States Go First: How States Can Save Consumers Money, Reduce Energy and Water Waste, and Protect the Environment with New Appliance Standards

Joanna Mauer, Andrew deLaski, and Marianne DiMascio

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American Council for an Energy-Efficient Economy
529 14th Street NW, Suite 600, Washington, DC 20045
Phone: (202) 507-4000 • Twitter: @ACEEEDC
Facebook.com/myACEEE • aceee.org

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About the Authors

Joanna Mauer, technical advocacy manager of the Appliance Standards Awareness Project (ASAP), leads technical advocacy in a range of US Department of Energy (DOE) regulatory proceedings for residential appliances and commercial equipment. She is the lead author of the 2013 ASAP and ACEEE report, *Better Appliances: An Analysis of Performance, Features, and Price as Efficiency Has Improved*, and a coauthor of previous appliance standards potential studies for ASAP and ACEEE. Joanna earned a bachelor of science degree in civil and environmental engineering from Cornell University and a master's degree in public policy from the University of Maryland with a specialization in environmental policy.

Andrew deLaski, executive director of ASAP since 1999, has been involved in each major US standards rulemaking stretching over three administrations. His work contributed to the efficiency standards titles of the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and other standards legislation since then. He is a coauthor of a series of national and state studies on standards savings potential and other, related work. He holds a master of public policy from the University of Michigan and a bachelor's degree in economics from the University of Virginia.

Marianne DiMascio is the outreach director for ASAP. Her primary role is to create awareness of and to increase support for appliance efficiency standards at the federal and state levels, building a coalition of supporters through outreach, education, and advocacy. She leads state standards development and provides technical assistance to state stakeholders. Marianne is coauthor of the ACEEE and ASAP reports, *The Efficiency Boom: Cashing In on Savings from Appliance Standards* and *Ka-Boom! The Power of Appliance Standards*. She holds a master of education from Harvard University and a bachelor's degree in social work from the University of New Hampshire.

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Executive Summary

New appliance standards that states can adopt in the near term have the potential to save consumers and businesses billions of dollars while conserving energy and water resources. Appliance standards boost local economies since consumers and businesses spend most of the economic savings on other goods and services. The energy and water savings from standards can improve electric system reliability and defer or reduce the need for new energy and water infrastructure, which lowers utility rates for consumers. And the energy savings from standards also result in reductions in emissions of air pollutants, which can provide public health benefits while helping states meet clean air standards and greenhouse gas emissions targets.

Appliance, equipment, lighting, and plumbing product standards are a proven, successful policy at the state level.[1] At least 18 states have enacted appliance standards at various times. These state standards have not only benefited the residents of those states, but have also helped spur national standards. Most of today's national standards, which cover products ranging from refrigerators to commercial air conditioners to electric motors, started out at the state level. Even when state standards do not become national standards, adoption by just a few states can be sufficient to affect national markets. By going first, states have driven changes to national markets that have delivered very large savings.

States now have the opportunity to build on this legacy and once again take the lead in advancing new appliance efficiency standards to save energy and water, lower utility bills for consumers and businesses, and reduce air pollutant emissions.

RECOMMENDED PRODUCTS FOR STATE STANDARDS

In this report we are recommending 21 appliance standards that states can adopt. We generally assumed a compliance date of 2020 for each of the recommended standards, and we estimated potential savings through 2035. Table ES1 lists the 21 products in order of potential national net present value savings. The savings figures take into account both utility bill savings and estimated impacts on product costs for items sold between 2020 and 2035.

Combined, the recommended standards have the potential to provide $113 billion in net present value savings for consumers and businesses, if enough states adopted the 21 recommended standards to cause only compliant products to be sold nationally. The recommended standards cover a wide range of energy- and water-using residential and commercial products. Fifteen of the standards offer potential national net present value savings of more than $1 billion each. Standards for faucets, which would save both water and energy used to heat water, represent the largest potential net savings. The next highest ranking items on the list are also water-using products: showerheads, lawn spray sprinklers, and toilets. Other products that offer large potential economic savings include computers and monitors, high color rendering index (CRI) fluorescent lamps, air purifiers, pool pump

[1] We use *appliance standards* as shorthand throughout this report to encompass minimum energy or water efficiency levels or maximum energy or water use limits applied to appliances, equipment, lighting products, and plumbing products.

replacement motors, commercial fryers, and commercial dishwashers. Additional products offer smaller but still significant dollar savings.

Table ES1. Potential national net present value savings from recommended state standards

Product	Net present value savings (billion 2016$)
Faucets	34.5
Showerheads	19.6
Lawn spray sprinklers	14.5
Toilets	9.3
Computers and monitors	6.9
High CRI fluorescent lamps	5.2
Air purifiers	2.9
Pool pump replacement motors	2.8
Commercial fryers	2.5
Commercial dishwashers	2.4
Commercial steam cookers	2.0
Portable air conditioners	2.0
Urinals	1.9
Audio/video equipment	1.7
Uninterruptible power supplies	1.4
Telephones	0.9
Water coolers	0.8
Ventilation fans	0.8
Portable electric spas	0.7
Hot food holding cabinets	0.3
Compressors	0.2
Total	**113**

State-by-state savings estimates for each of the 21 recommended standards are available online at https://appliance-standards.org/state-savings-state-standards.

ENERGY SAVINGS

Potential national cumulative electricity savings through 2035 for the package of recommended standards are about 590 billion kilowatt-hours (kWh). For comparison, that is enough electricity to power almost 50 million US households for one year (EIA 2017a). Potential annual electricity savings reach 41 billion kWh in 2035, or about 1.5% of current total residential and commercial annual electricity use (EIA 2017f). Potential national cumulative natural gas savings through 2035 are about 1,600 trillion Btus, which is enough to meet the space heating needs of half of all US homes heated with natural gas for one year. Annual natural gas savings reach 155 trillion Btus in 2035, or about 2% of current total residential and commercial annual natural gas use (EIA 2017a).

Figure ES1 shows the breakdown of potential national cumulative primary energy savings by product. Primary energy accounts for the losses in generation, transmission, and distribution associated with electricity consumption and allows for an equitable comparison between electricity and natural gas savings. (One unit of electricity consumed at a home or business translates to about three units of energy consumed at the power plant.) Total potential cumulative primary energy savings through 2035 are about 7,400 trillion Btus. Those savings are enough to meet the energy needs of all US homes and businesses for two months. Potential annual primary energy savings in 2035 equal 545 trillion Btus, or about 1.5% of current total residential and commercial annual energy use (EIA 2017a).

The recommended standards for faucets, high color rendering index (CRI) fluorescent lamps, and computers and monitors together represent more than half of the total potential cumulative primary energy savings, while the standards for showerheads represent another 13% of the total potential savings. (Standards for faucets and showerheads provide significant energy savings in addition to water savings by reducing the amount of hot water used.) Other standards with the greatest potential primary energy savings include those for commercial fryers, air purifiers, pool pump replacement motors, uninterruptible power supplies, and portable air conditioners, which together represent 22% of the total potential primary energy savings.

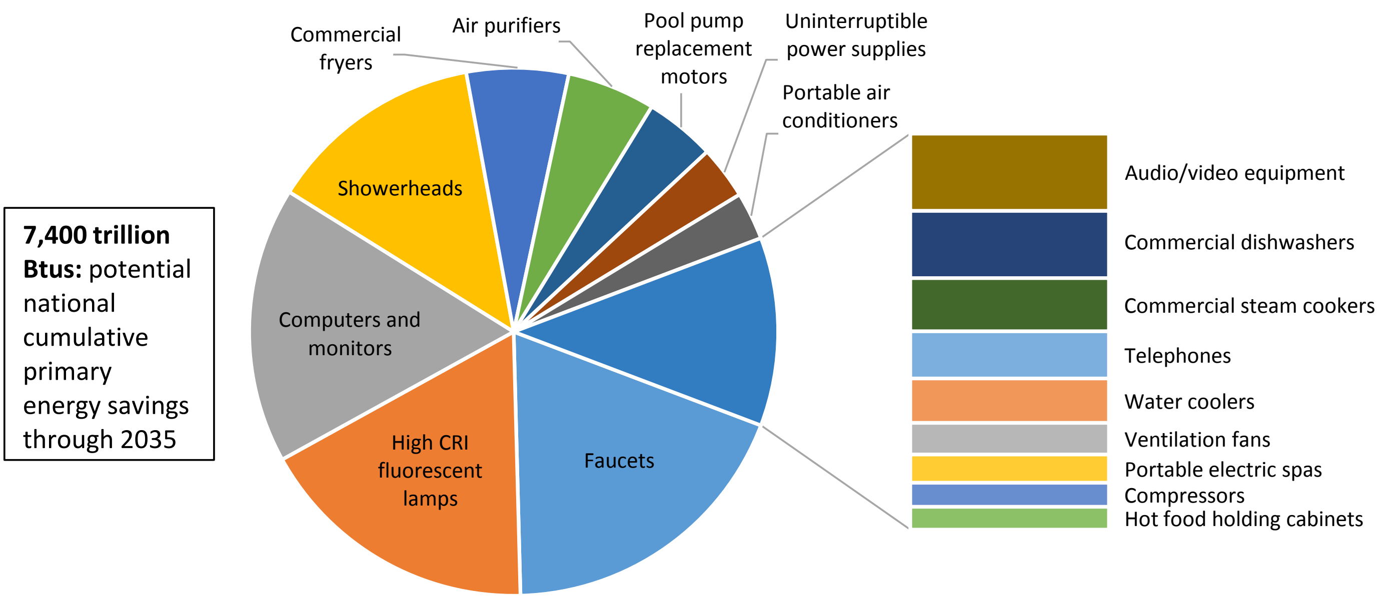

Figure ES1. Potential national cumulative primary energy savings through 2035 by product

WATER SAVINGS

Potential national cumulative water savings through 2035 from the seven recommended standards for water-using products are about 6.8 trillion gallons, or enough to meet the needs of every US household for eight months. Potential annual water savings reach about 630 billion gallons in 2035, or about 6% of current annual residential water usage (Maupin et al. 2014).

Figure ES2 shows the breakdown of potential cumulative water savings by product. Faucets represent more than one-third of the total potential cumulative water savings, while lawn spray sprinklers and showerheads represent 29% and 17% of total potential cumulative water savings, respectively. Standards for toilets also offer large potential water savings, while standards for urinals, commercial dishwashers, and commercial steam cookers offer smaller but still significant water savings.

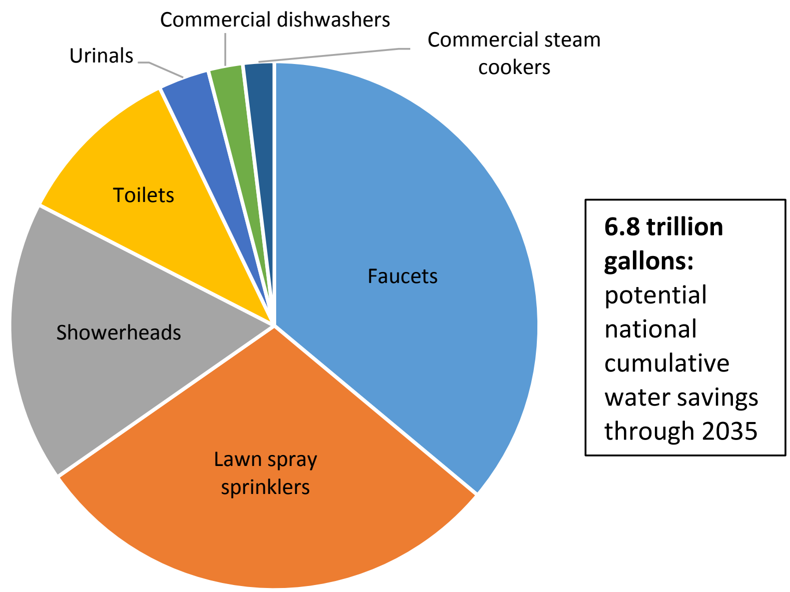

Figure ES2. Potential national cumulative water savings through 2035 by product

EMISSIONS REDUCTIONS

The energy savings from the recommended state standards would yield air pollutant emissions reductions including reductions of NOx, SO_2, and CO_2. NOx and SO_2 can harm the human respiratory system; children, the elderly, and people with asthma are particularly sensitive to the effects of these two emissions. Total potential national cumulative emissions reductions of NOx and SO_2 through 2035 are about 210,000 and 160,000 tons, respectively. Annual potential NOx and SO_2 emissions reductions reach about 15,000 and 10,000 tons, respectively, in 2035, or 1% and 0.5% of 2015 emissions from all US coal plants (EPA 2016b). Total potential cumulative CO_2 emissions reductions through 2035 are about 320 million metric tons (MMT). Annual potential CO_2 reductions in 2035 reach 23 MMT, which is equivalent to the annual CO_2 emissions of about seven average coal-fired power plants (EPA 2016a).

Table 3 in the report shows potential cumulative electricity, natural gas, primary energy, and water savings and emissions reductions through 2035 from the recommended standards for each of the 50 states and the District of Columbia. Tables A4 and A5 in the appendix show state-by-state potential annual energy and water savings and emissions reductions in 2025 and 2035.

ECONOMIC SAVINGS

All of the recommended standards are cost effective for the consumers and businesses that purchase these products in every state. Potential net present value savings range from $198 million in North Dakota to $16 billion in California. (California has already adopted six of the recommended standards and is therefore already realizing a significant portion of these potential savings.) The total national benefit–cost ratio for the package of recommended standards is 7.7, which means that the energy and water bill savings over the useful life of the products outweigh the estimated additional costs by a factor of more than 7. States with high energy prices or high outdoor water use generally have benefit–cost ratios higher than the national average. But even in states with low energy prices, benefit–cost ratios are very favorable. In every state, the potential energy and water bill savings outweigh the costs by a factor of more than 4.

In 2035 potential average annual per-household energy and water bill savings from the recommended standards for products used in homes reach a range of $72 in Iowa to $215 in Hawaii, with a US average of $106. Since one of the standards with the largest potential bill savings is for lawn spray sprinklers, states with the highest potential per-household utility bill savings tend to be those with the greatest per-household outdoor water use, something that varies significantly by state. These states include Arizona, California, Hawaii, Idaho, Nevada, and Utah. States with relatively high energy prices such as New York, New Jersey, and the New England states also have higher-than-average annual per-household savings. But the recommended standards would provide significant household savings in all states.

Table 5 in the report shows the economics of the recommended standards for each of the 50 states and the District of Columbia including net present value savings, benefit–cost ratios, and average annual per-household utility bill savings.

PRODUCTS FOR FUTURE CONSIDERATION

In addition to the 21 products that we are recommending for state standards, we have identified 7 products as good candidates for potential future state standards. These are products for which state standards would offer the potential for significant energy or water savings but which may need additional work on test procedures and/or recommended efficiency specifications. While not an exhaustive list, the product categories are: commercial clothes dryers, commercial and industrial fans, imaging equipment (i.e., copiers, printers, fax machines, and multifunction devices), landscape irrigation controllers, linear LED tube lamps and luminaires, servers and data storage equipment, and televisions and signage displays.

Introduction

Appliance standards ensure that products purchased by consumers and businesses meet a minimum level of energy and/or water efficiency. California adopted the first appliance efficiency standards in the 1970s, and other states followed suit. This laid the groundwork for the first national appliance standards, which were enacted in 1987. More than 55 product categories, ranging from refrigerators to commercial air conditioners to electric motors, are now subject to national standards. The great majority of these began as state standards. In 2015, the average US household saved almost $500 on utility bills due to existing national efficiency standards, and business energy bill savings equaled 8% of total business spending on electricity and natural gas. Accounting for products sold between 1987 and 2035 and for estimated impacts on product costs, existing standards are worth $2.4 trillion in cumulative net savings for consumers and businesses (deLaski and Mauer 2017).

Over the past eight years there has been tremendous progress at the national level in establishing new and updated appliance efficiency standards. During the Obama administration the US Department of Energy (DOE) set more than 50 new or updated standards for a wide range of residential, commercial and industrial, and lighting products. DOE estimates that efficiency standards adopted since 2009 will save consumers $550 billion on their utility bills through 2030 (DOE 2016d). Even given this enormous progress, ASAP and ACEEE found in a 2016 report that updates to existing standards that could be completed over the next eight years have the potential to save an additional 4 quadrillion Btus of primary energy annually and save consumers and businesses $65 billion per year on their utility bills by 2050 (deLaski et al. 2016). The potential primary energy savings in 2050 are equivalent to about 10% of total residential and commercial primary energy consumption in 2016 (EIA 2017a).

What are state appliance standards?

Appliance standards limit the energy and/or water wasted by specific household, commercial, and industrial products. “Appliance standards” can cover any energy- or water-using device, including home appliances, plumbing products, lighting products, and commercial and industrial equipment. In general, states can set standards for any products that are not subject to national standards. State standards are set by legislatures or state agencies and apply to products sold or installed in a given state.

While updates to national appliance standards offer very large potential savings, near-term progress at the federal level is uncertain. Several new standards that were all but completed during the Obama administration have been stalled, and the current administration’s proposed budget would impose deep cuts on the DOE offices responsible for standards. At the same time, many energy- and water-using products are not covered by national standards and therefore are eligible for state standards.

In this report we examine the opportunity for states to once again take the lead in advancing appliance standards to save energy and water, lower utility bills for consumers and businesses, and reduce air pollutant emissions. We provide recommendations for state standards for 21 products and estimates of state-by-state potential savings. We also outline how states can adopt appliance standards with very low administrative costs.

History of State Appliance Standards

Historically states have taken the lead in establishing appliance efficiency standards. Most often, California has been the first state to set a standard for a given product, but in some cases, other states have acted first.

California's first appliance standards, adopted in 1976, applied to refrigerators, freezers, room air conditioners, and central air conditioners (CEC 1976). Over the next several years the state expanded the scope of its standards to cover space heating and water heating equipment, plumbing fittings, fluorescent lamp ballasts, cooking appliances, and pool heaters (CEC 1985). In the early to mid 1980s other states including Florida, Kansas, Massachusetts, and New York set their own standards, generally equivalent to those in California (Nadel et al. 2005).

State standards set the stage for national standards: commercial refrigerators and freezers

California adopted the first appliance efficiency standards for commercial refrigerators and freezers, which took effect in 2003. The standards applied to reach-in refrigerators and freezers with doors, which are typically used in food-service establishments. California subsequently strengthened their initial standards for this equipment, and eight other states also adopted standards. In response to the proliferation of state-level standards, manufacturers and efficiency advocates negotiated the first national efficiency standards for commercial refrigerators and freezers, which were enacted as part of the Energy Policy Act of 2005 (EPAct 2005) and took effect in 2010. EPAct 2005 also directed DOE to complete rulemakings to determine whether to update the initial national standards and to establish standards for additional types of commercial refrigerators and freezers including refrigerated display cases, which are commonly used in supermarkets. DOE completed rulemakings in 2009 and 2014, and updated standards for all types of commercial refrigerators and freezers took effect in March 2017. Reach-in refrigerators and freezers just meeting the 2017 standards use about 45% to 65% less energy than the levels contained in the original 2003 California standards.

Appliance manufacturers became increasingly concerned about the proliferation of state standards, and in 1986 manufacturers negotiated with efficiency advocates and states to reach a consensus on national efficiency standards that would preempt the individual state standards for many major household appliances.[2] The resulting agreement formed the basis for the National Appliance Energy Conservation Act of 1987 (NAECA). In subsequent years states established standards for additional products, and in 1992 Congress enacted another round of standards as part of the Energy Policy Act (EPAct) for some common types of light bulbs, electric motors, commercial heating and cooling equipment, and plumbing fittings based on consensus agreements between product manufacturers and efficiency advocates (Nadel and Pye 1996).

In the 2000s states established standards for additional products such as commercial clothes washers, commercial refrigerators and freezers, and walk-in coolers and freezers (ASAP

[2] See box on page 4 for a discussion of preemption.

2016b). These standards led to negotiations among manufacturers, states, and efficiency advocates that resulted in new national standards for about 25 products as part of the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007 (EISA). Some of the other products for which states first established standards in the 2000s remain within state jurisdiction (compact audio equipment, hot food holding cabinets, pool pump motors, portable electric spas, televisions, and water coolers). States that currently have standards for some or all of these products include Arizona, California, Connecticut, Maryland, New Hampshire, Oregon, Rhode Island, and Washington as well as the District of Columbia.

In recent years California has generally taken the lead in establishing several new state-level appliance efficiency standards. In 2012 the California Energy Commission (CEC) finalized the first efficiency standards for battery chargers, which apply to chargers used in a diverse range of products from electric toothbrushes to power tools to electric forklifts (CEC 2012). Oregon adopted equivalent standards a year later, and in 2016 DOE finalized the first national battery charger efficiency standards, which largely aligned with the state standards. In its research for the national standard development process, DOE found that a very high percentage of products available nationally met the state standards. DOE noted that the state standards "had moved the market, not just in California, but nationally as well" (DOE 2016b). In addition to adopting battery charger standards, in 2013 Oregon also adopted television standards equivalent to those in California, as well as the first-ever standards for double-ended quartz halogen lamps, which are often used to light community sports fields (Oregon Laws 2013).

Which state goes first?

Most often, California has been the first state to establish appliance standards for a given product. But in some cases other states have gone first. For example, Massachusetts was the first to address state standards for distribution transformers, electric motors, and certain types of light bulbs; Rhode Island set the original high-intensity discharge (HID) lamp ballast standards; and Oregon set the first standards for double-ended quartz halogen lamps. Action by even small states has affected national markets. Most state standards have either become national standards or set a *de facto* efficiency floor because most manufacturers prefer to comply nationally rather than provide different products to different state markets.

California adopted the first-ever standards for small-diameter directional lamps and for computers and monitors in 2015 and 2016, respectively (CEC 2017b; CEC 2016a). The new California standards for small-diameter directional lamps (i.e., light bulbs), which will take effect in 2018, apply to lamps used in track lighting in both homes and businesses, such as common MR16 lamps. The standards for computers and monitors will take effect in 2018 or 2019, depending on the specific product, with the largest energy savings coming from improvements to the efficiency of desktop computers and monitors (CEC 2016b).[3]

[3] A second tier of standards for desktop computers and monitors will take effect in 2021.

California and Texas were the first states to adopt water efficiency standards for toilets and urinals that exceed the national standards established as part of EPAct 1992. (For certain plumbing products, federal law provides that if the national standards are not updated, state preemption sunsets. Since the original national standards enacted in 1992 for faucets, showerheads, toilets, and urinals had not been updated, DOE issued a rule in 2010 waiving federal preemption [DOE 2010]). The California and Texas standards, which were established by the state legislatures and signed into law by Governors Arnold Schwarzenegger and Rick Perry in 2007 and 2009, respectively, required that 100% of sales of toilets and urinals meet water efficiency levels equivalent to the Environmental Protection Agency's (EPA's) WaterSense specifications by 2014 (California Health and Safety Code Section 17921.3; Texas Health and Safety Code Section 372.002).[4] In 2015, in response to Governor Jerry Brown's 2014 emergency drought declaration, the CEC adopted new standards for faucets, showerheads, toilets, and urinals. With the exception of toilets, the new California standards provide greater water savings than those achieved by products meeting the WaterSense specifications (CEC 2015b). In addition to California and Texas, Colorado, Georgia, and New York City also have standards for one or more plumbing products that are stronger than the national standards (ASAP 2016b).

What is preemption?

Once the federal government establishes an efficiency standard for a particular product, federal law provides that states are prohibited, or preempted, from having state-level standards for that product. The purpose of federal preemption is to establish a consistent, national market. Various exceptions exist to preemption, sometimes specifically designed for states that have preexisting standards. In the case of some plumbing products, the federal law required DOE to waive preemption when standards were not updated. States are allowed to apply to DOE for state-specific waivers from federal preemption if they want to set standards that are more stringent than the federal standards, but only two waiver applications have been filed to date, and both were denied.

As shown in figure 1, 11 states plus the District of Columbia have existing state-level appliance efficiency standards.

[4] WaterSense, which is administered by EPA, is a voluntary labeling program that identifies water-efficient products.

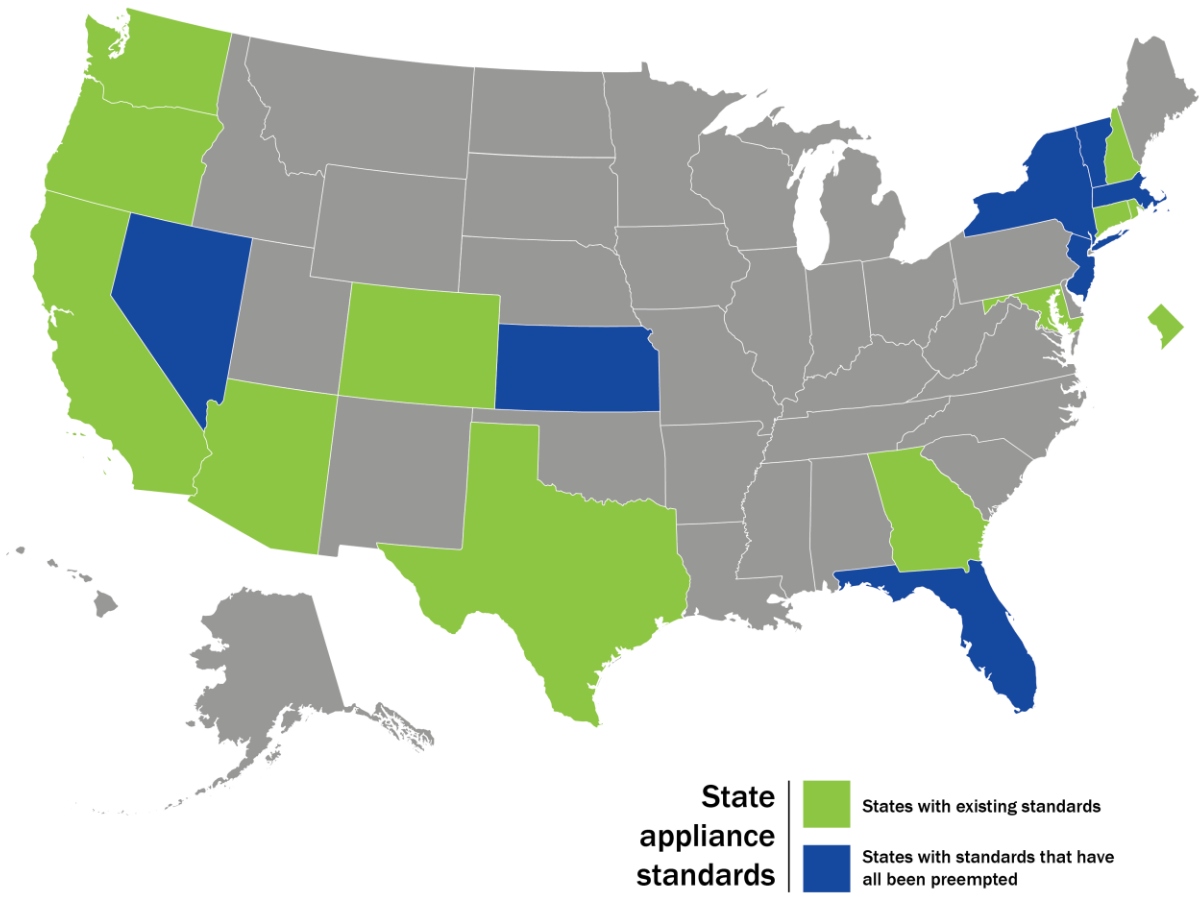

Figure 1. States with existing state-level appliance efficiency standards or with standards that have all been preempted

Seven other states (Florida, Kansas, Massachusetts, New Jersey, Nevada, New York, and Vermont) have adopted standards that have all been preempted by national standards (ASAP 2016b).

Benefits of Appliance Standards

Appliance efficiency standards can provide large electricity, natural gas, and water savings. These energy and water savings in turn provide numerous benefits to states, including

- Economic savings for consumers and businesses
- Benefits to local economies
- Improved electric system reliability and reduced need for new energy and water infrastructure
- Reductions in air pollutant emissions

CONSUMER AND BUSINESS ECONOMIC SAVINGS

As described above, existing appliance standards are providing significant utility bill savings for consumers and businesses. Savings tend to be greatest in areas with relatively high utility rates. One of the best ways to bring down high utility costs is to reduce energy waste with a range of policies, including appliance standards. Energy savings are particularly important for low-income households, which spend more than 7% of their income on energy bills compared with 3.5% for all households (Drehobl and Ross 2016). A 2011 survey of low-income households found that 24% of respondents sacrificed food and 37% went without medical or dental care due to unaffordable energy bills (NEADA 2011). Although more-efficient products often cost more up front, standards are designed to be cost effective: bill savings over time more than pay back any additional cost.[5]

Water and wastewater bills represent a surprisingly large portion of overall utility bills (i.e., energy and water bills) in many areas, and water prices are rising much faster than the cost of nearly every other household staple (Walton 2015). Figure 2 shows average 2015 residential electricity, gas and heating oil, and water and wastewater bills as a percentage of total energy and water bills. In 2015 water and wastewater bills made up 29% of total US average residential utility bills.[6] State standards have the potential to significantly reduce residential water and wastewater bills.

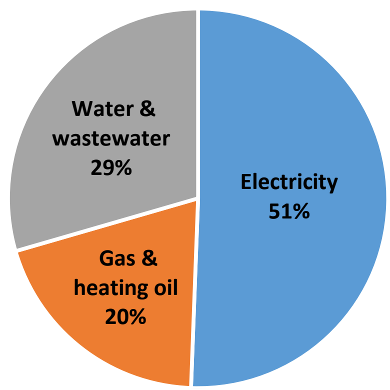

Figure 2. Average 2015 residential electricity, gas and heating oil, and water and wastewater bills as a percentage of total energy and water bills. *Source:* deLaski and Mauer 2017.

ECONOMIC BENEFITS TO LOCAL ECONOMIES

Reduced spending on energy and water bills boosts local economies since consumers and businesses spend most of the savings on other goods and services. Energy-related sectors of the US economy are much less job intensive than other areas of the economy such as the retail and service sectors. Utility bill savings that result from appliance standards therefore increase net employment levels by shifting economic activity from less labor-intensive sectors to more labor-intensive sectors. ACEEE and ASAP found in a 2011 report that existing national appliance efficiency standards generated about 340,000 jobs in 2010 (Gold et al. 2011). The economic benefits

Reduced spending on energy and water bills boosts local economies since consumers and businesses spend most of the savings on other goods and services.

[5] Appendix D describes market barriers that help explain why consumers and businesses often fail to select products that would save them money.

[6] There is significant variability among localities in terms of the relative magnitude of water and wastewater bills.

from appliance standards are most pronounced for states that import most of their energy from other regions. In these states, much of the money that would have gone to out-of-state power producers is instead spent locally.

ENERGY AND WATER SYSTEM BENEFITS

Appliance standards can improve electric system reliability by reducing peak electricity demand. This lowers the load and stress on the power distribution network, including on distribution transformers and feeder cables, and decreases the likelihood of failures in the distribution system (Raynolds and Cowart 2000). Investments in new transmission and distribution infrastructure may also be delayed or downsized by reducing electricity demand. For example, in Maine, investments in energy efficiency and other local resources such as demand response eliminated the need for $18 million in upgrades to transmission lines at one-third the cost (Anthony 2016). Similarly, natural gas savings can defer or reduce the need for new pipelines, and water savings can put off the need for expensive water infrastructure projects or enable those projects to be smaller than otherwise required. Deferring or reducing the need for new energy and water infrastructure in turn lowers future utility rates for consumers.

AIR EMISSIONS REDUCTIONS

The electricity and natural gas savings from appliance standards reduce emissions of air pollutants including NOx, SO_2, $PM_{2.5}$, and CO_2 by avoiding electricity generation from fossil fuel plants and reducing emissions from on-site burning of natural gas and heating oil. Reductions of NOx, SO_2, and $PM_{2.5}$ emissions can provide important public health benefits. NOx and SO_2 can harm the human respiratory system, while $PM_{2.5}$ particles can travel deep into the lungs and cause or aggravate heart and lung diseases. Children, the elderly, and people with asthma are particularly sensitive to the effects of NOx, SO_2, and $PM_{2.5}$.

The emissions reductions from efficiency standards can help states meet clean air standards and greenhouse gas emissions targets.

The emissions reductions from appliance standards can also help states meet clean air standards and greenhouse gas emissions targets. EPA encourages states to consider incorporating energy efficiency in their plans for meeting National Ambient Air Quality Standards (NAAQS). It notes that energy efficiency policies and programs "may be a cost-effective strategy that state, tribal and local agencies can use as part of multi-pollutant emissions reduction approaches to help attain and maintain compliance with NAAQS, as well as achieve other regulatory or nonregulatory objectives such as improving visibility, reducing regional haze, reducing air toxics, and limiting greenhouse gases" (EPA 2012b). Many states also have greenhouse gas emissions targets, and appliance standards can help states meet those targets by reducing CO_2 emissions.

Why appliance standards are a low-cost state policy

All of the product standards recommended in this report save money for the consumers and businesses that buy those products. Appliance standards are also a very low-cost policy for state government. A state standards program typically consists of three components: (1) efficiency standards and test methods; (2) manufacturer certification; and (3) enforcement. Administrative costs can be kept low for all three components because the recommended standards generally are based on existing programs.

State legislatures can write specific standards and test methods directly into law or reference existing standards or efficiency specifications (such as ENERGY STAR® or WaterSense).[1,2] By relying on existing specifications, states do not need to incur any costs related to the development of standard levels or the test procedures used for measuring efficiency. ASAP and ACEEE take this approach with a model state standards bill that is updated annually. Many states have based standards programs on this model legislation.

Most states require manufacturers to certify that a product meets a state's standards as a condition for sale in the state. States can reduce or even eliminate any state costs for certification by relying on the existing California Energy Commission (CEC) certification program and public database or the existing ENERGY STAR or WaterSense lists of qualified products. Relying on existing programs also reduces or eliminates certification costs for manufacturers. Another alternative for compliance certification is the Multi-State Appliance Standards Collaborative, which was developed when many state standards were established in the mid to late 2000s.[3] The multistate mechanism built upon the existing CEC system but enabled state-specific listings of certified products. Over the past decade, as federal standards activity picked up and state activity declined, the multistate collaborative became inactive. However the framework still exists if states see a need to revive it.

Most efficiency standards laws also authorize an agency to enforce state standards and levy penalties for noncompliance. Very few states have actively enforced standards. Even in the absence of active enforcement, compliance rates may be high in part because of the risk of fines and damage to a company's reputation. In addition, the competitive pressures of the market can assist in encouraging compliance: manufacturers keep an eye on competitors and sometimes report noncompliance. Moreover, once several states have adopted a standard, the impetus for replacement of the state standards with a federal standard becomes very strong.

California has recently stepped up enforcement. In 2011 the state legislature gave the CEC authority to assess monetary penalties for violations of the state's appliance efficiency regulations, and in 2015 CEC adopted enforcement regulations to implement a program for assessing fines for noncompliant manufacturers, distributors, and retailers (CEC 2015a). Other states that adopt California standards will benefit from CEC enforcement efforts.

[1] ENERGY STAR and WaterSense, both administered by EPA, are voluntary labeling programs that identify energy-efficient products and water-efficient products, respectively.

[2] A few state legislatures, such as California's, have granted an administrative agency authority to develop standards.

[3] See www.appliancestandards.org/states/.

Recommended Products for State Appliance Standards

AREAS OF OPPORTUNITY

Although national efficiency standards address many of the biggest energy-using products, states have the ability to set standards for products that are responsible for a large and growing share of energy use (where state standards are not preempted; see box on page 4). As shown in figures 3 and 4, in 2015 "other uses" represented 21% and 35% of total residential and commercial primary energy consumption, respectively. By 2035 "other uses" are projected to make up 25% and 45% of total residential and commercial primary energy use, respectively. These "other uses" are mostly within states' jurisdiction to set standards.

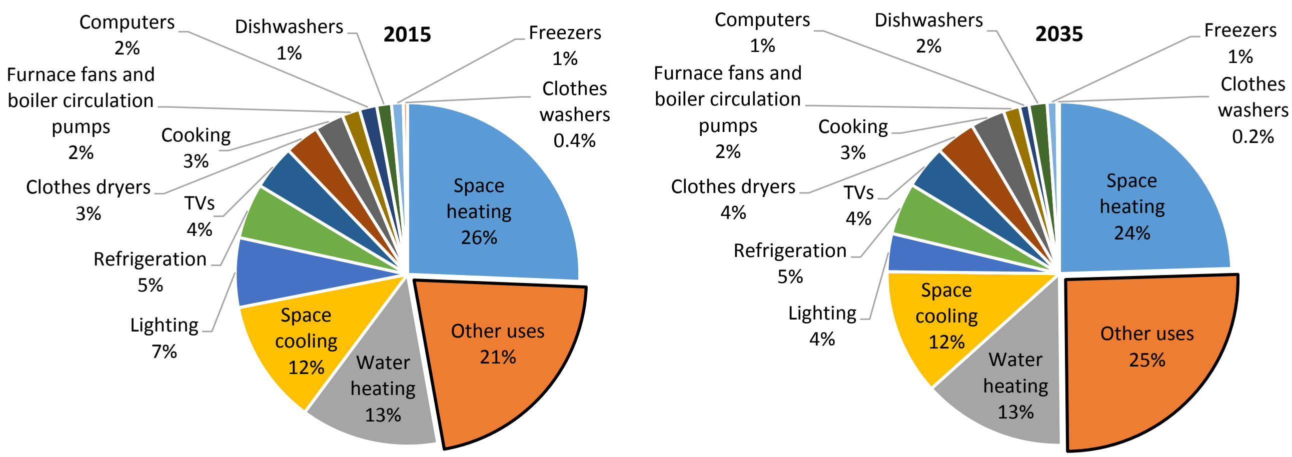

Figure 3. Residential primary energy consumption in 2015, and projected 2035 consumption, by end use as a percentage of total energy consumption. *Source:* EIA 2017a.

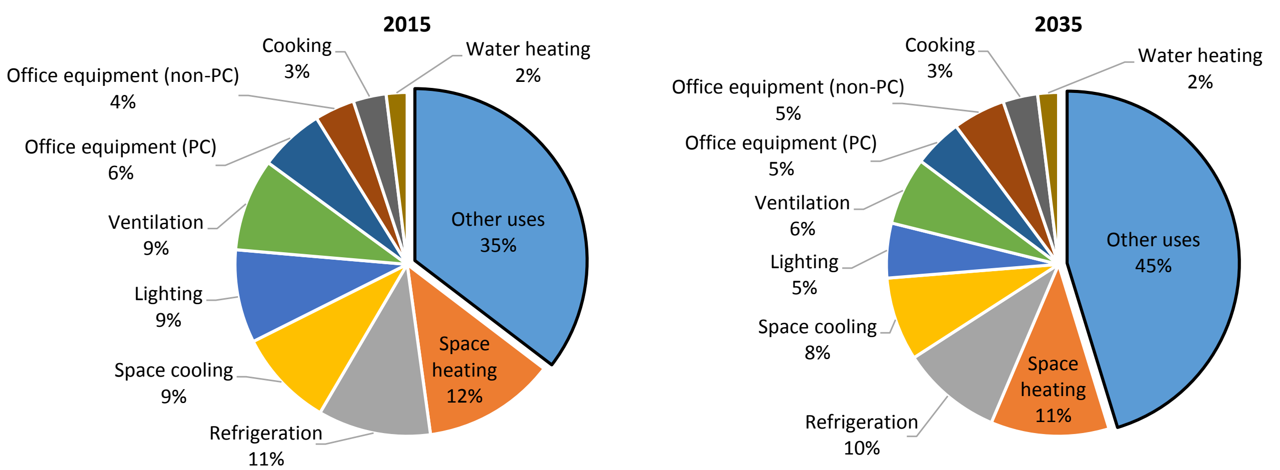

Figure 4. Commercial primary energy consumption in 2015, and projected 2035 consumption, by end use as a percentage of total energy consumption. *Source:* EIA 2017a.

Notably, even if the federal government was inclined to develop standards for these products, in many cases existing federal law constrains DOE's authority. For example, consumer products must meet certain energy use thresholds in order for DOE to set standards. Since 1987, DOE has set standards that were not specifically required by

Congress on only three occasions (for commercial and industrial pumps, miscellaneous refrigeration equipment, and dedicated-purpose pool pumps), each under the Obama administration.

In addition, the federal government has not effectively addressed water-using products. For example, while national standards were established in 1992 for faucets, showerheads, toilets, and urinals, these standards have never been updated. As described earlier, federal preemption currently does not apply to these plumbing products, and four states and New York City now have stepped in to establish state-level (or local-level) plumbing product standards that are stronger than the now-outdated national standards. Further, while outdoor water use represents about 36% of total residential water consumption, there are currently no efficiency standards at the national (or state) level for landscape irrigation equipment.[7]

Most of the standards we are recommending are either for products that are categorized as "other uses" or for water-using products. Ten of the recommended standards are for products that fall in the "other uses" category in either the residential sector (air purifiers, pool pump replacement motors, portable electric spas, telephones, uninterruptible power supplies, ventilation fans) or the commercial sector (commercial dishwashers, compressors, hot food holding cabinets, water coolers). Seven of the recommended standards are for water-using products (commercial dishwashers, commercial steam cookers, faucets, lawn spray sprinklers, showerheads, toilets, and urinals).

CRITERIA FOR SELECTING PRODUCTS

We examined a variety of sources to develop an initial list of potential products for state standards, including existing state standards, ENERGY STAR® and WaterSense specifications, Consortium for Energy Efficiency (CEE) specifications, existing standards in other economies, and research on builder-installed loads (Meier and Aillot 2015) and idle loads (Delforge, Schmidt, and Schmidt 2015). We also considered products for which DOE has initiated a rulemaking but has not yet established standards. Our initial list included almost 100 products.

We then evaluated five main criteria to come up with our final list of recommended products for state standards:

- Is there an existing efficiency specification (e.g., an existing state standard or ENERGY STAR specification) that can serve as the basis for a state standard?
- Is there an existing test procedure to measure efficiency?
- Can products from multiple manufacturers meet the potential standard level?

[7] According to the U.S. Geological Survey (USGS), total residential water consumption in 2010 was 27,197 Mgal/d (Maupin et al. 2014). Adjusted for population, estimated 2016 total residential water consumption was 28,581 Mgal/d. A Water Research Foundation study found that 2016 average residential indoor per-capita water consumption (excluding leaks) was 50.7 gal/d, and average household water consumption due to leaks was 17.0 gal/day (DeOreo et al. 2016). Total 2016 residential indoor water consumption was therefore about 18,370 Mgal/d.

- Are there sufficient data to reliably analyze potential costs and savings?
- Would the potential standard level be cost effective for purchasers of the regulated product?

Using these criteria, we came up with our final list of 21 products that we are recommending for state standards.

RECOMMENDED PRODUCTS FOR STATE APPLIANCE STANDARDS

Table 1 lists the recommended products for state standards and identifies for each of the products whether there is an existing state standard, ENERGY STAR or WaterSense specification, or pending DOE standard. It also lists the number of brands with products already meeting the recommended standard level and the estimated national market share of those products. The products are listed in order of potential net present value savings, taking into account both the utility bill savings and estimated impacts on product costs. (Net present value savings are shown in table 4.) For 11 of the products, at least one state has already adopted a standard. ENERGY STAR or WaterSense specifications exist for 15 of the products.[8] Finally, for three products (portable air conditioners, uninterruptible power supplies, and compressors) there is a pending DOE standard. (These pending DOE standards were issued in 2016 but have yet to be officially published in the Federal Register.[9])

For just two of the recommended products for state standards (lawn spray sprinklers and high CRI fluorescent lamps), no current state standard, ENERGY STAR or WaterSense specification, or pending DOE standard exists. However WaterSense has issued a draft specification for lawn spray sprinklers and plans to release a final specification by the end of the summer of 2017 (EPA 2016e; EPA 2017d). National standards for linear fluorescent lamps have been in place for more than two decades, but those standards exempt lamps with a high color rendering index (CRI). As discussed below, our recommended standard for high CRI fluorescent lamps would close this loophole in the national standards.

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[8] The ENERGY STAR program is generally intended as a tool to recognize and promote the models of a given product that are in the top 25% of their category in terms of efficiency. Where we are recommending that states adopt standards equivalent to an ENERGY STAR specification, those standards would be cost effective for purchasers and would achieve significant savings. (ENERGY STAR also ensures that multiple manufacturers have products that can meet any potential specification.) For these products, in most cases the market share of ENERGY STAR–qualified products is well above 25%, and EPA has indicated that it intends to revise the specification in 2017 (EPA 2015c). For three products (commercial fryers, hot food holding cabinets, and ventilation fans), the market share of products meeting the current ENERGY STAR specification is still relatively low, and therefore we are recommending that states adopt standards equivalent to an older version of ENERGY STAR.

[9] Several environmental and consumer groups, state attorneys general, and other state and municipal entities sued DOE in June 2017 to force publication of the pending standards. If these rules are completed by DOE, then it will no longer be necessary for states to adopt them.

Table 1. Recommended products for state standards, listed in order of potential net present value savings

Product	Existing state standard in one or more states	Existing ENERGY STAR or WaterSense specification	Pending DOE standard	Number of brands with products already meeting recommended standard level	Estimated national market share of products already meeting recommended standard level
Faucets	X	X		121 (res. lav.) 32 (public) 190 (kitchen)	54% (res. lav.) 79% (public) 41% (kitchen)
Showerheads	X	X		142	69%
Lawn spray sprinklers				9	10%
Toilets	X	X		33	57%
Computers and monitors	X	X		*	25%/17% desktops; 73% notebooks; 14% monitors
High CRI fluorescent lamps				**	**
Air purifiers		X		44	60%
Pool pump replacement motors	X			2	24%
Commercial fryers		X		10	21%
Commercial dishwashers		X		23	67%
Commercial steam cookers		X		9	53%
Portable air conditioners			X	*	15%
Urinals	X	X		5	28%
Audio/video equipment	X	X		24	50%
Uninterruptible power supplies	X	X	X	*	51%
Telephones		X		9	19%
Water coolers	X	X		31	62%
Ventilation fans		X		55	37%
Portable electric spas	X			103	71%
Hot food holding cabinets	X	X		27	62%
Compressors			X	*	72%

*For computers and monitors, portable air conditioners, uninterruptible power supplies, and compressors, data are not readily available to estimate the number of brands with compliant products. **We are currently not aware of any high CRI fluorescent lamps that meet the recommended standard level. While there is no clear technical barrier that prevents a high CRI T8 lamp from meeting the recommended standard level, there appears to be no market for high-efficiency high CRI lamps, and manufacturers therefore have no incentive to develop them. If the current exemption for high CRI lamps is eliminated by a state standard, we expect that manufacturers will introduce compliant high CRI lamps, and consumers will also have a choice of regular CRI fluorescent lamps and linear LED lamps.
Notes: The two values for the estimated market share for desktop computers correspond to the tier 1 and tier 2 standards. The number of brands with compliant ventilation fans reflects ENERGY STAR–qualified products before the specification change in 2015. For faucets, showerheads, toilets, computers and monitors, air purifiers, and urinals, we used models as a proxy for sales of compliant products.
Sources: DOE 2017; EPA 2016d; CEC 2016c; CEC 2016b; EPA 2017e; AHAM 2017; APSP 2016a; DOE 2016a; EPA 2015c; DOE 2016f; DOE 2016g; EPA 2015b; EPA 2014; CEC 2017a; Worth and Fernstrom 2014; EPA 2012a; DOE 2016e.

For almost all of the products for which data are available on the efficiency levels of current models, there are at least five brands that already have products meeting the recommended standard level.[10] The estimated national market share of products meeting the recommended standard levels ranges from 10% for lawn spray sprinklers to more than 70% for public faucets, notebook computers, portable electric spas, and compressors.[11] For about half of the products, the current market share of compliant products is at least 50%.

Below are descriptions of each of the 21 products and the recommended standard levels listed in order of potential net present value savings. Each heading includes the potential net present value savings from products sold between 2020 and 2035 (billion 2016$) and, where applicable, potential cumulative primary energy savings through 2035 (trillion Btus) and/or potential cumulative water savings through 2035 (billion gallons).

Faucets: $34.5 billion, 1,400 TBtus, 2,440 billion gallons

Faucets are subject to national efficiency standards, although the standards have not been updated since 1992. Under a provision in federal law specific to plumbing products, faucets are currently not subject to federal preemption. The national standards require that faucets use no more than 2.2 gallons per minute (gpm). In 2007, EPA finalized a WaterSense specification for lavatory faucets, which specifies a maximum flow rate of 1.5 gpm. California adopted standards for faucets in 2015 that set the maximum flow rate at 1.2 gpm for lavatory faucets, 0.5 gpm for public (commercial) faucets, and 1.8 gpm for kitchen faucets. Our recommended standards for faucets are equivalent to the California standards. For lavatory faucets, we are recommending that states adopt the California standard rather than the WaterSense specification. Since there is wide availability of products that meet the California standard, there is no cost to meet the more stringent California standard, and the California standard achieves 40% greater savings than the WaterSense specification. In addition to saving water, more-efficient faucets save a significant amount of energy by reducing the amount of hot water used. As of March 2017, 54%, 79%, and 41% of lavatory, public, and kitchen faucet models certified to DOE, respectively, meet the California standards (DOE 2017).

Showerheads: $19.6 billion, 980 TBtus, 1,170 billion gallons

Showerheads are subject to national efficiency standards, although the standards have not been updated since 1992. As with faucets, under a provision in federal law specific to plumbing products, showerheads are currently not subject to federal preemption. The national standards require that showerheads use no more than 2.5 gallons per minute (gpm). California recently adopted standards for showerheads that set the maximum flow rate at 1.8 gpm as of 2018. In 2010, EPA finalized a WaterSense specification for

[10] The exceptions are high CRI fluorescent lamps and pool pump replacement motors. High CRI fluorescent lamps are discussed in a note below table 1. For pool pump replacement motors, there are three major brands that offer replacement motors. Of these, at least two currently offer versions with variable speed, which is the basis for the recommended standard level.

[11] The exception is high CRI fluorescent lamps (see note below table 1). While the estimated market share of lawn spray sprinklers meeting the recommended standard level is only 10%, there is general manufacturer support for the WaterSense specification, which is the basis for the recommended standard level, and wide availability of compliant products.

showerheads, which stipulates a maximum flow rate of 2.0 gpm. Colorado has standards for showerheads that are equivalent to the WaterSense specification. Our recommended standard for showerheads is equivalent to the WaterSense level and the Colorado standard and represents water savings of about 20% relative to the national standard. As of March 2017, 69% of showerhead models certified to DOE use 2.0 gpm or less (DOE 2017). (States choosing instead to adopt the California standard would achieve greater savings. As of March 2017, 20% of showerhead models certified to DOE use 1.8 gpm or less.) In addition to saving water, more-efficient showerheads save a significant amount of energy by reducing the amount of hot water used.

Lawn Spray Sprinklers: $14.5 billion, 1,980 billion gallons

Lawn spray sprinklers are used as part of in-ground irrigation systems. EPA estimates that more than 13 million US homes have automatic lawn irrigation systems, and about half of all residential outdoor water use is for spray irrigation (EPA 2016d). Lawn spray sprinklers have a recommended operating water pressure, but in most cases the actual operating pressure is significantly higher, which results in wasted water, misting, and uneven coverage. Our recommended standard for lawn spray sprinklers would apply to the sprinkler body and is based on a WaterSense draft specification issued in 2016. (The sprinkler body is the exterior shell of the spray sprinkler that connects to the irrigation system piping and houses the spray nozzle.) The WaterSense draft specification would effectively require that sprinkler bodies contain internal pressure regulation. While the WaterSense specification is not yet final, there is general manufacturer support for the specification and wide availability of compliant products. WaterSense plans to release a final specification by end of the summer of 2017 (EPA 2017d). Lawn spray sprinkler bodies meeting the WaterSense draft specification can reduce water use by 10% on average. EPA estimates that roughly 10% of current irrigation systems use sprinkler bodies with internal pressure regulation (EPA 2016d).

Toilets: $9.3 billion, 700 billion gallons

Toilets are subject to national efficiency standards, although the standards have not been updated since 1992. Under a provision in federal law specific to plumbing products, toilets are currently not subject to federal preemption. The national standards require that toilets use no more than 1.6 gallons per flush (gpf). California, Colorado, Georgia, and Texas all have standards that require toilets to use no more than 1.28 gpf, which is equivalent to the WaterSense specification and represents water savings of 20% relative to the national standard. Our recommended standard for toilets is equivalent to the WaterSense level of 1.28 gpf. As of March 2017, 57% of toilet models certified to DOE use 1.28 gpf or less (DOE 2017).

Computers and Monitors: $6.9 billion, 1,260 TBtus

California established the first efficiency standards for computers and monitors in 2016. Our recommended standards for computers and monitors are equivalent to the California standards, which apply to desktops, notebooks (laptops), small-scale servers, workstations, and monitors. The standards for computers focus on reducing energy use when the computer is on but is not being used (idle mode); the monitor standards drive improvements in the display screen to decrease energy consumption when in use. The largest energy savings for computers come from improvements to the efficiency of desktops. Laptops are generally much more efficient already as a result of the need to prolong battery life (CEC 2016b). Our recommended standards would reduce the energy use of desktops and monitors by about 35% and 45%, respectively.

High CRI Fluorescent Lamps: $5.2 billion, 1,290 TBtus

Linear fluorescent lamps are long tube lamps (typically 4 feet) commonly used in places such as offices, retail stores, and warehouses. Linear fluorescent lamps are subject to national efficiency standards. However those standards exempt lamps with a high color rendering index (CRI). CRI is a measure of a light source's ability to accurately show colors of objects compared with an ideal or natural light source. The maximum CRI is 100, and fluorescent lamps with a CRI of 87 or greater are exempt from the national standards. When Congress enacted the first standards for linear fluorescent lamps, high CRI lamps were a niche product used for specialty applications only. The current national standards for linear fluorescent lamps are based on the efficiency performance of T8 lamps (1 inch in diameter), which are significantly more efficient than T12 lamps (1.5 inches in diameter). However the exemption for high CRI lamps has become a loophole in the standards as manufacturers have introduced less-efficient lamps with CRIs above 87 that are being used in general lighting applications. In the third quarter of 2016, these less-efficient T12 lamps made up 17% of all shipments of linear fluorescent lamps (NEMA 2017). Our recommended standard for high CRI fluorescent lamps would close this loophole in the national standards by requiring such lamps to meet the same efficiency requirements as regular CRI lamps.

Air Purifiers: $2.9 billion, 400 TBtus

Air purifiers (or room air cleaners) are portable units that remove fine particles, such as dust or pollen, from indoor air. Our recommended standard for air purifiers is based on ENERGY STAR Version 1.2, which has been in effect since 2004. More than four million air purifiers are sold in the United States each year (EPA 2015c). Typical air purifiers that do not meet the ENERGY STAR specification use more than 500 kWh per year on average, equivalent to the annual energy consumption of an average new refrigerator (Xcel Energy 2015; ASAP 2016a). Air purifiers meeting the ENERGY STAR specification use 40% less energy than standard models. As of March 2017, 60% of air purifier models certified through the Association of Home Appliance Manufacturers (AHAM) Certification Program were ENERGY STAR qualified (AHAM 2017).

Pool Pump Replacement Motors: $2.8 billion, 320 TBtus

Swimming pool pumps are used to circulate and filter pool water. There are about five million in-ground pools in the United States (APSP 2016b). DOE finalized the first national standards for pool pumps in January 2017. The standards for in-ground pool pumps are based on the performance of pumps with variable-speed motors, which can reduce energy use by about 65% relative to inefficient single-speed pumps. However pool pump motors are often replaced during the life of the pump, and the DOE standards do not apply to replacement motors. Since 2008 California has had standards for pool pump motors that require all except the smallest models to be two-speed or variable-speed. Arizona, Connecticut, and Washington also have standards for pool pump motors based on the California standards. Our recommended standard would ensure that the efficiency of pool pump replacement motors for in-ground pools is equivalent to that of motors in new pool pumps meeting the DOE standards. This would prevent inefficient single-speed replacement motors from undermining the energy savings from the DOE standards. Variable-speed pool pump motors that can be used as drop-in replacements for single-speed motors are currently available.[12]

Commercial Fryers: $2.5 billion, 460 TBtus

Commercial fryers are used in commercial kitchens and can be powered by either electricity or gas. Fryers are defined as either *standard* or *large vat* on the basis of their dimensions and capacity. Our recommended standard for commercial fryers is based on ENERGY STAR Version 2.0, which was in effect from 2011 until Version 3.0 took effect in October 2016. (ENERGY STAR Version 3.0 updated the specifications for electric fryers only, and data are not yet available on the market share of electric fryers meeting Version 3.0.) A standard electric fryer uses on average about 18,000 kWh per year, or roughly 1.5 times the annual electricity use of an average US household (EPA 2016c; EIA 2017a). According to EPA, commercial fryers meeting the ENERGY STAR specification offer shorter cook times, faster temperature recovery times, and extended oil life (EPA 2015a). Electric and gas fryers meeting ENERGY STAR Version 2.0 consume about 15% and 30% less energy, respectively, than standard models. Commercial fryers that meet the ENERGY STAR specification typically utilize advanced burner and heat exchanger designs, as well as improved insulation to reduce idle energy use. In 2015, 21% of shipments of commercial fryers were ENERGY STAR qualified (EPA 2015c).

[12] See, for example: www.centuryelectricmotor.com/MotorCategory.aspx?LangType=1033&id=6442450977; www.bestbuypoolsupply.com/eco-tech-ez-vs-pool-pump-motors.html.

Commercial Dishwashers: $2.4 billion, 150 TBtus, 140 billion gallons

Commercial dishwashers are used in places such as restaurants, bars, schools, hospitals, and institutional cafeterias. Our recommended standard for commercial dishwashers is based on ENERGY STAR Version 2.0, which has been in effect since 2013. Commercial dishwashers are designed in various configurations and include both "high temp" models, which use hot water to achieve sanitization, and "low temp" models, which use a chemical sanitizing solution. The ENERGY STAR specification includes an idle energy rate requirement, which reduces energy use when a dishwasher is powered on but not actively running, and a water efficiency requirement. ENERGY STAR–qualified dishwashers use about 20–40% less water than standard models. In 2015, 67% of total shipments of commercial dishwashers were ENERGY STAR qualified (EPA 2015c).

Commercial Steam Cookers: $2.0 billion, 120 TBtus, 130 billion gallons

Commercial steam cookers (or compartment steamers) are used in commercial kitchens and can be powered by either electricity or gas. Our recommended standard for commercial steam cookers is based on ENERGY STAR Version 1.2, which has been in effect since 2003. According to EPA, commercial steam cookers meeting the ENERGY STAR specification offer shorter cook times, higher production rates, and reduced heat loss (EPA 2017b). In addition to saving energy, commercial steam cookers meeting the ENERGY STAR specification consume about 90% less water than standard models. A traditional steam cooker uses on average about 175,000 gallons of water per year (EPA 2016c). While traditional steam cooker designs incorporate a separate boiler or steam generator to produce steam and require a continuous stream of water for cooling, almost all ENERGY STAR–qualified steam cookers use "boilerless" or "connectionless" designs, which do not require cooling water (Fisher Nickel, Inc. 2005). In 2015, 53% of total shipments of commercial steam cookers were ENERGY STAR qualified (EPA 2015c).

Portable Air Conditioners: $2.0 billion, 220 TBtus

Portable air conditioners are similar to window air conditioners, except instead of being mounted in a window, they sit on the floor and exhaust hot air through a window using a duct. While window air conditioners have been subject to efficiency standards for more than 25 years, portable air conditioners have never been. DOE estimates that a typical portable air conditioner sold today uses about 900 kWh per year, which is roughly twice what a typical new window air conditioner uses (DOE 2016f). DOE issued a final rule for portable air conditioners in December 2016, which would establish the first efficiency standards for these products. However the final rule has yet to be officially published in the Federal Register, and the status of the rule is uncertain. Our recommended standard for portable air conditioners is equivalent to that in the DOE final rule and would reduce energy consumption by more than 20% relative to the least-efficient products. DOE's testing in support of its rulemaking found that 15% of portable AC models meet the standards in the final rule (DOE 2016f).

Urinals: $1.9 billion, 210 billion gallons

Urinals are subject to national efficiency standards, although the standards have not been updated since 1992. Under a provision in federal law specific to plumbing products, urinals are currently not subject to federal preemption. The national standards require that urinals use no more than 1.0 gallons per flush (gpf). In 2007, EPA finalized a WaterSense specification for urinals, which stipulates a maximum water consumption rate of 0.5 gpf. Colorado has standards that are equivalent to the WaterSense specification, and California has more stringent standards that specify a maximum water use of 0.125 gpf for wall-mounted urinals. Our recommended standard for urinals is equivalent to the California standard of 0.125 gpf, which represents water savings of 88% relative to the national standard. We are recommending that states adopt the California standard rather than the WaterSense specification. Since there is sufficient availability of products that meet the California standard, there is no cost to meet the more stringent California standard, and the California standard achieves 75% greater savings than the WaterSense specification. As of March 2017, 28% of urinal models certified to DOE use 0.125 gpf or less (DOE 2017).

Audio/Video Equipment: $1.7 billion, 170 TBtus

Audio/video equipment includes products such as DVD and Blu-ray players, sound bars, and AV receivers. Our recommended standard for audio/video equipment is based on ENERGY STAR Version 3.0, which has been in effect since 2013. The ENERGY STAR specification applies to products that offer audio amplification and/or optical disc player functions. Audio/video equipment meeting the ENERGY STAR specification are more efficient than standard products in on mode, idle mode, and sleep mode; they also have automatic power-down features that reduce power consumption after a period of inactivity. ENERGY STAR–qualified audio/video equipment uses about 45% less energy than standard equipment. In 2015, 50% of total shipments of audio/video equipment were ENERGY STAR qualified (EPA 2015c).

Uninterruptible Power Supplies: $1.4 billion, 240 TBtus

Uninterruptible power supplies provide backup power in the event of a power failure and are typically used to protect hardware such as computers, data center equipment, and telecommunications equipment. DOE issued a final rule for uninterruptible power supplies in December 2016, which would establish the first national efficiency standards for these products. However the final rule has yet to be officially published in the Federal Register, and the status of the rule is uncertain. Our recommended standards for uninterruptible power supplies are equivalent to those in the DOE final rule and would reduce energy consumption for the most common types of uninterruptible power supplies by 40–50%. DOE estimates that 51% of shipments of uninterruptible power supplies meet the standards in the final rule (DOE 2016g).

Telephones: $0.9 billion, 100 TBtus

Telephones include both traditional analog phones and newer Voice over Internet Protocol (VoIP) phones. Our recommended standard for telephones is based on ENERGY STAR Version 3.0, which has been in effect since 2014. (Cell phones are not included.) Telephones meeting the ENERGY STAR specification consume less power in sleep mode than conventional models and also have automatic power-down features that reduce power consumption after a period of inactivity. Telephones meeting the ENERGY STAR specification use about 40% less energy than standard models. In 2015, 19% of total shipments of telephones were ENERGY STAR qualified (EPA 2015c).

Water Coolers: $0.8 billion, 100 TBtus

Water coolers are used to store and dispense drinking water. They include models that provide cold water only, as well as models that can provide both hot and cold water. Seven states (California, Connecticut, Maryland, New Hampshire, Oregon, Rhode Island, and Washington) and the District of Columbia currently have standards for hot and cold water coolers. Our recommended standard for water coolers is based on ENERGY STAR Version 2.0, which has been in effect since 2014 and applies to both cold only and hot and cold water coolers. Water coolers meeting the ENERGY STAR specification use about 30% less energy than standard models. In 2015, 62% of total shipments of water coolers were ENERGY STAR qualified (EPA 2015c).

Ventilation Fans: $0.8 billion, 70 TBtus

Ventilation fans include bathroom exhaust fans, utility room fans, and range hoods. Our recommended standard for ventilation fans is based on ENERGY STAR Version 3.2, which was in effect from 2012 until Version 4.0 took effect in 2015. (We are not recommending the adoption of ENERGY STAR Version 4.0 since no current data are available on the market penetration of qualifying products.) The efficiency specifications for ventilation fans in ENERGY STAR Version 3.2 are equivalent to those in the 2015 International Energy Conservation Code (IECC). According to EPA, ventilation fans meeting the ENERGY STAR specification are not only more efficient than standard models but are also quieter and last longer (EPA 2017f). Ventilation fans meeting ENERGY STAR Version 3.2 on average consume about 60% less energy than standard fans by using more-efficient motors and improved blade designs. As of 2014, about 37% of total shipments of ventilation fans met ENERGY STAR Version 3.2 (EPA 2014).

Portable Electric Spas: $0.7 billion, 60 TBtus

Portable electric spas are free-standing hot tubs that are electrically heated. More than five million US households have hot tubs (APSP 2016b). Typical portable electric spas waste a significant amount of energy through heat loss when the spa is not being used. California adopted the first standards for portable electric spas in 2004, and Arizona, Connecticut, Oregon, and Washington subsequently adopted their own. In 2014 the American National Standards Institute (ANSI) approved a new voluntary industry standard for portable electric spa efficiency (ANSI/APSP/ICC 14-2014), which was developed by the Association of Pool and Spa Professionals (APSP) and other stakeholders. The ANSI standard sets a more stringent limit on allowable standby energy consumption than the existing state standards. Our recommended standard is equivalent to the ANSI standard and would reduce energy use by about 20%. In 2014, 71% of all portable electric spas certified to the CEC met the ANSI standard (Worth and Fernstrom 2014).

Hot Food Holding Cabinets: $0.3 billion, 50 TBtus

Commercial hot food holding cabinets are used in places like restaurants, hospitals, and schools to keep food warm until it is ready to be served. Our recommended standard for hot food holding cabinets is based on ENERGY STAR Version 1.0, which was in effect from 2003 until Version 2.0 took effect in 2011, and is equivalent to existing standards in California, Connecticut, Maryland, New Hampshire, Rhode Island, Washington, and the District of Columbia. (We are not recommending the adoption of ENERGY STAR Version 2.0 since the market share of qualifying products was still low as of 2015.) Our recommended standard would reduce the idle energy rate of hot food holding cabinets, which is the power consumed when the product is maintaining the control set point. ENERGY STAR–qualified hot food holding cabinets use improved insulation to reduce heat loss. According to EPA, improved insulation also provides better temperature uniformity within the cabinet and keeps the external surface of the cabinet cooler (EPA 2017a). In 2011, 62% of total shipments of hot food holding cabinets met ENERGY STAR Version 1.0 (EPA 2012a).[13]

Compressors: $0.2 billion, 50 TBtus

Air compressors are used in commercial applications and industrial facilities to provide compressed air for a wide variety of processes such as the operation of pneumatic tools, pneumatic controls, and automated equipment. DOE estimates that a typical air compressor used in an industrial facility can consume as much as 280,000 kWh per year, equivalent to the annual electricity use of more than 20 US households (DOE 2016e; EIA 2017a). DOE issued a final rule for air compressors in December 2016, which would establish the first efficiency standards for this equipment. However the final rule has yet to be officially published in the Federal Register, and the status of the rule is uncertain. Our recommended standards for air compressors are equivalent to those in the DOE final rule. The standards would apply to rotary positive, lubricated air compressors, which are used almost exclusively in industrial facilities. Our recommended standards would reduce air compressor energy consumption by about 3%. DOE estimates that 72% of shipments of compressors already meet the efficiency levels in the final rule (DOE 2016e).

Savings Potential

METHODOLOGY

To estimate state-by-state potential savings from adoption of the recommended state standards, we first estimated potential national savings and costs. The costs reflect any

[13] Data from 2011 are the most recent data available.

additional cost of products meeting the recommended standard levels relative to less-efficient products. We estimated potential savings through 2035 and assumed a compliance date of 2020 for almost all of the recommended standards.[14] Our general methodology was based on sales of the affected products. We used estimates of annual product sales in 2020, average product lifetimes, per-unit energy and/or water savings, per-unit incremental costs, and the portion of sales already meeting the recommended standard levels. To simplify the analysis, we generally assumed that both annual product sales and the portion of sales that already meet the recommended standard levels remain constant over time.[15] In reality, both annual product sales and base case efficiency tend to increase over time. Thus, we implicitly assumed that these two factors cancel each other out.

We then calculated state-by-state energy and water savings and costs by allocating national product sales to each state and, where appropriate, making state-by-state adjustments to per-unit savings. (More detail is provided in Appendix B.) We assumed that the portion of product sales already meeting the standard level for each product is the same in all states due to a lack of data on state-level base case efficiency. For products used in multiple sectors (e.g., computers and monitors, which are used in both the residential and commercial sectors), we first allocated total product sales to the various sectors. We then allocated sales in each sector to each of the states.

We calculated NOx, SO_2, and CO_2 emissions reductions from electricity savings using state-by-state projected average power plant emissions rates through 2035. We calculated NOx and CO_2 emissions reductions from natural gas savings using emissions rates from natural gas combustion. We did not attempt to estimate $PM_{2.5}$ emissions reductions for this analysis. We calculated energy and water bill savings using projected state-by-state electricity and natural gas prices for the residential, commercial, and industrial sectors through 2035 and regional water and wastewater prices.

We calculated net present value savings as the difference between the present value of the total energy and water bill savings from products sold between 2020 and 2035 and the present value of the total estimated product price increases. We discounted future costs and savings to 2017 using a real discount rate of 5%. We calculated benefit–cost ratio as the present value of savings divided by the present value of costs. Finally, we calculated simple payback period as the additional cost of the more-efficient product divided by the first-year utility bill savings.

In calculating energy savings from standards for water-using products, we included only the direct energy savings from reduced hot water use (for those standards that save hot water). There is also significant embedded energy in water due to pumping and treatment. Energy embedded in water is equal to about 138 billion kWh annually, or roughly 3.5% of

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[14] The exceptions are the second tier of standards for desktop computers and the standards for pool pump replacement motors. For these we assumed a compliance date of 2021 to align with the compliance dates of the California tier 2 standards for desktops and the national standards for pool pumps.

[15] The exceptions are high CRI fluorescent lamps and pool pump replacement motors. See Appendix B for more detail on our estimates of shipments over time for these two products.

current total US annual electricity consumption (Griffiths-Sattenspiel and Wilson 2009; EIA 2017f). We did not attempt to estimate those additional energy savings for this analysis.

Appendix B contains details of our methodology and assumptions for each product, and Appendix C contains the sources for our product-specific assumptions.

ENERGY AND WATER SAVINGS AND EMISSIONS REDUCTIONS

New state-level appliance standards have the potential to provide significant energy and water savings and air pollutant emissions reductions. Figure 5 shows potential national annual primary energy savings and water savings from the recommended standards (if enough states adopted the standards to cause only compliant products to be sold nationally). Primary energy accounts for the losses in generation, transmission, and distribution associated with electricity consumption and allows for an equitable comparison between electricity and natural gas savings. (One unit of electricity consumed at a home or business translates to about three units of energy consumed at the power plant.) Figure 5 also shows the contributions of electricity and natural gas savings to total potential primary energy savings.

Annual savings would increase over time as less-efficient products in homes and businesses are replaced at the end of their useful lives by more-efficient products meeting the new standards. Potential annual primary energy savings in 2035 equal 545 trillion Btus, or about 1.5% of current total residential and commercial annual energy use (EIA 2017a). Electricity savings make up more than 70% of the total primary energy savings in 2035. Potential annual electricity savings reach 41 billion kWh in 2035, or about 1.5% of current total residential and commercial annual electricity use (EIA 2017f). Annual natural gas savings reach 155 trillion Btus in 2035, or about 2% of current total residential and commercial annual natural gas use (EIA 2017a). Potential annual water savings reach about 630 billion gallons in 2035, or about 6% of current annual residential water usage (Maupin et al. 2014).

Potential annual water savings reach about 630 billion gallons in 2035, or about 6% of current annual residential water usage.

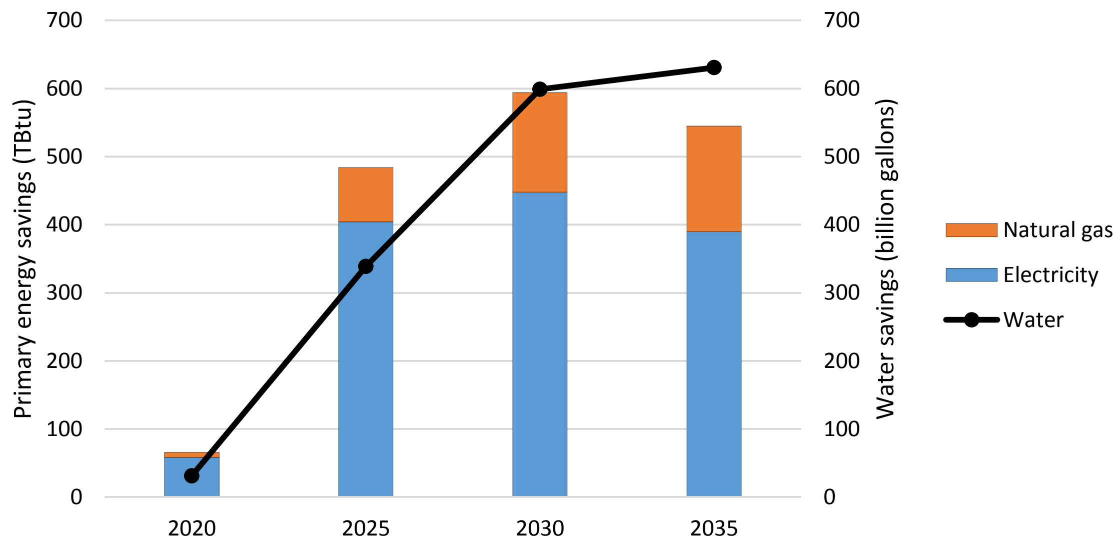


Figure 5. Potential national annual primary energy savings and water savings from the recommended standards

As can be seen in figure 5, potential annual energy savings increase rapidly from 2020 to 2025 and reach their peak in 2030. Savings increase rapidly in the early years of potential standards taking effect because two of the products with the greatest potential primary energy savings—high CRI fluorescent lamps and computers and monitors—have average lifetimes of just four to seven years.[16] Therefore standards for high CRI fluorescent lamps and computers and monitors would increase the efficiency of almost all of those products in use in a relatively short period. Potential annual primary energy savings decrease slightly between 2030 and 2035 because we take into account projected future declines in sales of linear fluorescent lamps as sales of LEDs are projected to increase. (As shown in table 2 and figure 6, below, standards for high CRI fluorescent lamps still represent the second-largest opportunity for cumulative primary energy savings.) We also assume that the standards for pool pump replacement motors would affect just seven years of product sales, beginning in 2021. (More detail on these assumptions is provided in Appendix B.)

Potential annual water savings increase more slowly from 2020 to 2025 and reach their peak in 2035. The seven water-using products all have average lifetimes of at least 10 years, which means that it would take at least 10 years until the majority of the existing products in use will have been replaced with more-efficient products meeting the new standards.[17]

Potential savings can also be reported on a cumulative basis. Table 2 shows potential national cumulative electricity, natural gas, primary energy, and water savings through 2035 along with potential cumulative emissions reductions for each of the 21 recommended standards. The products are listed in order of potential net present value savings. (Net present value savings are shown in table 4.) Potential national cumulative electricity savings

[16] We refer here to high CRI fluorescent lamps used in the commercial sector, which represent the vast majority of the potential savings.

[17] The exception is public (i.e., commercial) faucets, which have an average lifetime of three years.

through 2035 for the package of recommended standards are about 590 billion kilowatt-hours (kWh). For comparison, that is enough electricity to power almost 50 million US households for one year (EIA 2017a). Potential national cumulative natural gas savings through 2035 are about 1,600 trillion Btus, which is enough to meet the space heating needs of half of all US homes heated with natural gas for one year. Potential cumulative water savings through 2035 from the seven recommended standards for water-using products are about 6.8 trillion gallons, or enough to meet the needs of every US household for eight months.

The energy savings from the recommended standards would yield air pollutant emissions reductions including reductions of NOx, SO_2, and CO_2. As shown in table 2, potential national cumulative NOx and SO_2 emissions reductions are about 210,000 tons and 160,000 tons, respectively.[18] Total potential cumulative CO_2 emissions reductions through 2035 are about 320 million metric tons (MMT). (Annual potential NOx and SO_2 emissions reductions reach about 15,000 and 10,000 tons, respectively, in 2035, or 1% and 0.5% of 2015 emissions from all US coal plants (EPA 2016b). Annual potential CO_2 reductions reach 23 MMT in 2035, which is equivalent to the annual CO_2 emissions of about seven average coal-fired power plants (EPA 2016a). Annual savings and emissions reductions are provided in tables A1 and A2 in Appendix A.)

Annual potential CO_2 reductions reach 23 MMT in 2035, which is equivalent to the annual CO_2 emissions of about seven average coal-fired power plants.

Table 2. Potential national cumulative electricity, natural gas, primary energy, and water savings and emissions reductions through 2035 for each of the recommended standards, listed in order of potential net present value savings

	Potential cumulative savings through 2035				Potential cumulative emissions reductions through 2035		
Product	Electricity (billion kWh)	Natural gas (TBtu)	Primary energy (TBtu)	Water (billion gallons)	NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)
Faucets	81	619	1,397	2,442	46.5	19.4	65.4
Showerheads	58	427	983	1,169	32.6	13.9	46.0
Lawn spray sprinklers	--	--	--	1,977	--	--	--
Toilets	--	--	--	697	--	--	--
Computers and monitors	127	--	1,257	--	28.3	33.6	49.4
High CRI fluorescent lamps	130	--	1,290	--	29.9	37.5	54.7
Air purifiers	41	--	401	--	9.1	11.0	15.6

[18] Most of the NOx emissions reductions and all of the SO_2 emissions reductions come from electricity savings; lowered electricity demand can reduce emissions as a result of less burning of fossil fuels in power plants. SO_2 emissions are subject to nationwide and regional emissions caps, and there is a cap on NOx emissions in eastern states. SO_2 emissions in future years are expected to be well below the caps, which means that reductions in electricity demand will most likely translate into absolute reductions in SO_2 emissions (if the caps are not tightened). However, for NOx, reductions in electricity demand could allow for offsetting increases in NOx emissions (DOE 2016f).

Product	Potential cumulative savings through 2035				Potential cumulative emissions reductions through 2035		
	Electricity (billion kWh)	Natural gas (TBtu)	Primary energy (TBtu)	Water (billion gallons)	NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)
Pool pump replacement motors	32	--	320	--	6.9	7.9	12.2
Commercial fryers	1	453	463	--	20.9	0.3	24.5
Commercial dishwashers	4	103	146	143	5.6	1.1	7.2
Commercial steam cookers	8	40	116	129	3.5	2.0	5.1
Portable air conditioners	22	--	218	--	4.7	6.1	7.9
Urinals	--	--	--	210	--	--	--
Audio/video equipment	17	--	167	--	3.8	4.7	6.5
Uninterruptible power supplies	24	--	241	--	5.4	6.3	9.5
Telephones	10	--	102	--	2.3	2.8	4.2
Water coolers	10	--	96	--	2.2	2.5	4.0
Ventilation fans	7	--	69	--	1.6	1.9	2.7
Portable electric spas	6	--	61	--	1.5	1.8	2.3
Hot food holding cabinets	5	--	50	--	1.1	1.3	2.0
Compressors	5	--	52	--	1.2	1.6	2.3
Total	**588**	**1,643**	**7,425**	**6,769**	**207**	**156**	**321**

Totals may not sum due to rounding. Energy savings estimates do not account for the energy savings associated with reduced water consumption due to the energy embedded in water.

State-by-state savings estimates for each of the 21 recommended standards are available online at https://appliance-standards.org/state-savings-state-standards.

Figure 6 shows the breakdown of potential national cumulative primary energy savings by product. Total potential cumulative primary energy savings through 2035 are about 7,400 trillion Btus. Those savings are enough to meet the energy needs of all US homes and businesses for two months. The recommended standards for faucets, high CRI fluorescent lamps, and computers and monitors together represent more than half of the total potential cumulative primary energy savings, while the standards for showerheads represent another 13% of the total potential savings. (Standards for faucets and showerheads provide significant energy savings in addition to water savings by reducing the amount of hot water used.) Other standards with the greatest potential primary energy savings include those for commercial fryers, air purifiers, pool pump replacement motors, uninterruptible power supplies, and portable air conditioners, which together represent 22% of the total potential primary energy savings.

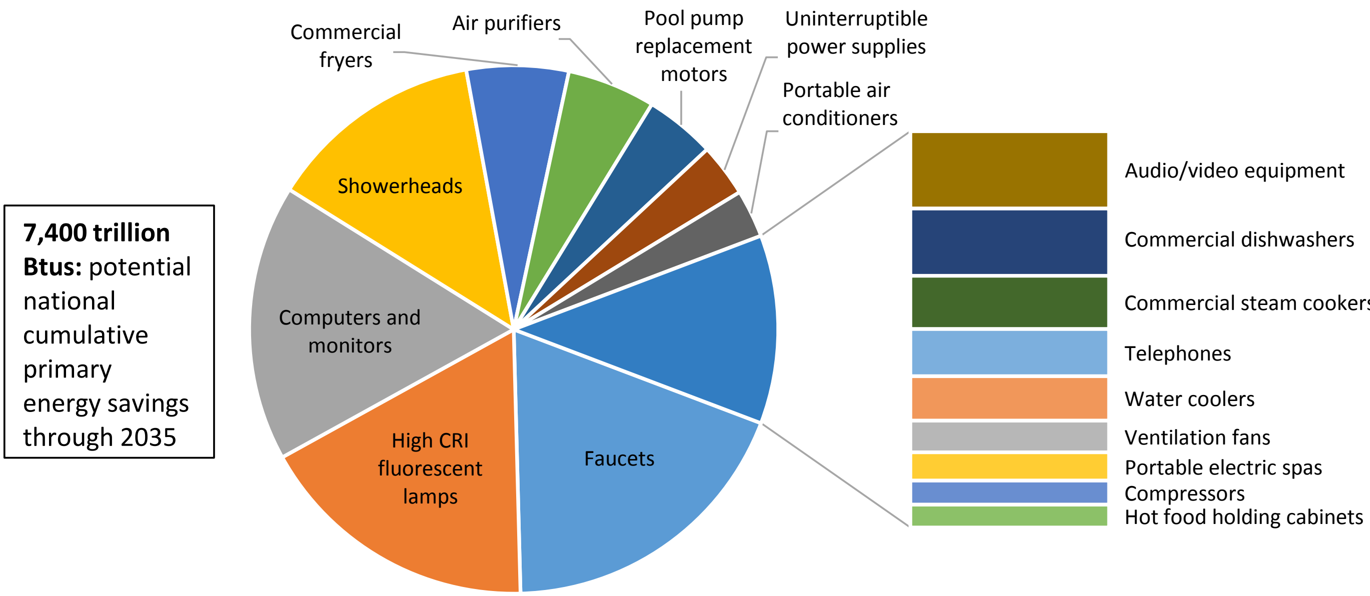


Figure 6. Potential national cumulative primary savings through 2035 by product

Figure 7 shows the breakdown of potential national cumulative water savings through 2035 by product. Faucets represent more than one-third of the total potential cumulative water savings, while lawn spray sprinklers and showerheads represent 29% and 17% of total potential cumulative water savings, respectively. Standards for toilets also offer large potential water savings, while standards for urinals, commercial dishwashers, and commercial steam cookers offer smaller but still significant water savings.

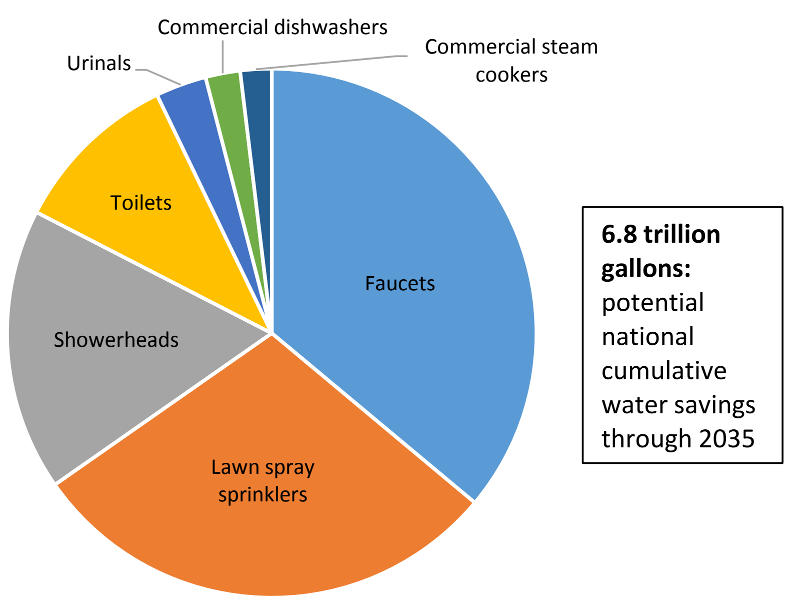


Figure 7. Potential national cumulative water savings through 2035 by product

The recommended standards would provide benefits for each of the 50 states and the District of Columbia. Table 3 shows potential cumulative electricity, natural gas, primary energy, and water savings and emissions reductions through 2035 for each state for the package of recommended standards. (Some states have already adopted one or more of the recommended standards. These states are already realizing some of the savings shown in table 3.) Potential energy savings vary by state mostly on the basis of population, with more populous states having greater savings potential. Water savings potential is driven by population as well as by residential outdoor water use since standards for lawn spray sprinklers provide the second-largest potential water savings. Potential emissions reductions are driven by both potential energy savings and regional variations in power plant emissions.

Table 3. Potential state-by-state cumulative electricity, natural gas, primary energy, and water savings and emissions reductions through 2035 for the package of recommended standards

	Potential cumulative savings through 2035				Potential cumulative emissions reductions through 2035		
State	Electricity (billion kWh)	Natural gas (TBtu)	Primary energy (TBtu)	Water (billion gallons)	NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)
Alabama	10	18	116	91	1.5	0.6	5.1
Alaska	1	5	16	16	2.2	0.3	0.6
Arizona	13	30	176	222	6.8	1.5	6.3
Arkansas	6	13	66	72	2.0	0.7	3.0
California	53	264	787	979	17.4	1.2	21.6
Colorado	7	35	111	139	6.9	0.8	6.2
Connecticut	6	21	79	66	2.2	0.4	2.3
Delaware	2	4	20	18	0.5	0.6	0.9
District of Columbia	2	3	22	18	0.5	0.7	1.0
Florida	49	51	474	422	17.9	4.0	24.5
Georgia	19	46	213	195	3.3	1.2	10.4
Hawaii	2	4	27	46	3.7	4.6	1.3
Idaho	2	9	36	61	1.2	0.2	1.1
Illinois	20	85	271	251	8.5	15.9	16.9
Indiana	12	35	141	123	3.8	7.5	8.3
Iowa	5	17	78	51	3.2	1.1	3.2
Kansas	5	18	75	53	2.1	0.5	3.5
Kentucky	9	17	104	74	2.2	3.4	5.5
Louisiana	10	21	112	112	3.4	1.1	5.2
Maine	2	8	29	20	0.8	0.2	0.8
Maryland	13	24	133	143	3.2	4.0	6.0
Massachusetts	12	42	149	111	4.2	0.8	4.4
Michigan	16	62	208	190	6.6	16.3	12.4
Minnesota	9	30	140	87	5.8	1.9	5.7

State	Potential cumulative savings through 2035				Potential cumulative emissions reductions through 2035		
	Electricity (billion kWh)	Natural gas (TBtu)	Primary energy (TBtu)	Water (billion gallons)	NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)
Mississippi	6	11	70	69	1.5	1.0	3.2
Missouri	11	30	168	127	4.7	8.9	9.1
Montana	2	6	24	25	0.8	0.1	0.7
Nebraska	3	12	48	42	2.0	0.6	2.0
Nevada	4	18	59	87	2.2	0.4	2.1
New Hampshire	2	8	29	23	0.8	0.2	0.8
New Jersey	16	60	250	175	5.5	5.3	9.4
New Mexico	3	13	46	45	1.8	0.3	1.8
New York	36	128	539	382	12.9	5.0	17.1
North Carolina	22	31	222	175	3.7	2.2	9.2
North Dakota	2	4	25	14	1.0	0.4	1.0
Ohio	21	61	257	192	6.9	13.8	15.2
Oklahoma	8	17	93	79	3.7	1.8	4.5
Oregon	9	15	102	104	3.4	0.8	2.9
Pennsylvania	25	65	358	196	7.4	10.4	14.3
Rhode Island	2	6	23	19	0.6	0.1	0.7
South Carolina	11	15	106	113	1.8	1.1	4.4
South Dakota	2	5	24	19	1.0	0.3	1.0
Tennessee	14	22	159	128	3.3	5.4	8.5
Texas	50	132	605	596	14.1	7.1	29.8
Utah	4	17	62	110	2.0	0.3	1.9
Vermont	1	4	14	10	0.4	0.1	0.4
Virginia	18	34	193	154	3.5	1.9	8.1
Washington	16	27	182	183	6.0	1.3	5.2
West Virginia	4	7	41	36	1.1	2.5	2.5
Wisconsin	10	32	126	86	4.4	14.8	9.0
Wyoming	1	3	16	19	0.7	0.1	0.6
United States	**588**	**1,643**	**7,425**	**6,769**	**207**	**156**	**321**

Energy savings estimates do not account for the energy savings associated with reduced water consumption due to the energy embedded in water.

Tables A4 and A5 in Appendix A show potential annual electricity, natural gas, primary energy, and water savings and emissions reductions in 2025 and 2035 for each of the 50 states and the District of Columbia.

ECONOMIC SAVINGS

The potential energy and water savings from the recommended standards would translate into large energy and water bill savings for consumers and businesses. Figure 8 shows potential national annual utility bill savings from the package of recommended state standards. Potential annual utility bill savings in 2035 are almost $16 billion. Water and wastewater bill savings represent half of the total potential utility bill savings in 2035.

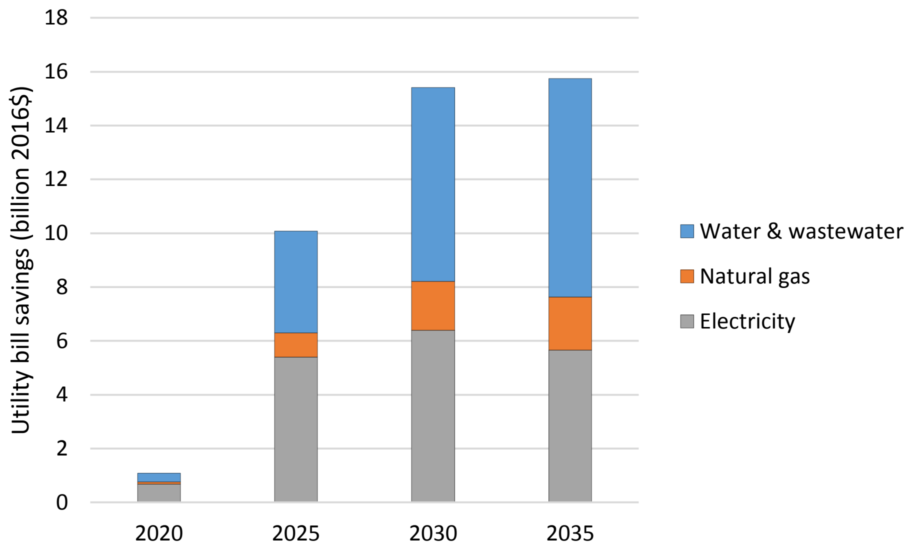


Figure 8. Potential national annual utility bill savings from the recommended standards

New state standards = $5,000 in annual savings for restaurants

Restaurants use about 2.5 times more energy per square foot than other commercial buildings (EPA 2010). Restaurants are already saving money on their electricity, gas, and water bills from efficiency standards for equipment such as commercial refrigerators and freezers, walk-in coolers, pre-rinse spray valves, and lighting products. And restaurants would save more with the recommended new state standards. For example, a restaurant owner with four types of food service equipment (commercial dishwasher, gas fryer, electric steam cooker, and hot food holding cabinet) would, on average, save about $5,000 per year on his electricity, gas, and water bills by using equipment that met the recommended standards rather than appliances with the basic efficiency levels found on the market today:

- Commercial dishwasher: $1,200 annual savings
- Gas fryer: $475 annual savings
- Electric steam cooker: $3,200 annual savings
- Hot food holding cabinet: $230 annual savings

The payback periods for these standards are less than 4 years, while on average the equipment lasts for at least 12 years.

Note: Savings are based on a high-temperature, stationary, single-door dishwasher; a standard-size gas fryer; a five-pan electric steam cooker; and a 22-cubic-foot hot food holding cabinet.

All of the recommended standards are cost effective for the consumers and businesses that purchase these products in every state. Table 4 shows the economics of the recommended state standards, including potential national net present value savings, benefit–cost ratio, and simple payback period, for each of the 21 products. The total potential national net present value savings, which take into account both utility bill savings and estimated impacts on product costs for products sold between 2020 and 2035, are $113 billion. For nine of the products there is no cost associated with the recommended standard level (i.e., available data show that products meeting the recommended standard level do not cost more than lower-efficiency products). For these products no benefit–cost ratio is listed and the payback period is 0 years (i.e., payback is immediate). The benefit–cost ratios for products for which more-efficient models do cost more range from 2.0 for high CRI fluorescent lamps to 11.6 for commercial steam cookers. The total benefit–cost ratio for the package of 21 standards is 7.7, which means that the total utility bill savings outweigh the total costs by more than a factor of 7. None of the recommended standards has a payback period of more than four years. The median payback period for all products is less than one year (0.9 years), which means the additional cost of more-efficient products is recovered very quickly.

Table 4. Economics of recommended standards listed in order of potential net present value savings

Product	Net present value savings (billion 2016$)	Benefit–cost ratio	Payback period (years)
Faucets	34.5	No cost	0.0
Showerheads	19.6	No cost	0.0
Lawn spray sprinklers	14.5	8.0	1.1
Toilets	9.3	No cost	0.0
Computers and monitors	6.9	2.6	2.0
High CRI fluorescent lamps	5.2	2.0	2.5
Air purifiers	2.9	3.0	2.7
Pool pump replacement motors	2.8	9.2	0.7
Commercial fryers	2.5	2.8	3.7
Commercial dishwashers	2.4	10.3	1.1
Commercial steam cookers	2.0	11.6	0.9
Portable air conditioners	2.0	4.1	2.3
Urinals	1.9	No cost	0.0
Audio/video equipment	1.7	No cost	0.0
Uninterruptible power supplies	1.4	3.1	1.9
Telephones	0.9	No cost	0.0
Water coolers	0.8	No cost	0.0
Ventilation fans	0.8	No cost	0.0
Portable electric spas	0.7	No cost	0.0
Hot food holding cabinets	0.3	3.9	2.5
Compressors	0.2	3.4	3.1
Total	**113**	**7.7**	–

Total net present value savings may not sum due to rounding. The total benefit–cost ratio is calculated as the present value of the total utility bill savings from products sold through 2035 for the package of 21 recommended standards divided by the present value of the total additional costs.

Table A3 in Appendix A shows potential national annual utility bill savings in 2025 and 2035.

Table 5 shows the economics of the recommended state standards for each of the 50 states and the District of Columbia, including potential average annual per-household utility bill savings. Potential net present value savings range from $198 million in North Dakota to $16 billion in California. (California has already adopted six of the recommended standards and is therefore already realizing a significant portion of these potential savings.) By state, the benefit–cost ratio for the package of recommended standards ranges from 4.9 to 13.7. States with relatively high energy prices or high outdoor water use generally have higher benefit–cost ratios, but even in states with low energy prices, benefit–cost ratios are very favorable. In all states the potential utility bill savings outweigh the additional costs by a factor of more than 4.

In 2035 potential average annual per-household utility bill savings increase to a range of $72 to $215.

Potential average annual per-household energy and water bill savings in 2025 from products used in homes range from $39 in Iowa, Minnesota, and North Dakota to $119 in Hawaii, with a US average of $59. In 2035 potential average annual per-household utility bill savings increase to a range of $72 to $215, with a US average of $106. Since one of the standards with the largest potential bill savings is for lawn spray sprinklers, states with the highest potential per-household utility bill savings tend to be those with the greatest per-household outdoor water use. These states include Arizona, California, Hawaii, Idaho, Nevada, and Utah. States with relatively high energy prices—such as New York, New Jersey, and the New England states—also have higher-than-average annual per-household savings. But the recommended standards would provide significant household savings in all states.

Table 5. State-by-state economics for the package of recommended standards

State	Net present value savings (million 2016$)	Total benefit–cost ratio	Average annual per-household utility bill savings (2016$) 2025	2035
Alabama	1,659	8.3	54	97
Alaska	297	8.8	63	117
Arizona	2,936	8.2	84	144
Arkansas	1,040	7.6	58	108
California	16,103	8.9	75	133
Colorado	1,688	7.4	53	102
Connecticut	1,406	8.8	62	112
Delaware	345	8.3	60	111
District of Columbia	338	6.0	66	121
Florida	7,767	8.2	68	114

State	Net present value savings (million 2016$)	Total benefit–cost ratio	Average annual per-household utility bill savings (2016$)	
			2025	2035
Georgia	3,317	7.6	56	101
Hawaii	958	13.7	119	215
Idaho	644	7.5	75	143
Illinois	3,801	6.8	51	88
Indiana	2,027	7.3	49	89
Iowa	768	6.7	39	72
Kansas	809	6.6	43	80
Kentucky	1,218	7.3	44	79
Louisiana	1,627	6.9	57	108
Maine	450	8.5	48	89
Maryland	2,471	8.2	69	128
Massachusetts	2,495	8.3	56	101
Michigan	2,974	6.9	48	88
Minnesota	1,377	6.7	39	73
Mississippi	1,060	8.0	61	110
Missouri	1,885	7.0	50	90
Montana	331	7.1	51	97
Nebraska	528	6.3	45	86
Nevada	1,069	8.3	70	130
New Hampshire	509	8.9	58	105
New Jersey	3,306	7.2	62	102
New Mexico	629	7.6	52	96
New York	9,217	9.1	79	128
North Carolina	3,231	7.6	52	95
North Dakota	198	4.9	39	74
Ohio	3,567	7.3	47	84
Oklahoma	1,188	6.6	51	95
Oregon	1,466	6.9	59	115
Pennsylvania	4,193	7.6	52	90
Rhode Island	407	8.8	58	106
South Carolina	1,893	8.2	65	118
South Dakota	243	6.1	46	87
Tennessee	1,975	7.2	48	88

State	Net present value savings (million 2016$)	Total benefit–cost ratio	Average annual per-household utility bill savings (2016$)	
			2025	2035
Texas	8,729	7.1	58	106
Utah	1,190	7.8	88	170
Vermont	218	8.4	51	93
Virginia	2,713	6.9	54	97
Washington	2,438	6.5	56	110
West Virginia	601	7.4	50	92
Wisconsin	1,851	7.8	47	83
Wyoming	222	6.4	63	120
United States	**113,374**	**7.7**	**59**	**106**

The total benefit–cost ratio for each state is calculated as the present value of the total utility bill savings from products sold through 2035 for the package of 21 recommended standards divided by the present value of the total additional costs. Per-household utility bill savings are based on savings from the standards for products used in homes.

Table A6 in Appendix A shows potential total annual utility bill savings in 2025 and 2035 for each of the 50 states and the District of Columbia.

In summary, new state standards have the potential to provide large energy and water savings and emissions reductions. The recommended standards would provide significant economic savings for consumers and businesses, and the potential utility bill savings significantly outweigh the additional cost of more-efficient products in all states.

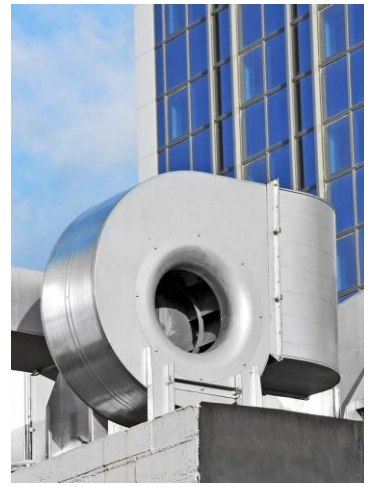
Products for Future Consideration

In addition to the 21 recommended standards, there are other products that will likely be good candidates for state appliance standards in the future. These are products for which additional work may be needed on test procedures and/or recommended efficiency specifications, but for which efficiency standards offer the potential for significant energy or water savings. While not an exhaustive list, the section below describes potential opportunities for state standards for seven additional products. These include various types of electronic equipment as well as commercial clothes dryers, commercial and industrial fans, landscape irrigation controllers, and LED tube lamps and luminaires.

COMMERCIAL CLOTHES DRYERS

Commercial clothes dryers are used in apartment buildings, laundromats, hotels, institutional facilities, and other commercial buildings where clothes and/or other textiles are washed. While there are national efficiency standards for commercial clothes washers, there are no standards for commercial clothes dryers. CEC opened a new docket in January 2017 for a rulemaking for commercial clothes dryers in California (CEC 2017c). The California investor-owned utilities (IOUs) estimate that the largest electric commercial clothes dryers each consume about 370,000 kWh per year, which is equivalent to the annual electricity use of about 30 US households (Porter and Denkenberger 2016; EIA 2017a). They further found that technologies such as heat exchangers, heater and fan modulation, and heat pump technology could reduce commercial clothes dryer energy consumption by 20–50%.

COMMERCIAL AND INDUSTRIAL FANS



Commercial and industrial fans are used in a wide variety of applications such as commercial building HVAC systems, commercial kitchen exhaust systems, materials handling, and agricultural ventilation. Ventilation in commercial buildings accounts for about 15% of total commercial building electricity consumption (EIA 2015). Fans are available with a wide range of efficiencies, and some models on the market have very efficient designs. However the actual efficiency of a fan in the field depends enormously on the specific application (i.e., flow and pressure), and a very efficient fan can perform very inefficiently if not properly applied. Therefore improved fan selection represents a huge opportunity for energy savings. DOE initiated a rulemaking for commercial and industrial fans in 2011. In 2015, a working group composed of representatives of fan, motor, and HVAC manufacturers; efficiency advocates; utilities; and DOE negotiated a number of items related to the scope of coverage, an efficiency metric, and test procedures for fans. The efficiency metric developed by the working group would drive both more-efficient fan designs and improved fan selection. However DOE has not yet published a proposed rule for standards, and the status of the rulemaking is uncertain. CEC opened a new docket in April 2017 to begin considering efficiency standards for commercial and industrial fans (CEC 2017d).

IMAGING EQUIPMENT

Imaging equipment includes copiers, printers, scanners, fax machines, and multifunction devices used both in homes and in businesses. Multifunction (or "all-in-one") devices combine copy and print functionality (and often scan and fax as well) and are becoming the dominant type of imaging equipment. More than 22 million multifunction devices and printers are sold annually in the United States (EPA 2015c). The first ENERGY STAR specification covering all types of imaging equipment took effect in 2007, and the current specification (Version 2.0) replaced it in 2014. In 2015 ENERGY STAR reported a 100% market penetration of ENERGY STAR–qualified multifunction devices and printers (EPA 2015c). However significant additional efficiency improvements are likely achievable. Lawrence Berkeley National Laboratory (LBNL) estimates that the energy consumption of office equipment utilizing laser printing technology could be reduced by 30% through the use of advanced toners that can work at lower temperatures (Desroches and Garbesi 2011).

LANDSCAPE IRRIGATION CONTROLLERS

Landscape irrigation controllers are used in homes that have an automatic lawn irrigation system. Conventional irrigation controllers use simple timers to turn the system on and off according to a preset schedule programmed by the user. These controllers can result in a significant amount of wasted water since the watering schedule is typically not adjusted to account for changing weather or plant watering needs. There is a WaterSense specification for irrigation controllers (Version 1.0) that has been in effect since 2011. Irrigation controllers meeting the WaterSense specification use local weather and landscape conditions to provide a watering schedule that better matches plants' needs.

Irrigation controllers may also use other types of controls to reduce wasted water from landscape irrigation. Rain shut-off devices turn off the irrigation system during rain events when irrigation is unnecessary; soil moisture sensors enable bypassing of scheduled irrigation cycles when soil moisture exceeds a user-defined threshold. LBNL found that weather-based controllers, rain shut-off devices, and soil moisture sensors reduce landscape irrigation water use on average by 15%, 21%, and 38%, respectively (Williams et al. 2014). While there are existing test procedures for weather-based controllers and rain shut-off devices, there is no test procedure for soil moisture sensors, and this is necessary in order to develop a technology-neutral standard. The development of a test procedure for soil moisture sensors would allow states to establish standards requiring that landscape irrigation controllers either meet the WaterSense specification for weather-based controllers or contain a rain shut-off device or soil moisture sensor. CEC opened a new docket in April 2017 to begin considering efficiency standards for landscape irrigation controllers (CEC 2017d).

LED TUBE LAMPS AND LUMINAIRES

Linear fluorescent lamps are long tube lamps commonly used in places such as offices, retail stores, and warehouses. In recent years linear LED lamps have started to replace fluorescent lamps. LED replacement options include both LED tube lamps that can be used in existing fixtures and integrated LED luminaires, where the lamp and fixture are part of a single package. DOE projects that by 2025 LEDs will make up almost half the stock of linear fixtures (Penning et al. 2016). LEDs have the potential to significantly reduce the energy consumption of linear fixtures. However there is significant variation in the efficiencies of current LED tube lamps and integrated LED luminaires. Standards for LED tube lamps and luminaires would ensure that customers are getting high-efficiency products when making the decision to install an LED product. In 2016, Australia issued draft standards for LED tube lamps and luminaires (Commonwealth of Australia 2016).

SERVERS AND DATA STORAGE EQUIPMENT

Computer servers and data storage equipment provide services and manage networked resources for client devices such as computers, wireless gear, and other network apparatus. LBNL estimates that in 2014 data centers accounted for 1.8% of total US electricity consumption and that servers were responsible for almost half of all data center energy use

(Shehabi et al. 2016). NRDC found that about half of the total energy used to power servers in the United States is wasted doing no useful work (NRDC 2012). The first ENERGY STAR specification for servers took effect in 2009, and the current specification (Version 2.0) has been in effect since December 2013. The ENERGY STAR specification includes a number of requirements such as maximum idle power levels, power supply efficiency, and power management requirements. However the specification is now outdated. EPA initiated a revision to the server specification in 2016 and has indicated that it will consider additional opportunities for efficiency gains such as active state efficiency criteria and ways to encourage right-sizing of power supplies (EPA 2013). The Version 1.0 ENERGY STAR specification for data storage equipment has been in effect since December 2013, but it is limited to power supply efficiency.

TELEVISIONS AND SIGNAGE DISPLAYS

California established the first efficiency standards for televisions in 2009, and Connecticut and Oregon have also adopted television standards. While the current state standards have had an impact in improving television efficiency, significant recent market changes point to the opportunity for large additional savings from updated television standards based on an improved test procedure. First, the current state standards apply to televisions with screen sizes up to about 57 inches diagonal (corresponding to a screen area of 1,400 square inches). However, in 2015, televisions with screen sizes between 50 and 60 inches represented the largest portion of sales, and almost 5% of units sold were larger than 60 inches (NRDC 2015). Second, limited NRDC testing found that playing movies with high dynamic range (HDR) on an HDR-capable television increased energy use by 30–50% compared with ultra-high-definition (UHD) content. Finally, NRDC also found that some leading manufacturers designed their televisions to disable energy-saving features whenever users changed the main picture setting (Horowitz 2016). An improved television test procedure combined with updated efficiency standards could achieve significant energy savings. EPA is currently working on a revised ENERGY STAR specification for televisions.

Signage displays are monitors that are typically installed in commercial spaces such as retail stores, restaurants, museums, hotels, outdoor venues, airports, conference rooms, and classrooms. Signage displays are very similar in construction to televisions. However, because a signage display typically operates 18–24 hours a day and is usually set at a higher brightness setting than a television, it can consume nine times more energy than a similar-size TV (Kundu and Donnelly 2015). In 2016 the CEC clarified that existing television standards in California apply to signage displays as well. There is also an ENERGY STAR specification for signage displays, and the current version (Version 7.0) took effect in 2016. Data on ENERGY STAR–qualified signage displays show that the most efficient products use just half the power of the least efficient ENERGY STAR–qualified products, indicating that there may be significant potential for energy savings. However additional market data are necessary in order to develop a recommended state standard.

Conclusion

States have the opportunity to once again take the lead in advancing appliance standards that save electricity, natural gas, and water. These energy and water savings would provide numerous benefits to states, including economic savings for consumers and businesses, benefits to local economies, improved electric system reliability and reduced need for new energy and water infrastructure, and reductions in air pollutant emissions. On a national level, the 21 recommended standards have the potential to provide $113 billion in net present value savings for consumers and businesses. In 2035 average annual per-household energy and water bill savings from the recommended standards for products used in homes could potentially reach a range of $72 in Iowa to $215 in Hawaii, with a US average of $106. All of the recommended standards are cost effective for the consumers and businesses that purchase these products, with the energy and water bill savings significantly outweighing the additional cost of more-efficient products in all states.

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Appendix A. Annual National and State-by-State Savings

Table A1. Potential national annual electricity, natural gas, primary energy, and water savings in 2025 and 2035

	Potential annual savings in 2025				Potential annual savings in 2035			
Product	Electricity (billion kWh)	Natural gas (TBtu)	Primary energy (TBtu)	Water (billion gallons)	Electricity (billion kWh)	Natural gas (TBtu)	Primary energy (TBtu)	Water (billion gallons)
Faucets	4.1	31.3	71.1	123.0	7.4	55.8	125.0	221.0
Showerheads	2.9	21.4	49.8	58.5	5.3	38.9	88.2	106.3
Lawn spray sprinklers	--	--	--	105.1	--	–	–	171.9
Toilets	--	--	--	30.3	--	–	–	82.1
Computers and monitors	8.8	--	87.9	–	9.8	–	95.4	–
High CRI fluorescent lamps	12.5	--	125.0	–	4.1	–	39.8	–
Air purifiers	2.2	--	21.6	–	3.5	–	34.3	–
Pool pump replacement motors	3.2	--	31.8	–	0.0	–	0.0	–
Commercial fryers	0.05	20.8	21.2	–	0.1	45.3	46.3	–
Commercial dishwashers	0.2	4.6	6.5	6.3	0.5	11.0	15.5	15.3
Commercial steam cookers	0.3	1.9	5.3	5.9	0.8	4.0	11.4	12.9
Portable air conditioners	1.0	--	10.7	–	2.0	–	20.0	–
Urinals	--	--	--	9.6	--	–	–	21.0
Audio/video equipment	1.3	--	12.7	–	1.3	–	12.3	–
Uninterruptible power supplies	1.7	--	17.0	–	1.9	–	18.3	–
Telephones	0.8	--	7.7	–	0.8	–	7.5	–
Water coolers	0.5	--	4.9	–	0.9	–	8.6	–
Ventilation fans	0.3	--	3.2	–	0.7	–	6.8	–
Portable electric spas	0.3	--	3.1	–	0.6	–	5.4	–
Hot food holding cabinets	0.2	--	2.3	–	0.5	–	4.9	–
Compressors	0.2	--	2.4	–	0.6	–	5.4	–
Total	**41**	**80**	**484**	**339**	**41**	**155**	**545**	**631**

Totals may not sum due to rounding. Energy savings estimates do not account for the energy savings associated with reduced water consumption due to the energy embedded in water. Potential savings for pool pump replacement motors are zero in 2035 because we assume that the recommended standard would affect just seven years of product sales beginning in 2021.

Table A2. Potential national annual emissions reductions in 2025 and 2035

Product	Potential annual emissions reductions in 2025			Potential annual emissions reductions in 2035		
	NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)	NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)
Faucets	2.4	1.1	3.4	4.1	1.7	5.8
Showerheads	1.7	0.8	2.4	2.9	1.2	4.1
Lawn spray sprinklers	--	--	--	--	--	--
Toilets	--	--	--	--	--	--
Computers and monitors	2.1	2.6	3.6	2.0	2.3	3.5
High CRI fluorescent lamps	2.9	3.8	5.4	0.8	1.0	1.5
Air purifiers	0.5	0.7	0.9	0.7	0.9	1.3
Pool pump replacement motors	0.7	0.9	1.2	0.0	0.0	0.0
Commercial fryers	1.0	0.01	1.1	2.1	0.02	2.4
Commercial dishwashers	0.3	0.1	0.3	0.6	0.1	0.8
Commercial steam cookers	0.2	0.1	0.2	0.3	0.2	0.5
Portable air conditioners	0.2	0.3	0.4	0.4	0.5	0.7
Urinals	--	--	--	--	--	--
Audio/video equipment	0.3	0.4	0.5	0.3	0.3	0.5
Uninterruptible power supplies	0.4	0.5	0.7	0.4	0.4	0.7
Telephones	0.2	0.2	0.3	0.2	0.2	0.3
Water coolers	0.1	0.1	0.2	0.2	0.2	0.3
Ventilation fans	0.1	0.1	0.1	0.1	0.2	0.3
Portable electric spas	0.1	0.1	0.1	0.1	0.2	0.2
Hot food holding cabinets	0.1	0.1	0.1	0.1	0.1	0.2
Compressors	0.1	0.1	0.1	0.1	0.2	0.2
Total	**13**	**12**	**21**	**15**	**10**	**23**

Totals may not sum due to rounding. Potential emissions reductions for pool pump replacement motors are zero in 2035 because we assume that the recommended standard would affect just seven years of product sales beginning in 2021.

Table A3. Potential national annual utility bill savings in 2025 and 2035

Product	Potential annual utility bill savings (million 2016$)	
	2025	2035
Faucets	2,295	4,621
Showerheads	1,300	2,623
Lawn spray sprinklers	1,172	2,210
Toilets	338	1,058
Computers and monitors	1,171	1,351
High CRI fluorescent lamps	1,505	523
Air purifiers	324	552
Pool pump replacement motors	500	0
Commercial fryers	226	548
Commercial dishwashers	142	383
Commercial steam cookers	128	308
Portable air conditioners	177	354
Urinals	108	271
Audio/video equipment	191	198
Uninterruptible power supplies	211	240
Telephones	97	100
Water coolers	57	106
Ventilation fans	48	110
Portable electric spas	45	85
Hot food holding cabinets	28	62
Compressors	18	45
Total	**10,081**	**15,748**

Totals may not sum due to rounding. Potential savings for pool pump replacement motors are zero in 2035 because we assume that the recommended standard would affect just seven years of product sales beginning in 2021.

Table A4. Potential state-by-state annual electricity, natural gas, primary energy, and water savings in 2025 and 2035

	Potential annual savings in 2025				Potential annual savings in 2035			
State	Electricity (GWh)	Natural gas (BBtu)	Primary energy (TBtu)	Water (billion gallons)	Electricity (GWh)	Natural gas (BBtu)	Primary energy (TBtu)	Water (billion gallons)
Alabama	659	884	7.2	4.5	711	1,754	9.0	8.6
Alaska	81	224	1.0	0.8	78	430	1.2	1.5
Arizona	904	1,472	11.7	11.4	861	2,886	12.0	20.2
Arkansas	372	633	4.3	3.7	402	1,242	4.9	6.7
California	3,905	12,946	50.9	49.5	3,401	24,730	59.0	90.3
Colorado	466	1,721	7.0	7.0	492	3,297	8.5	12.8
Connecticut	429	1,016	4.9	3.3	433	1,956	6.1	6.2
Delaware	126	177	1.3	0.9	139	351	1.5	1.7
District of Columbia	162	124	1.6	0.9	145	246	1.4	1.7
Florida	3,269	2,427	31.9	21.1	3,427	5,038	32.8	39.4
Georgia	1,324	2,238	14.2	9.7	1,339	4,381	15.2	18.3
Hawaii	148	166	1.6	2.3	183	344	2.2	4.2
Idaho	157	461	2.2	3.1	176	888	2.8	5.5
Illinois	1,473	4,161	17.9	12.5	1,294	7,954	19.7	23.5
Indiana	786	1,694	9.0	6.1	818	3,282	10.7	11.6
Iowa	336	823	5.0	2.5	368	1,591	5.9	4.8
Kansas	332	887	5.0	2.6	315	1,701	5.4	5.0
Kentucky	582	800	6.4	3.7	636	1,589	8.1	7.0
Louisiana	658	992	7.4	5.7	674	1,946	8.1	10.4
Maine	154	380	1.8	1.0	162	731	2.3	1.9
Maryland	846	1,137	8.8	7.2	911	2,250	9.6	13.2
Massachusetts	812	2,038	9.4	5.4	785	3,912	11.4	10.5
Michigan	1,112	3,044	13.4	9.4	1,080	5,835	15.6	17.8
Minnesota	611	1,453	9.1	4.2	651	2,809	10.4	8.2
Mississippi	398	539	4.4	3.5	427	1,070	5.4	6.4
Missouri	780	1,464	11.2	6.4	783	2,847	11.9	11.9
Montana	113	285	1.6	1.3	121	550	1.8	2.3
Nebraska	209	574	3.2	2.1	203	1,102	3.5	3.9
Nevada	254	872	3.7	4.4	263	1,675	4.5	7.9
New Hampshire	157	377	1.8	1.1	161	726	2.3	2.2
New Jersey	1,227	2,950	17.0	8.7	1,005	5,635	17.1	16.4
New Mexico	208	634	3.0	2.3	207	1,216	3.4	4.2

State	Potential annual savings in 2025 Electricity (GWh)	Natural gas (BBtu)	Primary energy (TBtu)	Water (billion gallons)	Potential annual savings in 2035 Electricity (GWh)	Natural gas (BBtu)	Primary energy (TBtu)	Water (billion gallons)
New York	2,559	6,253	35.6	19.0	2,330	11,968	38.6	35.8
North Carolina	1,451	1,456	14.5	8.6	1,645	2,955	16.3	16.5
North Dakota	123	194	1.7	0.7	115	376	1.7	1.3
Ohio	1,468	2,970	16.6	9.4	1,486	5,752	19.2	18.2
Oklahoma	546	830	6.2	4.0	558	1,628	6.7	7.4
Oregon	584	719	6.4	5.3	662	1,432	8.1	9.6
Pennsylvania	1,744	3,164	23.1	9.6	1,753	6,141	26.2	18.7
Rhode Island	126	298	1.4	0.9	128	573	1.8	1.8
South Carolina	685	708	6.9	5.7	790	1,438	7.8	10.5
South Dakota	108	223	1.6	0.9	109	432	1.7	1.7
Tennessee	914	1,033	9.8	6.4	1,025	2,081	12.5	12.0
Texas	3,460	6,401	40.2	29.9	3,419	12,485	43.6	55.4
Utah	271	828	3.9	5.7	297	1,599	4.8	10.0
Vermont	74	176	0.8	0.5	77	340	1.1	1.0
Virginia	1,260	1,656	13.0	7.6	1,277	3,267	13.6	14.4
Washington	1,046	1,276	11.4	9.2	1,179	2,541	14.4	16.8
West Virginia	252	350	2.6	1.8	284	691	3.0	3.3
Wisconsin	712	1,573	8.2	4.2	696	3,036	9.3	8.2
Wyoming	78	162	1.0	0.9	81	312	1.2	1.7
United States	**40,510**	**79,863**	**484**	**339**	**40,559**	**155,013**	**545**	**631**

Energy savings estimates do not account for the energy savings associated with reduced water consumption due to the energy embedded in water.

Table A5. Potential state-by-state annual emissions reductions in 2025 and 2035

State	Potential annual emissions reductions in 2025 NOx (tons)	SO_2 (tons)	CO_2 (thous. MT)	Potential annual emissions reductions in 2035 NOx (tons)	SO_2 (tons)	CO_2 (thous. MT)
Alabama	76	58	341	127	26	349
Alaska	158	21	37	147	18	44
Arizona	447	101	412	472	94	446
Arkansas	152	61	208	133	32	217
California	903	86	1,321	1,430	71	1,711
Colorado	463	58	394	500	51	465

State	Potential annual emissions reductions in 2025			Potential annual emissions reductions in 2035		
	NOx (tons)	SO_2 (tons)	CO_2 (thous. MT)	NOx (tons)	SO_2 (tons)	CO_2 (thous. MT)
Connecticut	125	32	130	176	30	185
Delaware	31	45	60	36	34	68
District of Columbia	35	58	72	32	36	65
Florida	1,150	350	1,559	1,279	191	1,782
Georgia	174	117	713	289	50	715
Hawaii	244	306	80	275	336	96
Idaho	68	14	61	92	14	87
Illinois	545	1,347	1,185	622	906	1,133
Indiana	242	601	573	283	443	575
Iowa	215	76	199	232	89	241
Kansas	137	41	234	157	33	251
Kentucky	141	185	377	172	358	388
Louisiana	263	107	362	216	54	358
Maine	46	11	48	66	11	69
Maryland	204	301	396	234	223	444
Massachusetts	242	60	252	336	55	354
Michigan	430	1,334	819	500	1,027	906
Minnesota	389	138	359	411	158	426
Mississippi	104	69	222	108	77	226
Missouri	306	702	611	346	596	643
Montana	47	10	41	60	10	56
Nebraska	137	47	127	138	49	145
Nevada	135	26	128	171	26	168
New Hampshire	46	12	48	65	11	69
New Jersey	355	436	646	402	246	658
New Mexico	116	23	111	137	22	135
New York	832	415	1,054	965	259	1,302
North Carolina	244	175	613	282	128	669
North Dakota	74	28	67	67	28	69
Ohio	444	1,123	1,061	504	805	1,033
Oklahoma	260	132	299	250	112	319
Oregon	208	51	174	259	53	225

State	Potential annual emissions reductions in 2025			Potential annual emissions reductions in 2035		
	NOx (tons)	SO_2 (tons)	CO_2 (thous. MT)	NOx (tons)	SO_2 (tons)	CO_2 (thous. MT)
Pennsylvania	472	820	966	542	576	1,016
Rhode Island	37	9	38	52	9	54
South Carolina	116	83	291	136	61	322
South Dakota	67	24	62	67	26	69
Tennessee	211	290	582	255	577	600
Texas	935	555	2,026	1,017	388	2,082
Utah	119	24	107	160	24	152
Vermont	22	5	22	31	5	32
Virginia	230	152	553	263	99	572
Washington	372	92	312	461	95	400
West Virginia	69	193	173	78	154	176
Wisconsin	284	1,037	606	324	895	631
Wyoming	44	8	37	49	7	44
United States	**13,167**	**12,049**	**21,171**	**15,406**	**9,683**	**23,239**

Table A6. Potential state-by-state annual utility bill savings in 2025 and 2035

State	Potential annual utility bill savings (million 2016$)	
	2025	2035
Alabama	144	228
Alaska	27	40
Arizona	253	410
Arkansas	88	149
California	1,422	2,184
Colorado	141	247
Connecticut	124	193
Delaware	30	48
District of Columbia	34	47
Florida	697	1,050
Georgia	292	463
Hawaii	78	129
Idaho	53	96

	Potential annual utility bill savings (million 2016$)	
State	2025	2035
Illinois	347	533
Indiana	179	285
Iowa	67	111
Kansas	73	116
Kentucky	106	171
Louisiana	143	234
Maine	38	63
Maryland	214	346
Massachusetts	225	341
Michigan	265	424
Minnesota	121	198
Mississippi	92	148
Missouri	168	267
Montana	29	48
Nebraska	47	78
Nevada	88	154
New Hampshire	44	70
New Jersey	317	444
New Mexico	54	90
New York	866	1,211
North Carolina	284	454
North Dakota	20	30
Ohio	324	496
Oklahoma	104	172
Oregon	125	217
Pennsylvania	375	579
Rhode Island	36	56
South Carolina	164	265
South Dakota	22	36
Tennessee	173	279
Texas	775	1,227
Utah	97	176
Vermont	19	30

	Potential annual utility bill savings (million 2016$)	
State	2025	2035
Virginia	247	382
Washington	209	365
West Virginia	52	85
Wisconsin	171	251
Wyoming	20	33
United States	**10,081**	**15,748**

Appendix B. Methodology and Assumptions

We estimated potential national annual electricity, natural gas, and water savings on the basis of estimates of annual product shipments in 2020, per-unit energy and/or water savings, and average product lifetimes. We took into account that some portion of sales will already meet the recommended standard level even in the absence of a standard.

With the exception of high CRI fluorescent lamps and pool pump replacement motors, we assumed that both annual shipments and the portion of shipments meeting the recommended standard level in the base case remain constant over time. In reality, both shipments and base case efficiency tend to increase over time. Thus, we implicitly assumed that these two factors cancel each other out.

We used the equation below to calculate savings in each year through 2035:

> *Annual savings = Number of installed units * Per-unit savings * (1 – % of shipments already meeting recommended standard)*
>
> where the number of installed units is:

- *Before full stock turnover: Annual shipments * (Number of years after compliance date + 0.5)*
- *After full stock turnover: Annual shipments * Average product lifetime*

In calculating the number of installed units meeting the new standard before full stock turnover (in the equation above), we accounted for products being purchased throughout the year. Thus, in any given year we counted only one-half year of savings from products purchased in that year.

For high CRI fluorescent lamps, we used historical data from DOE on shipments of linear fluorescent lamps through 2011 and NEMA data on T12 lamp shipments as a portion of total linear fluorescent lamp shipments in 2016 to calculate average rates of decline of T12 shipments between 2011 and 2016 by lamp type (DOE 2014; NEMA 2017). We then assumed that the average rates of decline of T12 lamps (i.e., high CRI lamps) from 2011 to 2016 would continue through 2035.

For pool pump replacement motors, we assumed that the impact of the recommended standard on product sales would be relatively short-lived since new national efficiency standards effectively requiring variable-speed pumps for most in-ground pools will take effect in 2021 and the average lifetime of a pool pump and motor is about seven years. (We assumed that consumers would replace failed variable-speed motors with replacement variable-speed motors.) We therefore assumed that the recommended standard would affect seven years of pool pump replacement motor sales beginning in 2021.

We calculated potential state-by-state electricity, natural gas, and water savings and costs by allocating national product sales to each state and, where appropriate, making state-by-state adjustments to per-unit savings. We assumed that the portion of sales already meeting the standard level is the same in all states due to a lack of data on state-level base case efficiency. For products used in multiple sectors (e.g., computers and monitors, which are used in both the residential and the commercial sectors), we first allocated total sales to the various sectors based on available data on the breakdown of sales by sector. We then allocated sales in each sector to each of the states.

For residential products for which product saturation does not vary significantly by region (e.g., air purifiers, computers and monitors, faucets), we used the number of households in each state to allocate product sales (Census Bureau 2017). For residential products (other than lawn spray sprinklers) for which saturation varies significantly by state or region (pool pump replacement motors, portable air conditioners, portable electric spas), we used data on equipment saturation from the Residential Energy Consumption Survey (RECS) 2009 to allocate sales (EIA 2011).[19]

For lawn spray sprinklers, we allocated sales on the basis of residential outdoor water use. To estimate state-by-state residential outdoor water use, we first calculated indoor water use for each state as:

> *Indoor water use = [Population * Per-capita indoor water use (excluding leaks)] + [Number of households * Per-household water use due to leaks]*

We used data from a 2016 study on residential water use for national average annual per-capita and per-household indoor water use (DeOreo et al. 2016). We assumed per-capita indoor water use (excluding leaks) and per-household indoor water use from leaks is the same in all states due to a lack of state-by-state data. We then calculated outdoor water use in each state by subtracting indoor water use from total residential water use. We used 2010 data on state-by-state total residential water use (Maupin et al. 2014) adjusted for the change in population in each state from 2010 to 2016.

For products that save hot water (faucets and showerheads), we made adjustments to per-unit savings based on the prevalence of electric and gas/oil water heaters in each state based on RECS 2009 (EIA 2011).[20] Finally, for products for which per-household consumption is correlated with household size (faucets, showerheads, and toilets), we made adjustments to per-unit savings based on average household size.

For products used in the commercial sector for lighting and computing (high CRI fluorescent lamps, computers and monitors, and uninterruptible power supplies), we allocated commercial sector sales to each state based on regional electricity consumption by end use from the Commercial Buildings Energy Consumption Survey (CBECS) 2012 and state-by-state commercial electricity use from EIA. We first allocated product sales to the nine US Census divisions based on end-use consumption, then allocated regional sales to individual states based on commercial electricity use (EIA 2015; EIA 2017e). For products used in the commercial sector for which energy and water use is more closely correlated

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[19] We used data on room air conditioners to allocate sales of portable air conditioners.

[20] The RECS regional data (for HI, AK, OR, and WA) does not represent the breakdown of water heating fuels in Alaska and Hawaii. Therefore for Alaska and Hawaii we used supplemental data sources on the breakdown of water heating fuels (Alaska Energy Authority 2012; R. Brown, energy engineer, Hawaii Energy, pers. comm., February 2, 2017).

with population (commercial food service equipment and plumbing products used in the commercial sector), we allocated sales based on population (Census Bureau 2017). For water coolers as well as the portion of compressors and telephones used in the commercial sector, we allocated sales based on commercial electricity use. Finally, for the portion of compressors used in the industrial sector, we allocated sales based on industrial electricity use.

Table B1 shows our assumptions for each of the 21 products.

Table B1. Assumptions for national annual shipments, average lifetime, per-unit savings, per-unit incremental cost, and percentage of shipments already meeting standard level.

Product	National annual shipments in 2020 (million)	Average lifetime (years)	Per-unit annual savings	Units	% savings relative to baseline products	Per-unit incremental cost (2016$)	% of annual shipments already meeting standard level
Faucets	48.3	--	--	--	--	--	--
residential lavatory	29.7	10.0	--	--	--	0	76%
electricity	--	--	32	kWh	39%	--	--
natural gas	--	--	0.23	MMBtu	39%	--	--
water	--	--	931	gallons	39%	--	--
kitchen	15.2	10.0	--	--	--	0	55%
electricity	--	--	75	kWh	17%	--	--
natural gas	--	--	0.55	MMBtu	17%	--	--
water	--	--	2,214	gallons	17%	--	--
public	3.4	3.0	--	--	--	0	95%
electricity	--	--	--	--	--	--	--
natural gas	--	--	2.63	MMBtu	77%	--	--
water	--	--	6,153	gallons	77%	--	--
Showerheads	16.3	10.0	--	--	--	0	70%
electricity	--	--	108	kWh	19%	--	--
natural gas	--	--	0.80	MMBtu	19%	--	--
water	--	--	2,179	gallons	19%	--	--
Lawn spray sprinklers	71.1	9.0	299	gallons	10%	3	10%
Toilets	16.1	--	--	--	--	--	--
residential	12.7	25.0	861	gallons	20%	0	58%
commercial	3.4	12.0	488	gallons	20%	0	45%
Computers and monitors	87.7	--	--	--	--	--	--
computers	66.8	--	--	--	--	--	--
desktops	19.4	5.0	--	--	37%	--	*
tier 1	--	--	30	kWh	--	10	--
tier 2	--	--	19	kWh	--	4	--
notebooks	45.4	4.0	4	kWh	11%	1	*
small-scale servers	0.5	5.0	24	kWh	8%	13	*
workstations	1.5	5.0	37	kWh	8%	13	*
monitors	20.9	7.0	28	kWh	46%	5	*
High CRI fluorescent lamps	43.7	--	--	--	--	--	--

Product	National annual shipments in 2020 (million)	Average lifetime (years)	Per-unit annual savings	Units	% savings relative to baseline products	Per-unit incremental cost (2016$)	% of annual shipments already meeting standard level
residential	7.1	15.0	16	kWh	50%	22	0%
commercial	36.6	4.9	97	kWh	35%	24	0%
Air purifiers	4.6	9.0	214	kWh	40%	81	60%
Pool pump replacement motors	0.2	7.0	3,292	kWh	65%	346	24%
Commercial fryers	0.1	12.0	--	--	--	1,781	21%
electricity	--	--	163	kWh	17%	--	--
natural gas	--	--	46	MMBtu	31%	--	--
Commercial dishwashers	0.1	13.2	--	--	--	1,058	67%
electricity	--	--	1,385	kWh	20%	--	--
natural gas	--	--	33	MMBtu	38%	--	--
water	--	--	45,808	gallons	38%	--	--
Commercial steam cookers	0.01	12.0	--	--	--	3,027	53%
electricity	--	--	10,927	kWh	55%	--	--
natural gas	--	--	40	MMBtu	54%	--	--
water	--	--	162,060	gallons	93%	--	--
Portable air conditioners	1.4	10.5	223	kWh	23%	77	37%
Urinals	0.9	12.0	4,095	gallons	88%	0	50%
Audio/video equipment	25.2	5.4	18	kWh	45%	0	50%
Uninterruptible power supplies	9.9	--	--	--	--	--	--
residential	1.0	6.1	64	kWh	30%	15	51%
commercial	9.0	6.1	64	kWh	30%	14	51%
Telephones	21.6	5.3	8	kWh	40%	0	19%
Water coolers	2.6	10.0	92	kWh	30%	0	62%
Ventilation fans	7.5	12.1	12	kWh	59%	0	37%
Portable electric spas	0.5	10.0	367	kWh	19%	0	71%
Hot food holding cabinets	0.1	12.0	2,197	kWh	37%	625	62%
Compressors	0.03	13.0	4,762	kWh	3%	1,068	72%

*For computers and monitors, the per-unit annual savings and % savings take into account sales that already meet the standard (i.e., savings are relative to the existing base case efficiency, not the least-efficient products available).
Notes: For the second tier of standards for desktop computers and the standards for pool pump replacement motors, national annual shipments reflect estimated shipments in the assumed compliance year of 2021 for these two standards. For the plumbing products (faucets, showerheads, toilets, and urinals) and portable air conditioners, we took into account that a significant portion of current models have efficiency levels that fall in between the baseline level and the recommended standard level in the estimates of the percentage of annual shipments already meeting the recommended standard level, so as not to overestimate potential savings.

We calculated state-by-state primary (source) electricity savings by multiplying annual electricity savings by projected average regional heat rates from EIA's 2017 *Annual Energy Outlook* (EIA 2017a). We then calculated total primary energy savings by summing primary electricity savings and natural gas savings. Table B2 shows projected heat rates for 2025 and 2035 for the nine US Census divisions.

Table B2. Regional heat rates in 2025 and 2035

	Heat rate (Btu/kWh)	
Region	2025	2035
New England	9,039	9,524
Middle Atlantic	11,454	11,441
East North Central	9,311	9,051
West North Central	12,522	11,612
South Atlantic	9,019	8,089
East South Central	9,647	10,183
West South Central	9,756	9,099
Mountain	11,296	10,621
Pacific	9,730	10,073

We calculated state-by-state NOx, SO_2, and CO_2 emissions reductions from electricity savings by multiplying annual electricity savings by respective state-by-state average emissions factors. We calculated emissions factors for each year of the analysis period for each of the North American Electric Reliability Corporation (NERC) regions by dividing projected electric power sector emissions by projected electric power sector generation using EIA's 2017 *Annual Energy Outlook* and assuming transmission and distribution losses of 5% (EIA 2017a; EIA 2017c). For states that span more than one NERC region, we calculated weighted-average emissions factors based on electricity sales (Kubes, Hayes, and Kelley 2016). Since Alaska and Hawaii are not included in the NERC region data, for these states we used emissions factors from eGRID for 2014 and adjusted for the average US change in emissions rates from 2014 to 2015 (EPA 2017c; EIA 2017a). For future years we assumed the rate of change of emissions factors for Alaska and Hawaii would be equivalent to the US average. Table B3 shows the projected NOx, SO_2, and CO_2 emissions factors for electricity savings for 2025 and 2035 for each state.

Table B3. State-by-state emissions factors in 2025 and 2035 for electricity savings

	2025 emissions factors			2035 emissions factors		
State	NOx (thous. tons/TWh)	SO_2 (thous. tons/TWh)	CO_2 (MMT/TWh)	NOx (thous. tons/TWh)	SO_2 (thous. tons/TWh)	CO_2 (MMT/TWh)
Alabama	0.054	0.088	0.434	0.067	0.037	0.355
Alaska	1.838	0.261	0.302	1.628	0.231	0.268
Arizona	0.420	0.111	0.353	0.396	0.109	0.340
Arkansas	0.331	0.163	0.467	0.189	0.080	0.374
California	0.080	0.022	0.120	0.089	0.021	0.116
Colorado	0.825	0.125	0.644	0.710	0.104	0.583
Connecticut	0.184	0.074	0.178	0.200	0.070	0.188
Delaware	0.180	0.356	0.388	0.145	0.245	0.353
District of Columbia	0.180	0.356	0.388	0.145	0.245	0.353
Florida	0.318	0.107	0.435	0.306	0.056	0.441
Georgia	0.054	0.088	0.434	0.067	0.037	0.355
Hawaii	1.602	2.073	0.474	1.419	1.836	0.420

State	2025 emissions factors			2035 emissions factors		
	NOx (thous. tons/TWh)	SO_2 (thous. tons/TWh)	CO_2 (MMT/TWh)	NOx (thous. tons/TWh)	SO_2 (thous. tons/TWh)	CO_2 (MMT/TWh)
Idaho	0.300	0.088	0.233	0.293	0.080	0.225
Illinois	0.241	0.915	0.635	0.201	0.700	0.543
Indiana	0.210	0.765	0.590	0.163	0.542	0.485
Iowa	0.529	0.226	0.455	0.435	0.243	0.427
Kansas	0.290	0.125	0.542	0.251	0.105	0.507
Kentucky	0.179	0.318	0.567	0.156	0.563	0.474
Louisiana	0.331	0.163	0.467	0.189	0.080	0.374
Maine	0.184	0.074	0.178	0.200	0.070	0.188
Maryland	0.180	0.356	0.388	0.145	0.245	0.353
Massachusetts	0.184	0.074	0.178	0.200	0.070	0.188
Michigan	0.262	1.200	0.588	0.217	0.951	0.548
Minnesota	0.529	0.226	0.455	0.435	0.243	0.427
Mississippi	0.200	0.175	0.480	0.140	0.181	0.392
Missouri	0.306	0.900	0.677	0.277	0.762	0.624
Montana	0.300	0.088	0.233	0.293	0.080	0.225
Nebraska	0.529	0.226	0.455	0.435	0.243	0.427
Nevada	0.377	0.103	0.310	0.359	0.098	0.299
New Hampshire	0.184	0.074	0.178	0.200	0.070	0.188
New Jersey	0.180	0.356	0.388	0.145	0.245	0.353
New Mexico	0.420	0.111	0.353	0.396	0.109	0.340
New York	0.214	0.162	0.286	0.180	0.111	0.289
North Carolina	0.122	0.121	0.371	0.090	0.078	0.308
North Dakota	0.529	0.226	0.455	0.435	0.243	0.427
Ohio	0.210	0.765	0.590	0.163	0.542	0.485
Oklahoma	0.406	0.242	0.466	0.315	0.202	0.412
Oregon	0.300	0.088	0.233	0.293	0.080	0.225
Pennsylvania	0.188	0.470	0.444	0.150	0.328	0.390
Rhode Island	0.184	0.074	0.178	0.200	0.070	0.188
South Carolina	0.122	0.121	0.371	0.090	0.078	0.308
South Dakota	0.529	0.226	0.455	0.435	0.243	0.427
Tennessee	0.179	0.318	0.567	0.156	0.563	0.474
Texas	0.186	0.160	0.475	0.131	0.113	0.411
Utah	0.300	0.088	0.233	0.293	0.080	0.225
Vermont	0.184	0.074	0.178	0.200	0.070	0.188
Virginia	0.122	0.121	0.371	0.090	0.078	0.308
Washington	0.300	0.088	0.233	0.293	0.080	0.225
West Virginia	0.210	0.765	0.590	0.163	0.542	0.485
Wisconsin	0.299	1.455	0.719	0.266	1.286	0.661
Wyoming	0.468	0.100	0.365	0.426	0.088	0.340

We calculated state-by-state NOx and CO_2 emissions reductions from natural gas savings by multiplying annual natural gas savings by natural gas emissions factors of 94 lb/million cu. ft. for NOx and 53.12 kg/thous. cu. ft. for CO_2 (EPA 1995; EIA 2016).

We calculated energy bill savings using state-by-state electricity and natural gas prices for the residential, commercial, and industrial sectors. We used price projections from EIA's 2017 *Annual Energy Outlook* to calculate electricity prices for each of the NERC regions for each year of the analysis period (2020–2035) relative to 2015 prices (EIA 2017a). We then applied these projections for the NERC regions to 2015 state-by-state electricity prices (EIA 2017b). For states that span more than one NERC region, we calculated weighted-average projected changes in electricity prices based on electricity sales (Kubes, Hayes, and Kelley 2016). Since Alaska and Hawaii are not included in the NERC region data, for these states we assumed the rate of change of electricity prices would be equivalent to the US average. Table B4 shows the projected residential, commercial, and industrial electricity prices for 2025 and 2035 for each state.

Table B4. State-by-state electricity prices for the residential, commercial, and industrial sectors in 2025 and 2035

State	2025 electricity prices (2016 cents/kWh)			2035 electricity prices (2016 cents/kWh)		
	Residential	Commercial	Industrial	Residential	Commercial	Industrial
Alabama	12.33	11.53	6.38	12.50	11.59	6.64
Alaska	21.43	18.78	15.64	21.71	18.97	15.81
Arizona	12.38	10.39	6.40	13.07	10.36	6.51
Arkansas	11.14	9.51	7.46	11.72	10.02	8.10
California	19.81	17.76	14.50	21.82	18.01	14.82
Colorado	11.74	9.24	6.95	11.94	9.09	7.13
Connecticut	19.05	15.91	16.23	21.37	17.00	17.56
Delaware	15.12	11.22	9.63	16.13	12.04	10.29
District of Columbia	14.63	13.15	10.21	15.61	14.11	10.91
Florida	13.79	11.27	9.94	13.74	11.12	9.93
Georgia	12.16	10.53	6.21	12.33	10.58	6.46
Hawaii	31.98	28.99	24.83	32.41	29.30	25.09
Idaho	10.48	7.54	6.48	11.28	7.28	6.34
Illinois	14.26	10.08	7.29	14.53	10.11	7.35
Indiana	13.54	11.24	7.67	13.98	11.41	7.82
Iowa	10.94	8.30	5.71	10.85	8.23	5.79
Kansas	12.07	9.67	7.53	11.83	9.40	7.51
Kentucky	9.54	9.18	5.52	9.26	8.94	5.63
Louisiana	10.58	9.90	6.48	11.13	10.43	7.03
Maine	14.20	12.42	11.34	15.93	13.27	12.27
Maryland	15.57	12.04	9.92	16.61	12.92	10.60
Massachusetts	18.04	15.73	16.97	20.23	16.81	18.36
Michigan	14.69	10.07	7.10	14.93	10.15	7.30
Minnesota	11.40	8.79	6.79	11.30	8.71	6.89
Mississippi	11.93	11.35	7.25	12.19	11.57	7.66
Missouri	11.69	9.30	6.58	11.47	9.04	6.47
Montana	11.48	9.89	5.23	12.36	9.55	5.11
Nebraska	9.97	8.07	7.34	9.89	8.00	7.45
Nevada	13.18	9.14	6.81	14.01	9.01	6.83
New Hampshire	16.83	14.90	15.97	18.88	15.92	17.27
New Jersey	17.81	14.00	12.37	19.00	15.02	13.22
New Mexico	12.73	10.30	6.47	13.43	10.27	6.58
New York	29.56	17.63	11.45	30.79	19.21	12.36

State	2025 electricity prices (2016 cents/kWh)			2035 electricity prices (2016 cents/kWh)		
	Residential	Commercial	Industrial	Residential	Commercial	Industrial
North Carolina	13.18	9.91	7.29	13.19	9.84	7.47
North Dakota	9.05	8.22	7.81	8.97	8.14	7.92
Ohio	14.98	11.58	7.84	15.47	11.75	8.00
Oklahoma	10.49	7.95	5.78	10.76	8.22	6.12
Oregon	11.25	8.50	5.86	12.11	8.21	5.73
Pennsylvania	15.53	10.66	8.28	16.42	11.25	8.74
Rhode Island	17.55	15.72	17.24	19.68	16.80	18.65
South Carolina	14.69	11.59	6.78	14.70	11.51	6.94
South Dakota	10.42	8.53	7.13	10.33	8.45	7.23
Tennessee	9.60	9.88	6.22	9.32	9.62	6.34
Texas	10.95	10.32	6.43	10.57	10.18	6.59
Utah	11.48	8.33	6.06	12.36	8.04	5.92
Vermont	15.55	14.48	12.87	17.44	15.48	13.92
Virginia	13.28	9.32	7.79	13.29	9.26	7.97
Washington	9.59	7.94	4.27	10.32	7.67	4.18
West Virginia	11.80	9.90	6.81	12.18	10.04	6.94
Wisconsin	18.10	13.62	9.64	18.93	14.12	10.23
Wyoming	11.27	8.72	6.55	11.93	8.47	6.50

We used price projections from EIA's 2017 *Annual Energy Outlook* to calculate natural gas prices for each of the nine US Census divisions for each year of the analysis period relative to 2015 prices (EIA 2017a). We then applied these regional price projections to 2015 state-by-state natural gas prices (EIA 2017d). Table B5 shows the projected residential and commercial natural gas prices for 2025 and 2035 for each state.

Table B5. State-by-state natural gas prices for the residential and commercial sectors in 2025 and 2035

State	2025 natural gas prices (2016$/MMBtu)		2035 natural gas prices (2016$/MMBtu)	
	Residential	Commercial	Residential	Commercial
Alabama	16.07	14.22	17.64	15.36
Alaska	10.09	10.88	12.78	13.68
Arizona	19.17	11.99	20.85	12.76
Arkansas	12.28	11.08	13.52	12.17
California	11.92	10.92	15.10	13.73
Colorado	9.30	8.50	10.12	9.05
Connecticut	13.04	9.19	14.33	9.67
Delaware	13.63	13.72	14.99	14.87
District of Columbia	12.93	14.19	14.23	15.39
Florida	21.11	14.00	23.22	15.18
Georgia	15.78	11.00	17.37	11.93
Hawaii	41.96	42.33	53.15	53.22
Idaho	9.66	8.64	10.51	9.20
Illinois	8.95	8.97	9.89	9.90
Indiana	10.02	9.37	11.07	10.34
Iowa	9.23	7.87	10.02	8.52
Kansas	11.03	10.74	11.97	11.63

State	2025 natural gas prices (2016$/MMBtu)		2035 natural gas prices (2016$/MMBtu)	
	Residential	Commercial	Residential	Commercial
Kentucky	12.36	11.05	13.57	11.94
Louisiana	11.57	10.61	12.73	11.65
Maine	17.51	15.14	19.25	15.93
Maryland	12.99	12.57	14.29	13.62
Massachusetts	13.58	11.55	14.93	12.16
Michigan	9.90	9.25	10.94	10.20
Minnesota	9.53	8.85	10.35	9.58
Mississippi	11.03	9.93	12.11	10.72
Missouri	12.58	11.07	13.66	11.98
Montana	9.29	9.25	10.11	9.85
Nebraska	9.61	7.75	10.43	8.39
Nevada	13.30	9.86	14.46	10.49
New Hampshire	16.87	14.57	18.55	15.33
New Jersey	9.07	10.16	10.00	10.94
New Mexico	9.71	7.19	10.56	7.66
New York	12.21	8.18	13.46	8.82
North Carolina	12.49	10.60	13.74	11.49
North Dakota	8.84	8.02	9.59	8.68
Ohio	10.69	7.87	11.81	8.68
Oklahoma	10.86	10.68	11.95	11.72
Oregon	13.01	13.70	16.48	17.23
Pennsylvania	12.03	11.13	13.27	11.99
Rhode Island	14.85	12.82	16.33	13.49
South Carolina	13.66	10.89	15.03	11.80
South Dakota	9.00	7.53	9.77	8.15
Tennessee	10.94	10.69	12.01	11.54
Texas	11.26	9.14	12.40	10.03
Utah	10.93	9.07	11.89	9.66
Vermont	15.18	8.43	16.69	8.87
Virginia	12.57	10.42	13.83	11.30
Washington	12.35	13.27	15.65	16.68
West Virginia	11.31	11.72	12.45	12.70
Wisconsin	9.60	8.35	10.60	9.21
Wyoming	10.49	8.46	11.42	9.00

For water and wastewater prices, we used regional prices derived from American Water Works Association/Raftelis and water price trends for each year of the analysis period (DOE 2016c). Table B6 shows the projected water and wastewater prices for 2025 and 2035 for the US Northeast, Midwest, South, and West.

Table B6. Regional water and wastewater prices in 2025 and 2035

	2025 water and wastewater prices (2016$/thousand gallons)			2035 water and wastewater prices (2016$/thousand gallons)		
Region	Water	Wastewater	Total	Water	Wastewater	Total
Northeast	4.71	6.66	11.37	5.43	7.67	13.10
Midwest	4.54	6.24	10.78	5.23	7.19	12.42
South	4.61	6.84	11.45	5.31	7.89	13.20
West	5.60	5.38	10.97	6.45	6.19	12.65

We calculated net present value savings as the difference between the present value of the total energy and water bill savings from products sold between 2020 and 2035 and the present value of the total estimated impacts on product costs. We discounted future costs and savings to 2017 using a real discount rate of 5%. We calculated benefit–cost ratio as the present value of savings divided by the present value of costs. Finally, we calculated simple payback period as the additional cost of the more-efficient product divided by the first-year utility bill savings.

Appendix C. Sources for Product Assumptions

Product	Sources
Faucets	E. Guy, H. Hauenstein, S. Schneider, T. Quinn, and E. Osann, *Faucets: Codes and Standards Enhancement (CASE) Initiative for PY 2013: Title 20 Standards Development: Analysis of Standards Proposal for Residential Faucets and Faucet Accessories*, Prepared for Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric, and Southern California Gas Company (San Francisco: CPUC, 2013). www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2C_Water_Appliances/California_IOUs_and_Natural_Resources_defense_Councils_Response_to_the_Invitation_for_Standards_Proposals_for_Faucets_-_Updated_2013-08-05_TN-71810.pdf. H. Singh, K. Rider, and T. Ngo, *Staff Analysis of Water Efficiency Standards for Toilets, Urinals, and Faucets* (Sacramento: CEC, 2015). docketpublic.energy.ca.gov/PublicDocuments/15-AAER-01/TN203718_20150220T141432_Staff_Analysis_of_Water_Efficiency_Standards_for_Toilets_Urinal.pdf. DOE, "Compliance Certification Database" (2017). Accessed March. www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A*.
Showerheads	H. Hauenstein and C. Richter, *Showerheads: Codes and Standards Enhancement (CASE) Initiative for PY 2015: Title 20 Standards Development: Analysis of Standards Proposal for Showerheads*, Prepared for Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric, and Southern California Gas Company (San Francisco: CPUC, 2015). docketpublic.energy.ca.gov/PublicDocuments/15-AAER-05/TN205606_20150731T141501_Sarah_Schneider_Energy_Solutions_on_behalf_of_California_IOUs_C.pdf. S. Steffensen, *Staff Analysis of Water Efficiency Standards for Showerheads* (Sacramento: CEC, 2015). www.energy.ca.gov/business_meetings/2015_packets/2015-08-12/Item_06/Item_6_Showerhead_Staff_Report_8-6-15.pdf. DOE, "Compliance Certification Database" (2017). Accessed March. www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A*.
Lawn spray sprinklers	A. Williams, Y. Chen, C. Dunham, H. Fuchs, and H. Stratton, *Methodology for National Water Savings Model and Spreadsheet Tool: Outdoor Water Use* (Berkeley: LBNL, 2016). https://eta.lbl.gov/sites/all/files/publications/lbnl-1004118.pdf. EPA, *WaterSense Draft Specification for Spray Sprinkler Bodies Supporting Statement* (Washington, DC: EPA, 2016). www.epa.gov/sites/production/files/2017-03/documents/ws-background-ssb-draft-specification-supporting-statement1.pdf. M. Maupin, J. Kenny, S. Hutson, J. Lovelace, N. Barber, and K. Linsey, *Estimated Use of Water in the United States in 2010* (Reston: US Geological Survey, 2014). pubs.usgs.gov/circ/1405/pdf/circ1405.pdf. W. DeOreo, P. Mayer, B. Dziegielewski, and J. Kiefer., *Residential End Uses of Water, Version 2: Executive Report* (Denver: Water Research Foundation, 2016). www.awwa.org/portals/0/files/resources/water%20knowledge/rc%20water%20conservation/residential_end_uses_of_water.pdf.

Product	Sources
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Appendix D. Market Barriers to Efficiency

Since the savings from more-efficient products evaluated in this report outweigh the costs, it is reasonable to ask why policies such as appliance efficiency standards are needed. If the savings for the user outweigh the additional cost of improved efficiency, won't purchasers select the more efficient product? The answer is that sometimes they do (which is why products evaluated in this report have significant market share already), but often a set of persistent and deeply rooted demand-side and supply-side market barriers stand in the way of more widespread selection of cost-effective, efficient options. This appendix describes some of the market barriers to cost-effective efficiency.

Demand-side market barriers include the split incentive problem, panic purchases, lack of information, and transaction costs. The split incentive problem refers to instances in which the purchaser of a product does not pay the utility bills to operate that product. For example, in the case of rental properties, the landlord purchases the appliances and HVAC equipment, but the tenant typically pays the utility bills. The landlord has no incentive to purchase even slightly more expensive efficient products since the utility bill savings would accrue to the tenant. Appliance standards ensure that products purchased by landlords meet a minimum level of efficiency, thereby lowering monthly bills for tenants. A similar situation can occur in business settings: in many companies the business unit or individual responsible for capital expenditures is different from the one responsible for operating costs including utilities.

Panic purchases occur in situations where a product such as a furnace or water heater has failed and the consumer's top priority is to replace the product as soon as possible. In these situations, consumers often are stuck with purchasing whatever product a contractor has on the truck. With appliance standards, all products, including those on the truck or in stock at stores, meet a minimum level of efficiency.

Consumers also typically do not have sufficient information to make an informed decision about purchasing a more-efficient product. It is very difficult for a consumer to estimate the life-cycle costs of different products, and in many cases consumers may not even know that different models can use different amounts of energy. Even if a consumer knows that efficiency varies among products and affects operating costs, obtaining sufficient information takes time and effort (i.e., imposes a transaction cost) that may outweigh the benefits of being able to select a more-efficient product, especially when per-unit savings may be relatively small and consumers are busy.

Supply-side barriers include limited stocking of efficient products, the bundling of efficiency into premium products only, and manufacturer price competition. Retail stores and equipment distributors have only limited space to store and display products. If efficient products are not in stock, they require a special order. Appliance standards ensure that all products stocked by retail stores and equipment distributors meet a minimum level of efficiency.

Manufacturers may often choose to bundle efficiency with other features in premium products only. In these cases consumers may not have the option to purchase a value-priced efficient product. With appliance standards, efficiency is available on all models, rather than on just the most expensive ones.

Finally, if a manufacturer chooses to voluntarily increase the efficiency of its products, it may find it very difficult to pass on even small product cost increases to consumers without risking a loss of market share.

Appliance standards overcome both demand-side and supply-side barriers to efficiency, ensuring that all products meet a minimum level of efficiency. By shifting purchases to a range of choices that save consumers and businesses money, standards also achieve public benefits derived from cutting energy and water waste.