerant is circulated.

Source: U.S. Cooler

THE STANDARD: In December 2004, the California Energy Commission adopted a standard for walk-in refrigerators and freezers. This standard included a variety of prescriptive requirements including insulation levels, motor types, and use of automatic door-closers (CEC 2004). Ideally a standard would specify a level of performance (e.g., kWh/ft^3/day) but this is difficult to do in practice as walk-ins are large and difficult to test and only limited test data are available. A major research project is needed to develop a performance standard; in the meantime, a prescriptive standard will provide large energy savings. The California standard provides a good foundation for other states, but we recommend that it be modified in three respects. First, the language needs to be clarified to make clear that doors must be insulated as should freezer floors. Second, freezer insulation levels need to be refined slightly so they can be reached with 4-inch thick panels. Third, an efficacy requirement for walk-in lighting should be included as many walk-ins use incandescent lights that are left on 24 hours per day.

KEY FACTS: According to a report on commercial refrigeration prepared for DOE, walk-ins account for about 18% of U.S. commercial refrigeration energy use (ADL 1996). Several other types of commercial refrigeration systems are covered by national standards (e.g., reach-in refrigerators and freezers, and ice-makers), leaving walk-ins as one of the largest categories that are not addressed. Analysis in California (PG&E 2004b) indicated that this standard will reduce walk-in energy use by an average of more than 40% and will have a simple payback to the user of about 1.5 years for freezers and 3.4 years for refrigerators. While the current market share of complying products is low, virtually all manufacturers can order complying components and meet the standards without difficulty.

3.2.2 Products That Are Recommended for State Standards Today in Some States

There are a few products where state standards may make sense in some states but not others. Probably the biggest reason for differences among states is climate. For example, pool pump standards make sense in states with average to longer-than-average pool seasons because the energy savings justify the extra cost of improved pumps and controls. This includes states warm enough for pools to be filled year-long or for much of the year. Even if it is too cold to swim, if pools are filled, then pumps and filters must continue to operate. Likewise, state furnace and boiler annual fuel utilization efficiency standards make sense where the heating season is long enough to justify stronger standards than for the country as a whole. Related to climate, several products are more widely used in some states than others, such as pool heaters and portable electric spas (hot tubs). We recommend states with significant saturations of these products consider standards on them. Another reason some states but not others may pursue standards on particular products has to do with a state's willingness to pursue waivers from federal preemption. Most of the standards we are recommending do not require such a waiver. But for products subject to federal standards, states must complete and file an application for a waiver from federal preemption. This process will require some additional effort relative to products not subject to federal standards. The following section includes three such products—commercial boilers, residential furnaces and boilers, and pool heaters. Finally, there are a few products for which California has just set standards that ambitious states should consider. We discuss each of these opportunities in the sections below.

Commercial Boilers

THE PRODUCT: Commercial boilers are used to heat commercial and multifamily residential buildings. Boilers heat water and generate either hot water or steam. The heated water or steam is circulated through radiators, baseboard units, or fan coils in order to heat a building. Commercial boilers are also used in some industrial process applications. Presently federal standards cover commercial boilers with a heating capacity of 300,000 Btu per hour or more. The federal standard has not changed since it was adopted in 1992; an update is overdue.

Source: Burnham

THE STANDARD: The present federal standard calls for a *combustion* efficiency of 80% for gas-fired boilers and 83% for oil-fired boilers. However, combustion efficiency is not a good efficiency descriptor as it only accounts for combustion inefficiencies and does not account for thermal inefficiencies such as heat radiated from the warm boiler. A better efficiency metric is *thermal* efficiency, which measures the heat contained in the water or steam as it leaves the boiler relative to the heat content of the fuel that is burned. Typically, the thermal efficiency of a boiler will be 2–3% less than its combustion efficiency. We recommend that states adopt a standard of 80% thermal efficiency for gas-fired boilers and 82% thermal efficiency for oil-fired boilers.

KEY FACTS: According to the April 2005 edition of the Institute of Boiler and Radiation Manufacturers Ratings for Commercial Boilers, 23 out of 25 manufacturers listed have complying products. Of the boilers with thermal efficiency data, about half the products meet our proposed standards. A recent analysis prepared by ACEEE indicates that the energy cost savings with such a standard are more than three times greater than the costs, with a simple payback period of fewer than five years (Nadel 2005b). Many utilities provide incentives for high efficiency boilers, but for higher thermal efficiencies than we propose here. For example, California utilities estimate a base case thermal efficiency for gas-fired boilers of 80% and are providing incentives for units with a thermal efficiency of 83% (Nadel 2005b; SCG 2006).

The current federal standard is based on a standard published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) in 1989. ASHRAE basically left this standard unchanged when the standard was revised in 1999.[13] In 2000, DOE reviewed the ASHRAE 1999 standard and concluded that "a more efficient level appears warranted" (DOE 2001). Unfortunately, DOE has done little work since then to develop a new standard. In September 2005, ACEEE submitted a formal proposal to ASHRAE asking them to update its standard to the values proposed here (Nadel 2005b). State action on commercial boiler standards could spur DOE or ASHRAE to act on an updated national standard.

Pool Heaters

THE PRODUCT: Pool heaters are used to heat the water contained in swimming pools, spas, and hot tubs. The water is heated as it passes through the pool heater, which is installed on the water line that circulates pool water through the filter. A thermostat turns on the heater when the water temperature is too low and shuts it off when the water reaches the desired temperature. Although there are several types of pool heaters, including those powered by gas, oil, electric resistance, heat pump, and solar energy, gas-fired heaters are the most widely used, offer good efficiency opportunities, and are the only type covered in this recommended standard.

THE STANDARD: In 1987, a national efficiency standard was established for gas-fired pool heaters under the National Appliance Energy Conservation Act (NAECA) requiring a minimal thermal efficiency of 78% (DOE 2004). Although DOE proposed a revision in 1994 (DOE 1994), the agency has never completed an update to the federal standard. Existing California regulations prohibit constant burning pilot lights in gas pool heaters. Currently California is the only state that has adopted standards other than those under federal regulations. (CEC also has a minimum standard for heat pump pool heaters.) DOE has found that electric ignition and an 80% thermal efficiency would be very cost effective for consumers (DOE 2004). Therefore, we recommend that states adopt a two-part standard disallowing constant burning pilot lights and requiring a minimum 80% thermal efficiency.

Source: Raypak

KEY FACTS: Basic, inefficient pool heaters have a standing pilot, which can be replaced with electronic ignition to reduce gas consumption. In addition, the thermal efficiency can be increased by adding additional heat exchange area relative to the current standard. Models

[13] ASHRAE did change the standard for boilers with heating capacity of 300,000 to 2.5 million Btu per hour to 75% thermal efficiency for gas and 78% thermal efficiency for oil, but these efficiency levels are often lower than the 1989 ASHRAE levels and the current federal standards.

with induced draft and pulse condensing elements are the most efficient, with thermal efficiencies of 91% and 96%, respectively—levels far above the recommended standard. These models, however, have not proved to be cost-effective (DOE 2004). Solar pool heaters have recently gained market share as a cost-effective way to heat swimming pools. These are recommended for appropriate applications, but cannot be mandated as not all applications have good sites for solar collectors. Pool heaters meeting the standards we recommend would save about $70 per year in gas costs, covering the additional upfront cost in about four years. Pool heaters last about 15 years on average. Most pool heater makers offer compliant products and about 70% of current national sales comply with the recommended standard.

Residential Pool Pumps

THE PRODUCT: Residential pool pumps are used to circulate and filter swimming pool water in order to maintain clarity and sanitation (PG&E 2004g).

Source: SpaSupport

THE STANDARD: In late 2004, the California Energy Commission adopted a standard with two parts. The first part bans the use of low-efficiency split-phase motors and capacitor start-induction run motors. The second phase requires two-speed pumps and controls. Two-speed operation saves large amounts of energy while still filtering the same amount of pool water because pumps operate much more efficiently at lower water flow rates. High-speed operation is only required intermittently (e.g., to run pool sweepers). The California standard, with minor modifications, is provided in Table 3.7.

Table 3.7. Proposed Standard for Swimming Pool Pumps

Effective Date	Requirements
January 1, 2006	Motor efficiency: new pool pump motors may not be split-phase, shaded-pole, or capacitor start–induction run types
January 1, 2008	(i) Pump motors of 1 horsepower or more shall have the capability of operating at two or more speeds with a low speed having a rotation rate that is no more than one-half of the motor's maximum rotation rate. (ii) Pump controls shall have the capability of operating the pool pump at least at two speeds. The default circulation speed shall be the lowest speed, with a high speed override capability being for a temporary period not to exceed 120 minutes.[14]

KEY FACTS: In warmer states (i.e., where pools are in operation all or most of the year), pool pumps can be among the largest consumers of electricity in the residential sector. For individual homes with pools, the pool pump is usually by far the single largest electricity user. For example, in California, pool pumps consume on average 2,600 kWh per year, an amount

[14] California specifies "one normal cycle" but does not define this term. We use 120 minutes here to be clearer. Cycles will generally be shorter than 120 minutes so the use of 120 minutes is probably conservative.

equal to 44% of the annual electricity consumption of a typical California household. Based on analysis in California, eliminating the least efficient types of pump motors (i.e., the phase one California standard) would save about 260 kWh per year per unit on average. The typical efficient pool pump costs about $85 more, but saves about 260 kWh per year. At national average electricity prices, these savings cover the additional cost in a little less than 4 years. Even larger savings can be achieved by shifting to two-speed pumps and controls (the phase two standard in California). This standard would cut electricity use by at least about 40% on average, or by about 1,040 kWh per year in the California example. Two-speed motors and pumps are available from at least six manufacturers. Five manufacturers are known to market controls for two-speed pump operation. The combination of two-speed pumps and controls is estimated to cost about $580. Based on national average energy prices (e.g., 9.4 cents/kWh), these improvements pay for themselves in lower energy costs in about 5 years. Pool pumps and motors last about 10 years on average (PG&E 2004g). This analysis does not include peak demand reduction benefits, which can be significant. In addition to California, this standard will be very cost-effective in states like Arizona, Florida, Nevada, and Texas. This standard may also be of particular interest in high-growth states where swimming pools are common with high-end new housing.

Portable Electric Spas (Hot Tubs)

THE PRODUCT: Portable electric spas are self-contained hot tubs. They are electrically heated and are popularly used in homes for relaxation and therapeutic effects. The most popular portable spas hold between 210 and 380 gallons of water; however, some models can hold as much as 500 gallons. “In-ground” spas are not included in this standard.

Source: Sundance

THE STANDARD: In December 2004, the California Energy Commission adopted a maximum standby energy consumption standard of 5 ($V^{2/3}$) Watts for portable electric spas where V = the total spa volume in gallons and 2/3 means to the two-thirds power. Standby energy consumption represents the majority (75%) of the energy used by electric spas and refers to consumption after the unit has been initially brought up to a stable temperature at the start of the season and when it is not being operated by the user (PG&E 2004i). The energy consumption calculation ($V^{2/3}$) proposed by CEC approximates total spa surface area, which is directly related to standby energy use. A maximum standby energy indexed to total spa surface area thus requires spas of all sizes to be equally efficient.

KEY FACTS: Over half the energy consumed by a typical electric spa is used for its heating system (PG&E 2004i). Heat is lost directly during use and through the cover and shell during standby mode. Improved covers and increased insulation levels are key measures to improving efficiency and can decrease standby energy use by up to 30% for a spa of average to low efficiency (PG&E 2004i). Another measure is the addition of a low-wattage circulation pump or improvements to pump efficiency that would generally save 15% of standby energy consumption of an average-efficiency spa. Automated programmable controls, which would allow users to customize settings based on predicted usage patterns, are a third measure to improve efficiency and could save roughly 5% of a spa's standby energy consumption. The California standard is a modest initial effort and is probably met by the majority of spas now being sold (PG&E 2004i). The CEC estimates that the products meeting the standard cost $100 more than basic models. At national average energy prices, this additional cost is covered within 4.3 years.

Residential Furnaces, Boilers, and Furnace Fans

Source: Carrier

This product class presents a special case for three reasons. First, heating is the largest residential energy use in most states and of growing concern due to recent increases in natural gas prices and home heating oil prices. Many homeowners have seen their heating bills double in the last few years. Second, residential furnaces and boilers are covered by federal standards that preempt state standards. Whether this preemption applies to furnace fans is a legal gray area.[15] Under the rules of this federal preemption, states can only implement standards more stringent than federal requirements if they apply for and are granted a waiver from federal preemption by DOE. Third, DOE is working on updated national standards for residential furnaces and boilers. However, this rulemaking is badly delayed (it was legally due for completion in 1994)[16] and DOE recently announced decisions that will severely limit the benefits from an eventual national standard. In its Advance Notice of Proposed Rulemaking published in August 2004, DOE said it would not address the electric efficiency of furnace fans and would not consider setting two national standard levels for fuel efficiency—a tougher one for cold states where improved efficiency is cost-effective and a weaker one for states where furnaces operate relatively few hours per year.[17]

Because of the combination of potentially large energy and economic savings and poor prospects for a timely and/or adequate federal standard, we recommend that individual states pursue standards for residential furnaces and boilers. This standard will be of particular interest to states with cold climates due to their higher heating loads and furnace operating hours, which improves the cost-effectiveness of efficiency improvements. We make this recommendation even though, unlike nearly all of the other standards recommended in this

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[15] DOE's current standard for furnaces only counts the fuel use (i.e., natural gas, oil, or propane) of a furnace, disregarding the substantial electricity used by furnace air handlers. The Energy Policy Act of 2005 clarified DOE authority to address furnace electricity use, but, based on DOE's appliance standards schedule published on January 31, 2006, DOE will not complete and implement a furnace fan standard sooner than 2018. A logical conclusion is that if DOE does not exercise its authority, states remain free to improve furnace fan electricity efficiency. However, because a furnace fan is a necessary component of a modern furnace, arguably preemption applies to the fan, whether or not the fan's energy use is included in the federal efficiency standard.

[16] According to the latest DOE schedule, it intends to complete a new furnace standard in the fall of 2007, which might be implemented eight years later.

[17] A detailed discussion of the federal standard opportunity for furnaces can be found in our 2004 report, *Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners and Distribution Transformers* (Nadel et al. 2004).

report, states will have to apply for waivers from federal preemption for all or part of a state furnace and boiler standard (commercial boilers and pool heaters are the only other exceptions). There are two key aspects to saving energy with improved furnaces: improving furnace fan or air handler efficiency, and improving the efficiency with which the furnace or boiler turns oil or gas into usable heat. We address each aspect of furnace efficiency separately here.

Furnace fans (or furnace air handlers)

THE PRODUCT: Furnace fans circulate air heated by the furnace through a home's duct system into the living space. For homes with central air conditioning, the furnace fan also serves to circulate air during the cooling season. Furnace fans operate on electricity. (For the purposes of this report, we use the terms "furnace fan" and "furnace air handler" interchangeably. The air handler consists of the fan and motor, housing, controls, and other necessary elements.)

THE STANDARD: Several metrics for ranking furnace electricity efficiency have been developed in the past few years including one developed for the California Energy Commission, one developed for gas utility programs in Massachusetts, and one developed by the furnace manufacturers' trade association (Gas Appliance Manufacturers Association—GAMA) in collaboration with CEE. Some voluntary programs have prescriptively required that furnace fans use high-efficiency motors. We recommend that states use the efficiency metric and threshold developed by GAMA and CEE. This program recognizes furnaces with electricity use that is no more than 2% of the total energy use of the appliance. Products can meet this standard by switching to energy-efficient motors such as permanent magnet motors, although other improvements in the air handler may also improve overall electrical efficiency. High-efficiency fans are commonly available with condensing furnaces, but can also be found on quite a few non-condensing models.

KEY FACTS: Furnace fans are among the largest users of electricity in a typical household, consuming around 1,250 kWh of electricity per year on a national average basis, or more than 12% of the average U.S. household's electricity use. About 770 kWh of this total is consumed during the heating season and the remainder (480 kWh) is used to circulate cooled air in the summertime. Furnace fans in colder than average states will use more electricity during the heating season and those in warmer states more during the cooling season than the average. Air handler efficiency improvements can reduce electricity consumption by about 65%, making improved furnace air handlers one of the largest potential sources of residential electricity use reduction. For a colder climate such as New England, such improvements would save about 550 kWh per year during the heating cycle and another 130 kWh per year for homes with central air conditioners (Sachs and Smith 2003). The savings on the heating cycle alone are about equal to the *total* annual energy consumption of a typical new refrigerator and pay back the cost of the more efficient fan (about $100 in mass production) within about 2 years in New England. In colder states, between 8 and 16% of current furnaces are already sold with high-efficiency fans. At least 420 furnace models from fifteen different manufacturers are available today with efficient fans and also meet the thermal efficiency requirements we recommend. Several hundred more models include efficient fans, but fall short on the thermal efficiency standard (GAMA 2006). However, this technology is almost always bundled with premium products only (Sachs and Smith 2003). For 2006 and 2007, a $50 federal tax credit is available for purchases of furnaces with fans that meet the GAMA/CEE specification (U.S. Congress 2005a).

Furnaces and boilers—fuel efficiency

THE PRODUCT: Furnaces and boilers are the most common type of heating equipment in the United States. Furnaces burn natural gas, propane, or oil for heat and distribute the heat through a duct system. Boilers burn fuel to heat water or create steam that is distributed through radiators for heating a home.

THE STANDARD: States first set standards for furnaces in the 1970s and 1980s. Some of these state standards included both electrical consumption and fuel consumption. Under the 1987 national standard established by Congress, furnace efficiency is measured in Annual Fuel Utilization Efficiency (AFUE), which only accounts for fuel use. AFUEs vary according to equipment type and fuel. We developed detailed recommendations for new national AFUE levels in a separate report published in the fall of 2004 (Nadel et al. 2004). We recommend slightly lower standards here for most technology types (see Table 3.8). A national standard is set with a long lead time before implementation and should be set at a level that maximizes cost-effective improvements. Also, national standards affect a much larger market, resulting in economies of scale in equipment design and production, reducing costs to levels often not possible for state standards. For these reasons, a national standard can be more stringent than what a state might establish.

Table 3.8. Recommended Furnace and Boiler Standards

Equipment Type	Current DOE Standard (AFUE)	Recommended State Standard (AFUE)
Natural gas and propane furnaces	78%	90%
Natural gas and propane hot water boilers	80%	84%
Oil-fired furnaces	78%	83%
Oil-fired hot water boilers	80%	84%
Gas and propane steam boilers	75%	82%
Oil-fired steam boilers	80%	82%
Furnace fan efficiency	None	Electricity use must be less than or equal to 2% of overall furnace site energy use.

KEY FACTS: For most of the country, the largest energy savings would come from requiring 90% or better AFUE gas furnaces. This level is identical to the current ENERGY STAR level for gas furnaces. The standards for oil furnaces and boilers deliver potentially significant oil savings where this equipment type is most common (i.e., Northeast states). Gas furnaces meeting the 90% AFUE standard are more expensive than typical gas furnaces that have an AFUE of about 80%. However, because using such furnaces can eliminate the need for a chimney, in new construction, they can be *cheaper* than conventional furnaces. Even in replacement and retrofit situations, these furnaces typically pay back their increased cost in 2 to 4 years in colder than average states—much less than their typical 18-year life. In 2004, about 32% of current national sales meet the 90% gas furnace standard (Mattingly

2005). However, in colder than average states, 40% to 80% of furnace sales met this standard. Depending on equipment type, between 15% and 75% of 2001 national sales met the standards we recommend for gas and oil-fired boilers and oil-fired furnaces (fuller details are provided in Table 3.10). Market shares in colder states tend to be higher (Kendall 2002). In colder than average states, the incremental cost of oil furnaces and boilers and gas boilers meeting the recommended standards pays back in lower energy bills within 1 to 5 years depending on the equipment type.

An alternative or complement to state standards on these products is to raise efficiency requirements in state building codes. Federal law permits states to set higher standards in their building codes provided alternative compliance paths allow NAECA minimum equipment efficiencies combined with other energy-saving measures (e.g., improved insulation or duct sealing). New York State is now considering a proposal along these lines and discussions have begun in several other states.

Other Products (General Service Incandescent Lamps and Digital Television Adapters)

In December 2004, the CEC adopted standards on several other products not evaluated for this report. Some of these products may merit consideration by other states, including general service incandescent light bulbs and digital television adaptors.

General service incandescent lamps are the familiar pear-shaped light bulbs found throughout most American homes. These products commonly come in 40, 60, 75, 100, and 150 W sizes, but often slightly lower wattage "energy-saving products" (e.g., 34, 52, 67, 90, and 135 watts) are available. Some of these lower-wattage products have improved fill gases or other improvements so that they produce about the same amount of light as their higher-wattage cousins. To encourage use of efficient but lower-wattage products, the CEC has developed a set of efficiency standards. Initial standards went into effect Jan. 1, 2006, and more stringent standards are now under consideration (CEC 2005). A final rule on the revised standards is expected in spring 2006. Such a standard can be a useful complement to compact fluorescent lamp (CFL) programs as they affect all lamps, not just the few percent each year that participate in CFL programs. Also, while CFLs are not cost-effective in applications with very low operating hours, the incremental cost of energy-saving incandescents is so low that they will be cost-effective in nearly all applications.

Digital television adapters (sometimes called DTAs) are small boxes that receive digital broadcast signals and convert these so they can be used by analog televisions. Congress has set a date in early 2008 by which all over-the-airwaves broadcast TV must shift to digital formats (U.S. Congress 2005b). In order for the tens of millions of analog TVs currently in homes to receive over-the-airwaves broadcasts after this date, they will need digital television adapters. Analog TVs hooked up to digital cable systems or satellite systems will not need a converter box separate from their cable or satellite box as the cable or satellite box will also generally serve the converter function. In 2003, the European Union drafted a voluntary Code of Conduct for digital TV converters that called for this equipment to use no more than 8 W of power in active modes and 1 W in standby mode.[18] In December 2004, the California Energy Commission adopted these levels as a mandatory standard. The Australian government is moving in a similar direction and is adopting a standard calling for no more than 14 W in active mode and 2 W in standby mode (Holt 2005). California is reviewing the Australian standard and other recent data and may make some changes to its standard (CEC 2006). New York must complete a rulemaking during 2006 to set standards for digital television adapters. We recommend that other states wait for New York to set its standards or California to finish its revisions before moving ahead.

We estimate that consumers will purchase television adapters for about one in five TVs currently in use between now and 2010. There will be a one-time spike in sales and energy consumption from these products as the legislation goes into effect. The recommended standard would ensure that this flood of new electronic equipment is relatively efficient by setting a maximum standby energy use level. Manufacturers can reduce standby energy use through electronics circuitry design and by powering down unneeded components when the product is not in use. Because reducing standby energy use requires improved design, rather than more or better materials or more complicated fabrication, we expect the long-term additional cost to make more efficient products would be close to zero. Assuming the additional cost is about $6, the energy bill savings would cover the additional cost for a box in less than 1 year (ACEEE & NRDC 2005).

3.2.3 Products Needing Some Additional Research Before State Standards Can Be Adopted

In addition to the products discussed above, several additional products are probably good targets for state efficiency standards following some additional research. Promising products include battery chargers and digital cable and satellite boxes. We discuss each of these briefly in the following paragraphs.

Battery Chargers

A typical home may have four to five rechargable devices such as cellular phones, cordless phones, and cordless tools (e.g., drills and hand vacuums). Each of these devices generally has its own battery charger, many of which continue to draw substantial amounts of power even when the battery is fully charged or disconnected from the charger. Smart circuits and other devices can substantially reduce the energy needed to maintain battery charge. Battery chargers differ from external power supplies (discussed above) in that external power supplies can serve many types of products, including some (but not all) battery chargers. The external power supply standard will regulate the efficiency of power provided to many battery chargers but will not regulate the efficiency of the charger itself. Pacific Gas & Electric and the California Energy Commission have begun research on the energy used by different types of battery charges in different modes (e.g., active charging, maintaining charge, and standby with no battery connected). Additional research is planned, leading

[18] The European Union has since changed this standard to 7 W active power and 2 W standby power, but the change was made too late for California to follow.

ultimately to a proposal for test procedures and standards for these products. Other states should monitor this work and consider standards based on its results.

Digital Cable and Satellite Set-Top Boxes

Cable and satellite set-top boxes convert signals from cable or satellite service providers for viewing programs on TVs. In 2001, EPA ENERGY STAR adopted maximum standby power use specifications for cable and satellite set-top boxes that call for a maximum standby power use of 15 W for most products (some additional power use is allowed for wireless receivers). However, these levels of energy use are fairly high and PG&E and the CEC are planning to conduct additional research on this issue. Further complicating the situation is the fact that multifunction boxes (e.g., cable boxes that also record or serve as an Internet access device) are becoming more common. Some of these boxes use more than 50 W of power in standby mode, using nearly as much electricity as an average new refrigerator. Additional research is needed to consider the range of products and appropriate energy use limits for each. For example, the European Union has developed a voluntary Code of Conduct that includes a power allowance for basic boxes and then specific adders for different features up to a maximum level (EC 2003). This and other options need to be researched in order to identify the best approach for regulating cable and satellite boxes. For cable TV, the cable company typically purchases the box and rents it to the consumer. For satellite TV, the service provider often “gives” the box away to customers who sign up for an initial period of service. In both cases, the companies have little incentive to purchase more efficient boxes if they cost even pennies more than conventional ones. Because reducing energy use requires improved system design, rather than more or better materials or more complicated fabrication, we expect the long-term additional cost to make more efficient set-top boxes would be close to zero. Because cable and satellite TV companies are unlikely to demand efficient set-top boxes from manufacturers until they are required by state standards, wider product availability may require that states adopt such standards.

3.3 Economics of Proposed Standard Levels

In the sections above, we have briefly summarized the consumer economics for each of the products for which we recommend specific standards. Table 3.9 provides the data behind these calculations and reports the benefit-cost ratio and simple payback period, on average, for each of the products. As can be seen, simple paybacks range from 0 to 5.8 years, with many of the products having a payback of less than 2 years. In other words, energy savings recoup any increase in product cost within 1 or 2 years. Afterwards, the consumer realizes net savings. The benefit-cost ratios calculated here take into account a 5% real discount rate. These calculations are based on national average electricity and natural gas prices for 2005. For areas with higher than average prices, paybacks will be shorter; where costs are lower, paybacks will be longer. For products with energy use that varies with climate (e.g., residential furnaces and boilers, and pool heaters), savings and payback period will vary with climate as well.

Table 3.9. National Average Consumer Economics of New Standards

Product	Incremental Cost	Annual per Unit Savings (kWh unless noted)	Annual per Unit Economic Savings	Average Product Life (years)	Benefit/Cost Ratio	Simple Payback (years)
Bottle-type water dispensers	$12	266	$25	8	12.5	0.5
Commercial boilers	$2,968	514 (therms)	$514	30	2.8	5.8
Commercial hot food holding cabinets	$453	1,815	$157	15	3.6	2.9
Compact audio products	$1	53	$5	5	21.8	0.2
DVD players and recorders	$1	11	$1	5	4.4	1.0
Liquid-immersed distribution transformers (per kVA)	$2.45	6	$0.52	30	3.3	4.7
Medium-voltage dry type transformers (per kVA)	$1.92	6	$0.52	30	4.0	3.8
Metal halide lamp fixtures	$30[b]	307	$26	20	11.1	1.1
Pool heaters	$295	58 (therms)	$70	15	2.5	4.2
Portable electric spas (hot tubs)	$100	250	$23	10	1.8	4.3
Residential boilers						
natural gas	$114	32 (therms)	$39	25	4.7	3.0
oil	$29	30 (gallons)	$63	25	30.6	0.5
Residential furnaces						
natural gas—Tier 1	$6	8 (therms)	$10	18	19.8	0.6
natural gas—Tier 2	$373	73 (therms)	$89	18	2.8	4.2
oil	$14	23 (gallons)	$48	18	40.3	0.3
furnace fans	$100	500	$47	18	6.0	2.1
Residential pool pumps[a]	$664	1,260	$118	10	1.4	5.6
Single-voltage external AC to DC power supplies	$0.49	4.1	$0.39	7	4.7	1.2
State-regulated incandescent reflector lamps	$0.73	61.00	$6	0.9	6.6	0.1
Walk-in refrigerators & freezers	$957	8,220	$771	12	6.7	1.2

[a] Savings from pool pumps are calculated based on operating hours in warm states.
[b] Includes $15 per fixture for pulse start ballast and incremental cost of three lamps.

3.4 Product Availability

Each of the products for which we recommend near-term state standards is readily available from multiple manufacturers. By only relying on standard levels that multiple manufacturers can achieve today, a state assures that there will be competition among suppliers once the new standards go into effect. Furthermore, with multiple states adopting these standards, we expect that additional manufacturers will move quickly to develop product offerings that can compete with the more efficient products on the market rather than cede market share.

Table 3.10 provides summary data of the number of manufacturers and estimated national market share for products complying with the standards. For most of these products, a majority of the major manufacturers offer compliant products. Where there are examples with few manufacturers (e.g., reflector lamps), this particular industry is very concentrated with few overall suppliers. The product and standard descriptions in Section 3.2 provided narrative detail about product availability not captured in this summary table.

Current market share varies widely—from a low of 10% to a high of 80%. We report here the most recent data and estimates available from a wide variety of sources. Nevertheless, some of these estimates are a few years old and market share of efficient products has grown. In general, products with higher market shares either have modest proposed standards (e.g., portable spas and residential oil-fired boilers) and/or have benefited from voluntary programs that have worked to build market share through education and/or purchase incentives (e.g., DVD players). As shown in Section 3.2, the consumer economics for purchasing all of these products is quite favorable, so it is not surprising that products meeting the standards have a significant and in some cases, growing market share. However, market share tends to reach a plateau because of the significant market-based barriers to efficiency described in Section 2.2.

Table 3.10. Availability of Products Meeting Proposed Standards

Product	Number of Manufacturers with Compliant Products	Estimated National Market Share of Compliant Product
Bottle-type water dispensers	11	41%
Commercial boilers	23+	50%
Commercial hot food holding cabinets	10	40%
Compact audio products	10	28%
DVD players and recorders	16	64%
External power supplies	20+	32%
Liquid-immersed distribution transformers	most	10%
Medium-voltage dry-type transformers	most	10%
Metal halide lamp fixtures	5+[a]	20%
Pool heaters	6	33%
Portable electric spas (hot tubs)	80	80%
Residential boilers (natural gas)	20	30%
Residential boilers (oil)	20	40%
Residential furnaces (natural gas)	15	34%
Residential furnaces (oil)	14	40%
Furnace fans	15	13%
Residential pool pumps	4	2%
State-regulated incandescent reflector lamps	3+[b]	55%
Walk-in refrigerators and freezers	most	low

[a] Five lamp manufacturers produce complying lamps and at least six ballast makers offer ballasts that operate compliant lamps. Many fixture manufacturers in turn put these ballasts and lamps into fixtures; all manufacturers can.

[b] The three dominant manufacturers all have products. In addition, some of the smaller manufacturers have products.

3.5 Minimizing State Implementation Costs

Appliance and equipment standards are among the lowest cost policies for a state to improve energy efficiency. This section describes how state implementation costs can be kept to a minimum.

3.5.1 Introduction

The standards recommended here were chosen in part because they can be adopted and implemented by a state at very low cost. Potential state responsibilities consist of standards development and adoption, state efforts to foster good compliance, and enforcement. State costs to carry out these responsibilities will be low because the technical standards are already developed and compliance can be encouraged in conjunction with standards already existing in other states and voluntary programs. Because these existing compliance mechanisms result in the standards largely being self-enforcing, state enforcement actions will be rare. The low costs incurred by states to establish and enforce standards are easily offset by the fact that the state itself is a major energy user—direct energy bill savings to the state can be greater than the costs of administering a standards program. The paragraphs below further explain how each of the state responsibilities in a standards program can be achieved at zero to minimal cost.

State costs for standards development are close to zero because nearly all of the recommended technical standards come from either existing state standards such as those adopted by California and other states or from well-established voluntary programs such as ENERGY STAR. Where a test method is necessary for consistent measurement of efficiency performance, such methods already exist. These other state or voluntary programs have in some instances invested considerable resources in developing appropriate technical standards and, in some cases, test methods. Other test methods have been developed by various trade associations and national or international testing organizations. There is no need for other states to repeat this standard or test method development work. Most recent state legislation has directly written technical standards into law or referenced existing standards, thereby effectively eliminating state agency responsibilities to develop initial standards. (New York is the exception since that state’s law requires an agency to develop the technical standards for most covered products.)

3.5.2 Compliance and Enforcement

States foster compliance with state standards through two primary mechanisms: certification and labeling. All states with standards programs have required manufacturer self-certification of compliance. Manufacturers are responsible for testing their own products and then certifying compliance to the state.[19] Certification typically must include brand name, model number information, efficiency performance, and a signed statement of compliance. States make lists of certified products publicly available. This certification and public listing of products certified for sale in the state serves two purposes. First, it encourages compliance

[19] For prescriptive standards (e.g., the requirement that unit heater have an intermittent ignition), no testing is required, but manufacturers still must certify that the prescriptive requirement is met.

since manufacturers will be very hesitant to certify false values to a state or deliberately sell into the state non-certified products. Second, it provides a central place for sellers, purchasers, competitors, and others interested in good compliance to see which products are certified for sale. A mechanism for low cost, collaborative state certification is discussed in Section 3.5.3 below. The weakness in certification is that it is impossible from simply looking at a product to tell whether it meets a state's standards. Rather, model numbers must be checked against a public database. This weakness can be addressed by labeling.

Some states, including Washington, Oregon, and Massachusetts, have chosen to bolster their effort to achieve good compliance by supplementing certification requirements with labeling. A simple label or mark can indicate that a product has been tested and meets a given efficiency level. California requires a limited number of products to carry a label (e.g., exit signs, torchieres, transformers, and pre-rinse spray valves). Maryland's statute requires that all covered products sold at retail carry a label but state regulations allow existing labels (e.g., California labels, ENERGY STAR labels, and industry program labels) that indicate performance at least as good as that required by state law to suffice. Labels have several benefits. First, they are readily viewed, allowing product sellers, purchasers, competitors, and anyone checking for compliance to easily tell if a product is in compliance. Second, like certification, they discourage cheating on a standard. Manufacturers will be very hesitant to deliberately label a non-compliant product. Distributors and retailers will be much more conscious of a visible label than they will be of a certification database. The downside to labels is that, for manufacturers, labels can be more costly than certification. Typically, manufacturers do not make items for specific states, so they will have to label all units, regardless of which state they ultimately are sold in. However, by relying on existing labels, states can avoid a proliferation of additional labeling requirements and avoid additional costs imposed on manufacturers. If a state sets a labeling requirement where one does not currently exist, the state should require a generic mark that can be used by other states subsequently adopting the same standard.

The "self-enforcing" nature of the standards is achieved by the combination of certification and labeling combined with the competitive pressures of the market. The burden of testing and then certifying and/or labeling falls to the manufacturer, not the state. (Even this burden is minimal since once one state has established such requirements, there should be no additional testing, certification, and labeling cost provided that other states choose the low-cost implementation path of piggy-backing off of existing requirements.) Manufacturers have a strong incentive to ensure their competitors are complying with the law. Potential compliance problems fall into two categories: manufacturers selling products into a state that have not been certified, and manufacturers providing false certifications. With regard to the first potential problem, in the extensive experience of the CEC, if the agency learns of products being sold that have not been certified, typically a warning letter and a dialog with the manufacturer are sufficient to solve the problem (Martin 2004). Some states, including Maryland and Washington, also have authority to conduct inspections of distributors and retailers to check that only compliant products are available. In the past, California has used summer interns to conduct spot-checking of products in stores. Regular staff only got involved when the interns found potential enforcement problems (CEC 1983). To address the potential problem of products being sold with false certifications, most state laws provide authority for spot-testing products. For example, if a state suspects a product has been falsely certified, the agency can test the product in question. If a product fails to meet the standard, the state can request that the manufacturer withdraw the model's certification and, if the manufacturer refuses, the state can reject the certification and "delist" the product from the database of certified products, making it illegal for sale in the state. Several states include provisions allowing the state to charge manufacturers for the cost of testing their products if the product certifications are found to be inaccurate. In the 30 years that California has had standards, CEC has only had to initiate formal enforcement actions on a few occasions and has never had to "delist" a product (Martin 2004).

Authority for state inspections and state testing of products are important because they represent a credible threat that a state may actively enforce standards if manufacturers are willfully disobeying state laws. But in practice state testing authority and inspection authority should be used very rarely, if at all. States can achieve reasonably good rates of compliance by encouraging compliance rather than by penalizing non-compliance. Information provided by the market and competitors can help identify potential problem areas. For example, in recent years, California has not had a budget for testing or inspections (Wilson 2004).

Finally, some state laws provide for agency authority to review and upgrade existing standards (e.g., New York and Connecticut) and/or expand the scope to additional products (e.g., Connecticut). In these states, agencies could incur costs associated with such future rulemakings. For example, in January 2006, New York issued a $150,000 request for proposals for technical assistance for setting its initial standards not specified in state law. However, in most instances, such rulemakings are optional. If pursued in the future, states should work collaboratively on updated or additional standards. Technical support for future standards development could be provided by utility ratepayer-based efficiency programs. For example, Pacific Gas and Electric Company provided extensive technical support to the latest round of new standards developed in California.

3.5.3 Joint State Certification and Databases of Certified Products

Several states have advanced detailed discussions about working together on product certifications and databases. Because the products addressed and the technical standards are very similar from one state to another, states will gain significant potential economies in collaboration. The basic structure of this emerging collaboration depends upon use of the existing California certification program and public database. The California Energy Commission and its staff have been eager to coordinate with other states interested in "piggy-backing" off its certification program and databases (Martin 2004; Wilson 2004). These databases represent a significant investment by the CEC, both for developing the databases and inputting the certification information received from manufacturers. CEC is willing to make verified data from manufacturer certifications available to other states working collaboratively. A group of other states is now working on developing a mechanism that will allow them to use the CEC data to come up with complete state-specific lists of certified products. The multi-state mechanism envisioned would be an automated Web-based service that would result in complete, state-specific listings of certified products. The service will include mechanisms for handling standards that diverge from those in effect in California and will be structured such that additional states can join. It also may include mechanisms for improving communications with manufacturers.

This effort is likely to further reduce costs for states while improving compliance. Working together, states can do an improved job of informing manufacturers of standards. In addition, the consequences for false certifications are magnified if several states are working together. Finally, a multi-state approach saves money not only for state government, but also for manufacturers, allowing them to certify once rather than to each individual state with standards.[20,21]

3.5.4 Waivers from Federal Preemption

Three of the products for which we recommend state standards are covered by existing federal standards—commercial boilers, pool heaters, and residential furnaces and boilers. In each case, the existing federal standard is outdated and DOE has missed deadlines for required updates. Congress set the existing federal residential furnace and boiler and pool heater standards in 1987 and established deadlines for DOE reviews and updates, if warranted, of January 1994 and January 1992, respectively. The commercial boiler standard is based on an industry consensus standard that dates to 1989 and should have been updated by DOE earlier this decade. State standards for these products, especially residential furnaces and boilers in cold-weather states, offer the potential for significant energy savings. Furthermore, state action on standards for these products could help prompt quicker action on federal updates.

In general, the federal appliance standards law preempts state standards on federally regulated products once an initial federal standard has become effective. However, the federal appliance standards law explicitly provides a path for states to set standards tougher than the federal minimums. By formal petition to DOE, states may request a waiver from federal regulation to implement a state standard based on "unusual and compelling State or local energy or water interests." These interests must be "substantially different in nature or magnitude than those prevailing in the U.S. generally" and must be such that the "costs, benefits, burdens and reliability of energy or water savings resulting from the State regulation make such regulation preferable or necessary [relative to other approaches]." A state petition must be in the context of its state energy plan. After receiving a waiver petition, DOE has up to one year to review the petition. In addition to considering the merits of the petition, DOE must consider whether the "State regulation will significantly burden manufacturing, marketing, distribution, sale or servicing of the covered product on a national basis." DOE can limit the scope of equipment for which it grants a waiver (U.S. Congress 2001). After a

[20] States with standards that vary in small ways from the California standards are still likely to find that the CEC database largely meets their purpose because of the thoroughness of CEC's certification requirements. Nevertheless, individual states may still need an alternate certification path for manufacturers that choose not to sell in California. A state might thus have an expanded version of the CEC database for its purposes or choose to maintain a small supplemental list of certified products.

[21] Maryland's initial regulations published in late 2004 provided for an entirely new certification process. Several commenters have urged the Maryland Energy Administration to scrap its go-it-alone approach and work collaboratively with the existing California program. Connecticut has yet to adopt proposed regulations.

waiver has been granted, a state standard generally would go into effect three years later, though DOE could shorten or lengthen the lead time to address state or manufacturer needs.

In 2005, California became the first state to file a petition for a waiver from federal preemption. As required by an act of the California legislature, the California Energy Commission set a state water-saving standard for residential clothes washers and the petition seeks to enforce the state standard.[22] In 2005, Massachusetts enacted a state standard for residential furnace and boiler efficiency. By state law, the state Division of Energy Resources must first determine if the state standard is preempted, and if so, pursue a waiver. These initial waiver applications will help provide a roadmap for subsequent states pursuing waiver applications.

3.5.5 Costs and Benefits to a State

Since these standards can be implemented at such low costs, they are incredibly cost-effective from a government perspective. This can be illustrated with the following rough calculations. A number of states where legislation has been introduced have estimated the state cost to implement a standards program. Most estimates range between zero and $70,000 (Elnecave 2004).[23] These estimates are consistent with our analysis that standards can be implemented at very low cost. We estimate that, for a typical state, developing and implementing the standards recommended here would require about half a person-year of staff time to write the regulations establishing the state standards and compliance mechanisms, and perhaps a quarter person-year to implement them. For example, Maryland brought in a lawyer on a special detail for a few months to draft the regulations and now is assigning implementation to regular staff. Assuming $150,000 per person-year (including salary and overhead), this works out to a 10-year cost (undiscounted) of roughly $412,500 (beyond 10 years, costs should be very low as the market will have transformed and little implementation support will be needed). As noted in Table 4.1 below, national net benefits from these standards would be approximately $63 billion, or an average of more than $1.2 billion per state (more for large states, less for small states). These benefits are about 3,000 times greater than our estimate of direct costs to a state government, and even allowing for the very rough nature of these calculations, it is clear that these new standards will be highly cost-effective from a governmental perspective.

Furthermore, these standards will directly reduce state government energy bills. For example, prior analyses have found that standards for just two products (which were subsequently incorporated into the federal Energy Policy Act of 2005)—exit signs and low-voltage distribution transformers—would directly save the Florida and Illinois state governments $800,000 and $850,000 per year, respectively, once the equipment stock turned over (deLaski, Metcalf, and Nadel 2003; FPIF 2003).

[22] See http://www.eere.doe.gov/buildings/appliance_standards/state_petitions.html for further information on the process, including to download the California petition. The California petition is very long and involved; other states would likely prepare much simpler petitions.
[23] Estimates of zero cost take into account that the state would save money on its own energy bills due to many of these standards.

4. OVERALL SAVINGS AND ECONOMICS

Table 4.1 summarizes the overall national energy savings potential and economics from minimum-efficiency standards for the above products. Table 4.2 shows the estimated national peak load reduction and emission reductions from the proposed standards. For the methodology, key assumptions, and sources we used to estimate these savings, see Appendix A. Data on energy and demand savings in 2010 are provided in Appendix B. State-specific savings data for each of the 50 states is available online at www.standardsASAP.org.

Table 4.1. Estimated Energy Savings and Economics of Proposed New Standards

Products	Effective Date	National Energy Savings in 2020		National Energy Savings in 2030		Cumulative Savings for Products Purchased Thru 2030	NPV for Purchases Thru 2030	Benefit-Cost Ratio
	(year)	(TWh)	(tril. Btu)	(TWh)	(tril. Btu)	(quads)	($ billion)	
Bottle-type water dispensers	2008	0.3	3	0.3	3	0.1	0.2	12.9
Commercial boilers	2012	NA	5	0.0	10	0.1	0.5	2.8
Commercial hot food holding cabinets	2008	0.4	4	0.4	5	0.1	0.2	3.7
Compact audio products	2008	1.7	18	1.7	17	0.4	1.7	22.9
DVD players and recorders	2008	0.2	3	0.2	3	0.1	0.2	4.6
Liquid-immersed distribution transformers	2008	8.2	85	14.7	148	1.8	7.3	3.4
Medium-voltage dry-type transformers	2008	0.5	5	0.9	9	0.1	0.5	4.1
Metal halide lamp fixtures	2008	9.0	94	14.4	145	1.9	8.6	11.5
Pool heaters	2012	NA	8	NA	14	0.2	0.7	2.7
Portable electric spas (hot tubs)	2008	0.2	NA	0.2	2	0.0	0.1	2.0
Residential furnaces and residential boilers	2012	13.1	225	27.7	467	4.8	21.2	4.6
Residential pool pumps	2008	3.1	32	3.1	31	0.6	1.1	1.6
Single-voltage external AC to DC power supplies	2008	4.9	51	4.9	49	1.0	3.7	4.9
State-regulated incandescent reflector lamps	2008	5.8	60	5.8	58	1.4	4.9	6.8
Walk-in refrigerators and freezers	2008	4.7	49	4.7	47	0.8	3.0	6.8
Total		51.9	641	78.9	1007	13.2	54.0	4.5

Note: See Appendix A for assumptions, methodology, and sources. NPV stands for net present value and is a measure of the cumulative value of the standards policy (benefits minus costs) in current dollars.

On a national basis, these new standards could save 52 TWh of electricity and over 0.6 quads of primary energy in the year 2020, while generating $54 billion in net savings for consumers and business owners for equipment purchased through 2030 (primary energy savings include reductions in fuel use in buildings plus reductions in fuel used at power plants). These standards would also save natural gas, including, in 2020, about 100 billion cubic feet of direct natural gas use in buildings (i.e., savings from reduced gas use for boilers, furnaces, and pool heaters) and an additional 240 billion cubic feet of natural gas used in power plants.[24] The primary energy savings from new standards is about one-fifth the projected savings from all existing federal standards including the most recent updates. The overall benefit-cost ratio is 4.5 to 1, better than the 3 to 1 ratio for existing standards. Clearly, significant savings potential exists for these products at a small increase in first cost, resulting in large energy and economic savings over the life of the equipment.

[24] Power plant savings assume that half the power saved would be generated with natural gas. The Energy Information Administration estimated that in 2020, 23% of power will come from natural gas-fired plants. However, it also estimated that 90% of the generating capacity built between now and 2020 will use natural gas as a fuel (EIA 2004). Our 50% assumption is roughly midway between these two figures.

Table 4.2. Estimated Summer Peak Load, Water, and Pollutant Reductions from New Standards

	Summer Peak Load Reduction		Water Savings	Pollutant Reductions in 2020			
	In 2020 (GW)	In 2030 (GW)	In 2020 (billion gal)	Carbon (MMT)	NOx (1000MT)	SOx (1000MT)	PM10 (1000MT)
Bottle-type water dispensers	0.04	0.04	0.02	0.1	0.1	0.6	0.0
Commercial boilers	NA	NA	NA	0.1	0.2	0.0	0.0
Commercial hot food holding cabinets	0.1	0.1	0.1	0.1	0.2	0.9	0.0
Compact audio products	0.2	0.2	0.1	0.3	1.0	4.1	0.1
DVD players and recorders	0.03	0.03	0.02	0.0	0.1	0.6	0.0
Liquid-immersed distribution transformers	1.1	2.0	1.0	1.6	4.7	19.6	0.3
Medium-voltage dry-type transformers	0.1	0.1	0.1	0.1	0.3	1.2	0.0
Metal halide lamp fixtures	2.9	4.7	2.4	1.7	5.1	21.3	0.3
Pool heaters	NA	NA	NA	0.1	0.3	0.0	0.0
Portable electric spas (hot tubs)	0.04	0.04	0.0	0.0	0.1	0.4	0.0
Residential furnaces and residential boilers	3.1	6.5	3.2	3.8	12.8	34.9	0.8
Residential pool pumps	0.7	0.7	0.4	0.6	2.8	7.3	0.1
Single-voltage external AC to DC power supplies	0.7	0.7	0.3	0.9	2.8	11.7	0.2
State-regulated incandescent reflector lamps	1.4	1.4	0.7	1.1	3.2	13.7	0.2
Walk-in refrigerators and freezers	1.1	1.1	0.5	0.9	2.6	11.2	0.1
Total	11.6	17.7	8.9	11.6	36.3	127.5	2.0

Note: See Appendix A for assumptions, methodology, and sources.

Another significant benefit from appliance standards is their impact on summer peak load. We estimate that the proposed standards would save a total of almost 12 GW of power in the year 2020. This is roughly equal to the generating capacity of 40 average power plants (i.e., 300 MW). This could significantly contribute to improved electric system reliability by eliminating the need for additional power plants and reducing the load on already stressed transmission and distribution systems. These standards will also save 9 billion gallons of water at power plants in the year 2020.

Emissions reductions from the reduced energy consumption would also be significant. In the year 2020, 12 MMT of carbon could be reduced, which would help the United States meet the global goal of reducing greenhouse gas emissions. The 12 MMT of carbon is equivalent to the annual carbon emissions of nearly 8 million “average” passenger cars (EPA 1997). These standards would also contribute to better air quality by reducing almost 40,000 metric tons of smog-forming NOx, 130,000 metric tons of SOx (the main component of acid rain), and 2,000 tons of fine particulate matter that contributes to asthma and various lung diseases. There would also be significant reductions in airborne emissions of mercury, another serious health hazard that is about to be subject to federal emissions standards.

5. CONCLUSION

For each of the equipment types discussed in this report, there are substantial opportunities to save energy by promoting more efficient equipment. Use of high-efficiency equipment is cost-effective for most consumers but due to a variety of market imperfections, many consumers are not purchasing the efficient equipment. In order to capture the substantial energy savings that are available from the use of improved-efficiency equipment, state governments and/or the federal government should establish minimum-efficiency standards on many of these products. Efficiency standards can make a significant contribution towards bringing U.S. energy supply and demand into better balance, thereby improving the long-term reliability of our electric grid while also helping our environment, our overall economy, and individual consumer pocketbooks.

There are many products that are ripe for state and federal action. About 1 quad of primary energy would be saved nationally in the year 2030 by setting standards for the products described in this report, equivalent to about 2% of U.S. residential and commercial energy use projected for that year. Stated another way, these standards could reduce projected growth in residential and commercial electricity use over the next two decades by about 6%. These savings are about one-fifth of the savings from standards established to date since 1987, with a benefit-cost ratio of about 5 to 1.

In most cases, voluntary or state standards have been developed that states can immediately adopt. In a few other cases, significant energy savings exist but additional research is needed before specific energy efficiency criteria can be set. DOE, state energy offices, and standard-setting organizations should work together to overcome these barriers in order to realize the additional savings from these products.

Finally, this type of research should be repeated in a few years to assess whether there are additional opportunities for standards, including products described in Sections 3.2.4 and 3.2.5 as well as products not discussed in this report.

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APPENDIX A. METHODOLOGY, ASSUMPTIONS, AND SOURCES

The analysis discussed in this report is based on the methodology ACEEE used for several recent national and regional studies on appliance and equipment efficiency standards (Kubo, Sachs, and Nadel 2001; Nadel et al. 2004; Raynolds and deLaski 2002). Table A.1 shows key assumptions regarding the effective date of standards, equipment lifetimes (and thus annual rate of equipment replacement), per-unit energy savings, and incremental unit equipment costs.

The sources for those and other assumptions—such as annual equipment sales and baseline equipment efficiency assumptions—are documented in Table A.4 at the end of this appendix.

Overview of Analysis Methodology

To calculate the potential energy savings of new standards for the products discussed in this report, we started with national estimates of equipment sales, energy use, energy savings, and peak demand and allocated or adjusted these figures based on available data for each state and region. The specific state and regional allocation and adjustment factors are discussed later in this appendix. The energy and peak demand savings then drove the calculation of the economic savings and emissions reductions achieved nationally and in each state.

Economic savings were calculated on a consumer basis by multiplying energy savings by **average retail rates for each individual state** (residential or commercial rates, as appropriate). We used retail rates from 2005 data compiled by the U.S. Energy Information Administration (EIA 2006a, 2006b). These rates are presented in Table A.2. We assumed retail rates remain constant through 2030.

We calculated economic costs by multiplying the per-unit incremental cost for each product by the number of units sold. Cumulative costs and cumulative savings cover the period from the effective date of the standard to 2030, and we discounted them to 2005 using a 5% real discount rate.

Similarly, we derived emissions reductions by multiplying the primary energy savings by average **marginal emissions factors for the country**. We derived emission factors for electricity from runs of the National Energy Modeling System with and without efficiency improvements. Emissions factors for direct combustion of natural gas and fuel oil come from EPA.

Table A.1. Effective Dates, Assumed Equipment Life, Annual Per-Unit Energy Savings and Incremental Costs

Product	Assumed standard (max. energy use or min. efficiency)	Basis for standard	Avg. life of equipment	Average per unit annual energy savings	Incremental equipment cost
Bottle-type water dispensers	Max. 1.2 kWh/day standby energy	ENERGY STAR & CEC Title 20	8	266 kWh	$12
Commercial boilers	Min. 0.81 thermal efficiency	Proposal to ASHRAE	30	514 therms	$2,968
Commercial hot food holding cabinets	Max. idle energy rate 40 W/ft^3	ENERGY STAR & CEC Title 20	15	1,815 kWh	$453
Compact audio products	Max. 2.0 W standby energy	ENERGY STAR & CEC Title 20	5	53 kWh	$1
DVD players and recorders	Max. 3.0 W standby energy	ENERGY STAR & CEC Title 20	5	11 kWh	$1
Liquid-immersed distribution transformers	Varies with size	TP-1 + 0.2	30	6 kWh	$2.45
Medium-voltage dry type transformers	Varies with size	TP-1 + 0.3	30	6 kWh	$1.92
Metal halide lamp fixtures	Pulse-start ballast	Pulse-start ballast	20	307 kWh	$30
Pool heaters	Min. 80% thermal efficiency & electric ignition	DOE 2004	15	58 therms	$295
Portable electric spas (hot tubs)	Max.5 V$^{(2/3)}$ standby energy	CEC Title 20	10	250 kWh	$100
Residential boilers					
natural gas	Min. 84 AFUE	Significant current sales	25	32 therms	$114
oil	Min. 84 AFUE		25	30 gallons	$29
Residential furnaces					
natural gas—Tier 1	Min. 80 AFUE	Non-condensing max	18	8 therms	$6
natural gas—Tier 2	Min. 90 AFUE	Condensing	18	73 therms	$373
oil	Min. 83 AFUE	Sig. current sales	18	23 gallons	$14
furnace fans	2% electricity ratio	GAMA/CEE specification	18	500 kWh (heating) & 120 kWh (cooling)	$100
Residential pool pumps	No split-phase or capacitor start–induction run types; 2-speeds	2-speed pump	10	1,260 kWh[a]	$664
Single-voltage external power supplies	Varies with size	CEC Title 20 (Tier 1) and other states' standards	7	4.1 kWh	$0.49
State-regulated incandescent reflector lamps	Varies with size	EPAct 1992 standard with MA exemptions	0.94	61 kWh	$1
Walk-in refrigerators and freezers	Typical installation from CEC case study	CEC Title 20 with a few modifications	12	8,220 kWh	$957

[a] Savings from pool pumps are calculated based on operating hours in warm states.

Detailed Methodology

1) <u>Calculation of national energy and peak demand savings</u>

We obtained national energy savings from proposed new standards by multiplying annual national sales figures for each appliance by per-unit energy savings. Per unit savings are the difference between a product just meeting the proposed standard and a typical basic efficiency new product. (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 proposed standards. We account for current market share of equipment meeting the proposed standard at the state level.) The analysis is static and assumes that equipment sales remain at current levels for all products. We also assumed that, in the absence of standards, efficiency levels remain at present levels. In actuality, product sales and efficiency are gradually increasing, even in the absence of standards. Thus, it is implicitly assumed that these factors counterbalance each other.

We used one of the following equations to calculate end-use electricity savings in 2010, 2020, and 2030:

(a) End-use electricity savings = annual sales volume x (years from effective date - 0.5) x per-unit electricity savings

(b) End-use electricity savings = annual sales volume x average product life x per-unit electricity savings

Similarly, we used one of the following equations to calculate end-use natural gas (NG) savings in 2010, 2020, and 2030:

(a) NG savings = annual sales volume x (years from effective date - 0.5) x per-unit NG savings

(b) NG savings = annual sales volume x average product life x per-unit NG savings

In each case, we used equation (a) when the average product lifetime is longer than the number of years from the effective date. Otherwise, we used equation (b) in order to avoid double counting the savings from replacements after 100% saturation. 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 times annual savings per unit.

For heat rates to calculate primary energy savings (primary energy input required to generate a unit of electricity, in Btu/kWh), we use 10,764 Btu/kWh for 2010, 10,424 Btu/kWh for 2020, and 10,056 for 2030 (EIA 2005). We use a 0.91 T&D loss factor—a 9% T&D loss (EIA 2003b).

To calculate peak generation savings, we multiplied electric generation 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. Table A.3 provides the sources of the peak factors used in the analysis.

We calculated peak capacity savings as:

Peak capacity savings = end-use electricity savings ÷ T&D loss factor x peak factor x reserve factor

The analysis assumed a conservative 10% reserve margin. Thus the reserve factor in the formula is 1.1. Historically, a reserve margin of 20% was typical, but utilities have cut down their margins during restructuring of the electric utility industry.

For overall water savings, we considered both direct and indirect water savings. Direct water savings are reduced water use for efficient 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 used at the power plant as part of the generation of electricity. For these calculations, we assumed 0.5 gallons of water saved per kWh of electricity, which in turn is based on an assumption that about half of the displaced generation is coal-fired and about half is gas-fired. Data on water use for coal and gas generation comes from data collected by the Southwest Energy Efficiency Project (SWEEP 2002).

2) State Allocation Factors

For most residential products, the state allocation factor is the ratio of households in the state to total national households (Census 2001). For most commercial products, we calculated the allocation factor in two steps: the factor started as the ratio of commercial building square footage to total building square footage in each census division, then we adjusted it using the ratio of state commercial sector energy use to commercial sector energy use in that census division (EIA 1999a). We further adjusted the allocation factors for each appliance according to the saturation and usage of each by census region and division. For example, the number of households in Massachusetts is 2.35% of the national total, but the overall allocation factor for central heat pumps for Massachusetts is 0.44%, due to lower saturation and usage compared to the national average. We found the data that supports saturation and usage rates in the Residential Energy Consumption Survey (RECS) 1997 and 2001 (EIA 1999b, 2003a) and the Commercial Building Energy Consumption Survey (CBECS) (EIA 1999c).

Using the following formulas, we derived state allocation factors:

For residential products:

a) *Allocation factor = (state households ÷ national households)*
x (saturation% in region/division ÷ national avg. saturation%)
x (usage in region/division ÷ national avg. usage)

For commercial products:

b) *Allocation factor = (building square footage in census division ÷ national building square footage) x (state commercial electricity ÷ commercial electricity use in census division)*
x (saturation% in census division ÷ national average saturation%)
x (usage in census division ÷ national average usage)

Exceptions to this methodology were:

- For low-voltage building transformers, straight commercial sector energy use was the indicator. For medium-voltage and liquid-immersed transformers, we used total state electricity use to allocate national savings among the states.
- For commercial walk-in refrigerators and freezers, the energy intensity data in CBECS is heavily influenced by built-up refrigeration systems used in places such as supermarkets. The energy use of this equipment is heavily influenced by climate since the condenser units are located outdoors. Packaged systems generally have the condensers indoors (they are part of the packaged unit) and are much less climate dependent. To adjust for this difference, we reduced the factor for variation from the national average in half. Thus, if in CBECS, a state has 84% the refrigeration intensity of the national average (e.g., intensity factor of 0.84), we reduced the variation in half (e.g., we used an intensity factor of 0.92).
- For reflector lamps, water dispensers, and hot food holding cabinets, population was used as a better indicator for allocating sales by state.
- For electric spas, pool pumps, and pool heaters, regional data from RECS and household income within a region were used to provide more weight to warmer states.

For all products, we discount state savings totals according to current sales estimated to meet the proposed standard, using state-specific estimates where available. For example, if 35% of sales already meet the proposed standard for a given product, the analysis credits the standards policy with savings from the other 65% of sales.

3) Calculating Economic Costs and Savings

We calculated consumer bill savings using the following formula:

Consumer bill savings = end-use electricity savings x state average electricity price+ natural gas savings x state average natural gas price

For electricity and natural gas prices used for this analysis, see Table A.2.

We calculated expected investment using the following formula:

Expected investment = annual sales volume x per-unit incremental cost

We discounted present value (PV) calculations to 2005 assuming a 5% real discount rate. The PV of expected investment aggregates the present value of annual investments from the effective date of each standard through 2030. The PV of savings aggregates the present value of societal savings/consumer bill savings from the effective date of the standard through the year in which products installed through 2030 die out. Essentially, these two measures give the cumulative costs and benefits of standard-complying products installed through 2030. Subtracting the PV of investments from the PV of savings yields the net present value (NPV) of the standards policy.

Table A.2. Average 2005 Retail Energy Costs by State

	Electricity (cents/kWh)		Natural Gas ($/1000 cubic feet)	
State	Residential	Commercial	Residential	Commercial
U.S Average	**9.38**	**8.64**	**12.07**	**10.69**
Alabama	8.0	7.5	14.91	12.05
Alaska	13.0	11.3	5.73	4.80
Arizona	9.0	7.6	13.50	9.62
Arkansas	7.9	6.1	11.57	9.74
California	12.1	12.1	11.28	10.04
Colorado	8.9	7.5	9.76	8.76
Connecticut	13.6	11.3	15.67	12.39
Delaware	9.0	7.7	12.40	10.77
District of Columbia	9.0	9.3	15.82	12.27
Florida	9.6	8.1	20.06	12.49
Georgia	8.7	7.7	16.66	14.40
Hawaii	19.9	18.3	30.19	24.75
Idaho	6.3	5.4	8.86	8.18
Illinois	8.5	8.2	10.65	10.16
Indiana	7.4	6.5	11.67	10.71
Iowa	9.5	7.0	11.86	9.92
Kansas	8.0	6.7	11.88	11.26
Kentucky	6.4	5.9	11.83	10.00
Louisiana	8.7	8.1	12.80	10.83
Maine	13.3	10.4	15.21	13.40
Maryland	8.3	10.6	13.91	11.04
Massachusetts	13.2	12.8	12.55	13.00
Michigan	8.7	8.0	9.69	8.57
Minnesota	8.4	6.7	10.57	9.51
Mississippi	8.6	8.2	12.35	8.36
Missouri	7.2	6.1	12.07	11.10
Montana	8.1	7.7	10.13	10.05
Nebraska	7.3	6.0	10.05	8.66
Nevada	10.0	9.3	12.14	10.01
New Hampshire	13.4	11.8	14.35	12.95
New Jersey	11.9	11.3	12.20	11.81
New Mexico	9.1	7.7	10.13	8.32
New York	15.3	13.0	14.00	12.04
North Carolina	8.7	6.9	13.60	11.70
North Dakota	7.0	6.1	10.72	9.53
Ohio	8.6	7.9	12.14	8.88
Oklahoma	8.0	6.9	10.97	10.39
Oregon	7.2	6.9	12.66	10.29
Pennsylvania	9.9	8.9	13.50	12.07
Rhode Island	12.5	11.3	14.31	12.85
South Carolina	8.7	7.4	13.74	12.11
South Dakota	7.8	6.2	11.16	9.61
Tennessee	6.9	7.0	12.65	11.05
Texas	10.7	8.6	10.32	9.50
Utah	7.7	6.2	9.29	7.70
Vermont	13.0	11.3	11.99	9.50
Virginia	8.3	6.0	14.24	10.72
Washington	6.5	6.2	11.42	10.00
West Virginia	6.2	5.5	12.49	11.59
Wisconsin	9.6	7.6	11.26	8.41
Wyoming	7.4	6.1	8.42	6.88

Sources: EIA (2006a, 2006b). Based on average prices in the first ten months of 2005.

4) Calculating Emission Reductions

We calculated carbon, nitrogen oxides, sulfur dioxide, and particulate emissions reductions for electric products using the following equation:

> *Emission reductions = end-use electricity savings ÷ T&D loss factor x regional marginal emission factor*

We used marginal emission factors calculated on a regional basis rather than straight emissions factors from the projected generation fuel mix. This gives a more accurate estimate of emissions reductions from new standards. For example, coal-fired power plants are often base load plants—they are the dirtiest, but also cheapest to operate under current regulatory conditions, so are likely to remain in operation. For electricity, projections from the National Energy Modeling System (NEMS) were used to develop the regional emission factors used in the analysis. We calculated regional emissions factors as the change in total regional emissions divided by the change in total generation when moving from the NEMS base case to an ACEEE policy case based on improved energy efficiency (Geller, Bernow, and Dougherty 1999). For additional details, see Thorne, Kubo, and Nadel (2000a). Carbon emissions savings for natural gas are based on DOE projections (EIA 2000b). Nitrogen oxides, sulfur dioxide, and particulate emissions reductions are based on data from the EPA Office of Air Quality Planning and Standards (EPA 1998). Specific national average emissions factors are summarized in Table A.3.

Table A.3. National Average Emissions Factors

	Carbon	**NOx**	**SO_2**	**PM_{10}**
Electricity (tons/GWh)	177.34	0.53	2.45	0.03
Natural Gas and Oil (MMT/Quad)	14.76	41.80	0.27	3.38

Sources: See paragraph above.

Table A.4. Sources for Key Assumptions

Products	Recent Year Sales	Current Standard or Baseline	New Standard or Average Use	Average Product Life	Per Unit Incremental Cost	Coincident Peak Factor
Bottle-type water dispensers	PG&E 2004e	PG&E 2004e	PG&E 2004e	PG&E 2004e	PG&E 2004e	1/8760 hrs/yr
Commercial boilers	DOE 2001	ASHRAE 90.1	Nadel 2005b	DOE 2001	DOE 2001	1/8760 hrs/yr
Commercial hot food holding cabinets	PG&E 2004i	PG&E 2004i	PG&E 2004i	PG&E 2004i	PG&E 2004i	1/8760 hrs/yr
Compact audio products	PG&E 2004g	PG&E 2004g	PG&E 2004g	PG&E 2004g	PG&E 2004g	1/8760 hrs/yr
DVD players and recorders	PG&E 2004g	PG&E 2004g	PG&E 2004g	PG&E 2004g	PG&E 2004g	1/8760 hrs/yr
Liquid-immersed distribution transformers	DOE 2004b	ORNL 1997; DOE 2005	ORNL 1997; DOE 2005	ORNL 1997; DOE 2005	DOE 2004	1/8760 hrs/yr
Medium-voltage dry type transformers	DOE 2005	ORNL 1997; DOE 2005	ORNL 1997; DOE 2005	ORNL 1997; DOE 2005	DOE 2005	1/8760 hrs/yr
Metal halide lamp fixtures	PG&E 2004d	PG&E 2004d	PG&E 2004d	PG&E 2004d	PG&E 2004d	EIA 2000a
Pool heaters	DOE 2004	DOE 2004	DOE 2004	DOE 2004	DOE 2004	NA
Portable electric spas (hot tubs)	PG&E 2004j	PG&E 2004j	PG&E 2004j	PG&E 2004j	PG&E 2004j	Avg. of EIA 2000a and 1/8760 hrs/yr
Residential boilers						
natural gas	DOE 2002	EIA 1999b	Nadel et al. 2004	DOE 2001	DOE 2004	NA
oil	DOE 2002	EIA 1999b	Nadel et al. 2004	DOE 2001	DOE 2004	NA
Residential furnaces						
natural gas	GAMA 2004	EIA 1999b; GAMA 2004	Nadel et al. 2004	DOE 2001	DOE 2004	NA
oil	DOE 2002	EIA 1999b	Nadel et al. 2004	DOE 2001	DOE 2004	NA
furnace fans	GAMA 2004	Sachs and Smith 2003	Sachs and Smith 2003	DOE 2001	Sachs and Smith 2003	Thorne, Kubo & Nadel 2000b
Residential pool pumps	PG&E 2004h	PG&E 2004h	PG&E 2004h	PG&E 2004h	PG&E 2004h	PG&E 2004h
Single-voltage external power supplies	PG&E 2004a	PG&E 2004a	PG&E 2004a	PG&E 2004a	PG&E 2004a	1/8760 hrs/yr
State-regulated incandescent reflector lamps	PG&E 2004c	PG&E 2004c	PG&E 2004c	PG&E 2004c	PG&E 2004c	EIA 2000a
Walk-in refrigerators and freezers	PG&E 2004b	PG&E 2004b	PG&E 2004b	PG&E 2004b	PG&E 2004b	Avg. of EIA 2000a and 1/8760 hrs/yr

APPENDIX B. ENERGY AND PEAK DEMAND SAVINGS FROM STANDARDS IN 2010

Product	National Energy Savings in 2010 (TWh)	National Energy Savings in 2010 (tril. Btu)	Summer Peak Load Reduction In 2010 (GW)
Bottle-type water dispensers	0.1	0.9	0.0
Commercial boilers	0.0	0.0	0.0
Commercial hot food holding cabinets	0.1	0.8	0.0
Compact audio products	0.9	9.3	0.1
DVD players and recorders	0.1	1.3	0.0
Liquid-immersed distribution transformers	1.6	17.6	0.2
Medium-voltage dry-type transformers	0.1	1.1	0.0
Metal halide lamp fixtures	1.8	19.3	0.6
Pool heaters	0.0	0.0	0.0
Portable electric spas (hot tubs)	0.0	0.5	0.0
Residential furnaces and residential boilers	0.0	0.0	0.0
Residential pool pumps	0.8	8.2	0.2
Single-voltage external AC to DC power supplies	1.7	18.8	0.2
State-regulated incandescent reflector lamps	5.8	62.1	1.4
Walk-in refrigerators and freezers	1.0	10.5	0.2
Total	14.0	150.4	3.1