Appliance Standards Awareness Project
American Council for an Energy Efficient Economy
Conservation Law Foundation
Consumer Federation of America
E4TheFuture
Florida Consumer Action Network
National Consumer Law Center
Natural Resources Defense Council
Northeast Energy Efficiency Partnerships
Southeast Energy Efficiency Alliance
Southwest Energy Efficiency Alliance
Texas Ratepayers Organization to Save Energy
Vermont Energy Investment Corporation
Vermont Public Interest Research Group

May 3, 2019

Ms. Celia Sher
U.S. Department of Energy
Office of the General Counsel, GC-33
1000 Independence Avenue SW
Washington, DC 20585-0121

Email: GSL2018STD0010@ee.doe.gov

Docket Number:	EERE-2018–BT–STD–0010
RIN:	1904-AE26

Dear Ms. Sher:

These comments comprise the response of the Appliance Standards Awareness Project and thirteen co-signing organizations to the Department of Energy (DOE) February 11, 2019 notice of proposed rulemaking (84 FR 3120). The co-signers represent a range of national, regional and state energy-efficiency, consumer advocacy and environmental organizations. We believe that DOE's proposal to rescind two rules (82 FR 7323 and 82 FR 7326) issued by the Department in January of 2017 is illegal. We also believe that DOE's proposal introduces uncertainty into the rapidly changing light bulb market that will cost consumers and retailers money. DOE's proposed rule would waste energy and dollars and damage the environment and we strongly urge DOE to withdraw it.

DOE's January 2017 rules expanded the definition of general service lamps (GSL) and brought reflector, candelabra-based, 3-way, globe-shaped and a wide range of other light bulbs under the definition of GSL. All these added bulb types are covered by the definition regardless of illumination technology. On the compliance date for the federal backstop GSL standard in the Energy Independence and Security Act (EISA) of 2007 (January 1, 2020), most light bulbs for sale in the U.S. will be required to meet a minimum energy efficiency requirement of 45 lumens per Watt. The 2020 GSL standards will accelerate the transition of the U.S. light bulb market away from inefficient incandescent and halogen bulbs to light emitting diode (LED) technology, making lighting more affordable, saving large amounts of energy, and reducing emissions of greenhouse gases and other pollutants from electricity generation.

DOE went through a comprehensive and robust standards rulemaking process to develop the January 2017 GSL definition rules. In March of 2016 DOE published a notice of proposed rulemaking (81 FR 14528). The Department also published a comprehensive technical support document for the proposed rule, held a public meeting, and received written comments. In October of 2016 the proposed rule was followed by a notice of proposed definition and data availability (NOPPDA) and in January 2017, after appropriate research and analysis, DOE issued the two GSL definition rules identified above.

As the Department stated at the time (82 FR 7326), DOE took this action because it "*is required under the Energy Independence and Security Act (EISA) of 2007 amendments to the Energy Policy and Conservation Act (EPCA) of 1975 to undertake a rulemaking to determine whether standards in effect for GSLs should be amended to establish more stringent standards; and determine whether exemptions for certain incandescent lamps should be maintained or discontinued. (42 U.S.C. 6295(i)(6)(A)(i)) In addition to that mandate, DOE has the authority to qualify lamps as general service lamps upon determining that they are 'used to satisfy lighting applications traditionally served by general service incandescent lamps.' (42 U.S.C. 6291(30)(BB)(i)(IV)).*" DOE met these statutory requirements by reviewing light bulb types exempted from the prior definition of GSL and by removing exemptions that were no longer warranted. DOE also revised the definitions of several exempted light bulb types to improve clarity and reduce the danger of loopholes in the GSL standard.

The Action proposed in DOE's February 2019 NOPR Would Be Illegal and the NOPR is Flawed

In February 2019 DOE published a notice of proposed rulemaking (NOPR) that would rescind the two January 2017 GSL definition rules and return to the prior definition of GSLs. We believe that this proposal, if finalized, would be illegal for several reasons including the following:

1. The Department does not have the authority for the actions proposed in the NOPR.
2. The "anti-backsliding" provision of EPCA[1] prevents DOE from reducing the savings from energy conservation standards.
3. The process used by the Department for developing the NOPR is flawed.

DOE's February 2019 rescission NOPR would void a Congressionally-mandated rulemaking and exempt many types of light bulbs from GSL standards. It would also undo the important improvements that the

[1] 42 US Code 6295(o)(1)

Department made to the definitions of exempt light bulb types, making the GSL standard less effective. DOE has no authority to take such actions.

We believe that if DOE issues a final rule rescinding the 2017 GSL definition rules then the Department will violate the anti-backsliding provisions of EPCA. The 45 lumens per Watt backstop GSL standard in EISA has been triggered, and that efficiency requirement applies to the January 2017 definition of GSLs. DOE can neither legally eliminate nor narrow the application of this Congressionally-required standard.

While the DOE's rulemaking to develop and issue the January 2017 GSL definition rules was both comprehensive and robust, DOE's rulemaking for the February 2019 rescission NOPR has been neither. DOE's NOPR claims that the January 2017 GSL definitions are not "legally justifiable," and that "the legal basis underlying those revisions misconstrued existing law." DOE also states that it "reassessed the legal interpretation underlying certain decisions made in the January 2017 definition final rules" in response to comments received to an August 2017 notice of data availability and request for information (NODA).

DOE received ten sets of comments to the NODA, from eighteen stakeholders. Several of those comments discuss the legality of the GSL standards. However, the only comments referenced in the February 2019 rescission NOPR were submitted by the National Electrical Manufacturers Association (NEMA) and associated lighting industry parties. Most of NEMA's comments appear to reiterate comments the organization made previously to DOE's October 2016 NOPDDA. DOE considered NEMA's arguments in 2016 and decided correctly on them in issuing the January 2017 rules. The February 2019 rescission NOPR provides little discussion of or explanation for this extraordinary change in legal direction by the Department, other than simply stating agreement with comments submitted by NEMA.

The February 2019 rescission NOPR is illegal because the Department lacks the authority to rescind its final rules, because taking such action would violate the anti-backsliding provisions of EPCA, and because DOE has followed a flawed rulemaking process. EarthJustice and the Natural Resources Defense Council (NRDC) have submitted a thorough legal analysis to this docket, as have the attorney general's offices of sixteen states and New York City which demonstrate why this NOPR is unlawful and should be withdrawn.

DOE's Proposed Rule Would Waste Energy and Money and Increase Pollution

DOE's 2015 Lighting Market Characterization reported that there were about six billion light bulbs in use in U.S. homes and businesses.[2] DOE's 2015 Residential Energy Consumption Survey (RECS) estimates that the average U.S. household used 1,105 kilowatt-hours (kWh) of electricity for lighting in 2015, or about 10% of average U.S. household total electricity consumption.[3] Lighting has been a leading driver of residential electricity consumption since the advent of residential electric service. The 2015 RECS also found that homes in regions of the country with higher adoption rates for LEDs and compact fluorescent lamps (CFL) used less energy for lighting than regions that used more incandescent and halogen bulbs. Improved light bulb energy efficiency has already had a large impact on consumers' electricity bills, and the federal backstop GSL standards will increase that benefit.

[2] U.S. Department of Energy Lighting Market Characterization 2015, https://www.energy.gov/eere/ssl/2015-us-lighting-market-characterization

[3] Bulb choice and the number of bulbs per household drive regional variations in household lighting consumption https://www.eia.gov/todayinenergy/detail.php?id=38452

DOE's February 2019 rescission NOPR would have an extremely negative impact on the effectiveness of federal GSL regulation. DOE is proposing to cut in half the volume of light bulbs currently in use in the U.S. that would be subject to the GSL standards. If only general service incandescent lamps (GSIL), CFL and LED are required to achieve 45 lumens per Watt starting in January of 2020, by 2025 the decrease in light bulb efficiency would result in the waste over 81 billion kWh per year, worth over $12 billion in electricity bill savings and equivalent to about $100 per household per year. By 2025 the electricity generation associated with this wasted energy would increase air pollution by an extra 19,000 tons of nitrogen oxides, 23,000 tons of sulfur dioxide, and 34 million metric tons of climate-changing carbon dioxide emissions each year— the annual CO_2 emissions equal to that of more than seven million cars. (Please see Attachment 1, ASAP/ACEEE issue brief appendix Tables B1 and B2)

Moreover, at the February 28th public meeting on the proposed rule, DOE's representative asserted that the backstop 45 lumens per Watt GSL standard has not been triggered and is "not legally operative."[4] Under this interpretation, the GSL standard would not apply to any bulb types this coming January, dramatically reducing expected savings from federal light bulb energy efficiency regulation. We believe that this recent interpretation by DOE of the backstop GSL standard is incorrect for the reasons given in the comments of NRDC and EarthJustice.

DOE's Proposal Increases Uncertainty in U.S. Light Bulb Market

DOE's February 2019 rescission NOPR injects damaging uncertainty into a rapidly changing U.S. light bulb market. By publishing this NOPR less than a year before the compliance date for the federal backstop GSL standards, the Department has created significant business uncertainty. Specific characteristics of the GSL standards, combined with actions either already taken or planned by several states, ensure that if DOE rescinds the February 2017 GSL definitions it will be strongly opposed and that federal light bulb regulation and the legal liability for compliance will remain unsettled for some time.

As of this writing California, Vermont, Washington and Colorado have adopted state standards requiring a minimum of 45 lumens per Watt for GSLs. The GSL standards in Vermont, Washington, and Colorado apply to light bulbs meeting DOE's January 2017 GSL definition, and California is in the process of expanding its GSL definition. Several other states are considering legislation to adopt similar standards. DOE's February 2019 rescission NOPR has created confusion for retailers who want to comply with the law. Although these state standards will help assure savings for residents of those states, manufacturers and retailers often claim that the resulting "patchwork quilt" of regulation poses challenges to their distribution and marketing, causing disruption for their businesses.

Unlike other lighting or appliance efficiency standards administered by DOE, there is a sales prohibition in the backstop GSL standard Congress included in EISA. This means that responsibility for compliance with the 2020 GSL standards extends beyond manufacturers to also include retailers. Sale prohibitions are also included in the Vermont and Washington GSL standards and will likely be part of similar standards adopted by other states in 2019. States that adopt their own GSL standards can enforce them against retailers for any light bulb type that is not pre-empted by federal standards. A special provision in EPCA[5] also allows any state to enforce federal energy efficiency standards for certain light bulbs. .

[4] Public Meeting Transcript, from page 51, line 10 to page 52, line 3.

[5] 42 U.S. Code 6304

Using this authority, states could seek injunctive enforcement of the 45 lumens per Watt GSL standard beginning January 1, 2020.

To accommodate international shipping and warehousing, most retailers need to order their light bulb inventories at least six months before offering them for sale. This means that light bulbs that are on the shelves on the compliance date for the backstop GSL standards must be ordered by the beginning of July 2019. Because DOE issued this NOPR only in February of 2019, and because hundreds of public comments have been submitted to this docket, it seems very unlikely that the Department would be able to complete a thorough review and publish a final rule before retailers need to order light bulbs to stock their shelves for January of 2020. The inevitable legal challenges to a DOE final rule that rescinds the January 2017 GSL definitions will take significantly longer to resolve. Therefore, DOE's February 2019 rescission NOPR poses significant risks for lighting retailers who will be forced to order stock before they know which standards apply, possibly ending up with unsaleable light bulbs and fines for non-compliance.

LED light bulbs have proven very popular with consumers, forcing manufacturers and retailers to respond rapidly to a changing light bulb market. The federal backstop GSL standards set a date for most incandescent and halogen light bulbs to exit the U.S. market, providing a clear road map for the lighting industry. The large number of light bulbs in use, and their large associated energy consumption, means that changes to national light bulb stock also have implications for electricity supply and energy efficiency program planning. DOE's February 2019 rescission NOPR has injected uncertainty into a regulatory environment that should provide stability and predictability.

DOE's 2017 GSL Definition Rules are Necessary and Beneficial

LED technology provides consumers light bulbs that are essentially the same shape and size as incandescent or halogen light bulbs but use less than one quarter the electricity and last 20 times as long. The prices of LED light bulbs have now fallen so far that consumers can often buy them for only slightly more than equivalent halogen light bulbs of similar brightness. The energy savings from LED bulbs pay back that price difference in less than one year, but because they last so much longer than halogens and incandescents, LED bulbs are much less expensive to own and use.

Table 1 shows the costs to consumers of purchasing and using LED light bulbs compared to incandescent or halogen light bulbs over a 10-year period. Using current light bulb prices and electricity costs, we estimate that LED light bulbs will save consumers at least 80% of their total lighting costs. Despite this strong economic advantage, obsolete incandescent and halogen bulbs will persist in the market for many years without strong energy efficiency standards. Some consumers will continue to buy obsolete light bulbs because they are familiar, are easily available where they happen to shop, or have the lowest purchase price, despite the overwhelming lifecycle economic benefits of LED light bulbs.

Table 1.

Halogen or Incandescent and Comparable LED Light Bulbs					Usage	Life		Purchase		Power		10 Year
Type	Brand[1]	Technology[2]	Model	Watts	Hrs/day	Hours	Years	Price[4]	10 yr cost	kWh/year	10 yr cost	Total Cost
A-type (325 lumens)	Eco-Smart	halogen	342006	29.0	2.3	1,250	1.5	$1.49	$10.01	24.3	$31.65	$41.66
A-type (490 lumens)	Eco-Smart	LED	A7A19A40WESD02	5.3	2.3	15,000	17.9	$1.98	$1.11	4.4	$5.78	$6.89
A-type (600 lumens)	Eco-Smart	halogen	304071	43.0	2.3	1,250	1.5	$1.49	$0.83	36.1	$46.93	$47.76
A-type (840 lumens)	Eco-Smart	LED	B7A19A60WESD34	9.5	2.3	15,000	17.9	$2.37	$0.59	5.9	$7.66	$8.25
A-type (1,490 lumens)	Eco-Smart	halogen	324442	72.0	2.3	1,000	1.2	$1.49	$12.51	60.4	$78.58	$91.09
A-type (1,600 lumens)	Eco-Smart	LED	A7A19A100WESD05	15.5	2.3	15,000	17.9	$3.79	$2.12	13.0	$16.92	$19.04
Globe (G25, 290 lumens)	Sylvania	incandescent	10546	40.0	1.7	2,500	4.0	$1.99	$4.94	24.8	$32.27	$37.21
Globe (G25, 350 lumens)	Eco-Smart	LED	25 40WE W27 CL	4.5	1.7	25,000	40.3	$2.66	$0.66	2.8	$3.63	$4.29
Reflector (BR40, 630 lumens)	Philips	incandescent	387795	65.0	2.9	2,000	1.9	$4.48	$23.71	68.8	$89.44	$113.15
Reflector (BR40, 945 lumens)	Eco-Smart	LED	1003026002	12.5	2.9	25,000	23.6	$4.87	$2.06	13.2	$17.20	$19.26

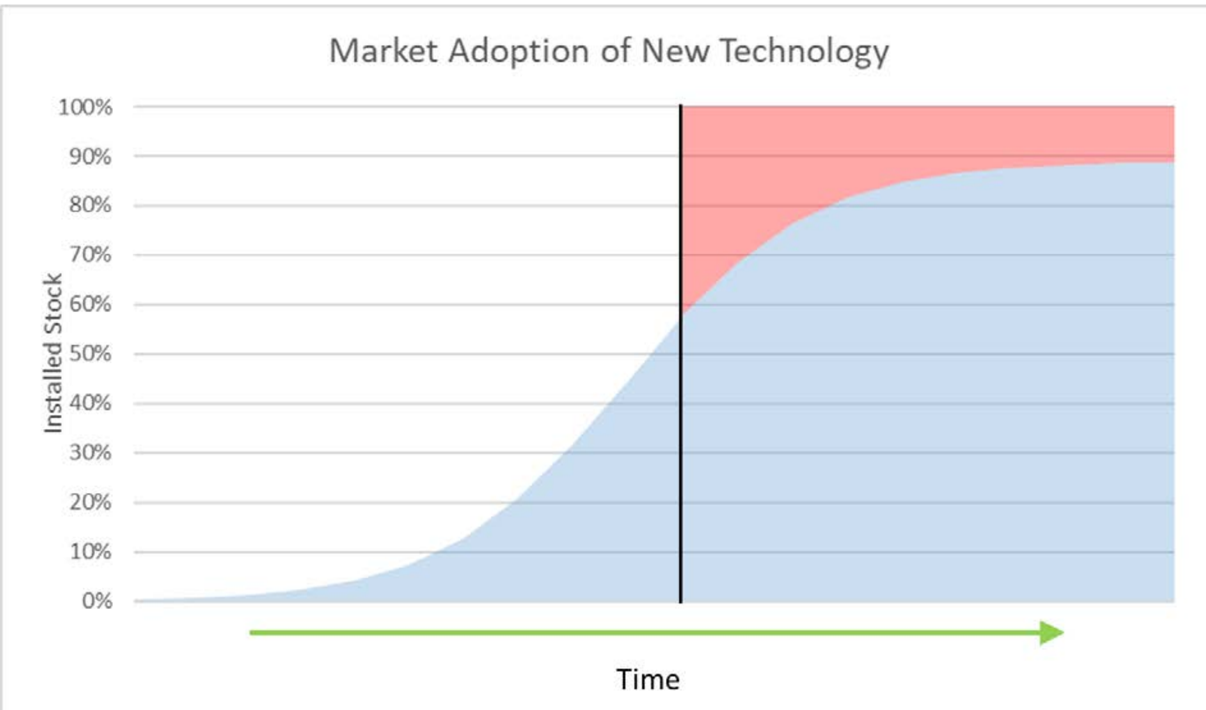
Notes:

1. Eco-Smart is the Home Depot house brand for light bulbs.
2. All LED bulbs are ENERGY STAR qualified and dimmable. Non-ENERGY STAR and non-dimmable versions are cheaper.
3. All LED bulbs are at least as bright as the comparable halogen or incandescent bulb.
4. All bulb prices obtained from HomeDepot.com on 5/2/2019 for single bulbs sold in mulit-packs of 2-4 bulbs with no incentives or rebates.
5. Assumed retail electricity price of $0.13/kWh held constant over 10 year analysis. Average residential usage from DOE LMC 2015.

Figure 1 illustrates the well-documented tendency of new technologies to follow an S-shaped market adoption curve. [6] In this illustrative example, a new technology is introduced as a replacement for an inferior, less energy efficient technology. Market forces drive adoption of the new technology slowly at first, but with steadily increasing acceleration until about mid-way through the curve. [7] After that point, the new technology continues to claim new market share, but at a decelerating rate. Eventually, the adoption of new technology plateaus and market share no longer increases over time.

The blue-shaded area under the curve represents the accumulated stock of the new technology in use, which is also directly correlated to the energy saved by the new energy efficient technology when it replaces the older inefficient technology. The vertical black line shows the effect of an energy efficiency standard. The red-shaded area represents the additional market share that the new technology claims when the old technology leaves the market more quickly and completely than it would have under the effect of market forces alone.

Figure 1.



LED light bulbs are currently somewhere in the middle of the S-curve, showing strong market acceptance and still experiencing rapid adoption but with slowing adoption coming soon. “A-type” light bulbs, the most common pear-shaped bulbs, are further along the adoption curve than the reflector, candelabra-based, 3-way, globe-shaped, and other light bulb types added to the GSL definition by DOE’s January 2017 rules. A-type bulbs are more likely to be LEDs today in large part because of the federal standards for A-type bulbs which took effect starting in 2012. Therefore, going forward the federal GSL

[6] McGrath, Rita Gunther, Harvard Business Review, November 25, 2013.

[7] Historically, different technologies have been adopted at different rates.

standards will drive proportionally more savings from light bulb types included under the expanded GSL definition in the January 2017 rules. For all types of light bulbs, the federal GSL standards will both accelerate the rate of penetration of LEDs into the U.S. market, and increase the maximum level of LED penetration, delivering large energy and dollar savings for consumers.

Summary

DOE's proposal to rescind the expanded GSL definition is illegal, disruptive to business, and costly to consumers. Even if the proposed action were lawful, restoring exemptions would needlessly waste enormous amounts of electricity and money and cause the unnecessary emission of millions of tons of greenhouse gases. The transition of the U.S. light bulb market to LED technology, like any significant technological change, will require adjustments by manufacturers, retailers and consumers. Congress enacted light bulb standards in 2007 and in 2017 DOE expanded the range of bulbs that must comply. Federal law and subsequent regulation provide a roadmap and calendar for this technology change, and for the realization of significant benefits for consumers and the economy. DOE's February 2019 NOPR introduces uncertainty and would increase costs for retailers and consumers while damaging the environment.

We respectfully request that DOE withdraw the proposed rule and confirm that the 45 lumens per Watt backstop standard included in the Energy Independence and Security Act of 2007 applies to the January 2017 GSL definition starting on January 1, 2020.

Thank you for the opportunity to provide these comments.

Sincerely,

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Vermont Energy Investment Corporation

Ben Edgerly Walsh
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Attachment 1: ASAP/ACEEE light bulb issue brief

US Light Bulb Standards Save Billions for Consumers But Manufacturers Seek a Rollback

Trump administration will soon announce plans

A revolution in lighting is sweeping through our homes and businesses as LEDs (light-emitting diodes) supplant older technologies. LEDs provide all the benefits of the old-fashioned Thomas Edison light bulbs while slashing costs for consumers. Yet the Trump administration will soon announce a decision that could stymie future progress.

National minimum energy efficiency standards for light bulbs, enacted by the US Congress and President Bush in 2007, helped spur the investments and market changes that have resulted in the low-cost, high-quality LEDs now widely available. Initial standards started taking effect in 2012, and in 2017 the Department of Energy (DOE) widened the range of light bulbs that must comply with tougher standards, slated for 2020. The 2020 standards will expand the LED market, further reducing costs for consumers and ensuring that affordable LEDs will be widely available for all the types of bulbs commonly used in US homes.

These standards will deliver huge savings, given the scale of the lighting market — more than six billion sockets in US homes. They will save a typical household about $180 per year by 2025. On a cumulative, national basis, consumers will realize more than $665 billion in electricity bill savings by 2050.

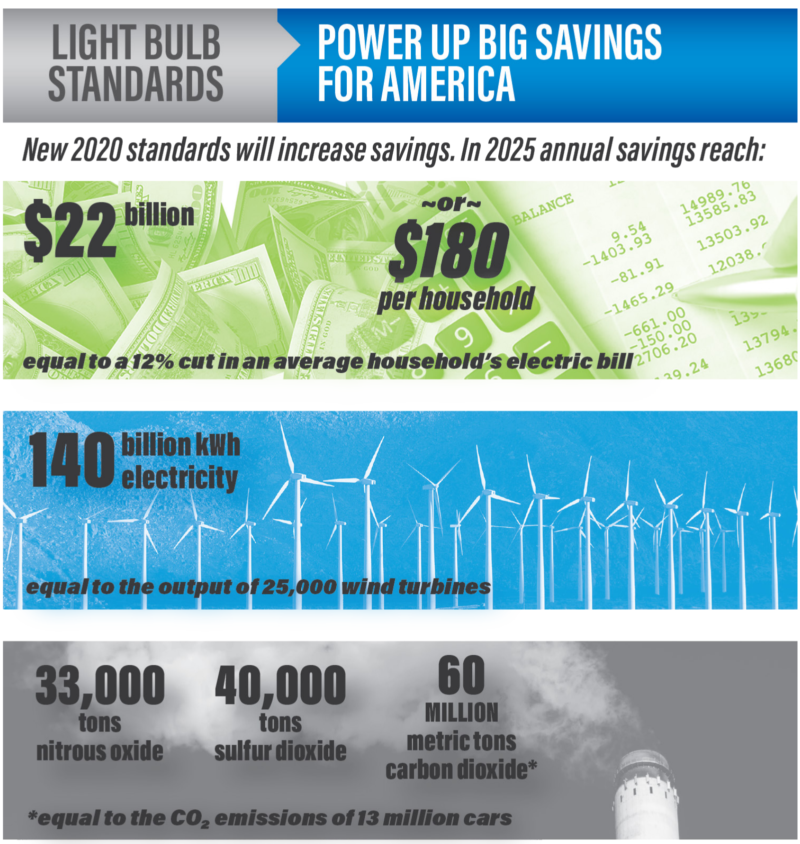

Figure 1. Light bulb standards by the numbers

Unfortunately, major light bulb manufacturers want to slow the pace of change. They are seeking to persuade the Trump administration to attempt an unlawful rollback of the 2020 standards. Such a rollback would waste energy and hurt consumers. This issue brief describes the status of the light bulb standards and how the market has responded to them. It provides up-to-date estimates of the savings from the light bulb standards and how much could be lost if the Trump administration attempts to roll them back. Appendices provide more in-depth background, the ASAP/ACEEE analysis methodology, and detailed results, including state-by-state savings estimates.

Americans save big with light bulb standards

US light bulb standards will save consumers more than $5 billion on electricity bills this year alone. After 2020, when manufacturers and retailers must comply with standards that are both stronger than initial standards and apply to a wider range of bulbs, annual consumer electricity bill savings will grow, reaching about $22 billion in 2025, or about $180 for an average household. Total electricity savings top 140 billion kilowatt hours in 2025, roughly the amount generated by 45 large coal-fired power plants or 25,000 wind turbines in a year. By reducing the amount of fuel burned for electricity, the standards cut harmful emissions such as smog-forming nitrogen oxides (NO_X), sulfur dioxide (SO_2), and globe-warming carbon dioxide (CO_2). The result? Cleaner air and fewer respiratory problems such as childhood asthma attacks.

These savings really add up. Through 2050, consumers' electricity bill savings will total more than $665 billion, and avoided CO_2 will total nearly 1,700 million metric tons (MMT). Savings don't only benefit consumers and the environment, they also boost the overall economy and employment as people spend their savings on other goods and services. ACEEE and ASAP estimate that domestic employment will be 115,000 jobs higher in 2025 due to the light bulb standards.[1]

Standards unleashed light bulb innovation

For more than a century, the Thomas Edison-invented incandescent bulb used in US homes had barely changed. Then in 2007, Congress and President George W. Bush enacted the Energy Independence and Security Act, setting off a two-stage race to improve light bulb efficiency. In the first stage, A-type bulbs, the most common light bulb shape (see figure 1), needed to reduce power consumption by 25-30% compared to conventional incandescent bulbs. For stage 2, Congress directed the US Department of Energy (DOE) to develop a stronger standard for 2020 and to determine which additional light bulb shapes, sizes, and special categories would be covered. Instead of picking one lighting technology as the winner, Congress set standards that cover many ways of generating light and let the market decide which technologies to further develop to meet those efficiency levels. But because DOE had a history of missing its legal deadlines, the law included a protective "backstop" standard to give innovators and manufacturers a firm, long-term efficiency target of at least 65-70% savings. If DOE missed procedural steps required by Congress or failed to establish a standard that met a minimum savings threshold, the backstop standard would automatically be triggered.

Figure 2. An LED A-type bulb. Source: Amazon.com

For stage 1, major light bulb manufacturers developed and introduced new lines of improved incandescent bulbs using halogen gas inside the bulb ("halogens") and other design improvements to compete against even more efficient compact fluorescent lamps (CFLs). But with an eye toward the stage 2 target, they and new companies (e.g., North Carolina-based Cree, Inc.) invested heavily in a new entrant in the race for bulb efficiency: LEDs.

1 Stickles, B. and J. Mauer, J. Barrett and A. deLaski. 2018. Jobs Created by Appliance Standards. Washington, DC: ACEEE; Boston: ASAP.

Figure 3: LED reflector, MR, globe, and candelabra bulbs. Sources: 1000bulbs.com and bulbs.com

In part due to later restrictions placed by Congress, DOE did not meet the statute's timetable, and the backstop has been triggered. However, as required by Congress, DOE did complete rules to define the scope of bulb types covered by the backstop standard.

In addition to A-type bulbs, the 2020 standards apply to reflectors (cone-shaped bulbs used in recessed ceiling light fixtures and track lights), globe-shaped bulbs, 3-way bulbs, and many decorative ones. Figure 2 shows LED versions of some of the more common bulbs

LEDs: A great deal for consumers

LEDs have plummeted in price and now cost as little as a dollar more than a comparable halogen bulb. Because LEDs last much longer than halogen bulbs, a consumer switching to LEDs will spend less on light bulbs over time. For example, as shown in the table, over a 10-year period, a typical consumer will spend $2.37 on a 60W-equivalent A-type LED bulb but $11.92 on a comparable halogen. And that's just the bulb costs. When electricity costs are factored in, that same consumer would spend a total of nearly $60 over 10 years if he/she chose halogen bulbs but less than $12 for an LED – a savings of nearly $50. Because many LEDs last longer than 10 years, the longer-term savings may be even greater. As shown in the table, other LED bulb types are also a great deal for consumers. Their 10-year savings range from about $38 to $92. As stronger standards covering more bulb types kick in as of 2020 and production scales up, LED prices are likely to become even more favorable.

Bulb type	Manufacturer	Bulbs			Electricity			10-year total cost	10-year total savings with LED
		Technology	Price	10-year cost	Watts	kWh/year	10-year cost		
A-type (60W equivalent)	EcoSmart	Halogen	$1.49	$11.92	43.0	36.1	$46.93	$58.85	$47.20
	EcoSmart	LED	$2.37	$2.37	8.5	7.1	$9.28	$11.65	
A-type (100W equivalent)	EcoSmart	Halogen	$1.49	$11.92	72.0	60.4	$78.58	$90.50	$68.51
	EcoSmart	LED	$5.62	$5.62	15.0	12.6	$16.37	$21.99	
Globe (G25, 40W equivalent)	Sylvania	Incandescent	$2.47	$12.35	40.0	24.8	$32.27	$44.62	$38.09
	EcoSmart	LED	$3.30	$3.30	4.0	2.5	$3.23	$6.53	
Reflector (BR30, 65W equivalent)	Philips/Signify	Incandescent	$3.49	$20.94	65.0	68.8	$89.44	$110.38	$92.59
	Cree	LED	$6.78	$6.78	8.0	8.5	$11.01	$17.79	

Notes: EcoSmart is the Home Depot house brand for light bulbs. All LED bulbs are ENERGY STAR® qualified and dimmable. Non-ENERGY STAR and non-dimmable versions are less expensive. All bulb prices were obtained from HomeDepot.com on 6/8/2018 for single bulbs sold in multi-packs of 2-6 bulbs. Annual electricity use assumes daily operating hours for A-type, globe, and reflector bulbs of 2.3 hours/day, 1.7 hours/day, and 2.9 hours/day, respectively. Rated lifetimes for the halogen A-type, incandescent globe, and incandescent reflector bulbs are 1,100 hours, 1,500 hours, and 2,000 hours, respectively. The LEDs have rated lifetimes of at least 15,000 hours. Electricity costs assume an electricity price of 13 cents/kWh.

that must meet the 2020 standards, including clear versions with exposed filaments. Any technology can comply, but with the popularity of LEDs for A-type bulbs, manufacturers have stopped investing in further improvements to incandescent bulbs. They have even begun phasing out CFLs.

LEDs are winning the race for the A-type bulb market. The stage 2 standards will lock in those savings. They will also expand the race and resulting savings to a wider range of light bulb sizes and shapes used in Americans' homes.[2]

Manufacturers lobby for a rollback that would slow progress and slash savings

Manufacturers supported the original 2007 law. Now, however, the three largest lighting companies –GE, Signify (formerly known as Philips Lighting), and Sylvania, as represented by their trade association, the National Electrical Manufacturers Association — are lobbying against implementation of the backstop. They want to change the rules of the race. They contend that DOE still has a choice about whether to implement the backstop. In its place, they are lobbying for DOE to leave the stage 1 standards in place for halogens and impose tougher standards only for LEDs. In other words, they want a race where each technology gets a different finish line, some of which have already been crossed. Manufacturers could keep on selling their current highly profitable halogen bulbs and, for some of the additional bulb shapes and sizes not covered by stage 1, even conventional incandescent product lines.

The manufacturers' proposed rollback could potentially eliminate all of the savings from the stage 2 standards, slowing the transition to energy-efficient lighting and hurting consumers. The average household would lose up to $115 in electricity bill savings in 2025. On a national, cumulative basis, consumers would lose more than $340 billion by 2050. Millions of tons of pollutants would be needlessly added to the atmosphere.

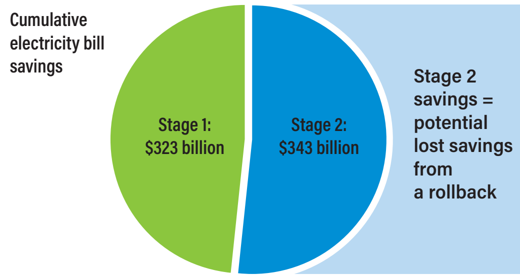

Figure 4. The cost of a potential rollback.

Manufacturers may have found a willing ear in the Trump administration. In summer 2017, DOE reached a legal settlement with the National Electrical Manufacturers Association. The terms of the settlement, which call for DOE to propose new rules in 2018, suggest that the administration may attempt to carry out the manufacturers' rollback wishes.

A rollback would break the law

Fortunately, the national appliance standards law forbids rollbacks. It prohibits DOE from weakening standards. Because the 2020 backstop has been triggered, any subsequent standard cannot be weaker or narrower in the range of light bulbs covered. An attempt by the Trump administration to substitute a weaker or less-comprehensive standard or to simply assert that the backstop standard does not apply will almost assuredly lead to lawsuits. The 2007 law provides another important layer of protection: state Attorneys General can step in to enforce federal light bulb standards. Legal action against manufacturers or retailers that fail to comply may prove the most effective way to guarantee the large savings from the light bulb standards. If the Trump administration attempts to formally roll back the standards or fails to enforce them, the courts will decide the standards' future and whether Americans will receive the resulting benefits.

Appendices available at https://appliance-standards.org/document/gsl-methodology

ASAP | APPLIANCE STANDARDS AWARENESS PROJECT

ACEEE American Council for an Energy-Efficient Economy

2 Appendix A is a detailed history of the light bulb standards.

An ASAP/ACEEE Issue Brief: Appendices

US light bulb standards save billions for consumers but manufacturers seek a rollback

Trump administration will soon announce plans

Appliance Standards Awareness Project and American Council for an Energy-Efficient Economy

July 2018

Appendix A: A history of light bulb standards

This appendix describes the origins and structure of the federal law that established US light bulb standards, the actions that triggered the backstop, the markets' response to the federal law, related state and international standards, and the National Electrical Manufacturers Association's (NEMA) effort to avoid backstop implementation.

State standards lead to a two-stage federal standard with a "backstop"

In the mid-2000s, several states began to consider setting standards designed to make light bulbs more energy efficient. California acted first, setting initial standards in 2004. Several other states, including New York, began legislative proceedings to consider state standards, with Nevada enacting standards in mid-2007.

Manufacturers strongly prefer a single national standard rather than state-by-state requirements, and national standards offer the potential for larger savings. As a result, manufacturers worked with energy efficiency, consumer, and environmental advocates including ASAP and ACEEE, with input from state policy makers to develop recommendations for Congress. In 2007, Congress approved the first national light bulb standards and President Bush signed them into law, based on a joint recommendation. The enacted standards established a two-stage transition to energy-efficient light bulbs. Stage 1 applied only to "A-type" (the most common shape) incandescent light bulbs and required savings of 25 – 30% compared to traditional incandescent bulbs. This standard took effect over a three-year period starting in 2012.

For stage 2, Congress required the US Department of Energy (DOE) to conduct a public rulemaking to develop an improved standard. That new standard would not be limited to incandescent technology. Congress also required DOE to determine additional bulb shapes, sizes, and special categories that would be covered (42 U.S. Code 6295(i)(6)(A)(i)). But because DOE had a history of missing legal deadlines and to provide a firm efficiency-improvement target for manufacturers and other innovators, the law included a critical protective provision: a "backstop" standard. If DOE missed any of a series of legislatively required procedural steps, including a January 2014 deadline for initiating the rulemaking and a January 2017 deadline for a final rule, or failed to develop a standard that met a minimum savings threshold, then an automatic default standard would be triggered, with compliance required as of January 2020. The law set the minimum savings threshold at "savings that are greater than or equal to the savings from a minimum efficacy standard of 45 lumens per watt" (42 U.S. Code 6295(i)(6)(v)).[1] (A lumen is a unit for measuring light output.) The backstop standard, also 45 lumens per watt, could easily be met by CFLs and LEDs, but would require big but theoretically achievable improvements for incandescent technology.

The backstop is triggered and DOE expands the range of covered bulbs

DOE's failure to comply with two of the statute's required steps has triggered the backstop. First, DOE failed to initiate the rulemaking for general service incandescent lamps by January 1, 2014 due to an appropriations rider championed by Rep. Michael Burgess (R-Texas), who was opposed to light bulb standards. Second, DOE failed to complete a final rule by January 1, 2017.

Separate from those deadlines, DOE could not set a standard that meets the statute's savings threshold and still allows significant sales of currently available halogen light bulbs. For a standard to generate "savings that are greater than or equal to the savings from a minimum efficacy standard of 45 lumens per watt" and still permit sales of today's halogen light bulbs, which have much lower efficacy, the standard would have to make up for the less-efficient halogens by requiring that other bulb types (LEDs and CFLs) become more efficient than they would be without new standards. Because these bulb types already use a small fraction of the electricity used by a halogen bulb, standards that push them to be even better could compensate for only a few halogen bulb sales. Therefore, any proposed standard that considers each technology separately could not meet the savings threshold. That triggered the backstop in a third way.[2]

DOE did, however, fulfill its obligation to specify which bulbs would be covered by the 2020 standards. DOE's definitional rules apply the stage 2 standards to a wide range of light bulbs. In addition to A-type light bulbs, compliance with the 2020 standards is now required for reflector (cone-shaped bulbs used in recessed ceiling and track lighting fixtures), globe-shaped, 3-way, and a range of decorative bulbs such as candelabra-shaped ones. LED versions of all these light bulbs types are readily available (82 Federal Register 7276 and 7322).

The market responds to minimum standards

The 2007 law unleashed a wave of lighting innovation, focused first on improved incandescent and later on LED technology. At the time the law was enacted, improved incandescent bulbs using halogen gas inside the bulb and other refinements already existed but were expensive, costing about $5 each. In

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[1] In its entirety, the backstop clause reads: ''(v) BACKSTOP REQUIREMENT.—If the Secretary fails to complete a rulemaking in accordance with clauses (i) through (iv) or if the final rule does not produce savings that are greater than or equal to the savings from a minimum efficacy standard of 45 lumens per watt, effective beginning January 1, 2020, the Secretary shall prohibit the sale of any general service lamp that does not meet a minimum efficacy standard of 45 lumens per watt."

[2] DOE acknowledged the triggering of the backstop several times during the Obama administration (e.g., 81 Federal Register 14540, 82 Federal Register 7316, and its "Statement Regarding Enforcement of 45 LPW General Service Lamp Standard"), but has not confirmed those prior statements since President Trump took office.

response to the minimum standard, manufacturers developed a new generation of less-expensive halogen incandescent bulbs that comply with the stage 1 standards. These bulbs typically cost about $1.50 each. Compact fluorescent lamps (CFLs) offered consumers an even more efficient choice.

In 2007, colored LEDs were used in specialty lights like traffic signals or as indicator lights, but an LED that could cost effectively produce white light for general illumination did not yet exist. With the expectation of stronger standards in 2020, researchers ramped up work on white light LEDs, and soon a range of new and established lighting companies brought LEDs to market.[3] By 2014, LEDs started to take off in the marketplace, generally taking market share from CFLs. Figure A1 below shows the relative market share (i.e., sales) of conventional incandescent, halogen, CFL, and LED A-type light bulbs over time.

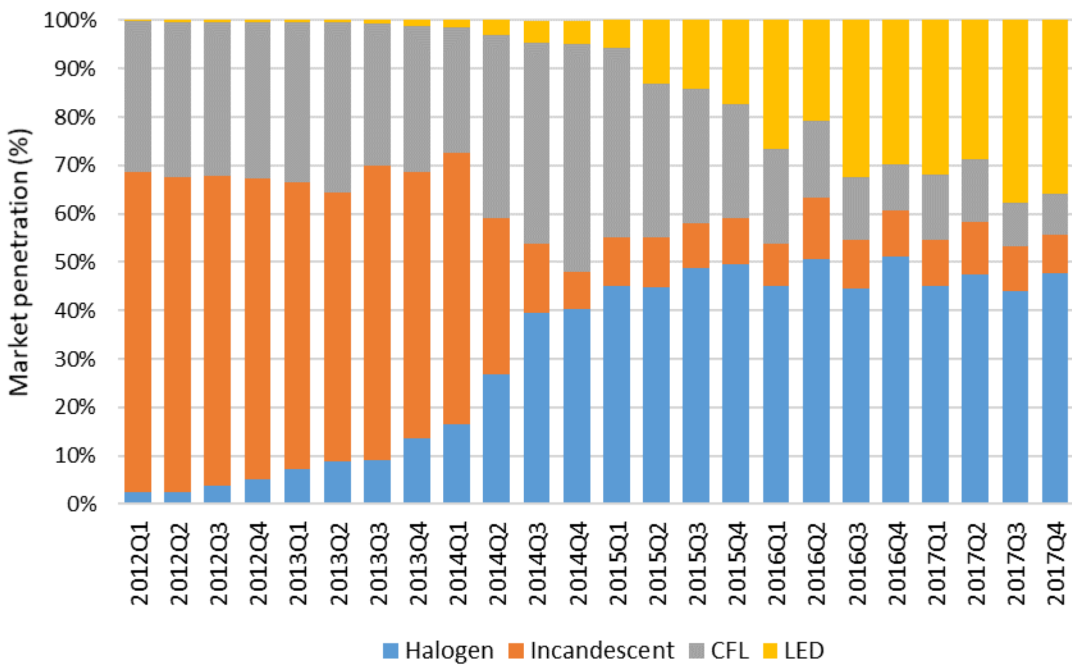

Figure A1. A-type bulb market share by technology. *Source:* National Electrical Manufacturers Association 2018.

As the figure shows, A-type halogen bulb sales started increasing in 2012 in response to the stage 1 standards but have plateaued since 2015. CFL market share reached its peak in 2014, but CFLs have since lost market share to LEDs. The A-type bulb market appears to have reached equilibrium since 2015; efficient bulbs (LEDs and CFLs) have about a 45% market share, and halogen and conventional incandescent market share has stabilized at about 55%. Because CFLs and LEDs last much longer than halogen and incandescent bulbs, the market share figures are not the same as the share of sockets with each technology type installed. An equal split of sales indicates that LEDs have a larger and growing share of sockets that contain an A-type bulb. (Similarly detailed data are not available for the bulb types

[3] The scientists who developed the technology enabling white light LEDs won the Nobel Prize in Physics in 2014 for work carried out in the 1990s. Over the past decade, DOE-funded research played a major role accelerating the advance of LED technology into market applications. A recent DOE brochure describes DOE's ongoing work: https://www.energy.gov/sites/prod/files/2017/01/f34/ssl-overview_oct2017.pdf

added for stage 2, but LED and CFL market share is generally much lower and conventional incandescent much higher for those bulb types.)

With LEDs' improving performance and declining prices, manufacturers stopped investing in improved halogen technology. One manufacturer, Venture Lighting, brought to market a halogen bulb with efficiency significantly above the stage 1 standards in 2013, but could not gain wide distribution. With manufacturers and retailers ramping down the marketing of CFLs, once compliance with the 2020 standards begins, LEDs will likely dominate the market for the range of bulbs covered by stage 2 standards. LED technology enables a broad array of choices in lighting color, controllability, and bulb shapes. LEDs can be built into traditional bulb shapes as well as flat panels, enabling new light fixture designs. They also offer the potential for a range of innovative features not possible with other technologies. Some recent LED bulbs can be controlled by the user's smart phone to change colors or dim (without the need of a dimmer switch) and even incorporate a speaker to play music. Others advertise light color changes that can mimic the progression of daylight, intended to support healthy sleep patterns. New innovations may be around the corner (CNET 2018).

State and international standards are moving forward

In general, federal standards for a product preempt state standards. However, the 2007 law included a special provision allowing California to implement light bulb standards in 2018 if DOE failed to adhere to required procedural steps, the same condition that triggered the backstop. California adopted state standards in 2008, anticipating that the backstop might be triggered, and the obligation to comply with the state standards began on January 1, 2018.

In 2017, Vermont enacted the backstop standard into state law as a protective measure, covering the same range of bulbs as the stage 2 standards. If DOE attempts to remove any bulb types from the federal standard, and hence from federal preemption, the state can enforce its standards. Bills in other states include similar protective provisions.

Internationally, European Union standards will complete the phaseout of halogen light bulbs on September 1, 2018. Canada adopted the US stage 1 standards and has begun the process for adopting the next stage. Standards are also pending in Australia. Recently, the United Nations, in collaboration with Signify/Philips Lighting and Natural Resources Defense Council, completed model regulations intended for use in developing countries that phase out conventional incandescent and halogen bulbs. These model regulations require efficiency levels stronger than the US stage 2 standards (UN Environment 2018).

NEMA's opposition to backstop implementation

NEMA, which represents light bulb manufacturers, has opposed DOE's conclusion that the backstop has been triggered and compliance will be required beginning in 2020. Under NEMA's alternative legal interpretation, DOE can still complete the rulemaking that was due by January 2017, meet the minimum savings threshold, and avoid implementing the backstop (NEMA 2016; NEMA 2017). NEMA sued DOE after the 2017 definitional rules were published and reached a settlement with the Department in summer 2017. That settlement does not mention the backstop standard, but it implies that DOE still has to decide whether to issue new standards for incandescent bulbs, which would illegally roll back the backstop if they set minimum efficiency at less than 45 lumens per watt. It also says that DOE may reassess the January 2017 definitions, presumably for the purpose of removing all or some of the newly added bulb types from the scope of standards. In addition, the settlement requires DOE to issue a supplemental notice of proposed rulemaking for LED bulb standards only and consider updated standards for CFLs, implying that DOE may regulate light bulbs based on the technology used for producing illumination (NEMA v. DOE 2017). The settlement agreement provides DOE with an opportunity to attempt to implement NEMA's interpretation of the law.

Manufacturers, represented by NEMA, also brought suit against California, arguing that DOE had met procedural requirements and thus California could not implement state standards. (As noted, these are the same procedural requirements that, if not met, trigger the backstop.) A federal court ruled against NEMA, allowing California's standards to take effect on January 1, 2018. The court rejected NEMA's arguments that the backstop had not yet been triggered (NEMA v. CEC 2017). NEMA subsequently dropped its suit and manufacturers

What's next?

DOE is scheduled to complete a supplemental proposed rule for light bulb standards later in 2018. This proposed rule will likely reveal any new legal strategies from the Department. A final rule will likely follow in 2019. If the final rule denies the applicability of the 2020 backstop or narrows the range of bulbs covered, that action would violate the 2007 law, as well as the anti-backsliding provision of the national appliance standards law, which prohibits DOE from weakening standards. Almost assuredly, those potential DOE actions or others to undermine the 2020 standards would lead to lawsuits against DOE. While manufacturers and retailers must comply with the backstop as of January 1, 2020, lawsuits may be unresolved until late 2019 or even later, creating significant uncertainty for manufacturers and retailers. In addition, the federal law includes a special provision empowering state Attorneys General to enforce light bulb standards. Whether or not DOE denies the applicability of the backstop, individual states may seek to enforce the backstop against retailers and manufacturers that fail to comply (42 U.S. Code 6304).

Appendix B: Detailed national results

Annual electricity savings from the light bulb standards grow from 68 billion kWh in 2020, reducing consumer electricity bills by $10 billion, to about 140 billion kWh in 2025, worth $22 billion in savings. Annual savings grow as more and more bulbs in use comply with stage 2 standards. Accounting for both stage 1 and stage 2 standards, cumulative electricity savings reach more than 4 trillion kWh through 2050, worth about $665 billion in consumer bill savings (expressed in constant 2017 dollars but without discounting). Table B1 provides the annual electricity and electricity bill savings in 2020 and 2025, as well as cumulative savings through 2050 due to the standards. The table separates stage 2 savings into savings from A-type bulbs and from five categories of bulb types included in the expanded scope of coverage. As detailed in the methodology (appendix D), all of these estimates take into account the share of sockets that would contain compliant bulbs even in the absence of standards.

Table B1. Annual electricity and electricity bill savings in 2020 and 2025 and cumulative savings through 2050 from the light bulb standards

		Annual savings in 2020		Annual savings in 2025		Cumulative savings through 2050	
		Electricity (billion kWh)	Electricity bills (billion 2017 $)	Electricity (billion kWh)	Electricity bills (billion 2017 $)	Electricity (billion kWh)	Electricity bills (billion 2017 $)
Stage 1	A-type	42.5	6.2	50.3	7.9	2,018	323
Stage 2	A-type	5.9	0.9	10.8	1.7	314	51
	Reflector	11.1	1.6	41.1	6.3	855	134
	MR	1.8	0.2	6.1	0.9	152	22
	Decorative	5.1	0.7	28.3	4.4	702	114
	Globe	0.5	0.1	3.0	0.5	83	13
	Misc. A-type	1.3	0.2	2.9	0.5	59	10
Stage 2 total		25.7	3.6	92.1	14.2	2,166	343
Total		**68**	**10**	**142**	**22**	**4,184**	**666**

Table B2. Annual emissions reductions in 2020 and 2025 and cumulative reductions through 2050 from the light bulb standards

		Annual emissions reductions in 2020			Annual emissions reductions in 2025			Cumulative emissions reductions through 2050		
		NOx (thous. tons)	SO2 (thous. tons)	CO2 (MMT)	NOx (thous. tons)	SO2 (thous. tons)	CO2 (MMT)	NOx (thous. tons)	SO2 (thous. tons)	CO2 (MMT)
Stage 1	A-type	10.9	12.1	18.3	11.8	14.3	20.9	476	614	811
Stage 2	A-type	1.5	1.7	2.5	2.5	3.1	4.5	73	94	125
	Reflector	2.8	3.2	4.8	9.6	11.7	17.1	199	255	343
	MR	0.4	0.5	0.8	1.4	1.7	2.5	35	45	61
	Decorative	1.3	1.4	2.2	6.7	8.1	11.8	163	210	280
	Globe	0.1	0.1	0.2	0.7	0.8	1.2	19	25	33
	Misc. A-type	0.3	0.4	0.6	0.7	0.8	1.2	14	18	24
Stage 2 total		6.6	7.3	11.1	21.6	26.2	38.4	502	647	866
Total		**18**	**19**	**29**	**33**	**40**	**59**	**978**	**1,261**	**1,677**

Figure B1 shows the breakdown of cumulative electricity bill savings. (The breakdowns of cumulative electricity savings and emissions reductions are very similar to the electricity bill savings breakdown.) Cumulatively, the stage 2 standards account for slightly more than half of the total bill savings from the light bulb standards. The vast majority of savings achieved by stage 2 is the result of the expanded scope of light bulbs covered. Savings from the expanded scope are especially large because these market segments were unaffected by stage 1. As a result, unlike with A-type bulbs, very inexpensive and inefficient conventional incandescent bulbs retain significant market share absent standards. A-type light bulbs contribute a significant but smaller share of stage 2 savings. In stage 1, a significant portion of the A-type bulb market has already shifted to long-lived CFLs and LEDs. We assume that trend will continue, which results in 90% of the in-use stock of A-type bulbs being LEDs by 2030 even without the stage 2 standards.

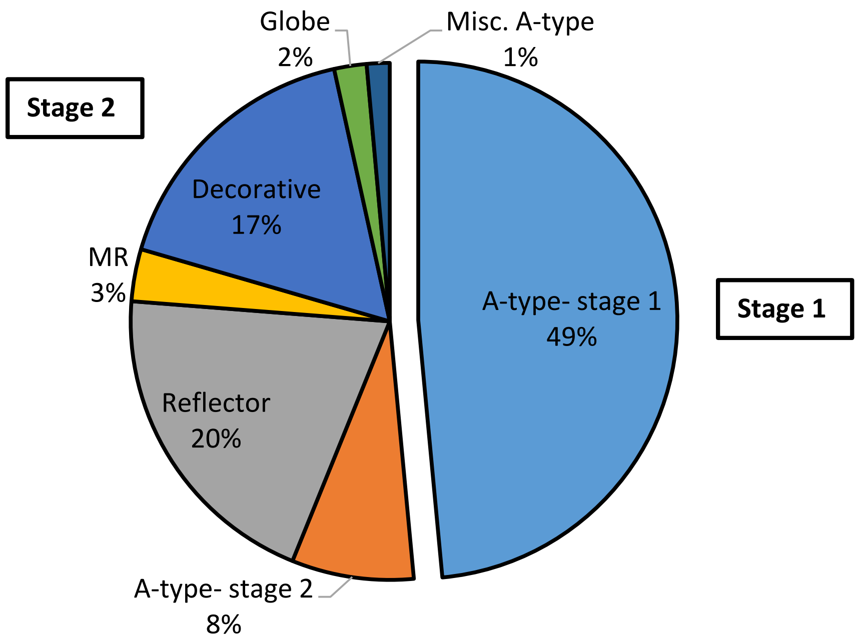

Figure B1. Breakdown of cumulative electricity bill savings through 2050

The savings from the stage 2 standards for A-type bulbs make up 8% of the total savings from the standards, whereas the savings from the expanded scope account for 44% of the total. Reflector bulbs account for the largest share of stage 2 savings, contributing 20% to the total cumulative savings. Decorative bulbs, primarily candelabra bulbs, are the second largest, making up 17%. Multifaceted reflectors or MR light bulbs, globe-shaped bulbs, and miscellaneous A-type bulbs represent 3%, 2%, and 1% respectively. (Miscellaneous A-type bulbs consist of rough service, vibration service, shatter resistant, 3-way, and very high light output bulbs.)

Notably, even the lamp types that contribute relatively small savings are still significant. As shown in table B1, each lamp type contributes cumulative electricity bill savings of at least $10 billion for consumers. For comparison purposes, the combined electricity savings from MR, globe, and miscellaneous A-type bulbs (which make up about 5% of the total light bulb savings) are greater than the savings from DOE's 2017 residential central air conditioner and heat pump standards.

Figure B2 shows annual electricity bill savings over time. Annual savings increase sharply after 2020 with the stage 2 standards. By 2025, most light bulbs in use will be compliant bulbs. The annual savings rate from stage 2 standards declines some after 2025 because a growing portion of consumers would select energy-efficient bulbs even if these standards did not exist. Annual savings from the stage 1 standards continue to increase over time, mainly due to projected increases in residential floor space, which results in more bulbs in use.

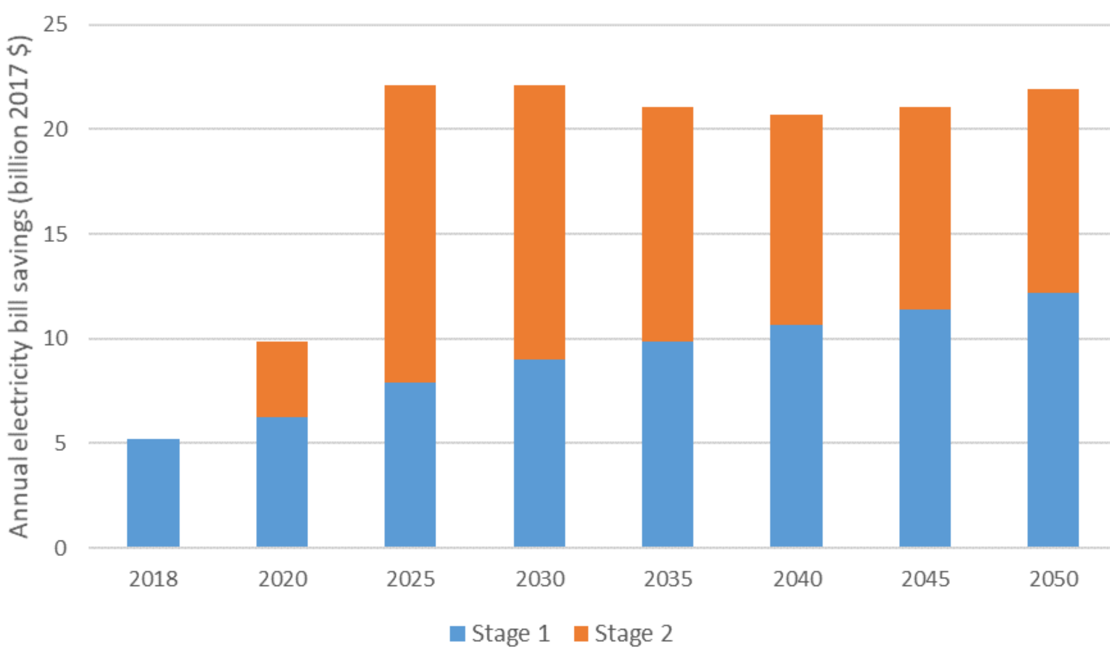

Figure B2. Annual electricity bill savings

Figure B3 shows how the light bulb standards affect consumer expenditures and savings. Electricity bill savings and total consumer savings (including the change in spending on light bulbs) largely reflect the electricity savings. Notably, total savings exceed bill savings starting in the early 2020s. Typically, products meeting an efficiency standard are modeled with an estimated incremental cost, resulting in net savings that are lower than electricity bill savings. That relationship holds during the first part of the analysis period for light bulbs. However, since efficient bulbs last much longer, consumers spend less on bulbs over time because they purchase fewer bulbs, even though they cost more on a per bulb basis (see text box table in the Issue Brief). Therefore, their total spending on bulbs is less with standards than without standards by the early 2020s. In 2025, consumers will save about $1.7 billion on bulb purchases in addition to their electricity bill savings. Cumulatively by 2050, consumers will spend $38 billion less on light bulbs due to efficiency standards. Calculated on a net present value basis using a 5% real discount rate, total savings for consumers over the analysis period are more than $360 billion.

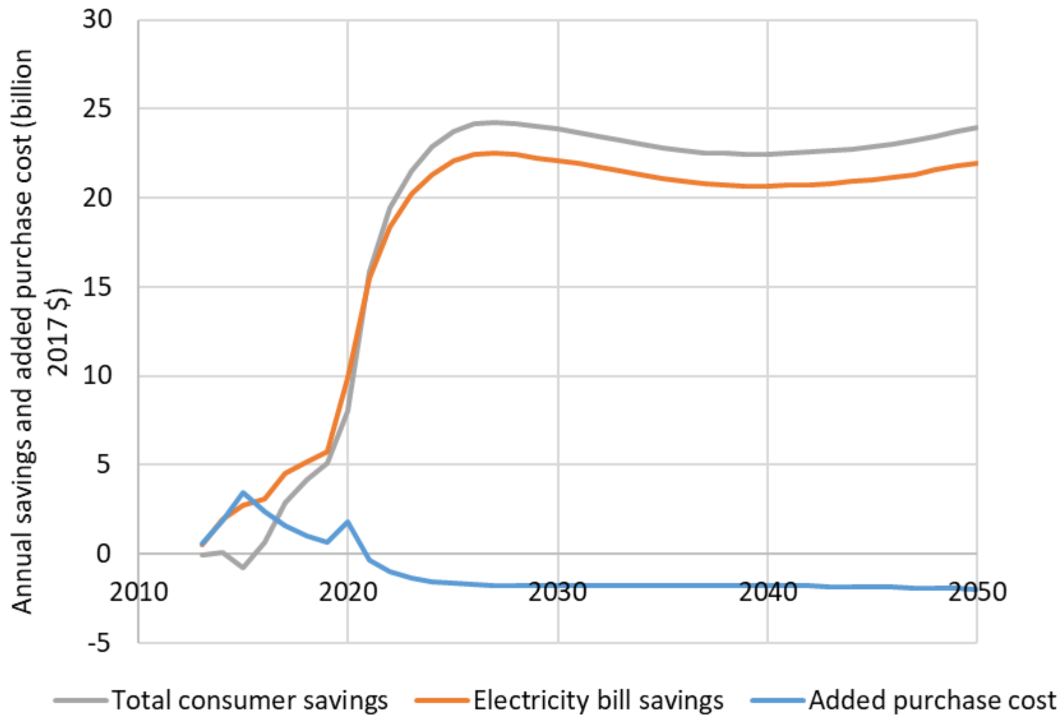

Figure B3. Consumer economic impacts

Appendix C: State-by-state results

This appendix consists of two tables that show electricity and bill savings (aggregate and average household) and emissions reductions in each of the 50 states and the District of Columbia in 2025. Emissions reductions are the result of electricity savings at fossil fuel power plants, but because power is produced regionally, the emissions reductions may occur at a plant outside of a state's borders. In addition, because total NO_x and SO_2 emissions are capped in some areas, the reductions due to the standard may help meet the caps rather than reduce total emissions. Appendix D explains the methodology used for calculating state-level impacts.

Table C1. Annual electricity, electricity bill, and per-household electricity bill savings in 2025

	Annual savings in 2025								
	Electricity (GWh)			Electricity bills (million 2017$)			Per-household electricity bills (2017$)		
	Stage 1	Stage 2	Total	Stage 1	Stage 2	Total	Stage 1	Stage 2	Total
Alabama	791	1,440	2,231	101	184	285	55	95	149
Alaska	107	197	303	24	44	67	96	165	261
Arizona	1,046	1,890	2,936	130	233	363	53	92	145
Arkansas	488	888	1,376	60	108	168	53	91	143
California	5,470	9,961	15,432	1,207	2,180	3,387	94	163	257
Colorado	876	1,572	2,448	101	180	281	49	85	134
Connecticut	579	1,053	1,632	121	219	341	90	155	245
Delaware	149	272	420	25	45	70	72	124	196
District of Columbia	118	233	351	18	35	53	66	113	179
Florida	3,158	5,793	8,950	386	699	1,085	52	90	142
Georgia	1,543	2,831	4,374	190	345	534	52	91	143
Hawaii	193	347	540	58	105	163	129	224	353
Idaho	255	458	712	24	43	68	41	71	111
Illinois	2,051	3,758	5,809	314	565	880	65	113	179
Indiana	1,074	1,957	3,031	155	279	434	62	106	168
Iowa	531	958	1,488	62	111	173	50	86	136
Kansas	477	875	1,352	64	116	180	57	99	156
Kentucky	734	1,330	2,064	73	131	204	42	73	115
Louisiana	739	1,372	2,111	86	158	244	49	86	135
Maine	235	423	659	39	70	109	71	123	193
Maryland	930	1,712	2,642	165	299	464	76	131	207
Massachusetts	1,093	1,996	3,089	218	396	613	85	147	232
Michigan	1,649	3,012	4,661	272	488	759	70	122	192
Minnesota	912	1,654	2,566	113	203	316	53	91	144
Mississippi	469	856	1,326	61	111	172	55	96	151
Missouri	1,013	1,853	2,866	125	227	352	53	91	144
Montana	176	318	495	19	33	52	45	78	123
Nebraska	317	578	895	34	61	94	45	78	123
Nevada	440	788	1,228	48	85	134	47	81	128
New Hampshire	223	403	626	43	77	120	82	142	225
New Jersey	1,365	2,541	3,905	268	489	757	84	145	229
New Mexico	326	588	914	40	72	112	52	91	143
New York	3,103	5,726	8,830	961	1,700	2,661	132	229	361
North Carolina	1,630	2,985	4,615	209	377	587	55	95	150
North Dakota	130	246	377	13	24	37	42	73	116
Ohio	1,965	3,596	5,561	300	541	840	65	113	178
Oklahoma	624	1,156	1,781	74	135	209	51	88	138
Oregon	660	1,210	1,870	68	122	190	44	76	119
Pennsylvania	2,119	3,869	5,988	367	656	1,023	74	128	202
Rhode Island	175	318	493	34	62	96	83	144	228
South Carolina	785	1,434	2,220	116	208	324	63	109	171
South Dakota	142	262	404	16	29	45	48	83	131

Tennessee	1,077	1,972	3,049	106	194	299	42	72	114
Texas	3,968	7,368	11,335	405	749	1,154	44	75	119
Utah	392	711	1,103	42	74	116	45	78	123
Vermont	110	198	308	20	36	56	78	134	212
Virginia	1,320	2,450	3,770	174	316	491	56	98	154
Washington	1,152	2,116	3,268	105	190	295	39	67	106
West Virginia	316	573	889	44	79	123	60	103	163
Wisconsin	987	1,805	2,791	171	309	480	74	128	202
Wyoming	97	179	276	10	19	29	45	79	124
U.S.	**50,277**	**92,080**	**142,357**	**7,879**	**14,209**	**22,088**	**67**	**116**	**183**

Table C2. Annual emissions reductions in 2025

	Annual emissions reductions in 2025								
	NOx (tons)			SO_2 (tons)			CO_2 (thous. MT)		
	Stage 1	Stage 2	Total	Stage 1	Stage 2	Total	Stage 1	Stage 2	Total
Alabama	52	94	146	81	147	228	351	640	991
Alaska	198	364	562	24	44	68	33	61	93
Arizona	437	790	1,227	123	222	344	444	802	1,246
Arkansas	132	241	373	66	120	185	218	397	615
California	492	897	1,389	115	210	326	741	1,350	2,092
Colorado	595	1,068	1,663	95	171	266	492	882	1,374
Connecticut	100	183	283	48	88	136	125	227	352
Delaware	27	50	77	41	74	115	58	106	164
District of Columbia	22	43	65	32	64	96	46	91	137
Florida	1,356	2,487	3,843	303	556	859	1,391	2,552	3,943
Georgia	101	185	286	158	290	447	685	1,258	1,943
Hawaii	312	561	873	342	614	956	93	168	261
Idaho	67	120	187	22	39	61	59	107	166
Illinois	509	933	1,442	1,804	3,304	5,108	1,332	2,441	3,774
Indiana	255	465	720	826	1,505	2,330	661	1,205	1,866
Iowa	296	534	830	144	259	403	270	488	758
Kansas	128	235	364	52	95	146	267	491	758
Kentucky	127	230	357	200	362	562	385	698	1,083
Louisiana	201	372	573	100	185	284	331	614	944
Maine	41	74	114	20	35	55	51	91	142
Maryland	171	315	487	254	467	721	363	669	1,032
Massachusetts	190	347	536	91	166	257	236	431	667
Michigan	311	568	879	949	1,733	2,682	898	1,640	2,537
Minnesota	509	923	1,432	247	447	694	465	843	1,308
Mississippi	83	152	236	74	134	208	218	398	616
Missouri	276	505	780	819	1,497	2,316	684	1,252	1,936
Montana	46	83	130	15	27	42	41	74	115
Nebraska	177	323	500	86	156	242	161	295	456
Nevada	159	285	444	47	83	130	157	280	437
New Hampshire	39	70	109	19	34	52	48	87	135
New Jersey	251	468	719	372	693	1,066	533	993	1,526
New Mexico	136	246	382	38	69	107	138	249	388
New York	472	870	1,342	275	507	782	1,063	1,961	3,024
North Carolina	144	264	408	171	313	484	544	996	1,540
North Dakota	73	137	210	35	67	102	66	125	192
Ohio	467	854	1,320	1,511	2,765	4,276	1,210	2,213	3,423
Oklahoma	243	450	692	132	245	377	293	543	836
Oregon	173	317	490	56	104	160	154	282	436
Pennsylvania	422	770	1,192	873	1,593	2,466	961	1,755	2,716
Rhode Island	30	55	86	15	26	41	38	69	106
South Carolina	69	127	196	82	150	233	262	479	741
South Dakota	79	146	226	39	71	109	73	134	206

Tennessee	187	342	528	293	537	831	565	1,035	1,600
Texas	658	1,222	1,880	453	841	1,294	1,855	3,444	5,299
Utah	103	186	289	34	61	94	91	166	257
Vermont	19	34	53	9	16	26	24	43	66
Virginia	117	217	333	138	257	396	440	818	1,258
Washington	302	554	856	99	181	280	269	493	762
West Virginia	75	136	211	243	441	683	194	353	547
Wisconsin	369	676	1,045	2,228	4,076	6,304	837	1,531	2,367
Wyoming	38	71	109	9	17	26	33	60	93
U.S.	**11,837**	**21,639**	**33,476**	**14,296**	**26,159**	**40,455**	**20,950**	**38,378**	**59,328**

Appendix D: Methodology

We estimated savings from the lamps[4] initially covered by the original Energy Independence and Security Act (EISA) 2007 standards, which are A-type medium screw base lamps ("A-type"), as well as five lamp types covered by the expanded definition (reflector, MR, decorative, globe, and miscellaneous A-type lamps). For the A-type lamps, we estimated savings for the stage 1 and stage 2 standards. For each of the lamp types, we calculated state-by-state annual energy savings and incremental purchase costs, emissions reductions, and electricity bill savings.

Annual energy savings and incremental purchase costs

<u>A-type lamps</u>

For the A-type lamps, because more than 95% are used in the residential sector (DOE 2017a), we calculated savings only for the residential sector. For the stage 1 base case (i.e., absent EISA), we assumed a 70% market share for conventional incandescent lamps and 30% for compact fluorescent lamps (CFLs) based on DOE's analysis of the EISA standards (DOE 2009).[5] CFLs and LEDs are close to interchangeable for savings analysis purposes. Because the average lifetime of CFLs is about five times longer than that of conventional incandescent bulbs, a 30% market share for CFLs results in a base case stock penetration of CFLs of almost 70% by 2020.

For the stage 1 standards case, we used data from the National Electrical Manufacturers Association (NEMA) on the market share of conventional incandescents, halogens, CFLs, and LEDs for 2012-2017 (NEMA 2017). Given the declining market share of CFLs, whose sales are largely being replaced by LEDs, we assumed that beginning in 2020, A-type lamp sales would be evenly split between halogens and LEDs. (Because the average lifetime of LEDs is more than 15 times longer than that of halogens, an even split in market share results in a stock penetration of halogens of less than 10% beginning in 2025.) We assumed linear increases/decreases between 2017 and 2020 for the market shares for halogens, CFLs, and LEDs. For stage 2, the base case is equivalent to the stage 1 standards case. For the stage 2 standards case, we assumed a 100% market share for LEDs beginning in 2020.

To calculate the residential stock of each lamp type in each year, we started with estimates of the stock in 2012, 2014, and 2015 as shown in Table D1.[6]

[4] Lamp is commonly used in the lighting industry to mean light bulb, rather than a lighting fixture. In this methodology, lamp means light bulb.

[5] We note that while it is possible that LEDs may have gained significant market share even absent the stage 1 standards, recent market data show that LEDs are largely replacing CFLs. Because the wattages of CFLs and LEDs are similar (and are both significantly lower than those of conventional incandescent and halogen lamps), incorporating LEDs in the stage 1 base case market share would likely have minimal impact on the results of our analysis.

[6] We estimated the total stock in 2012 and 2014 based on the 2015 stock and the average annual growth in floor space (EIA 2017b).

Table D1. Residential stock of A-type lamps in 2012, 2014, and 2015 by lamp type

Lamp type	2012 stock		2014 stock		2015 stock	
	Lamps (million)	% of total	Lamps (million)	% of total	Lamps (million)	% of total
Conventional incandescent	2,073	61%	905	26%	777	22%
Halogen	136	4%	905	26%	693	20%
CFL	1,156	34%	1,601	46%	1,814	51%
LED	34	1%	70	2%	240	7%
Total	3,399	100%	3,482	100%	3,524	100%

Sources: DOE 2015; DOE 2017a.

We used these stock estimates as estimates of the stock in the standards case. For the base case for 2012 and 2014, we assumed that absent the stage 1 standards, the stock of conventional incandescent lamps would have been equal to the combined stock of conventional incandescent and halogen lamps, and the stock of CFLs would have been equal to the combined stock of CFLs and LEDs. Our base case assumption is likely conservative because sales of CFLs likely increased due to the standards. Therefore, in the absence of the stage 1 standards, the share of conventional incandescents would likely have been higher than what we assume. (We calculated the base case stock in 2015 using the methodology described below for calculating the stock in future years.)

We calculated the number of lamps of each lamp type being replaced each year based on the stock in the previous year and the average lamp lifetime. We also accounted for shipments of lamps going to new construction based on EIA's projections of the average annual growth in residential floor space (EIA 2017a). We calculated the stock of each lamp type in each future year as the sum of replacement shipments, shipments to new construction, and lamps not being replaced (i.e., installed lamps that did not burn out in the previous year).

We calculated total annual energy use in each year based on the stock of each lamp type in each year and the per-unit energy use, and we calculated total purchase costs based on the number of shipments in each year and the purchase price for each lamp type. We calculated per-unit average annual energy use assuming average residential operating hours of 2.3 hours per day (DOE 2016). Table D2 shows our assumptions for each lamp type including average wattage, lifetime, annual energy use, and 2016 purchase price.

Table D2. Assumed average wattage, lifetime, annual energy use, and 2016 purchase price by lamp type

Lamp type	Average wattage (W)[7]	Average lifetime (years)[8]	Average annual energy use (kWh)	Average 2016 purchase price (2017 $)[9]
Conventional incandescent	63.0	1.2	52.9	0.51
Halogen	45.2	1.2	37.9	1.63
CFL	13.7	6.4	11.5	2.04
LED	10.5	19.3	8.8	4.38

Sources: DOE 2017a; DOE 2016; LUMEN Coalition 2011; DOE 2017b; APEX Analytics 2017.

LED prices are declining rapidly, and therefore we incorporated LED price trends developed by Lawrence Berkeley National Laboratory (LBNL) to project future LED prices relative to 2016 prices as shown in Figure A1.

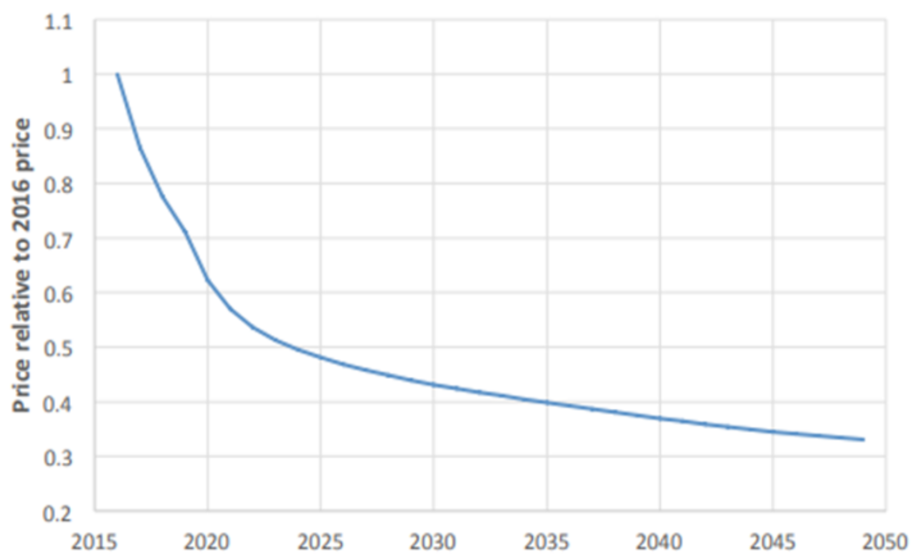

Figure D1. Projected future LED prices relative to 2016 prices. *Source*: Kantner et al. 2017.

We calculated annual energy savings and incremental purchase costs in each year based on the difference in total annual energy use and purchase costs in the base case and the standards case. We allocated national savings and costs to each of the 50 states and the District of Columbia based on the number of households in each state.

[7] We calculated average wattages for halogens, CFLs, and LEDs assuming wattages for 60 W conventional incandescent replacements of 43 W, 13 W, and 10 W, respectively.

[8] For conventional incandescent and halogen lamps, we assumed an average lifetime of 1,000 hours, or 1.2 years based on average annual operating hours of 2.3 hours/day.

[9] For LEDs, the average purchase price is the average of the prices of ENERGY STAR and non-ENERGY STAR LEDs.

Expanded definition lamps

For the five lamp types covered by the expanded definition, we developed the base case distributions of incandescent and LED shipments by lamp category starting with DOE's 2014 LED forecast (DOE 2014).[10] We followed LBNL's methodology of fitting a Bass adoption curve to the LED forecast for each lamp type to describe the LED market penetration in each year of the analysis period (Kantner et al. 2017). We then incorporated LBNL's central estimate of 25% "holdouts" (i.e., that 25% of the stock would remain incandescent (including halogen) in the absence of standards) by adjusting the parameter for maximum market penetration for each Bass adoption curve such that 25% of the stock would be incandescent at the end of the analysis period. (We also calculated savings assuming no holdouts; results are presented in Appendix E.) For the standards case, we assumed 100% market share for LEDs beginning in 2020.

Table D3 shows estimates of the 2015 stock of incandescents (including halogens) and LEDs by lamp category.

Table D3. Stock of expanded definition lamps in 2015 by lamp category and lamp type

Lamp category	2015 stock (million)		
	Incandescent	LED	Total
Reflector	787	10	797
MR	168	2	170
Decorative	1,344	0	1,344
Globe	330	0	330
Misc. A-type	83	0	83
Total	2,712	12	2,724

Sources: Kantner et al. 2017; DOE 2017c.

We assumed that all decorative, globe, and miscellaneous A-type lamps are used in the residential sector. We assumed that 96% of reflector lamps and 77% of MR lamps are used in the residential sector (and that the remaining lamps are used in the commercial sector) based on DOE's 2015 U.S. Lighting Market Characterization (DOE 2017a).

As with the A-type lamps, we calculated the number of expanded definition lamps of each lamp category and type being replaced each year based on the stock in the previous year and the average lamp lifetime. We accounted for shipments of lamps going to new construction based on EIA's projections of the average annual growth in residential and commercial floor space (EIA 2017a). We calculated the stock of each lamp type in each future year as the sum of replacement shipments, shipments to new construction, and lamps not being replaced.

We used assumptions for average annual operating hours, wattage, lifetime, and purchase price from Kantner et al. 2017. We used the LED price forecast shown in Figure A1 to calculate future LED prices relative to 2016 prices. As with the A-type lamps, we calculated annual energy savings and incremental

[10] We followed LBNL's methodology of excluding CFLs from the analysis since CFLs are unaffected by the backstop. CFLs also represent a low percentage of the total stock of expanded definition lamps.

purchase costs for the expanded definition lamps based on the difference in total annual energy use and purchase costs in the base case and the standards case for each lamp category. Finally, we allocated national savings and costs to each of the 50 states and the District of Columbia for lamps used in the residential and commercial sectors based on the number of households and commercial lighting electricity use, respectively.

Emissions reductions and electricity bill savings

We calculated state-by-state CO_2, NOx, and SO_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 2018 *Annual Energy Outlook* and assuming transmission and distribution losses of 5% (EIA 2018a; EIA 2018b). For states that span more than one NERC region, we calculated weighted-average emissions factors based on electricity sales (Kubes, Hayes, and Kelley 2016). Because Alaska and Hawaii are not included in the NERC region data, for these states we used emissions factors from eGRID for 2014 (EPA 2017). For future years we assumed the rate of change of emissions factors for Alaska and Hawaii would be equivalent to the US average.

We calculated electricity bill savings using state-by-state electricity prices for the residential and commercial sectors. We used price projections from EIA's 2018 *Annual Energy Outlook* to calculate electricity prices for each of the NERC regions for each year of the analysis period relative to 2016 prices (EIA 2018a). We then applied these projections for the NERC regions to 2016 state-by-state electricity prices (EIA 2017). 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). For Alaska and Hawaii we assumed the rate of change of electricity prices would be equivalent to the US average.

Appendix E: Alternate scenario for stage 2: What if the market transitions to LEDs on its own at a faster pace than expected?

An important assumption for estimating the impact of the stage 2 light bulb standards is what would happen in the absence of the standards. As explained in the methodology in Appendix D, for the bulbs covered by the expanded definition we assumed that at the end of the analysis period, 25% of sockets would remain filled with incandescent (including halogen) bulbs if there were no standards. For A-type lamps, we assumed a 50%/50% sales split between halogen and LED bulbs in the base case beginning in 2020, which, due to the much longer lifetime of LEDs, results in less than 10% of sockets being filled with halogens beginning in 2025.

We ran an alternate scenario to understand the impact of the stage 2 standards if consumers switched to compliant light bulbs at a greater rate in the base case. In the alternate scenario, we assumed no holdouts, which results in virtually all sockets being filled with LEDs by 2050 even absent the stage 2 standards. (For A-type bulbs, in the alternate scenario virtually all sockets are filled with LEDs by 2025.) The results for this scenario are shown in tables E1 and E2 below, which are similar to tables B1 and B2 in appendix B for the primary scenario.

Table E1. Annual electricity and electricity bill savings in 2020 and 2025 and cumulative savings through 2050 for stage 2 in the alternate scenario

		Annual savings in 2020		Annual savings in 2025		Cumulative savings through 2050	
		Electricity (billion kWh)	Electricity bills (billion 2017 $)	Electricity (billion kWh)	Electricity bills (billion 2017 $)	Electricity (billion kWh)	Electricity bills (billion 2017 $)
Stage 2	A-type	5.9	0.9	1.6	0.3	38	6
	Reflector	9.3	1.3	28.6	4.4	338	53
	MR	0.7	0.1	2.8	0.4	34	5
	Decorative	4.0	0.6	15.1	2.4	156	24
	Globe	0.4	0.1	1.8	0.3	22	3
	Misc. A-type	0.8	0.1	0.4	0.1	7	1
Stage 2 total		**21.1**	**3.0**	**50.4**	**7.9**	**595**	**93**

Table E2. Annual emissions reductions in 2020 and 2025 and cumulative reductions through 2050 for stage 2 in the alternate scenario

		Annual emissions reductions in 2020			Annual emissions reductions in 2025			Cumulative emissions reductions through 2050		
		NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)	NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)	NOx (thous. tons)	SO_2 (thous. tons)	CO_2 (MMT)
Stage 2	A-type	1.5	1.7	2.5	0.4	0.5	0.7	9	11	16
	Reflector	2.4	2.6	4.0	6.7	8.1	11.9	80	101	139
	MR	0.2	0.2	0.3	0.7	0.8	1.2	8	10	14
	Decorative	1.0	1.1	1.7	3.6	4.3	6.3	37	46	64
	Globe	0.1	0.1	0.2	0.4	0.5	0.7	5	6	9
	Misc. A-type	0.2	0.2	0.3	0.1	0.1	0.2	2	2	3
Stage 2 total		**5.4**	**6.0**	**9.1**	**11.9**	**14.3**	**21.0**	**142**	**176**	**245**

Figure E1 shows a comparison of annual electricity bill savings for stage 2 in the primary scenario and the alternate scenario. Annual electricity bill savings in the alternate scenario peak in 2025 at about $8 billion (compared to about $14 billion in the primary scenario). After 2025, annual savings decline at a faster rate in the alternate scenario than the primary scenario because of the faster transition to LEDs in the base case.

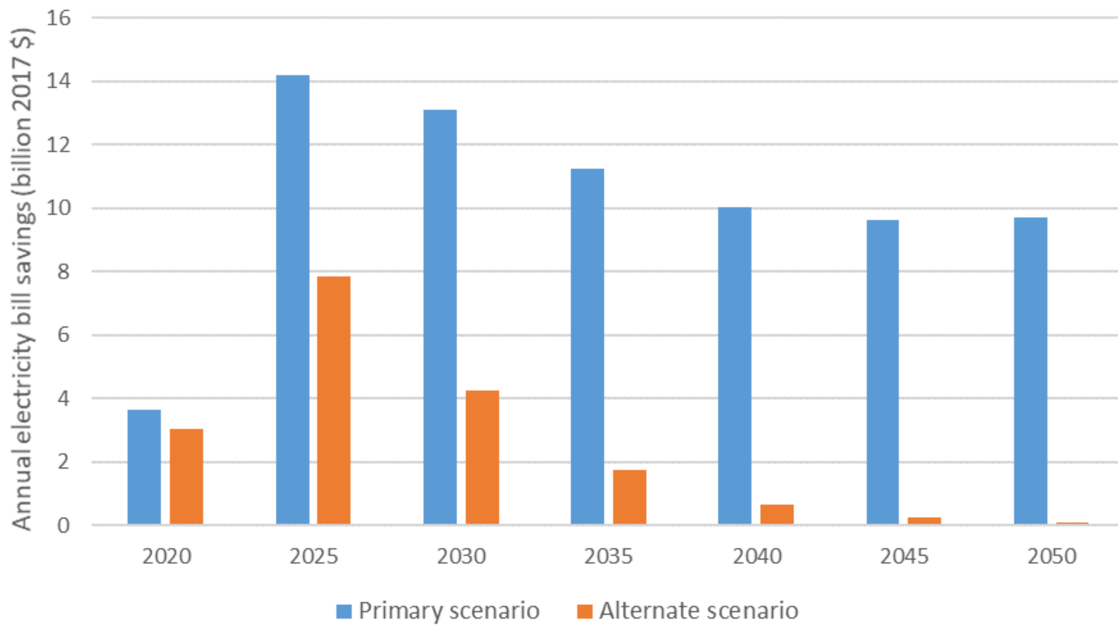

Figure E1. Annual electricity bill savings for stage 2 in the primary and alternate scenarios

The savings for stage 2 in the alternate scenario are less than in the primary scenario but still very large. For example, cumulative consumer bill savings are about $90 billion rather than $340 billion, and cumulative CO_2 savings are 245 MMT rather than 865 MMT. The sheer number of light bulbs in use and affected by the stage 2 standards and the big efficiency difference between incandescent (including halogen) and LED technology mean that even if standards accelerate the transition to LED technology by just a few years, the savings for consumers and the emissions reductions are still extremely large.

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