FEDERAL REGISTER

Vol. 81 Thursday,
No. 52 March 17, 2016

Part II

Department of Energy

10 CFR Parts 429 and 430
Energy Conservation Program: Energy Conservation Standards for General Service Lamps; Proposed Rule

DEPARTMENT OF ENERGY

10 CFR Parts 429 and 430

[Docket Number EERE–2013–BT–STD–0051]

RIN 1904–AD09

Energy Conservation Program: Energy Conservation Standards for General Service Lamps

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Notice of proposed rulemaking (NOPR) and announcement of public meeting.

SUMMARY: The Energy Policy and Conservation Act of 1975 (EPCA), as amended, prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including general service lamps (GSLs). EPCA also requires the U.S. Department of Energy (DOE) to periodically determine whether more-stringent, amended standards would be technologically feasible and economically justified, and would save a significant amount of energy. In this notice, DOE proposes amended energy conservation standards for GSLs, and also announces a public meeting to receive comment on these proposed standards and associated analyses and results.

DATES: *Meeting:* DOE will hold a public meeting on Wednesday, April 20, 2016, from 9:00 a.m. to 4:00 p.m., in Washington, DC. The meeting will also be broadcast as a webinar. See section VIII, ''Public Participation,'' for webinar registration information, participant instructions, and information about the capabilities available to webinar participants.

Comments: DOE will accept comments, data, and information regarding this NOPR before and after the public meeting, but no later than May 16, 2016. See section VIII, ''Public Participation,'' for details.

Comments regarding the likely competitive impact of the proposed standard should be sent to the Department of Justice contact listed in the **ADDRESSES** section before April 18, 2016.

ADDRESSES: The public meeting will be held at the U.S. Department of Energy, Forrestal Building, Room 6E–069, 1000 Independence Avenue SW., Washington, DC 20585. Any foreign national wishing to participate in the meeting should advise DOE as soon as possible by contacting *regina.washington@ee.doe.gov* to initiate the necessary procedures. Please also note that any person wishing to bring a laptop into the Forrestal Building will be required to obtain a property pass. Visitors should avoid bringing laptops, or allow an extra 45 minutes. Persons may also attend the public meeting via webinar.

Instructions: Any comments submitted must identify the NOPR on Energy Conservation Standards for GSLs, and provide docket number EERE–2013–BT–STD–0051 and/or regulatory information number (RIN) 1904–AD09. Comments may be submitted using any of the following methods:

1. *Federal eRulemaking Portal: www.regulations.gov*. Follow the instructions for submitting comments.
2. *Email: GSL2013STD0051@ee.doe.gov*. Include the docket number and/or RIN in the subject line of the message. Submit electronic comments in WordPerfect, Microsoft Word, PDF, or ASCII file format, and avoid the use of special characters or any form of encryption.
3. *Postal Mail:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Office, Mailstop EE–5B, 1000 Independence Avenue SW., Washington, DC 20585–0121. If possible, please submit all items on a compact disc (CD), in which case it is not necessary to include printed copies.
4. *Hand Delivery/Courier:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Office, 950 L'Enfant Plaza SW., Suite 600, Washington, DC 20024. Telephone: (202) 586–2945. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

Written comments regarding the burden-hour estimates or other aspects of the collection-of-information requirements contained in this proposed rule may be submitted to Office of Energy Efficiency and Renewable Energy through the methods listed above and by email to *chad_s_whiteman@omb.eop.gov*.

EPCA requires the Attorney General to provide DOE a written determination of whether the proposed standard is likely to lessen competition. The U.S. Department of Justice Antitrust Division invites input from market participants and other interested persons with views on the likely competitive impact of the proposed standard. Interested persons may contact the Division at *energy.standards@usdoj.gov* before April 18, 2016. Please indicate in the ''Subject'' line of your email the title and Docket Number of this rulemaking notice.

No telefacsimilies (faxes) will be accepted. For detailed instructions on submitting comments and additional information on the rulemaking process, see section VIII of this document (''Public Participation'').

Docket: The docket, which includes **Federal Register** notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov*. All documents in the docket are listed in the *www.regulations.gov* index. However, some documents listed in the index may not be publicly available, such as those containing information that is exempt from public disclosure.

A link to the docket Web page can be found at: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=83*. This Web page contains a link to the docket for this notice on the *www.regulations.gov* site. The *www.regulations.gov* Web page contains simple instructions on how to access all documents, including public comments, in the docket. See section VIII, ''Public Participation,'' for further information on how to submit comments through *www.regulations.gov*.

FOR FURTHER INFORMATION CONTACT: Ms. Lucy deButts, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE–5B, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 287–1604. Email: *gsl@ee.doe.gov*.

Ms. Celia Sher, U.S. Department of Energy, Office of the General Counsel, GC–33, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 287–6122. Email: *celia.sher@hq.doe.gov*.

For further information on how to submit a comment, review other public comments and the docket, or participate in the public meeting, contact Ms. Brenda Edwards at (202) 586–2945 or by email: *brenda.edwards@ee.doe.gov*.

SUPPLEMENTARY INFORMATION: DOE intends to incorporate by reference the following industry standard into 10 CFR part 430:

Underwriter Laboratories 1598C–2014 (''UL 1598C''), Standard for Light-Emitting Diode Retrofit Luminaire Conversion Kits, First Edition, dated January 16, 2014.

Copies of Underwriter Laboratories' Standard for Light-Emitting Diode Retrofit Luminaire Conversion Kits are available from *http://*

ulstandards.ul.com/standards-catalog/ or can be reviewed in person at U.S. Department of Energy, Building Technologies Program, 950 L'Enfant Plaza SW., Suite 600, Washington, DC 20024. See section VII.M for a further discussion of this standard.

Table of Contents

I. Synopsis of the Proposed Rule

Title III, Part B [1] of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (42 U.S.C. 6291–6309, as codified), established the Energy Conservation Program for Consumer Products Other Than Automobiles.[2] These products include general service lamps (GSLs), the subject of this document.

Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Furthermore, the new or amended standard must result in a significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)) EPCA also provides that not later than 6 years after issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a notice of proposed rulemaking (NOPR) including new proposed energy conservation standards. (42 U.S.C. 6295(m)(1))

In accordance with these and other statutory provisions discussed in this document, DOE proposes new and amended energy conservation standards for GSLs. The proposed standards, which are expressed in minimum lumen (lm) output per watt (W) of a lamp, are shown in Table I–1. These proposed standards, if adopted, would apply to all GSLs listed in Table I–1 and manufactured in, or imported into, the United States on and after the date three years after the publication of the final rule for this rulemaking. Table I–1 shows the efficacy levels proposed for the Integrated Low-Lumen, Integrated Low-Lumen Standby-Mode Functionality, Integrated High-Lumen, Integrated High-Lumen Standby-Mode Functionality, and Non-Integrated product classes.

TABLE I–1—PROPOSED ENERGY CONSERVATION STANDARDS FOR GENERAL SERVICE LAMPS

Product class	Trial standard level	DOE proposed efficacy level	Efficacy * (lm/W)	
			No standby mode	Capable of operating in standby mode
Integrated ** Low-Lumen (310 ≤ Initial Lumen Output <2,000).	TSL 3	EL 3	101.6 − 29.42 * 0.9983^Initial Lumen Output.	96.0 − 29.42 * 0.9983^Initial Lumen Output.
Integrated ** High-Lumen (2,000 ≤ Initial Lumen Output ≤2,600).	TSL 3	EL 2	73.4 − 29.42 * 0.9983^Initial Lumen Output.	70.5 − 29.42 * 0.9983^Initial Lumen Output.
Non-Integrated † (310 ≤ Initial Lumen Output ≤2,600 lumens).	TSL 3	EL 0	N/A	N/A.

* See chapter 5 of the NOPR technical support document for plots of the efficacy curves.

** Integrated lamp means a lamp that contains all components necessary for the starting and stable operation of the lamp, does not include any replaceable or interchangeable parts, and is connected directly to a branch circuit through an ANSI base and corresponding ANSI standard lamp-holder (socket).

† Non-integrated lamp means a lamp that is not an integrated lamp.

A. Benefits and Costs to Consumers

Table I–2 presents DOE's evaluation of the economic impacts of the proposed standards on consumers of GSLs, as measured by the average life-cycle cost (LCC) savings and the simple payback period (PBP).[3] The average LCC savings are positive for all product classes at all TSL levels analyzed.

[1] For editorial reasons, upon codification in the U.S. Code, Part B was redesignated Part A.

[2] All references to EPCA in this document refer to the statute as amended through the the Energy Efficiency Improvement Act of 2015, Public Law 114–11 (Apr. 30, 2015).

[3] The average LCC savings are measured relative to the efficacy distribution in the no-new-standards case, which depicts the market in the compliance year in the absence of standards (see section IV.F.9). The simple PBP, which is designed to compare specific ELs, is measured relative to the baseline model (see section IV.C.1.a).

TABLE I–2—IMPACTS OF PROPOSED ENERGY CONSERVATION STANDARDS ON CONSUMERS OF GENERAL SERVICE LAMPS (TSL 3)

Product class	Average LCC savings (2014$)	Simple payback period (years)
Residential Sector		
Integrated Low-Lumen	0.75	2.14
Integrated High-Lumen	0.96	3.86
Commercial Sector		
Integrated Low-Lumen	1.32	0.70
Integrated High-Lumen	2.02	1.23
Non-Integrated	0	—

DOE's analysis of the impacts of the proposed standards on consumers is described in section V.F of this proposed rule.

B. Impact on Manufacturers

The industry net present value (INPV) is the sum of the discounted cash flows to the industry from the reference year through the end of the analysis period (2015 to 2049). Using a real discount rate of 6.1 percent, DOE estimates that the INPV for manufacturers of GSLs in the case without new and amended standards is $911.0 million in 2014$. Under the proposed standards, DOE expects that manufacturers may lose up to 24.3 percent of this INPV, which is approximately $221.0 million. Additionally, based on DOE's interviews with the manufacturers of GSLs, DOE does not expect significant impacts on manufacturing capacity or loss of employment for the industry as a whole to result from the proposed standards for GSLs.

DOE's analysis of the impacts of the proposed standards on manufacturers is described in section V.J of this document.

C. National Benefits and Costs [4]

DOE's analyses indicate that the proposed energy conservation standards for GSLs would save a significant amount of energy. Relative to the case where no new or amended energy conservation standard is set (hereinafter referred to as the ''no-new-standards case''), the lifetime energy savings for GSLs purchased in the 30-year period that begins in the anticipated year of compliance with the new or amended standards (2020–2049) amount to 0.85 quadrillion Btu (quads).[5] This represents a savings of 16 percent relative to the energy use of these products in the no-new-standards case.

The cumulative net present value (NPV) of total consumer costs and savings of the proposed standards for GSLs ranges from $4.4 billion (at a 7-percent discount rate) to $9.1 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product and installation costs (only for the commercial sector) for GSLs purchased in 2020–2049.

In addition, the proposed standards for GSLs would have significant environmental benefits. DOE estimates that the proposed standards would result in cumulative emission reductions (over the same period as for energy savings) of 52 million metric tons (Mt) [6] of carbon dioxide (CO_2), 31 thousand tons of sulfur dioxide (SO_2), 91.5 thousand tons of nitrogen oxides (NO_X), 215 thousand tons of methane (CH_4), 0.64 thousand tons of nitrous oxide (N_2O), and 0.11 tons of mercury (Hg).[7] The cumulative reduction in CO_2 emissions through 2030 amounts to 14.5 Mt, which is equivalent to the emissions resulting from the annual electricity use of 1.3 million homes.

The value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 (otherwise known as the social cost of carbon, or SCC) developed by a recent federal interagency process.[8] The derivation of the SCC values is discussed in section V.L. Using discount rates appropriate for each set of SCC values (see Table I–3), DOE estimates the present monetary value of the CO_2 emissions reduction (not including CO_2 equivalent emissions of other gases with global warming potential) is between $0.362 billion and $5 billion, with a value of $1.6 billion using the central SCC case represented by $40.0/t in 2015. DOE also estimates the present monetary value of the NO_X emissions reduction to be $0.1 billion at a 7-percent discount rate and $0.3 billion at a 3-percent discount rate.[9]

[4] All monetary values in this section are expressed in 2014 dollars and, where appropriate, are discounted to 2015 unless explicitly stated otherwise. Energy savings in this section refer to the full-fuel-cycle savings (see section IV.H for discussion).

[5] A quad is equal to 10^{15} British thermal units (Btu). The quantity refers to full-fuel-cycle (FFC) energy savings. FFC energy savings includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and, thus, presents a more complete picture of the impacts of energy efficiency standards. For more information on the FFC metric, see section V.H.1.

[6] A metric ton is equivalent to 1.1 short tons. Results for emissions other than CO_2 are presented in short tons.

[7] DOE calculated emissions reductions relative to the no-new-standards case, which reflects key assumptions in the *Annual Energy Outlook 2015* (*AEO 2015*) Reference case. *AEO 2015* generally represents current legislation and environmental regulations for which implementing regulations were available as of October 31, 2014.

[8] *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* Interagency Working Group on Social Cost of Carbon, United States Government (May 2013; May 2013; revised July 2015) (Available at: *https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.*

[9] DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, ''Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,'' published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) See section V.L.2 for further discussion. Note that the agency is presenting a national benefit-per-ton estimate for particulate matter emitted from the Electricity Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional

Continued

Table I–3 summarizes the national economic benefits and costs expected to result from the proposed standards for GSLs.

TABLE I–3—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GENERAL SERVICE LAMPS (TSL 3) *

Category	Present value (Billion 2014$)	Discount rate (%)
Benefits		
Consumer Operating-Cost Savings	3.5	7
	7.6	3
CO_2 Reduction Monetized Value ($12.2/t case) **	0.4	5
CO_2 Reduction Monetized Value ($40.0/t case) **	1.6	3
CO_2 Reduction Monetized Value ($62.3/t case) **	2.6	2.5
CO_2 Reduction Monetized Value ($117/t case) **	5.0	3
NO_X Reduction Monetized Value †	0.1	7
	0.3	3
Total Benefits ††	5.3	7
	9.6	3
Costs		
Consumer Incremental Installed Costs ‡	−0.9	7
	−1.4	3
Total Net Benefits		
Including CO_2 and NO_X Reduction Monetized Value ††	6.2	7
	11.0	3

* This table presents the costs and benefits associated with GSLs shipped in 2020–2049. These results include benefits to consumers which accrue after 2049 from the products purchased in 2020–2049. The costs account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5-percent, 3-percent, and 2.5-percent discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3-percent discount rate. The SCC time series incorporate an escalation factor. The value for NO_X is the average of high and low values found in the literature.

† The $/ton values used for NO_X are described in section V.L. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, "Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants," published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.)* See section V.L.2 for further discussion. Note that the agency is presenting a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3-percent and 7-percent cases are derived using the series corresponding to average SCC with 3-percent discount rate ($40.0/t case).

‡ This reduction in product costs occurs because (1) more efficacious lamps have longer average lifetimes than less efficacious lamps, resulting in fewer replacement purchases, (2) the purchase price of more efficacious LED lamps is lower than the price of less efficacious LED lamps, and (3) the purchase price of LED lamps declines faster than the price of CFLs during the analysis period, resulting in LED lamps becoming less expensive than CFLs.

The benefits and costs of the proposed standards, for GSLs sold in 2020–2049, can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are the sum of: (1) The national economic value of the benefits in reduced operating costs, minus (2) the increase in product purchase prices and installation costs, plus (3) the value of the benefits of CO_2 and NO_X emission reductions, all annualized.[10]

Although DOE believes that the values of operating-cost savings and CO_2 emission reductions are both important, two issues are relevant. First, the national operating savings are domestic U.S. consumer monetary savings that occur as a result of market transactions, whereas the value of CO_2 reductions is based on a global value. Second, the assessments of operating-cost savings and CO_2 savings are performed with different methods that use different time frames for analysis. The national operating-cost savings is measured for the lifetime of GSLs shipped in 2020–2049. Because CO_2 emissions have a very long residence time in the atmosphere,[11] the SCC values in future years reflect future CO_2-emissions impacts that continue beyond 2100.

Estimates of annualized benefits and costs of the proposed standards are

approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule. Note that DOE is currently investigating valuation of avoided SO_2 and Hg emissions.

[10] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2015, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (*e.g.,* 2020 or 2030), and then discounted the present value from each year to 2015. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates, as shown in Table I–3. Using the present value, DOE then calculated the fixed annual payment over a 30-year period, starting in the compliance year, that yields the same present value.

[11] The atmospheric lifetime of CO_2 is estimated of the order of 30–95 years. Jacobson, MZ (2005), "Correction to 'Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming,' " *J. Geophys. Res.* 110. pp. D14105.

shown in Table I–4. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction (for which DOE used a 3-percent discount rate along with the average SCC series that has a value of $40.0/t in 2015),[12] the estimated cost of the standards proposed in this rule is $−93 million per year in increased equipment costs, while the estimated annual benefits are $373 million in reduced equipment operating costs, $95 million in CO_2 reductions, and $13.6 million in reduced NO_X emissions. In this case, the net benefit amounts to $574 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series that has a value of $40.0/t in 2015, the estimated cost of the proposed standards is $−82 million per year in increased equipment costs, while the estimated annual benefits are $438 million in reduced operating costs, $95 million in CO_2 reductions, and $17.2 million in reduced NO_X emissions. In this case, the net benefit amounts to $632 million per year.

TABLE I–4—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GENERAL SERVICE LAMPS (TSL 3)

	Discount rate	(Million 2014$/year)		
		Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Benefits				
Consumer Operating-Cost Savings	7%	373	334	404.
	3%	438	386	481.
CO_2 Reduction Value ($12.2/t case) **	5%	29	26	31.
CO_2 Reduction Value ($40.0/t case) **	3%	95	86	101.
CO_2 Reduction Value ($62.3/t case) **	2.5%	138	125	148.
CO_2 Reduction Value ($117/t case) **	3%	287	262	308.
NO_X Reduction Monetized Value†	7%	13.6	12.6	32.2.
	3%	17.2	15.8	41.1.
Total Benefits ††	7% plus CO_2 range	415 to 674	373 to 608	467 to 744.
	7%	481	433	537.
	3% plus CO_2 range	483 to 742	428 to 663	552 to 829.
	3%	549	488	623.
Costs				
Consumer Incremental Installed Product Costs ‡	7%	−93	−81	−105.
	3%	−82	−70	−95.
Net Benefits				
Total ††	7% plus CO_2 range	508 to 767	453 to 689	571 to 849.
	7%	574	513	642.
	3% plus CO_2 range	566 to 824	498 to 733	647 to 924.
	3%	632	558	718.

* This table presents the annualized costs and benefits associated with GSLs shipped in 2020–2049. These results include benefits to consumers which accrue after 2049 from the products purchased in 2020–2049. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The primary estimate assumes the reference case electricity prices and floorspace growth projections from the *Annual Energy Outlook (AEO) 2015* and decreasing product prices for both compact fluorescent lamps (CFLs) and LED GSLs, due to price learning. The Low Benefits Estimate uses the Low Economic Growth electricity prices and floorspace growth from *AEO 2015* and a faster decrease in product prices for LED GSLs. The High Benefits Estimate uses the High Economic Growth electricity prices and floorspace growth from *AEO 2015* and a slower decrease in product prices for LED GSLs. The methods used to derive projected price trends are explained in section V.G.1.b.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5-percent, 3-percent, and 2.5-percent discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3-percent discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section V.L. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, "Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants," published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) See section V.L.2 for further discussion. For DOE's Primary Estimate and Low Net Benefits Estimate, the agency is presenting a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3-percent and 7-percent cases are derived using the series corresponding to the average SCC with a 3-percent discount rate ($40.0/t case). In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

‡ This reduction in product costs occurs because (1) more efficacious lamps have longer average lifetimes than less efficacious lamps, resulting in fewer replacement purchases, (2) the purchase price of more efficacious LED lamps is lower than the price of less efficacious LED lamps, and (3) the purchase price of LED lamps declines faster than the price of CFLs during the analysis period, resulting in LED lamps becoming less expensive than CFLs.

[12] DOE used a 3-percent discount rate because the SCC values for the series used in the calculation were derived using a 3-percent discount rate (see section V.L.).

DOE's analysis of the national impacts of the proposed standards is described in sections V.H, V.J.1 and V.L of this NOPR. In addition to the national impacts described previously in this section, lamps that meet the expanded GSL definition proposed in this rulemaking would be subject to the 45 lm/W efficacy level starting in 2020 as specified by the EISA 2007 backstop provision. It is estimated that the impact of the EISA 2007 backstop on such lamps, excluding those included in the scope of coverage of this rulemaking, would bring about energy savings of approximately 3 quads for lamps sold in 2020–2049 and a carbon reduction of approximately 200 million metric tons by 2030.[13]

D. Conclusion

DOE has tentatively concluded that the proposed standards represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy. DOE further notes that products achieving these standard levels are already commercially available for all product classes covered by this proposal. Based on the analyses described above, DOE has tentatively concluded that the benefits of the proposed standards to the Nation (energy savings, positive NPV of consumer benefits, consumer LCC savings, and emission reductions) would outweigh the burdens (loss of INPV for manufacturers and LCC increases for some consumers).

DOE also considered more-stringent and less-stringent energy efficacy levels as potential standards, and is still considering them in this rulemaking. However, DOE has tentatively concluded that the potential burdens of the more-stringent energy efficacy levels would outweigh the projected benefits. Based on consideration of the public comments DOE receives in response to this notice and related information collected and analyzed during the course of this rulemaking effort, DOE may adopt energy efficacy levels presented in this notice that are either higher or lower than the proposed standards, or some combination of level(s) that incorporate the proposed standards in part.

[13] Meyers, S., A. Williams, P. Chan, and S. Price. *Energy and Economic Impacts of U.S. Federal Energy and Water Conservation Standards Adopted From 1987 Through 2014.* 2015. Lawrence Berkeley National Laboratory: Berkeley, CA. Report No. LBNL–6964E. (Last accessed January 20, 2016.) *http://eetd.lbl.gov/sites/all/files/lbnl-6964e.pdf.*

II. Introduction

The following section briefly discusses the statutory authority underlying this proposed rule, as well as some of the relevant historical background related to the establishment of standards for GSLs.

A. Authority

Title III, Part B of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles, a program covering most major household appliances.[14] Subsequent amendments expanded Title III of EPCA to include additional consumer products, including GSLs—the products that are the focus of this NOPR. In particular, amendments to EPCA in the Energy Independence and Security Act of 2007 (EISA) directed DOE to conduct two rulemaking cycles to evaluate energy conservation standards for GSLs. (42 U.S.C. 6295(i)(6)(A)-(B))

For the first rulemaking cycle, EPCA, as amended by EISA, directs DOE to initiate a rulemaking no later than January 1, 2014, to evaluate standards for GSLs and determine whether exemptions for certain incandescent lamps should be maintained or discontinued. (42 U.S.C. 6295(i)(6)(A)(i)) The scope of the rulemaking is not limited to incandescent lamp technologies. (42 U.S.C. 6295(i)(6)(A)(ii)) Further, for this first cycle of rulemaking, the EISA amendments provide that DOE must consider a minimum standard of 45 lumens per watt (lm/W). (42 U.S.C. 6295(i)(6)(A)(ii)) If DOE fails to meet the requirements of 42 U.S.C. 6295(i)(6)(A)(i)-(iv) or the final rule from the first rulemaking cycle does not produce savings greater than or equal to the savings from a minimum efficacy standard of 45 lm/W, sales of GSLs that do not meet the minimum 45 lm/W standard beginning on January 1, 2020, will be prohibited. (42 U.S.C. 6295(i)(6)(A)(v))

The EISA-prescribed amendments further directed DOE to initiate a second rulemaking cycle by January 1, 2020, to determine whether standards in effect for general service incandescent lamps (GSILs) should be amended with more-stringent requirements and if the exemptions for certain incandescent lamps should be maintained or discontinued. (42 U.S.C. 6295(i)(6)(B)(i)) For this second review of energy conservation standards, the scope is not limited to incandescent lamp technologies. (42 U.S.C. 6295(i)(6)(B)(ii))

[14] Part B was re-designated Part A on codification in the U.S. Code for editorial reasons.

Pursuant to EPCA, DOE's energy conservation program for covered products consists essentially of four parts: (1) Testing; (2) labeling; (3) the establishment of federal energy conservation standards; and (4) certification and enforcement procedures. The Federal Trade Commission (FTC) is primarily responsible for labeling, and DOE implements the remainder of the program. Subject to certain criteria and conditions, DOE is required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each covered product. (42 U.S.C. 6295(o)(3)(A) and (r)) Manufacturers of covered products must use the prescribed DOE test procedure as the basis for certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of those products. (42 U.S.C. 6293(c) and 6295(s)) Similarly, DOE must use these test procedures to determine whether the products comply with standards adopted pursuant to EPCA. (42 U.S.C. 6295(s)) The DOE test procedures for GSILs are set forth at title 10 of the Code of Federal Regulations (CFR), part 430, subpart B, appendix R, and test procedures for medium base compact fluorescent lamps (MBCFLs) are set forth at 10 CFR part 430, subpart B, appendix W. The term GSL includes these lamps and others including, compact fluorescent lamps (CFLs), general service light-emitting diode (LED) lamps, organic light-emitting diode (OLED) lamps, and any other lamps that the Secretary determines are used to satisfy lighting applications traditionally served by GSILs. 10 CFR 430.2 DOE has initiated test procedures for integrated LED lamps and compact fluorescent lamps, which includes integrated and non-integrated CFLs. EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6293)

DOE must follow specific statutory criteria for prescribing new or amended standards for covered products, including GSLs. Any new or amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and (3)(B)) Furthermore, DOE may not adopt any standard that would not result in the significant conservation of energy. (42 U.S.C. 6295(o)(3)) Moreover, DOE may not prescribe a standard: (1) For certain products, including GSLs, if no test procedure has been established for the product, or (2) if DOE determines by rule that the standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)–(B)) In deciding whether a proposed standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i)) DOE must make this determination after receiving comments on the proposed standard, and by considering, to the greatest extent practicable, the following seven statutory factors:

(1) The economic impact of the standard on manufacturers and consumers of the products subject to the standard;

(2) The savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered products that are likely to result from the standard;

(3) The total projected amount of energy (or as applicable, water) savings likely to result directly from the standard;

(4) Any lessening of the utility or the performance of the covered products likely to result from the standard;

(5) The impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the standard;

(6) The need for national energy and water conservation; and

(7) Other factors the Secretary of Energy (Secretary) considers relevant.

(42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

Further, EPCA, as codified, establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii))

EPCA, as codified, also contains what is known as an ''anti-backsliding'' provision, which prevents the Secretary from prescribing any amended standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product. (42 U.S.C. 6295(o)(1)) Also, the Secretary may not prescribe an amended or new standard if interested persons have established by a preponderance of the evidence that the standard is likely to result in the unavailability in the United States in any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States. (42 U.S.C. 6295(o)(4))

Additionally, 42 U.S.C. 6295(q)(1) specifies requirements when promulgating an energy conservation standard for a covered product that has two or more subcategories. DOE must specify a different standard level for a type or class of product that has the same function or intended use, if DOE determines that products within such group: (A) Consume a different kind of energy from that consumed by other covered products within such type (or class); or (B) have a capacity or other performance-related feature which other products within such type (or class) do not have and such feature justifies a higher or lower standard. (42 U.S.C. 6295(q)(1)) In determining whether a performance-related feature justifies a different standard for a group of products, DOE must consider such factors as the utility to the consumer of the feature and other factors DOE deems appropriate. Id. Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 6295(q)(2))

Federal energy conservation requirements generally supersede state laws or regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297(a)–(c)) DOE may, however, grant waivers of federal preemption for particular state laws or regulations, in accordance with the procedures and other provisions set forth under 42 U.S.C. 6297(d)).

Finally, pursuant to the amendments contained in EISA 2007, any final rule for new or amended energy conservation standards promulgated after July 1, 2010, is required to address standby-mode and off-mode energy use. (42 U.S.C. 6295(gg)(3)) Specifically, when DOE adopts a standard for a covered product after that date, it must, if justified by the criteria for adoption of standards under EPCA (42 U.S.C. 6295(o)), incorporate standby-mode and off-mode energy use into a single standard, or, if that is not feasible, adopt a separate standard for such energy use for that product. (42 U.S.C. 6295(gg)(3)(A)–(B)) DOE determined that it is not possible for GSLs included in the scope of this rulemaking to meet the off-mode criteria because there is no condition in which a GSL connected to main power is not already in a mode accounted for in either active or standby mode. DOE notes the existence of a small number of commercially available GSLs that operate in standby mode. DOE discusses GSLs that operate in standby mode in further detail in sections III.B.1 and V.A.1. DOE's test procedures under development for LED lamps and CFLs address standby mode energy use. In this rulemaking, DOE intends to incorporate such energy use into any amended energy conservation standards it adopts in the final rule.

The Natural Resource Defense Council, Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, Alliance to Save Energy, Consumer Federation of America, National Consumer Law Center, Northeast Energy Efficiency Partnerships, Northwest Energy Efficiency Alliance, and Northwest Power and Conservation Council (hereafter the ''Energy Efficiency Advocates'' or the ''EEAs'') jointly commented that initial test results by DOE's Commercially Available LED Product Evaluation and Reporting (CALiPER) testing program showed instances where manufacturers were exaggerating equivalency claims when making comparisons between more efficacious technologies and conventional incandescent lamps. In order to help consumers make well informed purchasing decisions, EEAs recommended DOE work closely with the FTC to establish minimum equivalency levels in this rulemaking in which manufacturers who claim that a 10 W LED lamp replaces a 60 W incandescent lamp should be required to comply with the corresponding lumen output levels contained in a table established by FTC and DOE. They recommended DOE consider ENERGY STAR®'s lumen equivalency table in its Lamps Specification as a starting point. (EEAs, No. 32 at pp. 13–14) [15] DOE notes that for these consumer products, the FTC is responsible for implementing and enforcing labeling requirements. (*See* 42 U.S.C. 6294) Such requirements are outside the scope of this rulemaking. However, DOE understands concerns regarding potentially incorrect lumen equivalency claims of covered products, and DOE will continue to work with FTC on labeling issues.

[15] A notation in this form provides a reference for information that is in the docket of DOE's rulemaking to develop energy conservation standards for GSLs (Docket No. EERE–2013–BT–STD–0051), which is maintained at *www.regulations.gov*. This notation indicates that the statement preceding the reference was made by EEAs, is from document number 32 in the docket, and appears at pages 13–14 of that document.

B. Background

1. Current Standards

This is the first cycle of energy conservation standards rulemakings for GSLs. Of the lamps covered by this rulemaking, only GSILs, modified spectrum GSILs, intermediate base incandescent lamp, candelabra base incandescent lamp, and MBCFLs have existing standards.

The Consolidated and Further Continuing Appropriations Act, 2015 (Publ. L. 113–235, Dec. 16, 2014; hereafter referred to as the ''Appropriations Rider''), in relevant part, restricts the use of appropriated funds in connection with several aspects of DOE's incandescent lamps energy conservation standards program. Specifically, section 313 states that none of the funds made available by the Act may be used to implement or enforce standards for GSILs, intermediate base incandescent lamps, and candelabra base incandescent lamps.[16]

The current standards for GSILs are summarized in Table II–1. In addition GSILs are required to have a coloring redering index (CRI) greater than or equal to 80. 10 CFR 430.32(x)(1). These standards for GSILs are currently subject to the Appropriations Rider.

TABLE II–1—EXISTING EFFICACY STANDARDS FOR GSILS

Rated lumen ranges	Maximum rate wattage	Minimum rate lifetime (hrs)	Effective date
1490–2600	72	1,000	1/1/2012
1050–1489	53	1,000	1/1/2013
750–1049	43	1,000	1/1/2014
310–749	29	1,000	1/1/2014

The current standards for modified spectrum GSILs are shown in Table II–2. In addition, modified spectrum GSILs are required to have a color rendering index greater than or equal to 75. 10 CFR 430.32(x)(1) These standards for modified spectrum GSILs are currently subject to the Appropriations Rider.

TABLE II–2—EXISTING EFFICACY STANDARDS FOR MODIFIED SPECTRUM GSILS

Rated lumen ranges	Maximum rate wattage	Minimum rate lifetime (hrs)	Effective date
1118–1950	72	1,000	1/1/2012
788–1117	53	1,000	1/1/2013
563–787	43	1,000	1/1/2014
232–562	29	1,000	1/1/2014

Current standards require that candelabra base incandescent lamps not exceed 60 rated watts and intermediate base incandescent lamps not exceed 40 rated watts. 10 CFR 430.32(x)(2)–(3) These standards for candelabra base incandescent lamp and intermediate base incandescent lamp are subject to the Appropriations Rider.

The current standards for MBCFLs are summarized in Table II–3. 10 CFR 430.32(u)

TABLE II–3—EXISTING EFFICACY STANDARDS FOR MBCFLS

Lamp configuration	Lamp power (W)	Minimum efficacy (lm/W)
Bare lamp	Lamp power <15	45.0.
	Lamp power ≥15	60.0.
Covered lamp, no reflector	Lamp power <15	40.0.
	15 ≥ lamp power <19	48.0.
	19 ≥ lamp power <25	50.0.
	Lamp power ≥25	55.0.
Lumen Maintenance at 1,000 Hours.	The average of at least 5 lamps must be a minimum 90% of initial (100-hour) lumen output at 1,000 hours of rated life.	
Lumen Maintenance at 40% of Rated Lifetime.	80% of initial (100-hour) rating (per ANSI C78.5 Clause 4.10).	
Rapid Cycle Stress Test	Per ANSI C78.5 and IESNA LM65 (clauses 2,3,5, and 6) exception: cycle times must be 5 minutes on, 5 minutes off. Lamp will be cycled once for every two hours of rated life. At least 5 lamps must meet or exceed the minimum number of cycles.	
Lamp Life	≥6,000 hours as declared by the manufacturer on packaging. ≤50% of the tested lamps failed at rated lifetime. At 80% of rated life, statistical methods may be used to confirm lifetime claims based on sample performance.	

[16] Public Law 113–235, Section 313 provides: ''None of the funds made available in this Act may be used—(1) to implement or enforce section 430.32(x) of title 10, Code of Federal Regulations; or (2) to implement or enforce the standards established by the tables contained in section 325(i)(1)(B) of the Energy Policy and Conservation Act (42 U.S.C. 6295(i)(1)(B)) with respect to BPAR incandescent reflector lamps, BR incandescent reflector lamps, and ER incandescent reflector lamps.

2. History of Standards Rulemaking for GSLs

DOE published notices in the **Federal Register** announcing the availability of the framework document and preliminary analysis, respectively. 78 FR 73737 (Dec. 9, 2013); 79 FR 73503 (Dec. 11, 2014). This NOPR is the next step of DOE's first cycle of review to evaluate standards for GSLs and whether the standards should apply to additional GSL types. (42 U.S.C. 6295(i)(A)) Additionally, this rulemaking satisfies the requirements under 42 U.S.C 6295(m)(1) for DOE to review the existing standards for MBCFLs, as CFLs are included in the definition of GSL. It also addresses 42 U.S.C. 6295(gg)(3) in which DOE is directed to incorporate standby-mode and off-mode energy use in any amended (or new) standard adopted after July 1, 2010, pursuant to 42 U.S.C. 6295(o).

Additionally, DOE is conducting a rulemaking setting energy conservation standards for ceiling fan light kits (hereafter the ''CFLK rulemaking''). The rulemaking published a NOPR proposing an efficacy standard for the lamps packaged with CFLKs. 80 FR 48624 (August 13, 2015). The California Energy Commission (CEC) asked DOE to consider incorporating CFLK standards in this GSL rulemaking because current CFLKs standards are strongly related to GSLs. (CEC, No. 31 at p. 2). While DOE acknowledges that certain GSLs are packaged with CFLKs, EPCA addresses CFLKs as a separate covered product. Moreover, CFLK standards apply to light kits packaged with lamps and GSL standards apply to individual lamps. Because of the statutory treatment of CFLKs and the difference in product type, market structure, and manufacturers, DOE declines to combine the CFLK and GSL rulemakings in this proposal.

III. General Discussion

DOE developed this proposal after considering verbal and written comments, data, and information from interested parties that represent a variety of interests. The following discussion addresses issues raised by these commenters.

A. Product Classes and Scope of Coverage

The term, general service lamp, includes GSILs, CFLs, general service LED lamps, OLED lamps, and any other lamps that the Secretary determines are used to satisfy lighting applications traditionally served by GSILs; however, this definition does not apply to any lighting application or bulb shape excluded from the ''general service incandescent lamp'' definition, or any general service fluorescent lamp or incandescent reflector lamp. (*See* 42 U.S.C. 6291(30)(BB)) section IV covers the comments and discussion on each part of this definition to clearly define the scope of this rulemaking.

When evaluating and establishing energy conservation standards, DOE divides covered products into product classes by the type of energy used or by capacity or other performance-related features that justify differing standards. In making a determination whether a performance-related feature justifies a different standard, DOE must consider such factors as the utility of the feature to the consumer and other factors DOE determines are appropriate. (42 U.S.C. 6295(q)) For further details on product classes, see section V.A.1 and chapter 3 of the NOPR technical support document (TSD).

B. Test Procedure

EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6293) Manufacturers of covered products must use these test procedures to certify to DOE that their product complies with EPCA energy conservation standards and to quantify the efficiency of their product. DOE is developing and amending test procedures for products included in the definition of GSLs. The term GSL includes GSILs, CFLs, general service LED lamps, OLED lamps, and any other lamps that the Secretary determines are used to satisfy lighting applications traditionally served by general service incandescent lamps. 10 CFR 430.2

DOE's test procedures for GSILs are set forth at 10 CFR part 430, subpart B, appendix R. These test procedures provide instructions for measuring GSIL performance largely by incorporating industry standards. These test procedures were updated in a final rule published in January 2012. 77 FR 4203 (January 27, 2012). The rule updated citations and references to the industry standards currently referenced in DOE's test procedures for GSILs and established a new test procedure for determining the rated lifetime of GSILs.

In the preliminary analysis of the general service fluorescent lamp (GSFL) and incandescent reflector lamp (IRL) energy conservation standards rulemaking (hereafter the ''GSFL and IRL standards rulemaking''), DOE determined that the term ''compact fluorescent lamps'' includes both pin base and medium base CFLs.[17] DOE's current test procedures for MBCFLs are set forth at 10 CFR part 430, subpart B, appendix W. These test procedures provide instructions for measuring MBCFL performance by referencing the August 9, 2001, ENERGY STAR® Program Requirements for CFLs Version 2.0. Currently there is no DOE test procedure for non-integrated CFLs (also referred to as pin base CFLs); however, DOE has initiated a CFL test procedure rulemaking to amend existing test procedures for MBCFLs at appendix W and to include test procedures for additional CFL metrics and CFL types, including non-integrated CFLs (hereafter the ''CFL test procedure rulemaking'').[18]

DOE is also currently completing a rulemaking to develop test procedures for LED lamps (hereafter the ''LED TP rulemaking''). DOE published a supplemental notice of proposed rulemaking (SNOPR) on July 9, 2015, to propose test procedures for integrated LED lamps. 80 FR 39644.

DOE is not considering establishing one test procedure for all GSLs. While DOE is maintaining a technology-neutral approach to this rulemaking, there are inherent mechanical and electrical differences between lamp types that require separate testing methods. Additionally, DOE test procedures frequently incorporate references to industry-approved test methods. The Illuminating Engineering Society of North America (IES) has developed separate standards for solid-state lighting (SSL) products (*i.e.,* LEDs and OLEDs) and CFLs. However, DOE intends to coordinate the test procedures in development for CFLs and integrated LED lamps and prescribe consistent testing methodologies when possible.

DOE is proposing changes to 10 CFR parts 429 and 430 of subpart B in support of any standards adopted in this GSL rulemaking. In 10 CFR part 429 subpart B, DOE is proposing to add GSLs to the annual certification filing requirements in section 429.12 and to remove the lamp types that are GSLs (*i.e.,* MBCFLs, GSILs, intermediate base incandescent lamps, and candelabra base incandescent lamps) from the filing requirements in § 429.12. As discussed in the proposed test procedure for certain categories of general service lamps published elsewhere in this issue of the **Federal Register**, in 10 CFR part

[17] The preliminary analysis technical support document for the GSFL and IRL Standards Rulemaking is available at *www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0006-0022.*

[18] *See* 80 FR 45724 (July 31, 2015).

430 subpart B DOE is proposing to add a new paragraph to § 430.23 for test procedures for GSLs.

1. Standby- and Off-Mode Energy Consumption

EPCA requires energy conservation standards adopted for a covered product after July 1, 2010, to address standby-mode and off-mode energy use. (42 U.S.C. 6295(gg)(3)) EPCA defines active mode as the condition in which an energy-using piece of equipment is connected to a main power source, has been activated, and provides one or more main functions. (42 U.S.C. 6295(gg)(1)(A)) Standby mode is defined as the condition in which an energy-using piece of equipment is connected to a main power source and offers one or more of the following user-oriented or protective functions: Facilitating the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer; or providing continuous functions, including information or status displays (including clocks) or sensor-based functions. Id. Off mode is defined as the condition in which an energy-using piece of equipment is connected to a main power source, and is not providing any standby or active mode function. *Id.*

To satisfy the statutory definition of off mode (42 U.S.C. 6295(gg)(1)), the lamp must not be providing any active mode function (*i.e.,* emitting light) or standby mode function. DOE determined that it is not possible for GSLs included in the scope of this rulemaking to meet the off-mode criteria because there is no condition in which a GSL is connected to main power and is not already in a mode accounted for in either active or standby mode. DOE notes the existence of a small number of commercially available GSLs that operate in standby mode. DOE discusses GSLs that operate in standby mode in further detail in section V.A.1.

C. Technological Feasibility

1. General

In each energy conservation standards rulemaking, DOE conducts a screening analysis based on information gathered on all current technology options and prototype designs that could improve the efficiency of the products or equipment that are the subject of the rulemaking. As the first step in such an analysis, DOE develops a list of technology options for consideration in consultation with manufacturers, design engineers, and other interested parties. DOE then determines which of those means for improving efficiency are technologically feasible. DOE considers technologies incorporated in commercially available products or in working prototypes to be technologically feasible. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(i).

After DOE has determined that particular technology options are technologically feasible, it further evaluates each technology option in light of the following additional screening criteria: (1) Practicability to manufacture, install, and service; (2) adverse impacts on product utility or availability; and (3) adverse impacts on health or safety. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(ii)–(iv). Additionally, it is DOE policy not to include in its analysis any proprietary technology that is a unique pathway to achieving a certain efficacy level. Section V.B of this NOPR discusses the results of the screening analysis for GSLs, particularly the designs DOE considered, those it screened out, and those that are the basis for the standards considered in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the NOPR TSD.

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt an amended standard for a type or class of covered product, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such product. (42 U.S.C. 6295(p)(1)) Accordingly, in the engineering analysis, DOE determined the maximum technologically feasible (''max-tech'') improvements in energy efficiency for GSLs, using the design parameters for the most efficient products available on the market or in working prototypes. The max-tech levels that DOE determined for this rulemaking are described in section V.C.5 of this proposed rule.

D. Energy Savings

1. Determination of Savings

For each trial standard level (TSL), DOE projected energy savings from application of the TSL to GSLs purchased in the 30-year period that begins in the year of compliance with the proposed standards (2020–2049).[19] The savings are measured over the entire lifetime of GSLs purchased in the above 30-year period. DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the no-new-standards case. The no-new-standards case represents a projection of energy consumption that reflects how the market for a product would likely evolve in the absence of new or amended energy conservation standards.

DOE used its national impact analysis (NIA) spreadsheet model to estimate energy savings from potential new or amended standards for GSLs. The NIA spreadsheet model (described in section V.H of this proposed rule) calculates savings in site energy, which is the energy directly consumed by products at the locations where they are used. Based on the site energy, DOE calculates national energy savings (NES) in terms of primary energy savings at the site or at power plants, and also in terms of full-fuel-cycle (FFC) energy savings. The FFC metric includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and thus presents a more complete picture of the impacts of energy conservation standards.[20] DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered products or equipment. For more information on FFC energy savings, see section V.H.1 of this proposed rule.

2. Significance of Savings

To adopt any new or amended standards for a covered product, DOE must determine that such action would result in ''significant'' energy savings. (42 U.S.C. 6295(o)(3)(B)) Although the term ''significant'' is not defined in the Act, the U.S. Court of Appeals for the District of Columbia Circuit, in *Natural Resources Defense Council (NRDC)* v. *Herrington,* 768 F.2d 1355, 1373 (D.C. Cir. 1985), opined that Congress intended ''significant'' energy savings in the context of EPCA to be savings that were not ''genuinely trivial.'' The energy savings for all of the TSLs considered in this rulemaking, including the proposed standards (presented in section VI.B), are nontrivial, and, therefore, DOE considers them ''significant'' within the meaning of section 325 of EPCA.

[19] Each TSL is comprised of specific efficacy levels for each product class. The TSLs considered for this NOPR are described in section VI.A. DOE conducted a sensitivity analysis that considers impacts for products shipped in a 9-year period.

[20] The FFC metric is discussed in DOE's statement of policy and notice of policy amendment. 76 FR 51282 (Aug. 18, 2011), as amended at 77 FR 49701 (Aug. 17, 2012).

E. Economic Justification

1. Specific Criteria

As noted above, EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII)) The following sections discuss how DOE has addressed each of those seven factors in this rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of a potential amended standard on manufacturers, DOE conducts a manufacturer impact analysis (MIA), as discussed in section V.J. DOE first uses an annual cash-flow approach to determine the quantitative impacts. This step includes both a short-term assessment—based on the cost and capital requirements during the period between when a regulation is issued and when entities must comply with the regulation—and a long-term assessment over a 30-year period. The industry-wide impacts analyzed include: (1) INPV, which values the industry on the basis of expected future cash flows; (2) cash flows by year; (3) changes in revenue and income; and (4) other measures of impact, as appropriate. Second, DOE analyzes and reports the impacts on different types of manufacturers, including impacts on small manufacturers. Third, DOE considers the impact of standards on domestic manufacturer employment and manufacturing capacity, as well as the potential for standards to result in plant closures and loss of capital investment. Finally, DOE takes into account cumulative impacts of various DOE regulations and other regulatory requirements on manufacturers.

For individual consumers, measures of economic impact include the changes in LCC and payback period (PBP) associated with new or amended standards. These measures are discussed further in the following section. For consumers in the aggregate, DOE also calculates the national NPV (and annualed national NPV) of the consumer costs and benefits expected to result from particular standards. DOE also evaluates the impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a standard.

b. Savings in Operating Costs Compared to Increase in Price (LCC and PBP)

EPCA requires DOE to consider the savings in operating costs throughout the estimated average life of the covered product in the type (or class) compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered product that are likely to result from a standard. (42 U.S.C. 6295(o)(2)(B)(i)(II)) DOE conducts this comparison in its LCC and PBP analysis.

The LCC is the sum of the purchase price of a product (including its installation) and the operating expense (including energy, maintenance, and repair expenditures) discounted over the lifetime of the product. The LCC analysis requires a variety of inputs, such as product prices, product energy consumption, energy prices, maintenance and repair costs, product lifetime, and discount rates appropriate for consumers. To account for uncertainty and variability in specific inputs, such as product lifetime and discount rate, DOE uses a distribution of values, with probabilities assigned to each value.

The PBP is the estimated amount of time (in years) it takes consumers to recover the increased purchase cost (including installation) of a more-efficient product through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost due to a more-stringent standard by the change in annual operating cost for the year that standards are assumed to take effect.

For its LCC and PBP analysis, DOE assumes that consumers will purchase the covered products in the first year of compliance with new or amended standards. The LCC savings for the considered efficacy levels (ELs) are calculated relative to the case that reflects projected market trends in the absence of amended standards. DOE's LCC and PBP analysis is discussed in further detail in section V.F.

c. Energy Savings

Although significant conservation of energy is a separate statutory requirement for adopting an energy conservation standard, EPCA requires DOE, in determining the economic justification of a standard, to consider the total projected energy savings that are expected to result directly from the standard. (42 U.S.C. 6295(o)(2)(B)(i)(III)) As discussed in section III.D.1, DOE uses the NIA spreadsheet models to project NES.

d. Lessening of Utility or Performance of Products

In establishing product classes and in evaluating design options and the impact of potential standard levels, DOE evaluates potential standards that would not lessen the utility or performance of the considered products. (42 U.S.C. 6295(o)(2)(B)(i)(IV)) Based on data available to DOE, the standards proposed in this document would not reduce the utility or performance of the products under consideration in this rulemaking.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from a proposed standard. (42 U.S.C. 6295(o)(2)(B)(i)(V)) It also directs the Attorney General to determine the impact, if any, of any lessening of competition likely to result from a proposed standard and to transmit such determination to the Secretary within 60 days of the publication of a proposed rule, together with an analysis of the nature and extent of the impact. (42 U.S.C. 6295(o)(2)(B)(ii)) DOE will transmit a copy of this proposed rule to the Attorney General with a request that the Department of Justice (DOJ) provide its determination on this issue. DOE will publish and respond to the Attorney General's determination in the final rule.

f. Need for National Energy Conservation

DOE also considers the need for national energy conservation in determining whether a new or amended standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(VI)) The energy savings from the proposed standards are likely to provide improvements to the security and reliability of the nation's energy system. Reductions in the demand for electricity also may result in reduced costs for maintaining the reliability of the nation's electricity system. DOE conducts a utility impact analysis to estimate how standards may affect the nation's needed power generation capacity, as discussed in section V.M.

The proposed standards also are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases (GHG) associated with energy production and use. DOE conducts an emissions analysis to estimate how potential standards may affect these emissions, as discussed in section V.K; the emissions impacts are reported in section VI.B.6 of this NOPR. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section V.L.

g. Other Factors

EPCA allows the Secretary of Energy, in determining whether a standard is economically justified, to consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) To the extent interested parties submit any relevant information regarding economic justification that does not fit into the other categories described above, DOE could consider such information under ''other factors.''

2. Rebuttable Presumption

As set forth in 42 U.S.C. 6295(o)(2)(B)(iii), EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effects that proposed energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the nation, and the environment, as required under 42 U.S.C. 6295(o)(2)(B)(i). The results of this analysis serve as the basis for DOE's evaluation of the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). The rebuttable-presumption payback calculation is discussed in section V.F of this proposed rule.

IV. Issues Affecting Scope of Coverage

This section examines the various issues affecting the scope of coverage of this rulemaking. These issues include: Restrictions of the Appropriations Rider; clarifications to the GSL definition; additional proposed definitions supporting the GSL definition; and lamps that DOE is proposing to exempt from the GSL definition. Additionally, DOE addresses the GSLs for which it is proposing standards. Finally, DOE discusses the proposed scope of metrics in the rulemaking. DOE received many comments on these issues in response to the preliminary analysis and responds to these comments below.

A. Appropriations Rider

GSILs are included in the definition of GSL. Although 42 U.S.C. 6295(i)(6) authorizes DOE to evaluate energy conservation standards for GSLs which, by definition, includes GSILs, the Appropriations Rider, in relevant part, restricts the use of appropriated funds in connection with several aspects of DOE's incandescent lamps energy conservation standards program. Specifically, section 313 of Public Law 113–235 prohibits expenditure of funds appropriated by that law to implement or enforce: (1) 10 CFR 430.32(x), which includes maximum wattage and minimum rated lifetime requirements for GSILs and maximum wattage requirements for candelabra base incandescent lamps and intermediate base incandescent lamps; and (2) standards set forth in section 325(i)(1)(B) of EPCA (42 U.S.C. 6295(i)(1)(B)), which sets minimum lamp efficiency ratings for IRLs. Because of the applicability of the Appropriations Rider to these lamps, DOE is not analyzing GSILs, intermediate-base incandescent lamps, or candelabra base incandescent lamps in this rulemaking. DOE is also directed by 42 U.S.C. 6295(i)(6)(A)(i)(II) to determine whether the exemptions for certain incandescent lamps should be maintained or discontinued based, in part, on exempted lamp sales collected from manufacturers. However, as stated, DOE is prohibited from using appropriated funds to implement or enforce standards for GSILs and thus cannot re-evaluate the existing exemptions for GSILs in the rulemaking. DOE received several comments on the inclusion of GSILs in the scope of this rulemaking.

Earthjustice commented that section 325(i)(6)(A)(i) of EPCA requires DOE to initiate a rulemaking proceeding no later than January 1, 2014, to determine whether the standards in effect for GSLs should be strengthened and whether ''the exemptions for certain incandescent lamps should be maintained or discontinued.'' To meet these obligations, Earthjustice asserted, DOE must, among other things, analyze standards for GSILs and lamps that have been exempted from the requirements applicable to GSILs. Earthjustice stated that DOE has failed to address these lamps, and is now in violation of its statutory duty to initiate a rulemaking that meets the requirements of section 325(i)(6)(A)(i) no later than January 1, 2014. (Earthjustice, No. 30 at p. 1)

DOE confirms that as the Appropriations Rider contains a congressional directive disallowing the use of appropriated funds to implement or enforce standards on any products in 10 CFR 430.32(x), such lamps are not included in this statutorily prescribed rulemaking at this time. Under 42 U.S.C. 6295(i)(6)(A)(v), if DOE fails to (1) complete a rulemaking in accordance with clauses (i) through (iv), which includes determining whether the exemptions for certain incandescent lamps should be maintained or discontinued, or (2) publish a final rule that will meet or exceed the energy savings associated with the EISA 2007 45 lm/W backstop, then the backstop will be triggered beginning January 1, 2020. Due to the Appropriations Rider, DOE is unable to perform the analysis required in clause (i) of 42 U.S.C. 6295(i)(6)(A). As a result, the backstop in 6296(i)(6)(A)(v) is automatically triggered.

Earthjustice stated that their comments on the previous stages of this rulemaking also explained that the plain language of the Appropriations Rider that currently prohibits DOE from using appropriated funds ''to implement or enforce section 430.32(x) of title 10, Code of Federal Regulations,'' does not prevent DOE from amending the standards for the lamp types exempted from the GSIL definition. Based on the preliminary TSD's discussion of the Appropriations Rider, Earthjustice stated that DOE may be misinterpreting the status of those 22 types of incandescent lamps exempted from EPCA's definition of ''general service incandescent lamp.'' The preliminary TSD states that DOE believes it is prohibited by the Appropriations Rider from modifying the existing exemptions for GSILs in this rulemaking. Earthjustice disagreed that the broad interpretation DOE gives the Appropriations Rider is reasonable and urged DOE to reconsider its interpretation. Additionally, if that interpretation remains unchanged, Earthjustice asked DOE to explain how the prohibition in the text of the Appropriations Rider applies to the exempted lamp types. (Earthjustice, No. 30 at pp. 1–2) The Pacific Gas and Electric Company, Southern California Gas Company, San Diego Gas and Electric, and Southern California Edison (hereafter, the ''California investor-owned utilities or the ''CA IOUs'') agreed in a joint comment that DOE has taken an overly restrictive interpretation of the Appropriations Rider, which specifically prohibits DOE from using appropriated funds ''to implement or enforce'' 10 CFR 430.32(x), but does not prevent DOE from amending standards for any incandescent lamp. CA IOUs thought the interpretation of the Appropriations Rider should allow room to close loophole opportunities that allowed inexpensive incandescent general service products to be sold as exempted products. (CA IOUs, No. 33 at pp. 1–2) Earthjustice further specified that nothing in EPCA suggests discontinuing the exemptions for these lamps would make them GSILs. The exemption that DOE must decide whether to maintain or discontinue is an exemption from the GSL standards, not an exemption from the statute's definition of the term ''general service incandescent lamp.'' Therefore, Earthjustice concluded that while DOE cannot use appropriated funds to implement or enforce standards for GSILs, there is no prohibition on applying standards to any of the 22 types of lamps exempted in EPCA's definition of ''general service incandescent lamp.'' If DOE regulated the exempted lamps outside the GSIL rubric, the Appropriations Rider does not block the path to energy conservation standards. For example, the preliminary TSD suggests that DOE believes it would be authorized to regulate the subset of exempted incandescent lamps that are subject to tracking requirements under section 325(l). DOE has continued meeting its obligation to collect and analyze shipment data for these lamps, notwithstanding the Appropriations Rider. 79 FR 15058 (Mar. 18, 2014). If the distinction DOE has drawn, that enables the implementation of standards for these lamps, is that they are not GSILs if regulated under section 325(l), DOE needs to consider that they would also not be GSILs if DOE adopts standards for them under section 325(i)(6)(A). (Earthjustice, No. 30 at p. 2)

By definition, GSL does not apply to any lighting application or bulb shape excluded from the ''general service incandescent lamp'' definition. (42 U.S.C. 6291(30)(BB)) Therefore, based on the GSL definition, the 22 incandescent lamps that are excluded in EPCA from the definition of GSIL would not be GSLs. It is the case, however, that DOE could determine under the authority in 42 U.S.C. 6295(i)(6)(A)(i)(II) to discontinue the exemption for the 22 types of lamps exempted from EPCA's definition of GSIL. If DOE were to do so and agreed with Earthjustice and the CA IOUs that discontinuing the exemptions would not make any of those lamps GSILs, it would be the case that those formerly exempted lamps would also not be GSLs for which DOE could establish standards in the current rulemaking. Rather, the formerly exempted lamp types would have to be considered GSILs in order for DOE to regulate the lamps under its authority to promulgate standards for GSLs. Since the Appropriations Rider prohibits the expenditure of funds to implement or enforce standards for GSILs, DOE would not be able to establish or amend energy conservation standards for any of these lamps. As a result, making a determination about discontinuing the exemption from the GSIL definition for any of the 22 types of lamps would make no difference in the GSL rulemaking, and DOE declines to address the exemptions at the present time.

The National Electrical Manufacturers Association (NEMA) and NRDC commented that they understand the rulemaking is complicated by the existence of the Appropriations Rider. NEMA acknowledged that they appreciated the explanation provided by DOE that the Appropriations Rider (and similar predecessor legislation) makes it difficult to consider the real baseline in this rulemaking and other issues; however, they fundamentally disagreed with DOE's approach to product classes in this rulemaking and the proposal for technology-neutral energy conservation standards. NEMA stated that the Appropriations Rider has influenced DOE's selection of this approach in a manner not intended by Congress in EISA 2007. (NEMA, No. 34 at p. 2; NRDC, Public Meeting Transcript, No. 29 at p. 42)

DOE notes that the definition of general service lamps includes lamps of various technologies including CFLs, LED lamps, and OLED lamps in addition to GSILs, and section 325(i)(6)(A)(ii)(I) explicitly states that the GSL rulemaking is not limited to incandescent lamp technologies. Therefore, as further discussed in section V.A.1, DOE is evaluating standards in a technology-neutral approach in this rulemaking in order to carry out the more expansive analysis of lamps that serve general service lighting applications intended by EPCA. While the Appropriations Rider has vast impacts on the analyses of this rulemaking, such limitations precipitate from the prohibition placed on the implementation or enforcement of standards on GSILs, the Appropriations Rider has not influenced DOE's proposed product class structure. While DOE may not analyze GSILs in this rulemaking, DOE has taken a broad interpretation for what can be considered a GSL, analyzing non-GSIL lamps intended to serve in general lighting applications. See section V.A.1 for the resulting product classes.

B. Clarification of General Service Lamp Definition

The term, general service lamp, includes GSILs, CFLs, general service LEDs, OLEDs, and any other lamps that the Secretary determines are used to satisfy lighting applications traditionally served by GSILs; however, this definition does not apply to any lighting application or bulb shape excluded from the ''general service incandescent lamp'' definition, or any general service fluorescent lamp or incandescent reflector lamp. (42 U.S.C. 6291(30)(BB)) Pursuant to the definition of GSL, DOE has the authority to consider additional lamps that it determines are used to satisfy lighting applications traditionally served by GSILs. In the preliminary analysis, DOE took a broad interpretation of what lamps can be considered GSLs. DOE determined GSLs are lamps intended to serve in general lighting applications (as defined in 10 CFR 430.2) by providing an interior or exterior area with overall illumination. Thus, DOE considered GSLs as lamps which have a lumen output of 310 lumens or greater, have an ANSI base,[21] are not a light fixture, operate on any voltage, are not designed and labeled for use in non-general applications, and are not or could not be considered in another rulemaking proceeding. DOE received several comments on this approach.[22]

Some stakeholders supported DOE's broad interpretation of GSLs. EEAs commented that DOE should include all lamps that provide light between 310 and 2,600 lumens in the GSL standards scope, regardless of the shape of the lamp's cover, or the size of the lamp's base. They urged DOE to limit exemptions to lamps that cannot provide general service illumination due to technical, definable characteristics. For example, limiting covered lamps to a list of conventional shapes creates an incentive for manufacturers to evade the standards by making a slight modification to the shape of the lamp, which does not provide any additional functionality. Therefore, EEAs requested that DOE broaden the scope of coverage to eliminate such loopholes. (EEAs, No. 32 at p. 5) Overall, CA IOUs agreed that some lamps previously excluded from the definition of GSIL can be used to provide general illumination and as replacements for GSLs. They supported DOE's findings that lamps with other

[21] A lamp base standardized by the American National Standards Institute.

[22] GSL preliminary analysis at 2–25.

ANSI bases (non-E26[23] screw bases), directional lamps, high-lumen lamps (>2,600 lumens), and lamps with operating voltage outside the range of 110–130 V could be considered GSLs. (CA IOUs, No. 33 at p. 2)

However, some stakeholders disagreed with DOE's interpretation of GSLs. GE stated that DOE is applying an extremely broad scope and should limit it to large potential for energy savings and lamp use. GE determined that the intent of this rulemaking is to look at lamps that provide the highest volume and therefore highest potential for energy savings; namely, the medium screw base lamps that are between 310 and 2,600 lumens where the bulk of the general lighting applications occur. (GE, Public Meeting Transcript, No. 29 at pp. 26–27) Southern Company also agreed that the intent of the legislation was for standard consumer lighting products, and that a scope that is too broad may result in unintended consequences for specialized industrial applications. They also cautioned against setting standards too high on CFLs and LED lamps with the potential of encouraging more people to use incandescent technology. (Southern Company, Public Meeting Transcript, No. 29 at pp. 27, 30–31)

DOE has interpreted the definition of GSLs in order to ensure that products used for general service lighting applications are included. DOE gave careful consideration to each criteria and what lamp types it would cover. DOE determined a lower bound lumen range and ANSI base specification were essential in identifying lamps used in general service lighting applications. DOE also found that voltages higher and lower than line voltage are also being used in general lighting applications and therefore, a voltage specification was not useful. Further DOE's interpretation accounted for exemption of specialty lamps that could not provide overall illumination and confirmation that there is no overlap of coverage among lamp rulemakings. Therefore, DOE finds that its interpretation adequately captures the intention of a general service lamp. DOE is proposing a new definition of ''general service lamp'' in section 430.2 to capture the criteria and exemptions discussed in more detail in the following sections.

DOE considered lamps' potential for energy savings, including impacts such as shifts to incandescent technologies, when determining which GSLs to establish standards for in this rulemaking (see section IV.E for further details).

DOE received specific comments on several aspects of the interpretation of the GSL definition, as discussed in the following sections.

1. General Lighting Applications

CA IOUs questioned the term general lighting application. They noted that it is defined in 10 CFR 430.2 as ''lighting that provides an interior or exterior area with overall illumination,'' and yet there is no definition of overall illumination. CA IOUs requested an interpretation from DOE. (CA IOUs, Public Meeting Transcript, No. 29 at p. 28) The definition for general lighting application was added to the CFR upon codifying the Energy Independence and Security Act of 2007 (Public Law 110–140; EISA 2007). DOE considers the term ''overall illumination'' to be similar in meaning to the term ''general lighting'' as defined in the industry standard ANSI/IES RP–16–10 (hereafter ''RP–16''). RP–16 states that ''general lighting'' means lighting designed to provide a substantially uniform level of illuminance throughout an area, exclusive of any provision for special local requirements.

2. Lamps Addressed in Other Rulemakings

As discussed previously, DOE has the authority to consider additional lamp types that it determines are used to satisfy lighting applications traditionally served by GSILs. To limit the probability that one lamp type might be subject to two different standards, DOE did not consider adding lamp types that are or could be addressed in a separate rulemaking proceeding. For example, the GSFL and IRL rulemaking considered establishing standards for additional types of fluorescent lamps (such as 2-foot linear fluorescent lamps). 80 FR 4041, 4055 (Jan. 26, 2015). While that rulemaking ultimately concluded that additional lamps should not be subject to standards, DOE did not consider the additional lamps evaluated as GSFLs to be candidates for coverage in the GSL rulemaking.

NEMA agreed with DOE's assessment in the preliminary analysis that SBMV lamps should not be included in this rulemaking as they are high-intensity discharge (HID) lamps, and as such could be covered in another rulemaking. (NEMA, No. 34 at p. 6) Further, Westinghouse acknowledged that they agreed with not considering any products that are covered under another rulemaking due to potential complications. (Westinghouse, Public Meeting Transcript, No. 29 at p. 39) Having received no other feedback on this topic, DOE continues not to propose standards in this rulemaking for products currently covered by other rulemakings. DOE requests comment on this approach.

3. High-Lumen Lamps (≤2,600 Lumens)

In the preliminary analysis, DOE considered including lamps with lumen output between 310 and 2,600 lumens.[24] DOE maintains this lower bound because lamps with lumen output less than 310 lumens do not provide sufficient overall illumination. Regarding lamps with a lumen output greater than 2,600 lumens, DOE believes that these lamps can be used in overall illumination and therefore meet the definition of GSL. However, in the preliminary analysis DOE considered not establishing standards for GSLs with lumens greater than 2,600 due to a potential shift to incandescent technologies. As noted previously, due to the Appropriations Rider, DOE is unable to consider modifying the existing exemption for GSILs with lumen output greater than 2,600 lumens. In the preliminary analysis, DOE reasoned that establishing energy conservation standards for higher lumen lamps in more-efficient technologies (*e.g.,* integrated and non-integrated CFLs), while not also addressing higher lumen incandescent lamps, may ultimately increase national energy consumption due to a shift to lower-cost incandescent technologies.[25]

EEAs recommended that DOE broaden the scope of coverage considered in the preliminary analysis to include lamps with outputs between 2,601 and 3,300 lumens. EEAs noted that this change would ensure lamps currently exceeding 150 W are also covered and would remove any incentive for manufacturers to introduce slightly brighter bulbs as a means to avoid compliance with standards. Conventional 150 W incandescent lamps produce around 2,500–2,700 lumens, and EEAs had noticed an increased amount of 150 W and 200 W incandescent lamps available in stores. EEAs stated that they also expect LED ELs to continue to increase, leading to new LED lamps that deliver higher light levels on the market by 2020. As DOE may not implement or enforce energy conservation standards on GSILs in this rulemaking, should DOE promulgate standards for CFLs and LED lamps with

[23] An E26 base, or medium screw base, means an Edison screw base identified with the prefix E–26 in the ''American National Standard for Electric Lamp Bases'', ANSI_IEC C81.61–2003, published by the American National Standards Institute. 10 CFR 430.2

[24] *Id.* at 2–27.

[25] *Id.* at 2–28.

outputs between 2,601 and 3,300 lumens, there could be an even more pronounced migration to the 150 W and 200 W incandescent lamps. (EEAs, No. 32 at p. 7)

Earthjustice found that DOE's determination that establishing standards for CFL and LED versions of high-lumen lamps, but not for high-lumen incandescent lamps, could increase national energy consumption fails to consider that including high-lumen lamps as GSLs would trigger the 45 lm/W backstop requirement. While Earthjustice disagreed with DOE's interpretation that the Appropriations Rider prohibits DOE from promulgating standards for high-lumen incandescent lamps, Earthjustice noted that even with DOE's interpretation, the backstop still applies to any lamps DOE determines meet the EPCA criterion for coverage as a general service lamp. Therefore, Earthjustice asserted that all high-lumen lamps, including incandescent high-lumen lamps, will need to meet a standard of 45 lm/W. Earthjustice urged DOE to reconsider its approach to the scope of coverage given the backstop provision's application to all GSLs. (Earthjustice, No. 30 at pp. 3–4)

Southern Company commented that if the backstop goes into effect and the standard is at 45 lm/W, there will most likely need to be exceptions based on available technology. Southern Company stated that there are instances where consumers trying to use higher lumen bulbs are forced to use incandescents because there is no product on the market that fits their size limitations. Southern Company requested DOE consider exceptions for products with space constraints or higher lumen outputs. (Southern Company, Public Meeting Transcript, No. 29 at pp. 131–132)

DOE agrees that the backstop under 42 U.S.C. 6295(i)(6)(A)(v), in all likelihood, will become effective beginning January 1, 2020. In this NOPR analysis, DOE further evaluated products in the high-lumen range and found limited product offerings and concluded that these products have a low market share and therefore, would not result in significant energy savings. (See chapter 3 of the NOPR TSD for further details.) Further, DOE agrees there are technological limitations currently to creating higher efficacy replacements while maintaining form factor for high lumen lamps. Hence, regardless of implications of the backstop, DOE maintains its decision not to establish standards for GSLs greater than 2,600 lumens in this rulemaking. DOE requests comment on the energy savings potential of standards for GSLs greater than 2,600 lumens.

4. Lamps without an ANSI Base

In the preliminary analysis, DOE considered GSLs to have an ANSI base to ensure they can be used in sockets commonly found in residential, commercial, and industrial fixtures.[26] NRDC asked for clarification on this ANSI base criterion for meeting the GSL definition. NRDC asked for example, if DOE would consider a lamp with a non-ANSI base that uses an adapter to fit a medium screw base socket; although, NRDC noted that this combination is not currently in practice. (NRDC, Public Meeting Transcript, No. 29 at pp. 24–25) Westinghouse commented that they make adapters, but stated that, as per EPAct, they are not permitted to make any adapter that converts a medium screw base socket to any other socket type. (Westinghouse, Public Meeting Transcript, No. 29 at pp. 25–26)

DOE is not aware of any lamps on the market relevant to the GSL scope that have a non-ANSI base which can be converted into an ANSI base via an adapter or other device. DOE will continue to monitor the market for such products and requests comments on whether such lamps are commercially available.

5. Operating Voltage

CA IOUs recommended that lamps designed and marketed to be operated at 130 V or higher (often marketed as long-life lamps) be included in the definition of GSL. (CA IOUs, No. 33 at p. 2) In the preliminary analysis, DOE stated that lamps with operating voltage outside the range of 110 to 130 V can be used in general lighting applications and are therefore, GSLs.[27] Specifically, DOE found that lamps operating on low voltage (*i.e.,* requires the use of a transformer) can provide overall illumination. However, DOE's interpretation of not requiring GSLs to operate on a specific voltage means that lamps operating at 130 V or higher are also within the scope of GSLs.

6. Summary of GSL Interpretation

In summary, DOE is proposing to interpret general service lamps as lamps intended to serve in general lighting applications and have the following basic characteristics: (1) An ANSI base with the exclusion of light fixtures; (2) lumen output of 310 lumens or greater; (3) operate at any voltage; (4) are not the subject of other rulemakings; and (5) are not designed and labeled for use in certain non-general applications (see section IV.D for more information).

[26] *Id.* at 2–28.

[27] *Id.* at 2–22.

C. Definitions Supporting GSLs

DOE also considered several definitions to support its interpretation of the GSL definition and received comments on certain definitions, discussed in the sections below.

1. General Service LED Lamps

General service LED lamps are included in the definition of GSL. LED lamps can be integrated or non-integrated. DOE does not currently have a definition for ''general service LED lamp,'' however ''light-emitting diode or LED'' is defined at 10 CFR 430.2 as a p-n junction solid-state device of which the radiated output, either in the infrared region, the visible region, or the ultraviolet region, is a function of the physical construction, material used, and exciting current of the device. In the preliminary analysis, DOE considered the following definition for general service LED lamps: ''*General service light-emitting diode (LED) lamp* means an integrated or non-integrated LED lamp designed for use in general lighting applications (as defined in 430.2).'' [28]

NEMA suggested additional wording to clarify the use of LEDs in general service LED lamps and proposed the language ''that uses light emitting diodes as the primary source of light'' be added to the end of DOE's proposed definition. (NEMA, No. 34 at p. 3) DOE agrees that the additional language may provide clarification by connecting the lamp type with the light source used. DOE therefore proposes the following definition for general service LED lamp and requests comment on whether further modifications are needed: ''*General service light-emitting diode (LED) lamp* means an integrated or non-integrated LED lamp designed for use in general lighting applications (as defined in 430.2) and that uses light-emitting diodes as the primary source of light.''

2. Organic Light-Emitting Diode Lamps

OLED lamps are also included in the definition of GSL. DOE does not currently have a definition for OLED lamp; however, OLED is defined at 10 CFR 430.2 as a thin-film light-emitting device that typically consists of a series of organic layers between two electrical contacts (electrodes). In the preliminary analysis, DOE considered defining ''*Organic light-emitting diode or OLED lamp* to mean an integrated or non-

[28] *Id.* at 3–5.

integrated lamp that uses OLEDs as the primary source of light.'' [29]

NEMA noted that a typographical error existed in the definition considered for OLED lamp and suggested the following revisions: ''Organic light-emitting diode or OLED lamp means an integrated or non-integrated lamp designed for use in general lighting applications that uses OLEDs as the primary source of light.'' (NEMA, No. 34 at p. 3) DOE agrees that specifying that OLED lamps are for use in general lighting applications further clarifies the scope of the GSL rulemaking. DOE also appreciates NEMA noting the typographical error and has corrected the error in the proposed definition. Therefore, DOE is proposing the following definition for OLED lamp in this NOPR analysis and requests comment on whether further modifications are needed: ''*Organic light-emitting diode or OLED lamp* means an integrated or non-integrated lamp designed for use in general lighting applications that uses OLEDs as the primary source of light.''

3. Integrated Lamp and Non-integrated Lamp

In the preliminary analysis, DOE considered defining integrated lamps and non-integrated lamps for GSLs as: ''*Integrated lamp* means a lamp that contains all components necessary for the starting and stable operation of the lamp, does not include any replaceable or interchangeable parts, and is connected directly to a branch circuit through an ANSI base and corresponding ANSI standard lamp-holder (socket)'' and ''*Non-integrated lamp* means a lamp that is not an integrated lamp.'' [30]

NEMA disagreed with DOE's proposed definition of integrated lamp stating that the bases on integrated lamps mentioned in the definition should be limited to those bases most commonly used with the lamps covered within the rulemaking's scope. Currently, these bases would be limited to medium screw bases and GU24 bases [31] for integrated lamps, but those could be adjusted if the scope of the regulation changed in the future. NEMA suggested the following definition: ''Integrated lamp means a CFL or LED lamp that contains all components necessary for the starting and stable operation of the lamp, does not include any replaceable or interchangeable parts, and is intended to be connected directly to a branch circuit through a Medium Screw Base or a GU24 base.'' (NEMA, No. 34 at pp. 2–3)

NEMA also disagreed with the DOE's proposed definition of non-integrated lamps because many of the lamps that would be covered by this broad definition are not within the scope of the rulemaking. (NEMA, No. 34 at p. 7) GE added that the non-integrated lamp definition is too broad and remarked that DOE needs to provide the specifics of what a non-integrated lamp is within the scope of this rulemaking. (GE, Public Meeting Transcript, No. 29 at pp. 52–53) NEMA suggested the following definition: ''Non-integrated lamp means a lamp that requires additional external components for starting and stable operation of the lamp, such as a ballast or a driver and has a single-ended 2-pin or 4-pin base.'' (NEMA, No. 34 at p. 3)

DOE developed the definitions of ''integrated lamp'' and ''non-integrated lamp'' to be technology neutral and broadly encompass any ANSI base in order to cover all lamp types within the GSL scope, and not just those for which standards are being set in this rulemaking. Further, for standards specific to a base type, DOE would clearly state the base type to which standards are applicable. Additionally, lamp designs of GSLs are either integrated (*i.e.,* include within them all components for operation) or are non-integrated (*i.e.,* require an external component for operation). Because all lamps fit in either one or the other configuration, DOE finds that its approach to defining non-integrated lamps as any lamp that is not an integrated lamp to comprehensively include all possible GSLs with the external component configuration. Therefore, DOE proposes to maintain the definitions of ''integrated lamp'' and ''non-integrated lamp'' as specified in the preliminary analysis.

4. Hybrid Lamps

In the preliminary analysis, DOE noted that the CFL test procedure rulemaking is proposing the definition of ''*Hybrid compact fluorescent lamp* to mean a compact fluorescent lamp that incorporates one or more supplemental light sources of different technology.'' 80 FR 45724 (July 31, 2015).

NEMA commented that DOE's proposed definition of hybrid CFLs was vague and suggested the following definition to increase clarity: ''Hybrid compact fluorescent lamp means a compact fluorescent lamp that incorporates one or more supplemental light sources of different technology, such as halogen or LED, which are energized and operated independently and may or may not operate simultaneously.'' (NEMA, No. 34 at p. 4) Because this definition is being proposed in the CFL test procedure rulemaking, DOE will address NEMA's comment within that rulemaking.

5. Base Types

As NEMA agreed with the preliminary definition of pin base lamps (NEMA, No. 34 at p. 4), and DOE received no other comments, DOE is continuing to propose the definition of ''*Pin base lamp* to mean a lamp that uses a base type designated as a single pin base or multiple pin base system in Table 1 of ANSI C81.61, Specifications for Electrics Bases.''

In the preliminary analysis, DOE also considered defining ''*GU24 base* to mean the GU24 base standardized in ANSI C81.61.'' NEMA agreed with the proposed definition for GU24 base. (NEMA, No. 34 at p. 4) Since DOE received no further comments, DOE is continuing to propose the definition for GU24 base as specified in the preliminary analysis.

In the preliminary analysis, for non-integrated lamps DOE had identified pin bases and screw bases as the only bases that would meet the scope of GSLs. DOE requested comment on this assessment. NEMA confirmed that there are no other base types for non-integrated lamps that meet the definition of GSLs. (NEMA, No. 34 at p. 7)

6. Light Fixture

In the preliminary analysis, DOE considered adding the definition of ''light fixture'' to the **Federal Register** in order to ensure that complete light fixtures with ANSI bases (*e.g.,* certain retrofit kits) are not included in the scope of this rulemaking. Specifically, DOE considered the definition for ''*Light Fixture* to mean a complete lighting unit consisting of lamp(s) and ballast(s) (when applicable) together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamp(s) to the power supply.'' [32]

NEMA agreed with the considered light fixture definition. (NEMA, No. 34 at p. 4) DOE is proposing to slightly modify the definition to clarify that a light fixture may contain light sources other than lamps, such as LED modules or arrays, and drivers in addition to ballasts. Therefore, DOE is proposing the following definition for ''light fixture'' in this NOPR analysis and is requesting comment on this definition:

[29] A typographical error occurred on p. 3–6 of the preliminary analysis stating ''as light'' rather than ''of light.''

[30] GSL preliminary analysis at 3–4.

[31] Medium screw base is defined in 10 CFR 430.2, and DOE proposes a definition for GU24 base in section IV.C.5.

[32] *Id.* at 3–6.

''*Light Fixture* means a complete lighting unit consisting of light source(s) and ballast(s) or drivers(s) (when applicable) together with the parts designed to distribute the light, to position and protect the light source, and to connect the light source(s) to the power supply.''

7. LED Downlight Retrofit Kits

DOE did not consider a definition for LED downlight retrofit kits in the preliminary analysis; however, DOE conducted a survey of the market and found several LED downlight retrofit kits available at common distribution channels and determined a definition was necessary to clarify whether these kits are considered GSLs. DOE found that LED downlight retrofit kits are designed to directly replace traditional downlights that use technologies such as incandescent or halogen lamps or CFLs. DOE also determined that LED downlight retrofit kits generally use an ANSI lamp base and are certified to the UL 1598C standard for LED Retrofit Luminaire Conversion Kits.[33] The retrofit kits integrate the light source and trim and therefore require the existing trim and lamp to be removed before installing in the existing fixture housing. DOE does not consider LED downlight retrofit kits to be GSLs because the kits integrate additional components such as the trim and require the existing trim to be removed. In support of the scope of this rulemaking, DOE is proposing a definition for LED downlight retrofit kits which aligns with the definition for SSL Downlight Retrofits in the May 29, 2015, ENERGY STAR Program Requirements for Luminaires (Light Fixtures) Version 2.0 (hereafter ''ENERGY STAR Luminaires Specification V2.0'').[34] The definition proposed for ''*LED Downlight Retrofit Kit''* means a product intended to install into an existing downlight, replacing the existing light source and related electrical components, typically employing an ANSI standard lamp base, either integrated or connected to the downlight retrofit by wire leads, and is a retrofit kit classified or certified to UL 1598C . LED downlight retrofit kit does not include integrated lamps or non-integrated lamps.'' DOE requests comment on the definition proposed.

8. Summary of Definitions

In the preliminary analysis, DOE developed definitions for the following terms in support of the scope of the rulemaking: ''Integrated lamp,'' ''non-integrated lamp,'' ''general service LED lamp,'' ''OLED lamp,'' ''light fixture,'' ''pin base lamp,'' and ''GU24 base.'' In the NOPR analysis, DOE is continuing to propose the definitions considered in the preliminary analysis for these terms except for the edits to ''general service LED lamp,'' ''OLED lamp,'' and ''light fixture,'' as specified in previous sections. DOE is also proposing a new definition for ''LED downlight retrofit kits.'' The proposed definitions are detailed in chapter 3 of this NOPR TSD.

D. Exempted Lamps

DOE considered whether lamps designed or labeled for specific applications could provide overall illumination and therefore meet the definition of general service lamp. DOE determined that the exemptions for specialty applications listed in 42 U.S.C. 6291(30)(D)(ii) are only applicable to GSILs.[35] Although the GSIL exemptions do not automatically apply to other lamp technologies, DOE considered whether these exemptions should be continued for GSLs. The definition of ''general service incandescent lamp'' includes the following list of exempted incandescent lamps:

(1) An appliance lamp;
(2) A black light lamp;
(3) A bug lamp;
(4) A colored lamp;
(5) An infrared lamp;
(6) A left-hand thread lamp;
(7) A marine lamp;
(8) A marine signal service lamp;
(9) A mine service lamp;
(10) A plant light lamp;
(11) A reflector lamp;
(12) A rough service lamp;
(13) A shatter-resistant lamp (including a shatter-proof lamp and a shatter-protected lamp);
(14) A sign service lamp;
(15) A silver bowl lamp;
(16) A showcase lamp;
(17) A 3-way incandescent lamp;
(18) A traffic signal lamp;
(19) A vibration service lamp;
(20) A G shape lamp (as defined in ANSI C78.20) and ANSI C79.1–2002 with a diameter of 5 inches or more;
(21) A T shape lamp (as defined in ANSI C78.20) and ANSI C79.1–2002 and that uses not more than 40 watts or has a length of more than 10 inches; and
(22) A B, BA, CA, F, G16–1/2, G–25, G30, S, or M–14 lamp (as defined in ANSI C79.1–2002) and ANSI C78.20 of 40 watts or less.
10 CFR 430.2

In the preliminary analysis, DOE assessed whether each specified lamp type provides overall illumination and therefore can be used in general lighting applications.[36] DOE found the lumen output of some of these lamps was insufficient to provide overall illumination. Thus, DOE considered not establishing standards for appliance lamps, black lights, bug lamps, colored lamps, infrared lamps, marine signal lamps, mine service lamps, plant lights, sign service lamps, silver bowl lamps, showcase lamps, and traffic signal lamps under the GSL rulemaking because the lamps are intended for use in non-general applications. DOE preliminarily determined that left-hand thread lamps, marine lamps, reflector lamps, rough service lamps, shatter-resistant lamps, 3-way lamps, vibration service lamps, and lamps of several specific shapes could provide overall illumination and therefore do not require exemption for standards. DOE received comments regarding these potential exemptions and definitions for these lamp types. Therefore, in this NOPR analysis, DOE is proposing definitions for each of the specified lamp types to better delineate the GSL definition, especially in regards to determining the possible GSLs that use technologies other than incandescent and operate in applications equivalent to those of the lamps exempted from the GSIL definition. DOE requests comment on the definitions proposed. In addition, DOE requests comment on if there are any other lamp types that do not serve in general lighting applications and should be exempted from general service lamp standards.

1. Exempted Lamp Types

NEMA agreed that colored lamps, appliance lamps, black light lamps, bug lamps, plant lamps, infrared lamps, sign service lamps, showcase lamps, marine signal lamps, mine service lamps, silver bowl lamps, and traffic signal lamps should be exempted from standards since these are low volume lamps designed for specialty applications and do not provide overall illumination. (NEMA, No. 34 at pp. 4–5) CA IOUs and EEAs also recommended that DOE look closely at plant light lamps, bug lamps, silver bowl lamps, colored lamps, and appliance lamps to ensure that adequate legal definitions are in place to prevent lamps that could easily be used in general lighting applications from being

[33] Underwriter's Laboratory. *Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kit.* 2014. Underwriter's Laboratory Inc. (Last accessed July 21, 2015.) *http://ulstandards.ul.com/standard/?id=1598C&edition=1&doctype=ulstd.*

[34] ENERGY STAR. *ENERGY STAR Program Requirements: Product Specification for Luminaires (Light Fixtures): Eligibility Criteria, Version 2.0.* 2015. U.S. Environmental Protection Agency: Washington, DC (Last accessed July 7, 2015.) *https://www.energystar.gov/sites/default/files/Luminaires%20V2.0%20Final%20Specification.pdf.*

[35] GSL preliminary analysis at 3–7.

[36] *Id.*

manufactured and marketed under these exemptions. (CA IOUs, No. 33 at p. 2; EEAs, No. 32 at pp. 6–7) DOE discusses these lamp types and others that it is proposing to exempt, as well as the relevant definitions, in the sections that follow.

a. Colored Lamp

In the preliminary analysis, DOE considered the definition for ''*Colored lamp* to mean a colored fluorescent lamp, a colored incandescent lamp, or a lamp designed and marketed as a colored lamp and not designed or marketed for general lighting applications with either of the following characteristics (if multiple modes of operation are possible [such as variable CCT], either of the below characteristics must be maintained throughout all modes of operation): (1) A CRI less than 40, as determined according to the method set forth in CIE Publication 13.3; or (2) A correlated color temperature less than 2,200 K or greater than 7,000 K as determined according to the method set forth in IES LM–66 or IES LM–79 as appropriate.'' [37]

NEMA agreed with the considered definition of colored lamps. (NEMA, No. 34 at p. 3) GE commented that this definition has been used successfully for linear fluorescent lamp technology for years and tends to push lamps into areas that define the colored space. Therefore, GE found it logical for this definition to also to work for CFLs or LED lamps. However, GE also noted that a definition for colored lamps needs to be further reviewed within the industry. (GE, Public Meeting Transcript, No. 29 at pp. 42–43) EEAs urged DOE to develop clear legal definitions for each exempted lamp type in order to prevent a manufacturer from simply applying an inexpensive removable cover to an incandescent lamp that could be used in general service applications if the cover was removed. They recommended that DOE include language in its definition that would not exempt such lamps that are operable once one or more components are removed. Additionally, EEAs noted that the definition of colored incandescent lamp includes lamps with a correlated color temperature (CCT) below 2,500 K, which might also represent a potential loophole as it is not far from the 2,700 K of conventional lamps. EEAs asked that DOE eliminate this language in its regulations. (EEAs, No. 32 at p. 6) In interviews, some manufacturers noted that colored lamps are evaluated based on perceived color, and as such would be better defined by the wavelength of the light emitted, rather than the CRI or CCT. However, given the different possible colors of colored lamps, manufactuers noted it would be problematic to include distinct wavelengths in the definition, especially given the definition's application to developing LED technologies. Given that CRI and CCT may be the best descriptors of the lamp type overall, DOE received feedback from manufacturers interviewed that the lower CCT limit should be raised to 2,500 K to accommodate the demand for 2,200–2,450 K atmospheric mood lighting in hospitality applications. Accordingly, DOE continues to propose defining this lamp type with CRI and CCT, but broadens the lower CCT range to less than 2,500 K as: ''*Colored lamp* means a colored fluorescent lamp, a colored incandescent lamp, or a lamp designed and marketed as a colored lamp and not designed and marketed for general lighting applications with either of the following characteristics (if multiple modes of operation are possible [such as variable CCT], either of the below characteristics must be maintained throughout all modes of operation): (1) A CRI less than 40, as determined according to the method set forth in CIE Publication 13.3; or (2) A correlated color temperature less than 2,500 K or greater than 7,000 K as determined according to the method set forth in IES LM–66 or IES LM–79 as appropriate.''

[37] *Id.* at 3–8.

b. Appliance Lamp

CA IOUs and EEAs recommended that DOE establish a maximum allowable light output for appliance lamps to prevent the lamps from being used in general service applications. EEAs specified that DOE should establish this maximum allowable light output level at approximately 400 lumens. CA IOUs and EEAs noted that these lamps often utilize thicker glass in order to withstand higher temperatures, but they could potentially be made to look and operate like a conventional GSIL. EEAs added that a manufacturer could simply alter a current 43 W halogen incandescent, add a thicker glass enclosure, and market it as an equivalent of a GSL, only identifying it as an appliance lamp in smaller print on the front of the package. EEAs stated that the 400-lumen limit, a light output just below conventional 40 W incandescent lamps, would be sufficient to illuminate the small oven spaces for which appliance lamps are intended and prevent them from being used as a loophole to compliance with standards. (CA IOUs, No. 33 at p. 2; EEAs, No. 32 at pp. 6–7)

A statutory definition of appliance lamp currently exists at 42 U.S.C. 6291(30)(T). Appliance lamp is defined as: ''*Appliance lamp* means any lamp that— (1) Is specifically designed to operate in a household appliance, has a maximum wattage of 40 watts, is sold at retail (including an oven lamp, refrigerator lamp, and vacuum cleaner lamp); and (2) Is designated and marketed for the intended application, with (i) The designation on the lamp packaging; and (ii) Marketing materials that identify the lamp as being for appliance use.'' 10 CFR 430.2.

DOE acknowledges that the 40 W limit currently included in the statutory definition of appliance lamp is intended for incandescent technology; however, DOE is unable to modify this wattage limit as it is part of a statutory definition. Per the definition, appliance lamps are required to be designated and marketed as such on both the lamp packaging and marketing materials. Further, DOE clarified the term ''designed and marketed'' in the GSFL and IRL standard rulemaking to ensure that the marketing materials explicitly stated the intended application of the exempted lamp. DOE defined ''designated and marketed'' to mean that the intended application of the lamp is clearly stated in all publicly available documents (*e.g.,* product literature, catalogs, and packaging labels). 80 FR 4053–4054 (Jan. 26, 2015). Therefore, DOE believes the specialty application of appliance lamps will be sufficiently clear, thus preventing consumers from using appliance lamps in general service lighting applications.

c. Black Light Lamp

In interviews, DOE presented a preliminary definition of ''*Black light lamp* to mean a lamp that is designed and marketed as a black light lamp and is an ultraviolet lamp that emits a significant portion of its radiative power in the UV–A band (315 to 400 nm).''

Manufacturers agreed with this preliminary definition of black light lamps based on the definition of black light lamp in the industry standard RP–16. RP–16 defines black light lamp as an ultraviolet lamp that emits a significant portion of its radiative power in the UV–A band (315 to 400 nm). However, DOE determined that additional specificity was necessary for the definition of black light lamp to clearly describe the exemption. Therefore, DOE proposes to exempt black light lamps defined as: ''*Black light lamp* means a lamp that is designed and marketed as a black light lamp and is an ultraviolet lamp with the highest radiant power peaks in the UV–A band (315 to 400 nm) of the electromagnetic spectrum.''

d. Bug Lamp

In manufacturer interviews, DOE presented a preliminary definition of bug lamp ''*Bug lamp* to mean a lamp that emits a significant portion of its radiative power in the UV–A band (315 to 400 nm) and the visible spectrum (380 to 770 nm).''

Manufacturers disagreed with this definition, noting that bug lamps are not those lamps made to attract insects, but rather those designed to emit light outside the typical perception of night-flying insects. Such lamps emit light only in the red or yellow part of the spectrum and are marketed as a bug lamp. Therefore, in this NOPR DOE proposes to exempt bug lamps defined as: ''*Bug lamp* means a lamp that is designed and marketed as a bug lamp, has radiant power peaks above 550 nm on the electromagnetic spectrum, and has a visible yellow coating.''

e. Plant Light Lamp

In manufacturer interviews, DOE received feedback on the following preliminary definition for plant light lamps: ''*Plant light lamp* means a lamp that contains a filter to suppress the yellow and green portion of the spectrum. Plant light lamps must be specifically designed and marketed for plant growing applications.''

Some manufacturers noted that the definition applies only to incandescent lamps, as other lighting technologies are not constrained to use filters. Manufacturers pointed out that the main purpose of such lamps is to mimic sunlight for growing plants indoors. The light output of the lamp may be more tailored to the needs of the specific plants being cultivated. Therefore, DOE amends the preliminary definition and instead proposes to exempt plant light lamps defined as: ''*Plant light lamp* means a lamp that is designed to promote plant growth by emitting its highest radiant power peaks in the regions of the electromagnetic spectrum that promote photosynthesis: blue (440 nm to 490 nm) and/or red (620 to 740 nm). Plant light lamps must be designed and marketed for plant growing applications.''

f. Infrared Lamp

In manufacturer interviews, DOE received feedback on the following preliminary definition for infrared lamp: ''*Infrared lamp* means a lamp that radiates predominately in the infrared spectrum (770 nm to 1 mm).''

Manufacturers commented that DOE should align the definition with that used in the RP–16. Further, manufacturers specifically requested that DOE remove the wavelength range and add a clause that the visible radiation is not of principle interest. RP–16 defines ''infrared lamp'' as a lamp that radiates predominately in the infrared; the visible radiation is not of principal interest. DOE finds the wavelength range necessary for clearly describing the exemption and also believes that describing the primary application of infrared lamps (*i.e.,* to provide heat) is more straightforward. Therefore, DOE proposes defining infrared lamp to align with the RP–16 definition with slight modifications as: ''*Infrared lamp* means a lamp that is designed and marketed as an infrared lamp, has its highest radiant power peaks in the infrared region of the electromagnetic spectrum (770 nm and 1 mm), and which has a primary purpose of providing heat.''

g. Sign Service Lamp

In interviews, DOE received feedback from manufacturers generally agreeing with a preliminary definition of sign service lamps, proposed below. DOE received some feedback regarding additional technology-specific features that should be incorporated in the definition. However, DOE is proposing technology-neutral definitions to support the scope of the rulemaking. Therefore, DOE proposes to define sign service lamps as: ''*Sign service lamp* means a vacuum type or gas-filled lamp that has sufficiently low bulb temperature to permit exposed outdoor use on high-speed flashing circuits, is designed and marketed as a sign service lamp, and has a maximum rated wattage 15 watts.''

h. Showcase Lamp

In manufacturer interviews, DOE received feedback on the following preliminary definition for showcase lamp: ''*Showcase lamp* means a lamp that has a T-shape as specified in ANSI C78.20 and ANSI C79.1 and a length exceeding 25 cm [centimeters] and is marketed as a showcase lamp.''

The majority of manufacturers agreed with a preliminary definition of showcase lamps, however DOE received some feedback to remove the length requirement, as there was concern that showcase lamps varied in length. DOE agrees the definition is sufficiently narrow without the length requirement and therefore proposes to define showcase lamps as: ''*Showcase lamp* means a lamp that has a T-shape as specified in ANSI C78.20 and ANSI C79.1, is designed and marketed as a showcase lamp, and has a maximum rated wattage of 75 watts.''

i. Marine Signal Service Lamp, Mine Service Lamp, Silver Bowl Lamp, and Traffic Signal Lamp

In interviews, DOE received feedback from manufacturers agreeing with several preliminary definitions of exempted lamp types including marine signal service lamps, mine service lamps, silver bowl lamps, and traffic signal lamps. DOE did not receive any negative feedback or suggested changes. Therefore, DOE proposes to define these terms as: ''*Marine signal service lamp* means a lamp that is designed and marketed for marine signal service applications''; ''*Mine service lamp* means a lamp that is designed and marketed for mine service applications''; ''*Silver bowl lamp* means a lamp that has a reflective coating applied directly to part of the bulb surface that reflects light toward the lamp base and that is designed and marketed as a silver bowl lamp''; and ''*Traffic signal lamp* means a lamp that is designed and marketed for traffic signal applications.''

j. Designed and Marketed

In the recent final rule for general service fluorescent lamps and incandescent reflector lamps, DOE adopted a definition for the term ''designed and marketed'' to ensure that the intended application of the lamp is clearly stated in all publicly available documents (*e.g.,* product literature, catalogs, and packaging labels). DOE believes that it is important that all public disclosures be consistent about the intended use or application of the lamp. 80 FR 4042, 4053–4054 (January 26, 2015).

DOE is proposing a revised definition of ''designed and marketed'' to clarify that the term means that a lamp is specifically designed for a specialty application and that, when distributed in commerce, the packaging and all publicly available documents indicate the intended application. This will help ensure that lamps that are exempt from the definition of general service lamp do not have packaging or marketing materials that imply they are for use in general lighting applications. DOE proposes to revise the definition of ''designed and marketed'' to read: ''*Designed and marketed* means that the product is specifically designed to fulfill the indicated application and, when distributed in commerce, is designated and marketed for the intended application, with the designation on the packaging and all publicly available documents (*e.g.,* product literature, catalogs, and packaging labels) indicating the intended application. This definition is applicable to terms related to the following covered lighting products: Fluorescent lamp ballasts; fluorescent lamps; general service fluorescent lamps; general service incandescent lamps; general service lamps; incandescent lamps; incandescent reflector lamps; medium base compact fluorescent lamps; and specialty application mercury vapor lamp ballasts.''

2. Non-Exempted Lamp Types

In the preliminary analysis, DOE determined that several of the specified lamp types were able to provide overall illumination and therefore could serve in general lighting applications and did not require an exemption from standards. NRDC and CEC expressed their support of the determination that many of the currently exempt lamps do provide overall illumination and therefore do not need to be exempted. (NRDC, Public Meeting Transcript, No. 29 at p. 12; CEC, No. 31 at p. 2) DOE discusses these lamp types in the following sections.

a. Reflector Lamp

In the preliminary analysis, DOE considered defining the term ''reflector lamp'' in support of the scope of coverage and presented the definition for ''*Reflector lamp* to mean a lamp that has an R, PAR, BPAR, BR, ER, MR, or similar bulb shape as defined in ANSI C78.20 and ANSI C79.1 and is used to direct light.'' [38]

NEMA agreed with the proposed definition of reflector lamps. (NEMA, No. 34 at p. 4) However, NEMA did not think it was appropriate to include reflector lamps as covered products in this rulemaking because they are designed for specific applications and offer unique performance and efficiency features. (NEMA, No. 34 at p. 6) DOE observes that reflector lamps provide overall illumination and serve in general lighting applications. DOE finds no evidence that reflector lamps would be prohibited from use in general service applications, and therefore proposes the definition of reflector lamp considered in the preliminary analysis. DOE welcomes comment on including non-IRLs in the definition of GSLs.

DOE also considered the following definition for ''non-reflector lamp'' in the preliminary analysis to further define the scope: ''*Non-reflector lamp* means a lamp that is not a reflector lamp.'' [39] NEMA commented that the definition of non-reflector lamp was vague and suggested modifying the definition to mean ''an integrated or non-integrated lamp that is not a reflector lamp.'' (NEMA, No. 34 at p. 4) DOE notes that the definitions for reflector and non-reflector are intended to describe the shapes of the lamps specifically. DOE is therefore maintaining the definition for non-reflector lamp. DOE proposes definitions for integrated and non-integrated lamp in section IV.C.3.

b. Rough Service Lamp, Shatter-Resistant Lamp, and Vibration Service Lamp

In the preliminary analysis, DOE noted that rough service lamps and vibration service lamps are defined specifically in the context of incandescent or halogen technology. However, DOE determined that the utility of rough service, vibration service, and shatter-resistant lamps is their service in applications where vibrations occur or in applications where broken glass due to shattering would be a safety hazard and therefore must be contained. DOE believes that LED lamps are inherently durable and thus can provide the necessary utility to serve in these applications.

NRDC and CA IOUs commented that special treatment lamps such as shatter-resistant and vibration service lamps can be used in general applications. (NRDC, Public Meeting Transcript, No. 29 at pp. 12–13; CA IOUs, No. 33 at p. 2) EEAs agreed that energy-efficient CFLs and LED lamps already exist on the market to meet the needs of each of these lamp types, and in some cases provide superior functionality. As LED lamps are not filament based, they are more robust than vibration service incandescent lamps. (EEAs, No. 32 at pp. 5–7) NEMA commented that the rough service lamp definition and vibration service lamp definition are unique to incandescent technology and are not applicable to CFL or LED lamp technology as those lamps are more shock resistant by design. NEMA further noted that shatter-resistant lamps normally contain a coating that absorbs a small portion of the light output; and therefore, light absorption factors would have to be considered when setting efficacy regulations covering this technology. (NEMA, No. 34 at p. 5) However, as LED lamps capable of operating in shatter-resistant applications exist at the highest ELs, DOE finds there is no technological reason to separate them into their own product class, let alone exempt them from standards. Because DOE found that the utilities offered by these lamp types are available at higher levels of efficacy, DOE is proposing not to exempt non-incandescent lamps for use in rough service, shatter-resistant, and vibration service applications in this GSL rulemaking.

c. Three-Way Lamp

In the preliminary analysis, DOE determined that 3-way lamps are able to provide overall illumination, and therefore can be used in general lighting applications. Further, DOE found that 3-way CFLs and LED lamps are available, and one of the most-efficacious GSLs currently available on the market is a 3-way LED lamp. Therefore, DOE found no technological reason not to include non-incandescent 3-way lamps in this GSL rulemaking.[40]

NRDC and CA IOUs agreed that 3-way lamps can be used in general applications. (NRDC, Public Meeting Transcript, No. 29 at pp. 12–13; CA IOUs, No. 33 at p. 2) EEAs agreed that 3-way CFLs and LED lamps already exist on the market designed to replace conventional 3-way incandescent lamps. (EEAs, No. 32 at pp. 6–7) NEMA commented that if 3-way CFL or LED lamps are regulated, the efficiency requirements should be evaluated based on the highest, most energy consuming setting, as is done in other current standards (*e.g.,* ENERGY STAR) for these products. NEMA explained that 3-way CFLs will operate at different efficacies at different light levels and it is important that DOE base compliance with standards at the most-efficacious or highest light output level. Forcing the lower light output settings to meet high ELs would be very problematic for industry and may remove this product utility from the market. (NEMA, No. 34 at p. 5) DOE agrees with NEMA that the unique utility of 3-way lamps needs to be retained and that 3-way lamps performance varies depending on the light output setting. Therefore, in both the CFL TP NOPR and the LED TP SNOPR, DOE proposed to operate CFLs and LED lamps at the maximum input power. 80 FR 45724 (July 31, 2015); 80 FR 39644 (July 9, 2015). Further, when tested at the highest output level, DOE finds that 3-way lamps are available at the highest ELs and therefore proposes not to exempt 3-way lamps from this rulemaking.

d. Left-Hand Thread Lamp and Marine Lamp

DOE did not consider providing exemptions for left-hand thread lamps or marine lamps in the preliminary analysis. NEMA and EEAs agreed that

[38] *Id.* at 3–9.

[39] *Id.*

[40] *Id.* at 3–8.

the left-hand thread lamp and marine lamp exemptions are not necessary for CFL or LED lamp technology. (NEMA, No. 34 at p. 6; EEAs, No. 32 at pp. 6–7) DOE agrees that these lamp types provides overall illumination and can serve in general lighting applications, and therefore continues not to propose an exemption for left-hand thread lamps or marine lamps from GSL standards.

e. Lamps of Specific Shapes

In the preliminary analysis, DOE determined that lamps of several specific shapes (such as G, T, B, BA, CA, F, G16.5, G25, G30, S, and M14, as defined in ANSI C79.1–2002 and ANSI C78.20) provide overall illumination, and therefore can serve in general lighting applications and do not require an exemption from standards.[41] EEAs agreed with DOE's determination that lamps of these shapes provide overall illumination and can serve in general lighting applications and as such would no longer warrant an exemption. (EEAs, No. 32 at pp. 6–7) NEMA commented that specific lamp shapes exempted in the current incandescent rule primarily provide decorative illumination and are not wholly functional in all general service applications. NEMA stated that decorative lamp shapes provide unique technical challenges for both CFL and LED lamp technology, and they cannot be assumed to be capable of reaching similar efficacy levels. NEMA noted that the technical effort necessary to mimic the consumer-demanded performance attributes of some decorative products would come with corresponding trade-offs in efficacy. NEMA added that because manufacturers are only beginning to develop these types of lamps, the size of this impact on efficacy is not well-known. NEMA commented that regulating this emerging product category at this time would slow product innovation, as well as development and consumer acceptance, as standards inhibit the flexibility of the manufacturer to experiment with product specifications that may relate to the utility of the product. NEMA suggested DOE regulate these products in a future rulemaking. (NEMA, No. 34 at p. 6)

DOE recognizes the rapid development of LED lamps, and notes that products with certain lamp shapes are part of emerging product lines at this time. As stated previously, DOE determined that these lamps could serve in general lighting applications because they emit a minimum of 310 lumens, thus providing overall illumination. However, based on comments received and feedback from manufacturer interviews, DOE considered whether lamps of these certain shapes were able to achieve the same level of efficacy as the more common 60 W A-shape equivalent replacements. DOE also considered whether lamps of these shapes could achieve those higher levels of efficacy in their existing form factors.

DOE found that in general the lamps of these certain shapes were not able to achieve the highest levels of efficacy under consideration in the NOPR analysis while maintaining their form factors. (See section V.C.5 for more information on the ELs.) DOE compared the size of the CFL and LED lamps that were available in these certain shapes to more efficacious 60 W A-shape equivalent replacements to determine if the form factors were smaller, which could indicate that space constraints were preventing the lamps from achieving comparable efficacies. DOE found that B-shape lamps (including blunt shape), C- and CA-shape lamps (including candle shape), F-shape lamps (including flame or flame tip shape), S-shape lamps, and torpedo or torpedo tip shape lamps were considerably smaller in size than the 60 W A-shape equivalent replacements. Therefore, DOE is proposing to exempt from the standards proposed in this rulemaking lamps of these shapes that have a diameter of less than or equal to 1.875 inches when measured at the widest point. DOE also determined that the G-shape lamps (including globe shape) with lamp diameter when measured at the widest point of less than or equal to 2.0625 inches and A15 lamps with diameter when measured at the widest point of less than or equal to 2.185 inches were also notably smaller in size than the 60 W A-shape equivalent replacements. DOE is therefore also proposing to exempt these lamp types from the standards proposed in this rulemaking. In summary, DOE is proposing to exempt B-, blunt, C-, CA-, candle, F-, flame, flame tip, S-, torpedo, and torpedo tip shape lamps with a diameter of less than or equal to 1.875 inches; G- and globe shape lamps with a diameter of less than or equal to 2.0625 inches; and A15 lamps with a diameter of less than or equal to 2.185 inches. DOE notes that these lamps are general service lamps but is not proposing standards for these lamps in this NOPR analysis. DOE will reconsider these exemptions from GSL standards as the market continues to evolve. DOE welcomes comment on the exemptions proposed for non-incandescent lamps of certain shapes, in particular on the proposed diameters.

E. GSLs Under Consideration for Standards

In the preliminary analysis, DOE did not consider establishing standards for all GSLs. Specifically, DOE considered establishing standards in this rulemaking for the following GSLs: (1) Integrated, non-reflector, medium screw base lamps with a lumen output between 310 and 2,600 lumens; (2) integrated and non-integrated, non-reflector GU24 base lamps with a lumen output between 310 and 2,600 lumens; and (3) non-integrated, non-reflector, pin base, CFLs with a lumen output between 310 and 2,600 lumens.

EEAs stated that their support for including a lamp type as a covered lamp is contingent on DOE ultimately setting a standard for that lamp type. EEAs stated they do not support DOE covering a lamp type, and thereby preempting state standards, without also establishing standards. (EEAs, No. 32 at p. 5)

In the preliminary analysis, DOE did not consider establishing standards for GSLs for which it determined that there would be low potential for energy savings; it would not be technologically feasible to establish standards; and/or restrictions from the Appropriations Rider prevented consideration of standards. DOE notes that for GSLs, state preemption requirements are specified for California and Nevada under 42 U.S.C. 6295(i)(6)(A)(vi). Namely, beginning, January 1, 2018, no provision of law could preclude these states from adopting: (1) A final rule adopted in accordance with 42 U.S.C. 6295(i)(6)(A)(i)–(iv); (2) the minimum efficacy standard of the backstop requirement (45 lm/W) if no final rule was adopted; or (3) for the state of California, any California regulations related to the covered products adopted pursuant to state statute in effect as of the date of enactment of EISA 2007. 42 U.S.C. 6295(i)(6)(A)(vi). Other than these narrow exceptions, EPCA's statutory pre-emption provision would prohibit any state from adopting energy conservation standards for any type of GSL regardless of whether DOE sets standards for that type of GSL.

CA IOUs and Earthjustice commented that any lamp type determined to be a general service lamp in this rulemaking also becomes subject to the backstop requirement. These commenters stated that EPCA's definition of ''general service lamp'' incorporates a few specific types of lamps, including GSILs, CFLs, and LED lamps, but it also authorizes DOE to determine that a lamp is a general service lamp if it is ''used to satisfy lighting applications

[41] *Id.*

traditionally served by general service incandescent lamps.'' 42 U.S.C. 6291(30)(BB)(i). Therefore, commenters asserted that if DOE determines that a type of lamp meets this criterion, it automatically becomes subject to the backstop requirement. CA IOUs noted that setting standards for CFL and LED lamp technologies should not be problematic as the backstop would stop market migration to incandescent technologies. (CA IOUs, Public Meeting Transcript, No. 29 at p. 32; Earthjustice, No. 30 at p. 3) DOE agrees that if the backstop goes into effect on January 1, 2020, per statutory requirement, any lamp that DOE determines is a GSL would be subject to the backstop.

NRDC stated that should the Appropriations Rider be lifted, DOE should review the coverage of other base types, lumen outputs above 2,600, and other such lamps in this rulemaking. (NEMA, No. 34 at p. 2; NRDC, Public Meeting Transcript, No. 29 at p. 42) As noted in the preliminary analysis, DOE's evaluation of GSLs for which to establish standards considered the restrictions based on the Appropriations Rider. If the limitation on DOE's use of appropriated funds per the Appropriations Rider is removed during the course of this rulemaking, DOE will consider revising the scope of the rulemaking.

DOE also received several specific comments on its assessment of GSLs considered for standards in this rulemaking.

1. Integrated Candelabra and Intermediate-Base Lamps

In the preliminary analysis DOE determined that while these lamp types are within the scope, it would not set standards for GSLs with candelabra and intermediate bases in this rulemaking due to the Appropriations Rider.[42] Earthjustice stated that as of March 2015, DOE will be in violation of its obligation to review and amend the energy conservation standards for intermediate-base incandescent lamps and candelabra base incandescent lamps under 42 U.S.C. 6295(m)(1). (Earthjustice, No. 30 at p. 1) EEAs urged DOE to cover lamps with candelabra and intermediate bases as equivalent, given that GSIL versions of these lamps currently are subject to wattage limits only and there is nothing inherently unique about these lamps besides the size of the screw base. EEAs stated that candelabra and intermediate-base lamps are available using incandescent, CFL, and LED technology. (EEAs, No. 32 at p. 5)

DOE evaluated integrated GSLs with intermediate and candelabra bases. DOE identified one incandescent/halogen reflector candelabra base integrated lamp and a limited number of incandescent/halogen reflector intermediate-base integrated lamps. However, as stated previously DOE is not considering these lamp types due to the Appropriations Rider. DOE identified very few reflector candelabra base or intermediate base integrated lamps in CFL or LED technology. Due to this low market share and thereby low energy savings potential, DOE continues to maintain its decision not to establish standards for reflector candelabra and intermediate-base integrated lamps.

Regarding non-reflector lamps, DOE found that there are fewer candelabra and intermediate bases offered in CFL and LED lamp technology compared to the number offered with incandescent/halogen technology; the latter technology cannot be considered due to the Appropriations Rider (see section IV.A for further details). Due to this low market share and thereby low energy savings potential, DOE continues to maintain its decision not to establish standards for non-reflector candelabra and intermediate base integrated lamps.

2. Pin Base Lamps

DOE considered several types of integrated and non-integrated pin base lamps in the preliminary analysis including non-integrated pin base CFLs, non-integrated pin LED lamps, pin base lamps with GU24 bases, and MR16 pin base lamps.[43] DOE received comments on its assessment of whether standards should be established for these lamp types.

a. Non-Integrated Pin Base CFLs and LED Lamps

In the preliminary analysis, DOE considered establishing standards for non-integrated pin base CFLs. NEMA, GE, and Philips commented that non-integrated pin base lamps that go in dedicated fixtures and have dedicated ballasts are mostly commercial products and consumers have not been buying them for many years. Because such lamps are not an acceptable replacement for traditional GSILs, NEMA, GE, and Philips did not support including them in the scope. (NEMA, No. 34 at p. 16; GE, Public Meeting Transcript, No. 29 at pp. 40–41; Philips, Public Meeting Transcript, No. 29 at p. 41) GE commented that they do not believe there are significant opportunities to save energy with pin base lamps and do not think that pin base lamps should be included in an analysis aimed at medium screw base lamps as they are not replacements for such lamps. (GE, Public Meeting Transcript, No. 29 at pp.39–40, 79) NEMA explained that non-integrated pin base CFLs are rarely used in residential applications and cannot directly replace medium screw base GSLs without replacing the entire fixture. Fixtures using these lamp types are nearly all designed for commercial applications. (NEMA, No. 34 at p. 7, 11–12) Due to the complexity, the limited energy savings potential, and the maturity of this product line, NEMA suggested that DOE remove the product category from the scope of this rulemaking. (NEMA, No. 34 at p. 16)

Although non-reflector pin base non-integrated lamps are available in incandescent/halogen, CFL, and LED technologies, CFLs are by far the most common type. DOE determined that the term compact fluorescent includes both integrated and non-integrated CFLs and therefore DOE considered non-integrated, or pin base, CFLs in the scope of this rulemaking. DOE notes that the market share of pin base CFLs is not insignificant given the vast number of product offerings and common use in commercial applications. Further, DOE's analysis of non-integrated pin base lamps within the non-integrated product class has shown that there are levels of efficacy as well as reduced wattage options and therefore, a standard for these lamps is technologically feasible. DOE's analysis showed that the proposed efficacy levels for these lamp types would retain almost all the different base type options for non-integrated pin-base base CFLs. See section V.C for further details regarding the engineering analysis for the non-integrated product class. For these reasons, DOE continues to consider standards for non-integrated pin base lamps.

DOE also received comments on non-integrated pin base LED lamps. Regarding LED replacements for non-integrated pin base CFLs, NEMA acknowledged that there are some LED lamp replacements being developed at this time but noted that they do not create energy savings as they generally have an identical wattage to non-integrated pin base CFLs and represent a loss of utility as they do not work with some types of controls and dimming systems. Lamp and ballast pairings that NEMA has investigated do not have Underwriters Laboratories (UL) listing, which they considered significant. They stated that if one is going to retrofit pin base CFLs, there are more efficacious

[42] *Id.* at 3–11.

[43] *Id.* at 3–12.

choices than the non-reflector pin base non-integrated LED lamps. Additionally, compatibility problems with reduced wattage lamps are not well understood in the DOE analysis, and could result in field issues if pursued. Finally, NEMA asked DOE to afford the same recognition of the implications of a lamp rule on non-integrated ballast systems as they did in the GSFL and IRL standards rulemaking. (NEMA, No. 34 at p. 7, 11–12)

DOE agrees with NEMA regarding the issues with non-integrated pin base LEDs currently available on the market. DOE evaluated the non-integrated pin base LED lamps and found they are still in the development stage and currently do not maintain the same utility (*e.g.,* lumen output, system compatibility) of the pin base CFLs they are designed to replace. DOE therefore is not proposing to establish standards for these lamp types in this rulemaking.

b. GU24 Base Lamps

In the preliminary analysis, DOE considered including integrated and non-integrated GSLs with GU24 bases. NEMA commented that they believe the market share for integrated CFLs with GU24 bases is insignificant (less than 4 percent), and that GU24 base CFL products should be excluded from scope. Additionally, NEMA commented that currently there are no additional bases besides medium screw base used for GSLs that have a significant market share. (NEMA, No. 34 at p. 7) As stated previously, DOE has taken a broad interpretation of GSL and considers lamps with base types other than medium screw bases to be general service lamps because lamps with other base types, including GU24, are frequently used in general lighting applications. Further, DOE found that of the integrated pin bases considered, lamps with GU24 bases compose the vast majority of the market. While GU24 lamps may not currently be sold in the same volume as medium screw base lamps, DOE expects their sales to increase as a result of regulations, such as California's Building Code Standards Title 24,[44] which allows for the use of GU24 base lamps as high efficacy light sources. Given their expected market share, DOE proposes to include GU24 base integrated lamps in the GSL rulemaking.

c. MR16 Lamps

In the preliminary analysis, DOE considered not establishing standards for integrated and non-integrated pin base MR16 lamps.[45] GE agreed that MR16 lamps should not be covered in this rulemaking because they are still being developed to be a suitable replacement for the other technologies. (GE, Public Meeting Transcript, No. 29 at pp. 39–40) NEMA agreed that current MR16 LED lamps cannot provide all the functionality of currently available halogen MR16 lamps and should not be regulated during this rulemaking as it is a developing product category. (NEMA, No. 34 at p. 7)

CA IOUs and EEAs also supported DOE's proposal to not cover LED MR16s or other small diameter directional lamps (those with diameters less than 2.25 inches) in this rulemaking at this time. However, CA IOUs disagreed with DOE's rationale behind the decision. CA IOUs observed that DOE stated in the preliminary TSD that it would not consider setting standards for LED MR16s because DOE did not believe that LED technology is able to provide the same utility as halogen technology in the MR16 lamp shape. CA IOUs noted that DOE referenced the 2014 CALiPER study that found tested LED lamps provided a lower center beam candle power (CBCP) than would be predicted based on their claimed halogen equivalence (using ENERGY STAR's CBCP calculator). However, CA IOUS asserted that the CALiPER report did not conclude that LED MR16s are not able to provide the same utility as their halogen counterparts; thus, DOE should be cautious about drawing such conclusions. EEAs also disagreed with DOE's finding that energy-efficient options do not currently exist for MR16s and commented that there are many high-quality LED lamps in this form factor that meet a range of application needs. CA IOUs additionally stated that there are currently LED products that provide more center beam intensity than the minimum required by ENERGY STAR for a 50 W equivalent lamp of the same beam angle. Further, CA IOUs noted that DOE is not considering standards for halogen MR16s due to the Appropriations Rider, and therefore this comparison is irrelevant. (CA IOUs, No. 33 at pp. 2–3; EEAs, No. 32 at p. 7)

Instead, CA IOUs and EEAs supported the proposal not to include LED MR16s in this rulemaking because of momentum in multiple states (such as California and Washington) to regulate MR16s. CA IOUs and EEAs stated that such efforts would promote market transformation and lay the groundwork for NES. Once they are adopted at the state level, CA IOUs suggested that DOE should consider adopting standards for these products at levels equal to or higher than those adopted by the states. They requested that DOE remove or correct its statement that LED technology is not able to provide the same utility as halogen technology because there is no reason for DOE to make such an assessment in this rulemaking, and because there is not sufficient evidence to support such a claim. EEAs suggested that DOE should not establish standards for MR16 lamps based on the rational that the Appropriations Rider prevents DOE from updating IRL standards. EEAs noted that improved standards for substitutes or near-substitutes could backfire, further shifting the market to the unregulated lamps. (CA IOUs, No. 33 at pp. 2–3; EEAs, No. 32 at p. 7)

DOE finds that a comparison of halogen MR16 lamps to LED MR16 lamps is essential in determining if it is technologically feasible to set standards for these lamps. Data provided in the CALiPER report and DOE's assessment of MR16 products on the market do provide sufficient evidence that, at this time, LED MR16s are not able to provide the same utility as their halogen counterparts. From the CALiPER report, DOE determined that none of the tested lamps emitted comparable lumen output to the 50 W halogen MR16 lamps that CALiPER tested, despite 17 of the 27 products claiming equivalency to that wattage (or higher), nor could any CALiPER tested lamp match the ENERGY STAR predicted CBCP for 50 W halogen MR16s at any beam angle.[46] (See chapter 3 of the NOPR TSD for more information.) DOE also assessed MR16 LED lamps on the market and found that, in general for a given beam angle, the maximum lumen output of halogen lamps is not always achieved by LED replacements and the CBCP of LED replacements is generally lower than halogen lamps. Further, DOE found very few 120 V 50 W equivalent MR16s and no 12 V 50 W equivalent MR16s that met the Energy Star predicted CBCP based on halogen equivalencies, although some do meet the minimum ENERGY STAR requirements. Drawing its conclusions from not only the CALiPER report but its own evaluation of products on the market, DOE maintains that, at this time, LED technology is currently not able to provide the same utility as halogen technology in the MR16 lamp shape.

[44] California Energy Commission's Building Code Standards are available at: *http://www.energy.ca.gov/title24/*.

[45] *Id.* At 3–13.

[46] U.S. Department of Energy. CALiPER Application Summary Report 22: LED MR16 Lamps. June 2014. (Last accessed November 21, 2014.) *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_22_summary.pdf.*

Hence, DOE is not setting standards for MR16 lamps in this rulemaking because more-efficient replacements maintaining the same utility are not available.

3. Organic Light-Emitting Diode Lamps

DOE considered not setting standards for OLED lamps in the preliminary analysis because OLED lamps are an emerging technology with limited commercial availability, and it remains unclear if the efficacy of existing OLED products can be improved.[47] NEMA agreed that it was premature to establish standards for OLED products at this time. This is due to concern with regulating emerging product categories, creating a substantial risk of slowing product innovation, development, and consumer acceptance. (NEMA, No. 34 at p. 6) GE agreed with DOE's position stating that most of industry believes it is too early to regulate OLEDs because it is a developing technology and there is not enough information about how it is going to develop. (GE, Public Meeting Transcript, No. 29 at pp. 19–20) Thus, DOE continues to not propose standards for OLED lamps in this NOPR analysis.

4. Summary of GSLs Under Consideration for Standards

In summary, DOE is proposing standards for the following GSLs: 1) integrated, non-reflector, medium screw base lamps with an initial lumen output between 310 and 2,600 lumens; 2) GU24 base, integrated and non-integrated, non-reflector lamps with an initial lumen output between 310 and 2,600 lumens; and 3) non-integrated, non-reflector, pin base, CFLs with an initial lumen output between 310 and 2,600 lumens. For further details on the assessment of GSLs considered for standards see chapter 3 of this NOPR TSD. DOE requests comments on its assessments of GSLs for which standards should be proposed.

F. Scope of Metrics

Because CFLs are included in the definition of a GSL, this rulemaking satisfies the requirements under 42 U.S.C 6295(m)(1) to review existing standards for MBCFLs. EPAct 2005 amended EPCA by establishing energy conservation standards for MBCFLs. Performance requirements were specified for five metrics: (1) Minimum initial efficacy; (2) lumen maintenance at 1,000 hours; (3) lumen maintenance at 40 percent of lifetime; (4) rapid cycle stress; and (5) lamp life. (42 U.S.C. 6295(bb)(1)) In addition to revising the existing requirements for MBCFLs, DOE has the authority to establish requirements for additional metrics including CRI, power factor, operating frequency, and maximum allowable start time based on the requirements prescribed by the August 9, 2001, ENERGY STAR® Program Requirements for CFLs Version 2.0, or establish other requirements after considering energy savings, cost effectiveness, and consumer satisfaction. (42 U.S.C. 6295(bb)(2)–(3))

DOE received several general comments regarding the determination of metrics in the preliminary analysis. CA IOUs recommended that DOE analyze the impacts of improvements to the minimum quality metrics for GSLs and adopt standards that result in increased energy savings or increased LCC savings for consumers as they believe that cost-effective improvements to performance aspects, such as product lifetime and power factor, may be achievable and those are two metrics where DOE has the authority to set standards. (CA IOUs, No. 33 at p. 8) In this proposal, DOE considered energy savings, cost effectiveness, and consumer satisfaction when assessing performance metric requirements pertinent to this rulemaking, including lifetime and power factor.

DOE received several overarching comments about adopting the latest ENERGY STAR specifications for existing and proposed additional MBCFL metrics. NRDC and EEAs supported updating the performance requirements for CFLs with the intent of aligning with ENERGY STAR. (NRDC, Public Meeting Transcript, No. 29 at pp. 46–47; EEAs, No. 32 at p. 8) GE stated that ENERGY STAR is supposed to be promoting a higher quality type of product. In regards to product lifetime, GE noted that traditionally, the DOE minimum standard lifetime of a product is a couple of thousand hours fewer than the ENERGY STAR requirement. GE suggested that DOE should consider levels other than those prescribed by ENERGY STAR for the non-energy efficiency related quality metrics. Furthermore, GE commented that, since the latest ENERGY STAR specifications for lamps came out recently, fewer lamps may meet the new criteria. (GE, Public Meeting Transcript, No. 29 at pp. 46, 48–50) Southern Company added that there are times that ENERGY STAR has a high percentage of the products on the market before updating standards, but the long-term goals of ENERGY STAR is closer to the range of 20 percent of the market. (Southern Company, Public Meeting Transcript, No. 29 at pp. 48–49) Philips stated that ENERGY STAR, by definition, should only represent the top 25 percent of the marketplace. Therefore, should DOE align performance requirements with ENERGY STAR, 75 percent of available products could be forced off the market. (Philips, Public Meeting Transcript, No. 29 at p. 47)

NRDC thought that more CFLs met ENERGY STAR requirements and urged DOE to examine the market share of CFLs that are ENERGY STAR qualified. (NRDC, Public Meeting Transcript, No. 29 at p. 48) EEAs stated that, unlike other ENERGY STAR product categories, the vast majority of CFLs on the market meet the existing ENERGY STAR requirements. In addition, EEAs noted the current ENERGY STAR specification was finalized in 2014 and the DOE regulations will not go into effect until 2020. (EEAs, No. 32 at p. 8) CA IOUs and EEAs recommended that DOE consider performance metric revisions to be consistent with the latest ENERGY STAR specification. The ENERGY STAR Program recently initiated an update to its Lamps Specification (Version 2), and if finalized in time, CA IOUs urged DOE to consider aligning with its specifications. (CA IOUs, No. 33 at p. 10; EEAs, No. 32 at p. 8))

DOE recognizes that ENERGY STAR requirements are meant to distinguish a certain premium among available products on the market. In its review of existing metrics for MBCFLs and determining additional metrics to establish for these lamp types, DOE examined various sources including the latest ENERGY STAR market share estimates, ENERGY STAR specifications (ENERGY STAR Program Requirements Product Specification for Lamps [Light Bulbs] Eligibility Criteria Version 1.1 [hereafter ''ENERGY STAR Lamps Specification V1.1'']), industry standards, and characteristics of lamps currently on the market.[48] The most recent market penetration report of ENERGY STAR lamps for the year 2014 indicated that 64 percent of CFLs were ENERGY STAR certified, indicating wide market adoption.[49] Based on this comprehensive evaluation, DOE determined the performance metrics that would appropriately satisfy the requirements of energy savings, cost

[47] GSL preliminary analysis at 3–6.

[48] DOE understands that ENERY STAR has completed an update to its current lamp specifications. Because this version remained in draft stage, at the time of this analysis, DOE referenced the ENERGY STAR Lamps Specification V1.1, the specifications currently in effect.

[49] ENERGY STAR. Unit Shipment and Market Penetration Report Calendar Year 2014 Summary. (Last accessed January 20, 2016.) *http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2014_USD_Summary_Report.pdf?f531-f608.*

effectiveness, and consumer satisfaction for MBCFLs.

1. Existing MBCFL Metrics

a. Lumen Maintenance

For lumen maintenance at 1,000 hours, DOE requires that the average of at least five lamps be a minimum of 90 percent of initial lumen output at 1,000 hours. The ENERGY STAR Lamps Specification V1.1 maintained this requirement with the added specification that all units must be surviving at 1,000 hours. For lumen maintenance at 40 percent of lifetime, DOE requires that 80 percent of the initial lumens must be achieved at 40 percent of lifetime. The ENERGY STAR Lamps Specification V1.1 also maintained this requirement with the added specification that no more than three units may be less than 75 percent of the initial lumen rating. In the preliminary analysis, DOE considered maintaining its current requirements for lumen maintenance at 1,000 hours and at 40 percent of lifetime for MBCFLs.[50]

EEAs noted that the test procedure utilized by ENERGY STAR currently requires a sample size of 10 lamps, five base up and five base down, unless the manufacturer restricts specific use or position. EPAct 2005 (*i.e.,* the current DOE standards) only require five samples. EEAs recommended that DOE utilize 10 samples in its requirements to be consistent with ENERGY STAR. EEAs also supported inclusion of ENERGY STAR's requirement that all units shall be surviving at 1,000 hours, and no more than three units may have lumen maintenance less than 75 percent at 40 percent of rated life. (EEAs, No. 32 at p. 8) However, NEMA commented that the current statutory and regulatory requirements for CFLs for lumen maintenance are acceptable. (NEMA, No. 34 at p. 8)

DOE determined that its current requirements for lumen maintenance adequately address potential issues with lumen depreciation that could lead to consumer dissatisfaction. DOE noted that the ENERGY STAR Lamps Specification V1.1 also maintained these requirements and added the requirements that all units shall survive at 1,000 hours and no more than three units may be 75 percent of the initial lumen rating. DOE, however, determined these additional requirements were not necessary to confirm the quality of the lamp; the existing requirements would ensure the lumen maintenance would be satisfactory to consumers. DOE assessed data submitted for the Compliance Certification Management System (CCMS) reporting requirements and found that the majority of lamps certified exceeded the minimum lumen maintenance standards. Regarding sample size, the number of MBCFL units tested is dictated by the DOE test procedure for these lamps, amendments to which are not within the scope of this rulemaking. (See section III.B for further details on relevant test procedures for GSLs.) Therefore, DOE is proposing to maintain the existing requirements of 90 percent of initial lumen output at 1,000 hours and 80 percent of initial lumen output at 40 percent of lifetime for MBCFLs.

b. Rapid Cycle Stress Testing

DOE has a minimum requirement for rapid cycle stress for MBCFLs that requires at least five lamps to survive cycling once per every two hours of rated lifetime. The ENERGY STAR Lamps Specification V1.1 specifies that CFLs with a start time greater than 100 milliseconds (ms) (*i.e.,* non-instant start) survive cycling once per hour of rated lifetime or a maximum of 15,000 cycles; and that CFLs with a start time less than or equal to 100 ms (instant start) are only required to survive cycling once per every two hours of rated lifetime. In the preliminary analysis, DOE considered increasing the number of cycles required for non-instant start lamps to once per every hour of rated life, or a maximum of 15,000 cycles and maintaining the requirement for instant start lamps to survive one cycle per every two hours of rated lifetime.[51]

NEMA commented that the current statutory and regulatory requirements for CFLs for rapid cycle stress testing are acceptable and increasing rapid cycle stress tests to current ENERGY STAR standards is not necessary to set an energy conservation standard. (NEMA, No. 34 at p. 8)

DOE found that manufacturers do not publish information on rapid cycle stress for MBCFLs. Further, manufacturers simply report the number of surviving units for DOE CCMS reporting requirements. However, as stated previously, the latest ENERGY STAR market penetration report indicates that 64 percent of CFLs were ENERGY STAR certified thus indicating the majority of CFLs meet the rapid cycle stress requirements.[52] Therefore, in this NOPR, DOE proposes to maintain the requirement for instant start lamps (*i.e.,* MBCFLs with a start time less than or equal to 100 ms) to survive one cycle per every two hours of lifetime and increasing the number of cycles required for non-instant start lamps (*i.e.,* MBCFLs with start times greater than 100 ms) to once per every hour of rated life or a maximum of 15,000 cycles.

c. Lifetime

DOE currently requires a minimum lifetime of 6,000 hours for MBCFLs. The ENERGY STAR Lamps Specification V1.1 requires the minimum lifetime to be 10,000 hours. In the preliminary analysis, DOE considered revising the lifetime standard for MBCFLs to adopt ENERGY STAR's minimum of 10,000 hours for MBCFLs.[53] NEMA commented that the current statutory and regulatory requirements for CFL lifetime are acceptable and that increasing the minimum lifetime standard to the ENERGY STAR level of 10,000 hours is not necessary for energy conservation standards. NEMA and GE added that if the minimum lifetime were increased, industry would recommend no more than 8,000 hours for the federal minimum as, by definition, not all products are intended to meet ENERGY STAR performance levels. (NEMA, No. 34 at p. 8; GE, Public Meeting Transcript, No. 29 at p. 46)

As previously noted, DOE understands that ENERGY STAR requirements are meant to determine the more energy-efficient products on the market. However, based on an assessment of commercially available lamps in manufacturer catalogs, DOE found that the majority of MBCFLs on the market have lifetimes of at least 10,000 hours. Further, of the MBCFLs for which data was submitted to DOE for CCMS reporting, 83 percent have a lifetime of at least 10,000 hours. Given that commercially available MBCFLs are already achieving this higher level of performance, DOE does not find such a minimum to be indicative of only the premium products on the market. Therefore, in this NOPR, DOE is proposing requiring MBCFLs to have a minimum lifetime of 10,000 hours.

2. Additional MBCFL Metrics

a. Color Rendering Index

DOE does not currently have a standard for CRI. The ENERGY STAR Lamps Specification V1.1 requires that CFLs have a CRI of at least 80. In the preliminary analysis, DOE considered adding a requirement for CRI of 80 or

[50] GSL preliminary analysis at 3–17.

[51] *Id.*

[52] ENERGY STAR. Unit Shipment and Market Penetration Report Calendar Year 2014 Summary. (Last accessed January 20, 2016.) *http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2014_USD_Summary_Report.pdf?f531-f608.*

[53] *Id.* at 3–18.

greater for MBCFLs.[54] NEMA stated that CRI is not necessary for consideration in this rulemaking. Additionally, they commented that they do not believe that CRI is an appropriate characteristic for a minimum energy conservation standard. (NEMA, No. 34 at p. 8–9)

DOE has explicit authority to consider a CRI standard for MBCFLs. (42 U.S.C. 6295(bb)(2)) Furthermore, a standard for CRI ensures consumer satisfaction because high CRI light sources render colors well, which could encourage the adoption of energy-efficient technology. Based on an assessment of commercially available lamps in manufacturer catalogs, DOE found that over 99 percent of MBCFLs on the market have a CRI of at least 80. Because a minimum CRI requirement would increase consumer satisfaction and DOE found that nearly all commercially available MBCFLs are already achieving a CRI of at least 80, DOE is proposing to require MBCFLs to have a CRI of 80 or greater.

b. Power Factor

DOE does not currently have a standard for power factor, however, DOE has explicit authority to consider power factor for MBCFLs. (42 U.S.C. 6295(bb)(2)) DOE reviewed industry specifications for MBCFLs and found that the ENERGY STAR Lamps Specification V1.1 and V2.0 require that CFLs have a power factor of 0.5 or greater. The industry standard ANSI C82.77 Harmonic Emission Limits—Related Power Quality Requirements for Lighting Equipment [55] suggests a power factor of 0.5 for integrally ballasted medium screw base compact light sources with input power less than or equal to 35 W. Based on an assessment of commercially available lamps in manufacturer catalogs, DOE determined that the majority of MBCFLs have a power factor in the range of 0.5 to 0.6 and a limited number of MBCFLs have a power factor greater than 0.6. Therefore, in the preliminary analysis, DOE considered adding a standard for power factor of 0.5 or greater for MBCFLs.[56]

NEMA commented that adding power factor requirements was not necessary and urged DOE to refrain from including a power factor requirement for GSLs in this rulemaking. They did not agree with DOE's assertion that a minimum power factor requirement could decrease energy use because that conclusion appeared to be based on a document not relevant to GSLs.[57] Additionally, NEMA commented that there are trade-offs associated with increasing the power factor in CFL and LED lamps that will reduce lamp efficacy and increase energy use, which contradicted DOE's statement in the preliminary analysis. (NEMA, No. 34 at p. 8) Further, NEMA commented that increasing the power factor for residential ballasts would raise ballast losses, which would more than offset any gains in distribution efficiency and could have a negative impact on system reliability. (NEMA, No. 34 at pp. 9–10)

On the contrary, CA IOUs and EEAs noted that improving a lamp's power factor has significant financial benefits for electric utility customers, as well as societal greenhouse gas benefits. A load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. CA IOUs and EEAs stated that higher currents mean increased energy losses both on the customer side of the meter, and on the utility side (grid losses). The losses from a small load (for example a CFL) with a poor power factor may be small, but losses increase exponentially as the total current increases (power loss is a function of the current squared times the resistance of the wiring). CA IOUs calculated that three lamps with poor power factor on a circuit result in nine times the losses of one lamp. (CA IOUs, No. 33 at p. 9; EEAs, No. 32 at p. 9)

Furthermore, CA IOUs and EEAs noted that grid efficiency is an integral part of electric rate design. In other words, if electric grids do not operate efficiently, rate payers will end up paying more for the energy they use through higher rates. So, in addition to the losses on the customer side of the meter, in the long run, consumers also pay for losses on the utility side of the meter. Therefore, CA IOUs stated that given CFLs now constitute roughly 30–40 percent of the screw base GSL market, CFL power factor has huge implications for consumer energy bills, grid efficiency, and greenhouse gas emissions. (CA IOUs, No. 33 at p. 9; EEAs, No. 32 at p. 9) NEMA, however, stated that GSLs do not typically represent a major portion of the power used, and in any scenario where CFLs or LED lamps are used to replace traditional incandescent lamps, the substantially lower wattage of these replacement lamps will result in a reduced lighting load regardless of power factor. (NEMA, No. 34 at pp. 8–9)

NEMA argued that CFLs used in the home have a leading power factor that tends to offset the lagging power factor of motor loads and helps to balance the overall power factor of the home. (NEMA, No. 34 at p. 10) CA IOUs disagreed that a combination of leading and lagging power factors will cancel each other out. They noted that displacement power factor is generally associated with capacitive and inductive loads; inductive loads, like motors, have ''lagging'' power factor, where current lags behind voltage, while typical capacitive loads (capacitors, electronics) have ''leading'' power factor (where the current leads voltage). However, CA IOUs pointed out that these types of equipment with poor power factor do not ''cancel each other out'' if they are non-linear loads with distortion power factor. CFL ballasts are an example of such a non-linear load (*i.e.,* they draw current in short spikes which generally do not relate to the voltage waveform). For these types of non-linear loads, the combination of leading and lagging power factors will not cancel each other out predictably, consistently, or effectively. Additionally, there is no displacement effect unless the two types of linear-load equipment within a given metered circuit operate at exactly the same time. CA IOUs noted that the low incidence of concurrent operation is rarely considered when the displacement argument is made. (CA IOUs, No. 33 at pp. 9–10)

In its determination of additional metrics for MBCFLs, DOE may consider features that are indicative of lamp quality, specifically energy usage, cost effectiveness, and consumer satisfaction. (42 U.S.C. 6295(bb)(3)) Due to the non-linear loads and the different phase angles associated with these loads, realizing the effect of a lamp's power factor on lagging power factors created by motors connected to the grid is difficult and depends on what is active on the grid.[58] However, DOE finds that power factor does impact energy use and, in general, it is important to ensure grid losses are minimized. Passive and active technologies that can correct power factors in lamps are commercially available and the circuitry used in power factor correction (PFC) is made to be very efficient, while consuming small

[54] *Id.* at 3–19.

[55] *ANSI C82.77 Harmonic Emission Limits—Related Power Quality Requirements for Lighting Equipment* (January 17, 2002)

[56] GSL preliminary analysis at 3–19.

[57] Specifically, DOE referenced *Reducing Power Factor Cost,* available here: *http://www.energy.gov/eere/amo/downloads/reducing-power-factor-cost.*

[58] USAID Asia. *Power Factor: Policy Implications for the Scale-up of CFL Programs.* 2010. (Last accessed July 13, 2015.) *http://standby.iea-4e.org/files/otherfiles/0000/0057/2010_USaid_PF_study_CFLs.pdf.*

amounts of power.[59] Therefore, DOE finds that setting a minimum power factor standard for MBCFLs to ensure that low quality products are not being used on the electrical grid is ultimately relevant to energy usage, cost effectiveness, and consumer satisfaction.

Upon reviewing ENERGY STAR's qualified product list for non-directional CFLs, EEAs reported that of the 1,189 models on the list, 225 had a power factor of 0.5 and 957 had a power factor of 0.6. As 80 percent of the listed models already have a power factor of 0.6, EEAs recommend DOE consider a power factor of at least 0.6. (EEAs, No. 32 at p. 9)

CA IOUs recounted that in the earlier days of the U.S. CFL market, most major manufacturers offered CFLs with PFC, and some still do. CA IOUs stated that in the United States, high power factor (0.85 or greater) is common in non-integrated CFL lamp-and-ballast systems, while less common among integrated CFLs, which have very low power factors, in the range of 0.5 to 0.6. The industry has settled on these values because that is all that has been required by ENERGY STAR, which is referenced by most utility programs. Other countries have promoted or adopted policy initiatives to encourage or require high power factor in CFLs, and these products are available from a number of major manufacturers at competitive prices in other markets. CA IOUs commented that in the European Union, high power factor is common in higher wattage CFL products (above 25 W). India is another market that has a large presence of high power factor CFLs, including many residential, lower-wattage product lines. CA IOUs provided the example of the Philips Tornado HPF line. CA IOUs' research found that there is a wide variety of high power factor CFL products offered at popular Indian online retailers at prices that are comparable to low power factor product prices. CA IOUs and EEAs encouraged DOE to draw from these international markets (where products are produced in large quantities) as a reference point for product costs, given that residential, integrated high power factor products are not as common in the United States. (CA IOUs, No. 33 at pp. 8–9; EEAs, No. 32 at p. 9) Further, CA IOUs recommended that DOE adopt a minimum power factor requirement for integrated and non-integrated CFLs of 0.85, as PFC chips are relatively inexpensive and are extremely cost-effective. (CA IOUs, No. 33 at pp. 8–9)

DOE agrees that MBCFLs exist with a power factor greater than 0.8, but found these lamps to be extremely uncommon in the U.S. market. Based on EPA's ENERGY STAR Certified Light Bulbs Database, less than 1 percent of MBCFLs had a power factor greater than 0.8. As noted DOE considered ENERGY STAR requirements, industry standards, and characteristics of lamps in the current market. The vast majority of the U.S. market reports power factors in the range of 0.5 to 0.6 for CFLs, which is consistent with ENERGY STAR and ANSI C82.77 requirement of a minimum power factor of 0.5 for these lamps. Thus, DOE believes that requiring a minimum power factor of 0.5 is achievable for MBCFLs while supporting improved overall efficacy.

c. Start Time

DOE does not currently have a standard for start time. The ENERGY STAR Lamps Specification V1.1 requires that the time needed for a lamp to become fully illuminated must be within one second of application of electrical power. In the preliminary analysis, DOE considered requiring a start time of within one second of the application of electrical power for MBCFLs.[60] NEMA stated that adding start time requirements is not necessary for energy conservation standards. Additionally, NEMA did not agree that start time has any effect on energy efficiency. (NEMA, No. 34 at p. 9)

Westinghouse agreed with a one-second start time requirement for CFLs. Regarding the definition of ''fully illuminated,'' Westinghouse believed ENERGY STAR requires 80 percent of rated lumens, not 100 percent. Westinghouse noted that the definition needed to be clarified. (Westinghouse, Public Meeting Transcript, No. 29 at p. 45)

EEAs noted that one of the complaints consumers voice about CFLs is the reduced level of light some CFLs produce when first turned on and the time it takes for the lamp to reach full brightness. EEAs suggested DOE include standards not just for start time, but also for run-up time. On February 13, 2015, the U.S. Environmental Protection Agency (EPA) issued its first draft of Version 2.0 of its lamp specification, which shortened the required time to achieve 80 percent stabilized light output to 60 seconds or less, from the current Version 1.0 requirement that allows 120 seconds. EEAs suggested DOE adopt the new run-up time from the draft of Version 2 of the ENERGY STAR lamp specifications. (EEAs, No. 32 at p. 8)

DOE finds that start time impacts consumer satisfaction, because a delay in starting is undesirable and can affect acceptance of a more-efficient lamp technology. Manufacturers do not publish information on start time for MBCFLs. However, one-second start time has been the ENERGY STAR specification for several years, and DOE finds that such a start time is reasonable for MBCFLs. DOE requests information on start times of the CFL market.

Further, DOE notes that it is the ENERY STAR specification for run-up time rather than start-up time that requires the lamp to achieve 80 percent stabilized light output. The ENERGY STAR specification for start time is the time it takes to maintain continuous illumination from the time the lamp is turned on. While DOE understands the distinction in these measurements and usefulness of the run-up time measurement, DOE finds that both start time and run-up time are capturing the consumer requirement of having a lamp provide light output in a timely manner. Because start time is more noticeable by consumers and an immediate indication of a low quality lamp, and to limit undue burden to manufacturers, DOE is proposing to require only start time for MBCFLs. Hence, in this NOPR, DOE is continuing to propose a requirement for start time. However, instead of specifying at full illumination, DOE's proposed requirement for start time is that the lamp must remain continuously illuminated within one second of application of electrical power.

d. Total Harmonic Distortion, Correlated Color Temperature, Operating Frequency

In the preliminary analysis DOE did not consider setting requirements for total harmonic distortion (THD), CCT, or operating frequency.[61] DOE determined that THD is directly related to power factor and setting a minimum power factor requirement will effectively set a standard for THD. DOE found that different CCTs are desirable depending on the application. DOE determined that operating frequency does not directly impact energy savings, cost effectiveness, or consumer satisfaction. NEMA agreed that requirements for THD, CCT, and operating frequency should not be considered. (NEMA, No. 34 at p. 8) Receiving no other comments and finding no other evidence to support standards for these factors, in this NOPR, DOE is not proposing

[59] Ibid.

[60] GSL preliminary analysis at 3–20.

[61] *Id.* at 3–18.

standards for THD, CCT, or operating frequency.

3. Additional Integrated LED Metric

EEAs asserted that DOE possesses the authority to require LED performance specifications in order to provide the consumer satisfaction necessary to assure that the energy savings anticipated from standards are achieved in practice. Yet, because CEC is currently evaluating its own performance quality metrics for LEDs, EEAs recommended that DOE not consider adopting such requirements at this time. (EEAs, No. 32 at pp. 8–9) CA IOUs encouraged DOE to continue monitoring the progress underway in CEC's Title 20 rulemaking regarding quality metrics for LED GSLs, and consider the resulting standards for adoption. (CA IOUs, No. 33 at p. 10)

As noted in section IV.F.2.b, DOE finds that power factor does impact energy use and, therefore, is also proposing a power factor requirement for integrated LED lamps. DOE considered ENERGY STAR requirements, industry standards, and characteristics of lamps in the current market. The vast majority of the U.S. market reports power factors greater than 0.7 for integrated LED lamps, which is consistent with ENERGY STAR Specification for Lamps V1.1 and ANSI C82.77 requirement of a minimum power factor of 0.7 for these lamps. DOE notes that the ENERGY STAR Specification for Lamps V2.0 [62] finalized December 2015 has adjusted the power factor requirement for general purpose lamps between 5 and 10 watts to 0.6 and exempted lamps less than 5 watts from a power factor requirement. In making this decision, ENERGY STAR noted recent growing sales trends for lower cost LED lamps with power factors below 0.7.[63] DOE requests comment on its proposal to require integrated LED lamps to meet a power factor of 0.7 or the reason and supporting information for choosing another power factor.

4. Summary of Metrics

DOE is proposing to maintain the existing requirements for lumen maintenance at 1,000 hours and lumen maintenance at 40 percent of lifetime. DOE is proposing to increase the stringency of some existing standards for MBCFLs, raising the required lifetime standard for MBCFLs to a minimum of 10,000 hours, and the number of cycles required for non-instant start lamps (*i.e.,* lamps with start times greater than 100 ms) to once per every hour of rated life with a maximum of 15,000 cycles. Finally, DOE is proposing three new performance metrics for MBCFLs; namely, requiring such lamps to have a CRI of 80 or greater, a power factor of 0.5 or greater, and a start time of within one second of the application of electrical power. NRDC agreed overall with the updates to the CFL quality parameters. (NRDC, Public Meeting Transcript, No. 29 at p. 13) CEC commented that additional standards for lifetime, lumen maintenance, power factor, and spectral content were needed because standards for efficacy without these quality metrics are less meaningful in implementation. (CEC, No. 31 at p. 2) DOE agrees with this assessment and provides the following table to summarize the MBCFL performance metrics proposed in this rulemaking. In addition, in this NOPR analysis, DOE is proposing that integrated LED lamps be required to meet a power factor of 0.7 or greater, as shown in Table IV–1. DOE requests any comments regarding proposed metrics for GSLs in this NOPR analysis.

TABLE IV–1—PERFORMANCE METRICS FOR MEDIUM BASE COMPACT FLUORESCENT LAMPS AND INTEGRATED LED LAMPS

Lamp type	Metric	Minimum standard considered
MBCFLs	Lumen maintenance at 1,000 hours.	90 percent of initial lumen output at 1,000 hours.
	Lumen maintenance at 40 percent of lifetime.*	80 percent of initial lumen output at 40 percent of lifetime.
	Rapid cycle stress	MBCFL with start time > 100 ms: survive one cycle per hour of lifetime* or a maximum of 15,000 cycles.
		MBCFLs with a start time of ≤ 100 ms: survive one cycle per every two hours of lifetime.*
	Lifetime*	10,000 hours.
	Power factor	0.5.
	CRI	80.
	Start time	The time needed for a MBCFL to remain continuously illuminated must be within one second of application of electrical power.
Integrated LED Lamps	Power factor	0.7.

* Lifetime refers to lifetime of a compact fluorescent lamp as defined in 10 CFR 430.2.

V. Methodology and Discussion of Related Comments

This section addresses the analyses DOE has performed for this rulemaking with regard to GSLs. Separate subsections address each component of DOE's analyses.

DOE used several analytical tools to estimate the impact of the standards proposed in this document. The first tool is a spreadsheet that calculates the LCC savings and PBP of potential amended or new energy conservation standards. The national impacts analysis uses a second spreadsheet set that provides shipments forecasts and calculates NES and NPV of total consumer costs and savings expected to result from potential energy conservation standards. DOE uses the third spreadsheet tool, the Government Regulatory Impact Model (GRIM), to assess manufacturer impacts of potential standards. These three spreadsheet tools are available on the DOE Web site for this rulemaking: *http://www1.eere.energy.gov/buildings/*

[62] ENERGY STAR. ENERGY STAR Program Requirements: Product Specification for Lamps (Light Bulbs): Eligibility Criteria, Version 2.0. 2015. U.S. Environmental Protection Agency: Washington, DC (Last accessed January 29, 2016). *http://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2_0%20Program%20Requirements.pdf.*

[63] ENERGY STAR. ENERGY STAR Program Requirements: Product Specification for Lamps (Light Bulbs): Eligibility Criteria, Version 2.0 DRAFT FINAL. 2015. U.S. Environmental Protection Agency: Washington, DC. (Last accessed January 29, 2016.) Available at: *http://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2%200%20Draft%20Final%2012-04-2015.pdf.*

appliance_standards/rulemaking.aspx?ruleid=83. Additionally, DOE used output from the latest version of the Energy Information Administration's (EIA's) *Annual Energy Outlook* (*AEO*), a widely known energy forecast for the United States, for the emissions and utility impact analyses.

A. Market and Technology Assessment

In the energy conservation standards rulemaking process, DOE conducts a market and technology assessment to provide an overall picture of the market for products concerned. Based primarily on publicly available information, the analysis provides both qualitative and quantitative information. The market and technology assessment includes the major manufacturers, product classes, retail market trends, shipments of covered products, regulatory and non-regulatory programs, and technologies that could be used to improve the efficacy of GSLs. DOE is restricted by the Appropriations Rider from using appropriated funds to implement or enforce standards for GSILs and therefore is not considering GSILs in this rulemaking at this time. See section IV.A for further details.

1. Product Classes

DOE divides covered products into classes by: (a) The type of energy used; (b) the capacity of the product; or (c) other performance-related features that justify different standard levels, considering the consumer utility of the feature and other relevant factors. (42 U.S.C. 6295(q)) In evaluating product class setting factors, DOE considers their impact on both efficacy and consumer utility. After evaluating several GSL characteristics, in the preliminary analysis, DOE considered ballast/driver location and lumen output as product class setting factors, resulting in three product classes: (1) Non-Integrated (*i.e.,* ballast/driver location external to the lamp); (2) Integrated Low-Lumen (*i.e.,* ballast/driver location internal to the lamp with light output from 310 to less than 2,000 lumens); and (3) Integrated High-Lumen (*i.e.,* lamps with light output from 2,000 to 2,600 lumens).[64]

DOE received some general comments regarding the product class structure presented in the preliminary analysis. CA IOUs support DOE's proposal to establish product classes based only on lumen output and ballast/driver location. (CA IOUs, No. 33 at p. 4) NEMA, however, disagreed with the preliminary analysis product class structure. NEMA stated that product classes should be determined by technical capability and varying utility of differing technological approaches to produce the same light output. NEMA asserted that placing all GSLs in common lumen ranges will result in the elimination of all technologies and all product utilities except that provided by the most-efficacious technology. Therefore determining product classes based only on lumen output is not appropriate for GSLs. NEMA also stated it was not good public policy to adopt a technology-neutral approach for GSLs under EPCA, in particular for general service CFL and LED lamp segments presently under consideration in this rulemaking, and for the halogen incandescent, CFL, and LED lamp classes. (NEMA, No. 34 at p. 11)

NEMA proposed a product class structure that would set separate product classes for standard incandescent/halogen lamps, modified spectrum incandescent lamps, LED lamps, and CFLs, further sub-divided by bare CFLs and covered CFLs. Further NEMA proposed five lumen package product class divisions. (NEMA, No. 34 at p. 13) NEMA's proposed product classes as well as comments on specific product class setting factors are discussed in detail in the following sections.

a. Lamp Technology

In the preliminary analysis, DOE did not find unique performance features in any lamp technology (*i.e.,* CFLs or LED lamps) that warranted separate product classes and therefore presented a technology-neutral product class structure. Several stakeholders supported DOE's decision not to set separate product classes for CFLs and LED lamps.

CEC stated that DOE's approach recognizes the general purpose of the lamps, focuses on achieving cost-effective energy savings, and avoids substitution issues caused by product classes. (CEC, No. 31 at pp. 1–2) EEAs noted that the product class structure recognizes that many technologies provide general illumination and allows all technologies to compete on a level playing field. (EEAs, No. 32 at p. 3) Earthjustice and CA IOUs agreed with DOE's decision noting that neither CFLs nor LED lamps represent a distinct utility for the consumer. (Earthjustice, No. 30 at p. 4; CA IOUs, No. 33 at p. 4) CA IOUs however, recognized that CFLs play an important role in the market as the current low-cost, high-efficacy option and they will continue to monitor the progress of LED lamps as their prices continue to drop and approach parity with CFLs. (CA IOUs, No. 33 at p. 4) While NRDC agreed with DOE's technology-neutral approach to product classes, they recommended that DOE continue to consider how LED lamps will evolve. (NRDC, Public Meeting Transcript, No. 29 at p. 13, 100–101) Southern Company stated that while there may not be enough differences to justify a separate class, there were sufficient differences in performance characteristics to warrant both CFLs and LED lamps on the market and urged DOE to set criteria to allow for a broad range of products to exist. (Southern Company, Public Meeting Transcript, No. 29 at p. 101)

In its product class determination, DOE does not factor in costs and bases its assessment on performance characteristics that clearly provide a crucial utility to consumers. 42 U.S.C. 6295(q). As noted in the above stakeholder comments and confirmed by DOE's own analysis in chapter 3 of the NOPR TSD, no such utility was identified that would necessitate separate product classes for CFLs and LED lamps.

NEMA disagreed with the technology-neutral approach to product classes and recommended three technology-based product classes with separate efficacy levels to allow each technology to remain available: Incandescent/halogen, CFL, and LED lamps, all of which have a medium screw base and are designed to operate directly on 120 or 130 volts. NEMA commented that the three technologies offer considerable differences in performance and utility; and allow consumers to choose the best technology for their application. In general, NEMA stated that filament lamps are low-cost omnidirectional point sources, CFL lamps are low-cost omnidirectional diffuse sources, and LED lamps are high cost directional point sources. (NEMA, No. 34 at p. 13)

Specifically, NEMA noted several differences between CFLs and LED lamps: LED lamps have a higher initial cost than CFLs; LED lamps have a longer lifetime than CFLs which are also susceptible to a shortened lifetime due to frequent switching; and LED lamps have very high efficiency while CFLs have relatively high efficiency. Further, while CFL operation is affected by high or low ambient temperature, LED lamp operation is affected only by high ambient temperature. NEMA noted CFLs' natural slow start as an advantage for dark area eye adaptation. Additionally, NEMA noted CFLs are omnidirectional, have diffuse light, low pleasing surface brightness while LED lamps are a directional point source, have extremely high chip surface brightness, and require special optics and diffusing materials for

[64] *Id.* at 2–59.

omnidirectional applications. Another difference cited was that color can be modified with some loss in efficiency at high chromaticity and high CRIs for CFLs and low chromaticity and high CRIs for LED lamps. (NEMA also noted several similarities between CFLs and LED lamps: Good CRI capability, vibration resistant, unaffected by occasional direct water spray, low heat source, and dimming with limitations.) (NEMA, No. 34 at pp. 12–13)

When determining product classes DOE does not factor in cost. (*See* 42 U.S.C. 6295(q)) DOE considers costs in determining the economic justification of standard levels for each product class. DOE did not find that the differences between CFLs and LED lamps noted by NEMA identified a unique utility that required separate product classes for each lamp type. LED lamp features of longer life, lack of issues due to frequent switching, and ability to operate in low ambient temperature would not be eliminated if LED lamps and CFLs were in one product class, as LED lamps are more efficient than CFLs. Further, the slow start in CFLs is usually considered a disadvantage and the potential for it being useful in dark area eye adaptation seems a limited application and of less value to the typical consumer compared to the benefit of an instant on LED lamp.

Moreover, although CFLs and LED lamps may attain color with a certain loss in efficiency at different ends of the chromaticity spectrum, they are able to achieve the same ranges of CCTs and CRIs. Likewise, while LEDs are a directional point source, with the use of optics and diffusing materials, they are able to attain omnidirectionality similar to that of CFLs. The surface brightness of LEDs is also mitigated by optics and covers. Additionally, LED lamps are designed and marketed for GSL applications and are being used as replacements for CFLs. Therefore, the utilities valued by consumers would not be eliminated in a technology-neutral product class structure.

NEMA stated that the unusual market distribution further illustrates the problems with putting all technologies together in the same product classes. The candidate standard level (CSL) 1 becomes mostly CFLs, while CSL 2 and CSL 3 represent older LED lamp technologies that are still on the market because of the rapid LED lamp product evolution. CSL 4 and 5 represent differing types of LED lamp technology that could never be met by CFLs. (NEMA, No. 34 at p. 22) GE added that there is a vast difference in technology between CFLs and LED lamps, one is very mature and one is still in an evolving stage. (GE, Public Meeting Transcript, No. 29 at p. 100) GE suggested two separate classes for CFLs and LED lamps because they would have different baselines and different efficiencies over time. GE further noted that having CFLs and LED lamps in one product class implies that CFLs will be eliminated and one criteria of this regulation is not to eliminate an entire product class. (GE, Public Meeting Transcript, No. 29 at p. 72)

The observed distribution of lamp technologies at ELs is a function of the general higher efficiency of LED technology relative to CFL technology. However, a product class division must be based on both a difference in efficacy and a unique consumer utility. Similarly, DOE cannot create a separate product class based on the maturity of a technology unless it results in a unique consumer utility. DOE standards are also not structured to eliminate products. Based on DOE's own evaluation, comments from stakeholders, and feedback in manufacturer interviews, DOE did not find any unique features that required separate product classes for lamp technologies (*i.e.,* CFLs and LED lamps).

Westinghouse warned that by not having two separate product classes for CFLs and LED lamps, ensuring higher lumen products are available to consumers would be challenging, particularly since the volume of CFLs is in the lower lumen bins and the necessary economies of scale may no longer exist from a manufacturing standpoint. (Westinghouse, Public Meeting Transcript, No. 29 at pp. 73–74) In its product class determination, DOE ensures that consumer utility is met by GSL products across lumen ranges at all ELs (see section V.A.1.c). In this NOPR analysis, DOE declines to establish a product class based on lamp technology.

NEMA understood that DOE cannot currently address incandescent/halogens, but commented that it should be recognized as a product class within the general service lamp area which is currently regulated. NEMA commented that the unique utility and attributes of incandescent or halogen lamp technologies are: low initial cost, omnidirectional point source with good optical control, ability to provide high sparkle and high brightness, operation unaffected by high or low ambient temperature, warm color appearance difficult to modify without loss of efficiency, very high CRI, relative low efficiency, relative short lifetime, adversely affected by vibration and direct water contact, lifetime not affected by frequent switching, good infrared source, immediate on to full brightness, great full range dimming in all applications. (NEMA, No. 34 at p. 12) DOE is not considering incandescent/halogen lamps in this rulemaking due to the Appropriations Rider. See section IV.A for further details.

b. Lamp Component Location

In the preliminary analysis, DOE considered a product class based on the location of the ballast or driver of the lamp: (1) Integrated lamps in which the ballast or driver are enclosed within the lamp and (2) non-integrated lamps in which the ballast or driver is an external, replaceable component. DOE is also proposing definitions for ''integrated lamp'' and ''non-integrated lamp'' in this NOPR (see IV for further details). NEMA commented that non-integrated pin base CFLs should not be included in the scope of this rulemaking and, therefore, should not be given a GSL product class. (NEMA, No. 34 at p. 11)

Non-integrated pin base CFLs are within the proposed scope of this rulemaking, and DOE is establishing standards for these lamps (see section IV.E.2). DOE determined that self-ballasted lamps may have lower inherent efficacy compared to lamps that utilize external ballasts due to the additional components and circuitry integrated into a self-ballasted lamp. The use of a self-ballasted lamp can be advantageous in that a consumer need only replace one lamp unit rather than two separate components. Self-ballasted lamps are also generally more compact and thus can be used in applications with size constraints. For these reasons, as in the preliminary analysis, DOE proposes establishing separate product classes based on ballast location in this NOPR analysis. (See chapter 3 of the NOPR TSD for further details.)

c. Lumen Package

In the preliminary analysis, DOE considered the product class setting factor of lumen package within the integrated lamp product classes. DOE determined that higher lumen output products cannot achieve the same levels of efficacy as lower lumen output products and considered the following product class divisions within the integrated lamp product class: (1) Low Lumen (*i.e.,* from 310 to less than 2,000 lumens) and (2) High Lumen (*i.e.,* 2,000 to 2,600 lumens). DOE received several comments supporting preliminary analysis' lumen package product class division.

Earthjustice noted that following the EPCA provision for establishment of product classes, DOE correctly concluded that lumen output provides the only basis for product class divisions among integrated lamps. (Earthjustice, No. 30 at p. 4) EEAs also agreed with DOE's decision noting that high-lumen lamps may require different technological approaches to manage heat and maintain a form factor that fits consumer fixtures making them less efficient than low-lumen lamps. (EEAs, No. 32 at p. 3) Noting that LED lamps are not currently widely available above 2,000 lumens, CA IOUs tentatively supported the distinction between High-Lumen and Low-Lumen product classes. However, they noted one product class for integral lamps would be sufficient if higher lumen LED lamps become available. Additionally, CA IOUs stated that no further lumen package product class divisions were necessary because the sloped standards under consideration adequately address the difference in efficacy achieved by products of different lumen outputs. (CA IOUs, No. 33 at p. 4)

NEMA recommended that DOE consider more than two lumen package divisions. NEMA commented that with all technologies, efficiency decreases with decreasing wattage due to inescapable power losses from components. GE and NEMA stated that there are four natural, lumen ranges associated with wattage equivalencies as defined in existing GSIL standards and commonly used by consumers (see 10 CFR 430.32(x(iii)(A)) These lumen ranges are as follows: 100 W = 1,490–2,600 lumens, 75 W = 1,050–1,489 lumens, 60 W = 750–1,049 lumens, 40 W = 310–749 lumens. NEMA suggested that DOE should establish product classes based on these lumen ranges for each of its recommended lamp technology product class divisions (*i.e.,* incandescent/halogen, modified spectrum halogen, bare CFL, covered CFL, LED lamps). Asserting that the 100 W equivalent lumen bin was exaggerated at the higher end [65] and agreeing with DOE's proposal that the higher lumen range can be limited to 2,000 lumens for current LED lamp technology, NEMA proposed splitting the 1,490–2,600 lumen bin into 1,490–2,000 lumens and 2,000–2,600 lumens product class divisions. NEMA asserted that technical limitations and performance can vary greatly depending on the wattage and technology and this approach would allow DOE to set a lumens per watt number, wattage limit, a linear equation, a quadratic equation or an exponential equation as necessary within the lumen range and technology under consideration for each product class. (NEMA, No. 34 at p. 13; GE, Public Meeting Transcript, No. 29 at pp. 54–55)

NRDC stated that it was open to refining the 1,999 lumen upper bound under consideration in the preliminary analysis but did not support the four bin approach because it could result in gaming, and consequently dimmer bulbs. Instead, they advocated the use of a smooth continuous curve for the regulations. (NRDC, Public Meeting Transcript, No. 29 at pp. 55–56)

DOE analyzed commercially available lamps and found that a continuous equation best describes the relationship between efficacy and lumens rather than lumen bins. Further, DOE assessed equations of the ELs analyzed to ensure that consumer utility would be met by GSLs across all lumen ranges. In doing so, in the preliminary analysis, DOE determined that higher lumen output products cannot achieve the same levels of efficacy as lower lumen output products, specifically LED lamp replacements for incandescent lamps of wattages higher than 100 W. Because DOE determined that higher lumen packages offer a consumer utility, DOE considered a product class division based on lumen package. Therefore, in this NOPR analysis, within the integrated lamp product classes, DOE is continuing to propose separate product classes for lumen outputs from 310 to less than 2,000 and from 2,000 to 2,600.[66]

Hence, NEMA's proposal to establish product classes by lumen bins per GSIL standards to allow for flexibility in setting the type of standard is not necessary for preserving consumer utility and would result in an inconsistent configuration of standards for products covered under this rulemaking. Instead, DOE finds that its equation-based approach to standards and product class division based on high and low lumens, appropriately captures how GSL technologies are achieving ELs across lumen ranges using a consistent methodology.

Southern Company warned that many CFLs in the range of 1500 lumens will not fit in enclosed fixtures and unless LED lamps in this lumen range improve, products will not be available on the market. Southern Company recommended DOE consider a product class addressing physical constraint for higher lumen products. (Southern Company, Public Meeting Transcript, No. 29 at pp. 131–132) Westinghouse noted that even above 1600–1800 lumens, the physical size becomes a concern in terms of fitting in fixtures, particularly for LED lamps, and expressed concern that the 1,999 lumen upper bound might be too high. (Westinghouse, Public Meeting Transcript, No. 29 at p. 54) NRDC responded that there are 100 watt-equivalent LED lamps that offer 1,600 lumens and the form factor is similar to the lower wattage, lower light output LED lamps, which should address size constraints issues. (NRDC, Public Meeting Transcript, No. 29 at pp. 55–56; 132–133)

DOE did ensure that an integrated LED lamp in the 1,500–1,600 lumen range certified for enclosed fixtures met the highest ELs being analyzed. Therefore, DOE does not find that an additional product class related to lumen package is necessary.

d. Standby Mode

In the preliminary analysis, DOE evaluated setting a product class based on the ability of a lamp to operate in standby mode.[67] DOE believes that standby mode operation offers a consumer utility because these lamps have the ability to be remotely turned off, turned on, dimmed, among other functionality. However, DOE assumed that the market would shift to the lowest energy consuming method available, such as Bluetooth, and the energy consumed in standby mode would be negligible. Therefore, DOE did not consider standby mode functionality as a product class setting factor. NEMA agreed that standby power for LED products will be minimal compared to impacts of the classifications shown above and would not require a separate class. (NEMA, No. 34 at p. 14)

However, Westinghouse and the Northwest Energy Efficiency Alliance (NEEA) commented that standby power consumption for smart lamps is not zero. (Westinghouse, Public Meeting Transcript, No. 29 at pp. 239–240; NEEA, Public Meeting Transcript, No. 29 at p. 244) Westinghouse stated that smart lamps are similar to a fan remote control in that a switch has to be left on in order for the lamps to receive a control signal and this functionality consumes at least a minimal amount of power. (Westinghouse, Public Meeting Transcript, No. 29 at pp. 239–240)

In the NOPR analysis, DOE conducted testing on commercially available lamps with standby mode capability and determined that while standby power

[65] NEMA noted that the 100 W and 40 W ranges are exaggerated on the high end and the low end to extend the regulated product range to just above 25 W and just below 150 W traditional incandescent lamps.

[66] The higher bound of 2,600 lumens aligns with the scope of this rulemaking (see section [scope section on lumens]).

[67] GSL preliminary analysis at 2–58.

consumption can vary based on the standby technology used, it is not negligible. DOE conducted active mode and standby mode testing per the LED Test Procedure SNOPR[68] of all lamps with standby mode functionality found on the market. These lamps were designed with varying communication methods, including Zigbee, Bluetooth, Wi-Fi, and radio frequency remote controls. The majority of lamps identified also operate using a central hub for communication between the end-user and the lamp itself. DOE's test results, as presented in appendix 5A, indicate that the tested standby power generally varied between 0.2 W and 0.5 W. Specifically, the measured standby power was less than 0.5 W for 29 out of 31 tests. DOE finds that these results indicate that lamps with standby power have a non-negligible standby power consumption that will likely lower their efficacy, compared to lamps without standby power, all things being equal. Therefore, based on utility and impact on efficacy DOE is proposing a product class division based on standby mode.

e. Covering

In the preliminary analysis, DOE evaluated lamp cover (*i.e.,* something added to the lamp such that the main light source is not distinguishable) as a product class setting factor.[69] However, unable to find a consistent correlation between the addition of a cover and efficacy, DOE did not consider a product class division for lamps with covers versus without covers. DOE received several comments regarding a product class setting factor based on lamp cover.

CA IOUs supported DOE's decision to include covered and bare lamps in one product class because when considering the whole GSL product category, there is no relationship to efficacy. While minor efficacy reduction results from covering a CFL, CA IOUs pointed out that some of the most efficient and most cost-effective products on the market are LED lamps that have the ''covered'' appearance. (CA IOUs, No. 33 at p. 4) Earthjustice also noted that covered CFLs provide no distinct utility because covered LED lamps are available to provide the same aesthetic values at higher efficacies. (Earthjustice, No. 30 at p. 4)

Southern Company, however, stated that there are some functional differences between covered and bare lamps such as aesthetics: consumers will not use bare spiral lamps where they are visible. Southern Company emphasized that this is not a trivial consideration for consumers and recommended that separate product classes be set up for bare and covered lamps. (Southern Company, Public Meeting Transcript, No. 29 at pp. 108–110) Philips commented that one of the biggest advantages for the covered CFL is that it eliminates concerns about mercury because they are almost unbreakable, which is unique to CFLs and creates a large market for them. (Philips, Public Meeting Transcript, No. 29 at pp. 109–110)

NEMA recommended that DOE establish a product class for CFLs and within it bare and covered product class divisions. NEMA asserted that while covered CFLs have meaningfully lower efficiency they provide a unique utility in contrast to bare lamps. NEMA also noted that the CSLs proposed for CFL are not for two levels of performance of the same product, but instead for different products. CSL 0 is for a lamp with a cover, and CSL 1 is for bare spiral lamps. (NEMA, No. 34 at p. 12, 15) Southern Company added that bare and covered product class divisions would avoid the preliminary analysis results where CSL 1 is cheaper than CSL 0. (Southern Company, Public Meeting Transcript, No. 29 at pp. 108–110)

As noted previously, DOE is not proposing a separate product class for CFLs. In the preliminary analysis, DOE found that while a cover generally decreased efficacy in CFLs, a cover in the form of phosphor coating transforms light emitted from LEDs into visible light and increases efficacy.[70] Further many LED lamps that have covers also have high efficacies. Therefore, when considering all lamp technologies, a covering on a lamp does not have a consistent correlation with efficacy and there are products with coverings available at the highest levels of efficacy analyzed. For these reasons, in this NOPR analysis, DOE is continuing to not propose a product class for covered versus bare products. Regarding the differences in representative CFLs for the baseline and CSL 1 of the integrated lamp product classes presented in preliminary analysis, see section V.C for further details.

f. Lamp Spectrum

In the preliminary analysis, DOE evaluated lamp spectrum (*i.e.,* modified spectrum versus standard spectrum lamps) as a product class setting factor.[71] However, not finding a consistent correlation between spectrum and efficacy in GSL products, DOE did not consider spectrum as a product class setting factor. DOE received several comments regarding spectrum as a potential product class division.

NEMA stated that a modified spectrum product class was not necessary for CFLs and LED lamps. NRDC also agreed with not setting product class based on modified spectrum. CA IOUs supported the decision to remove the product class distinction for modified spectrum lamp. CA IOUs continued that there is no relation between efficacy potential and spectrum modification when considering the whole GSL product class. (NEMA, No. 34 at p. 14; NRDC, Public Meeting Transcript, No. 29 at p. 13; CA IOUs, No. 33 at p. 4) EEAs agreed with the determination that a manufacturer can produce a modified spectrum lamp without a decrease in efficacy and that a separate product class for modified spectrum lamps GSLs is not warranted. (EEAs, No. 32 at p. 9)

Modified spectrum is achieved by increasing the contrast between reds and greens in the spectral power distribution (SPD). Because efficacy is impacted in different ways based on the method used to achieve modified spectrum GSLs, DOE did not consider separate product classes for standard and modified spectrum GSLs. Therefore, DOE continues to not consider spectrum as a product class setting factor in this NOPR analysis. DOE also notes that this rulemaking is not removing any product classes based on spectrum applicable to existing standards.

EEAs stated that the current standards for modified spectrum GSILs are 25 percent less efficient than non-modified spectrum GSILs (10 CFR 430.32(x)(iii)(B)) and are too generous. EEAs stated that shelf space at big box retailers for modified spectrum GSILs can exceed that for non-modified spectrum, indicating that producing modified spectrum GSILs is the easiest way to comply with existing standards. EEAs continued that while they did not have specific sales data, it was likely that consumers that purchase modified spectrum GSILs receive less light than the conventional incandescent lamp they meant to replace, potentially causing consumers to shift to the 75 W equivalent lamp, instead of the 60 W, to increase light levels, resulting in increased energy consumption. (EEAs, No. 32 at pp. 9–10) DOE notes that it is not considering incandescent/halogen lamps in this rulemaking due to the Appropriations Rider. See section IV.A for further details.

[68] 80 FR 39644 (July 9, 2015).

[69] GSL preliminary analysis at 2–54.

[70] *Id.*

[71] *Id.* at 2–57.

g. Summary of Proposed Product Classes

In this NOPR analysis, DOE reevaluated the product class setting factors considered in the preliminary analysis and also considered an additional class setting factor. DOE is maintaining the product class divisions presented in the preliminary analysis and adding standby mode as product class setting factor. Table V–1 is a summary of the GSL product classes proposed in this NOPR. DOE requests comments on the proposed product classes.

TABLE V–1—PROPOSED GSL PRODUCT CLASSES

Lamp type	Initial lumen output	Standby mode/No standby mode
Integrated GSLs (*e.g.,* Self Ballasted CFL, Integrated LED lamp)	310 ≤ Initial Lumen Output < 2,000	No Standby Mode. Capable Of Operating In Standby Mode.
2,000 ≤ Initial Lumen Output ≤ 2,600	No Standby Mode. Capable Of Operating In Standby Mode..	
Non-Integrated GSLs (*e.g.,* Externally Ballasted CFL)	310 ≤ Initial Lumen Output ≤ 2,600	

2. Technology Options

In the technology assessment, DOE identifies technology options that are feasible means of improving lamp efficacy. This assessment provides the technical background and structure on which DOE bases its screening and engineering analyses. To develop a list of technology options, DOE reviewed manufacturer catalogs, recent trade publications and technical journals, and consulted with technical experts.

In the preliminary analysis, DOE identified several technology options that can improve the efficacy of GSLs.[72] Recognizing that GSLs comprise multiple lamp types, each with their own mechanisms for improving efficacy, DOE identified technology options by lamp type. Specifically, DOE presented technology options for CFL and LED lamp types and also identified a change in technology (*e.g.,* moving from CFLs to LED lamps) as a technology option. DOE received several comments on these options, as discussed in the following sections.

a. CFL Technology Options From the Preliminary Analysis

Stakeholders provided general comments regarding CFL technology. NEMA commented that the apparent differences in CFL efficacies are likely the result of differing manufacturing processes employed by individual manufacturers, rather than of superior design. (NEMA, No. 34 at p. 10) DOE has observed CFL efficacies of lamps with similar characteristics (*e.g.* CCT, CRI, shape) ranging from 57.1 lm/W to 69.2 lm/W, a difference that is likely not explainable by improved manufacturing processes alone. Further, numerous CFL products are offered at one particular efficacy from several manufacturers. DOE therefore finds that the different levels of CFL efficacies are not just the result of differences in how the lamps are manufactured.

GE and NEMA stated that many of the technology options listed have already been used over the years to optimize CFL efficacy and such technology is no longer able to make large improvements. (GE, Public Meeting Transcript, No. 29 at p. 59; NEMA, No. 34 at p. 9) Specifically, NEMA commented that while improvements have been made in glass coatings, a technological breakthrough would be needed to capture further efficacy gains with this option and there are no actions underway that would result in major improvements. Regarding electrode coatings, NEMA noted that their overall performance is already designed for energy conservation and long life, stating that further changes may shorten lamp lifetime. Additionally, potential improvements to this technology would be minimal. For higher efficiency phosphors, NEMA stated that because of rare earth oxide availability and cost issues, all coating resources are being used to reduce losses and optimize current technology performance, and current high efficiency phosphor technology is limited until a technological break-through occurs, which is unlikely. NEMA also stated that manufacturers have already reached the limits of gas fill technology.

In the preliminary analysis, DOE considered glass coatings, highly emissive electrode coatings, and higher efficiency phosphors as technology options for CFLs. As NEMA notes, these are mechanisms for improving lamp efficacy. Based on DOE's research of manufacturer catalogs, recent trade publications, and technical journals, and through discussions with technical experts, DOE concludes that there are various combinations of highly emissive electrode coatings; weights and mixes of phosphors; types and ratios of fill gases; and glass coatings that can be used in CFLs. Because of the range in efficacy levels for CFLs on the market, the less efficacious CFLs must not be using the optimal forms and/or combinations of these mechanisms. Additionally, DOE does not incorporate cost in the technology assessment. DOE considers costs in determining the economic justification of any standard levels developed using these technologies. Therefore, DOE proposes these technologies as means of improving the efficacy of current product offerings of CFLs in this NOPR analysis.

NEMA also commented that the effectiveness of any cold spot design is limited by the ambient temperature of a lamp in operation as the cold spot temperature can never be lower than adjacent ambient temperature, which limits the potential light output gains through cold spot optimization. (NEMA, No. 34 at p. 9)

In the preliminary analysis, DOE identified cold spot optimization as a technology option for improving CFL efficacy. The ''cold spot'' is the lowest temperature on the CFL where the vaporized mercury condenses. The cold spot is a function of current density, and light output increases with current density until it reaches a certain saturation point. Therefore, lamp efficacy can be increased at the optimal cold spot temperature. In a study of commercially available T2 and T3 CFLs, researchers found that light output reaches a maximum at about 48 °C for

[72] *Id.* at 3–45.

lamps with a fixed current of 140 mA.[73] According to the OSRAM Web site, the cold spot for fluorescent lamps should be designed to reach temperatures between 45 °C and 50 °C at 100 percent luminous flux.[74] These optimal cold spot temperatures could be achieved for a range of ambient temperatures. DOE understands that it may be difficult to achieve the most optimal cold spot temperature at very high ambient temperature environments, but these situations would be limited and some gains could still be possible with the level of cold spot optimization that is achievable. Therefore, DOE continues to consider cold spot optimization as a means for improving lamp efficacy and proposes it as a technology option in this NOPR analysis.

Regarding ballast components, NEMA agreed that the use of higher grade components could slightly reduce energy loss and that cost impact must be evaluated in determining requirements. However, NEMA stated that they are unaware of any emerging technology that promises to lower ballast losses while maintaining the performance of current premium ballast designs. (NEMA, No. 34 at p. 10)

In the preliminary analysis, DOE identified improvement in quality of electronic ballast components used in integrated CFLs and improved ballast circuit designs as means of improving the efficacy factor of the ballast, and thereby overall lamp efficacy.[75] Regarding the cost of improved ballast components, as noted previously, DOE does not factor in cost when assessing viability of technology options, but instead analyzes cost when determining the economic justification of using viable technologies. Regarding circuit designs, DOE identified advanced designs, such as cathode cut-out technology, integrated circuits, improved starting method, and synchronous rectification that could increase ballast efficiency. Because there are different levels of ballast efficiencies for integrated CFLs, DOE finds that circuit designs and/or features of varying efficiencies must be in use. Therefore, DOE continues to consider ballast designs as a means from improving efficacy and considers it as a technology option in this NOPR analysis.

NEMA disagreed with active cooling as a technology option and commented that active cooling approaches for CFLs have been studied, but are absolutely cost prohibitive, and may lower efficacy due to the power needs of the active cooling system. (NEMA, No. 34 at p. 9) DOE did not identify active cooling as a technology option to improve CFL efficacy in the preliminary analysis. DOE did consider active thermal managements systems for enhancing LED lamp efficacy which is discussed in section V.A.2.b.

Additionally, NEMA stated that manufacturers are already producing lamps with ideal diameters for maximum efficiency. (NEMA, No. 34 at p. 9) DOE notes it did not consider higher efficiency diameters as a means for improving CFL technology in the preliminary analysis.

b. LED Lamp Technology Options From the Preliminary Analysis

Stakeholders had some general comments on LED lamp technology. GE noted that LED lamps are a newer technology and therefore more likely to have continued efficacy advancements than CFLs. (GE, Public Meeting Transcript, No. 29 at p. 59) NEEA observed that an energy conservation standard promulgated by this rulemaking would not require compliance until 2020. As even the technology options under consideration that are in early stages of development are being commercialized at a fast pace, DOE will likely have more information on them before the final rule stage of this rulemaking. NEEA encouraged DOE to take into account all new information that emerges between the preliminary analysis and the NOPR. (NEEA, Public Meeting Transcript, No. 29 at pp. 60–61)

As part of the NOPR analysis, DOE does a thorough assessment of the technology options relevant to this rulemaking. In the NOPR analysis, DOE provides updates on the progress in research and development for the technologies identified in the preliminary analysis, as well as identifying any new technology options that may have emerged. DOE received several specific comments on technology options identified for increasing LED lamp efficacy in the preliminary analysis that are discussed below.

Efficient Down Converters

NEMA commented that efficient down converters are not in use today due to technical challenges surrounding narrow-band phosphors that enable high spectral efficiency, including robust packaging for lumen maintenance while achieving high quantum efficiency under high temperature and flux. (NEMA, No. 34 at p. 10) CA IOUs, however, supported the inclusion of quantum dot and phosphor emitter materials as technology options in the preliminary analysis. (CA IOUs, Public Meeting Transcript, No. 29 at p. 62)

In the preliminary analysis, DOE presented efficient down converters as a technology option that uses high-efficiency wavelength conversion materials to convert narrow band monochromatic light emitted by LED lamps into white light.[76] Feedback from manufacturer interviews indicated that manufacturers are continually trying to improve down conversion methods. One method is using phosphor, which involves incorporating the phosphor in the body of a blue LED, causing some of the blue light to be converted into yellow light and the remaining blue light to be mixed with the yellow light, resulting in white light. The vast majority of white LED lamps currently used in SSL applications employ the phosphor-conversion approach.[77] The performance of phosphor conversion can be increased by using improved phosphor material. DOE acknowledges that current phosphors have high quantum yields, but show wide emission spectra and saturation effects at high temperatures and high flux.[78] DOE has found there are research efforts and existing patents on optimized phosphor coating for LED lamps. DOE is funding a project that intends to increase the thermal conductivity of the encapsulant, resulting in lower temperature of phosphor particles by as much as 50 °C and raising the effective quantum efficiency (QE) to 95 percent for the phosphors at 150 °C at 35 A/cm^2 in white-light-emitting SSL sources.[79] Further, DOE is also aware of ongoing research regarding the use of quantum dots as a down conversion method. (See chapter 3 of the NOPR TSD for further details.) Therefore, based on the use of this technology in GSL products and the indication of continued research and development to resolve existing issues and further improve efficacy, DOE continues to consider efficient down

[73] Feng, Xiangfen and Yang, Hu. *Design Principle Study of High Efficiency Compact Fluorescent Lamps.* LEUKOS VOL 8 NO 4. (April 2012): 301–311.

[74] Osram Sylvania. *Cold Spot technology: Condensation point in the discharge tube.* 2015. (Last accessed July 14, 2015.) *http://www.osram.com/osram_com/news-and-knowledge/fluorescent-lamps/professional-knowledge/cold-spot-technology/index.jsp.*

[75] GSL preliminary anaylsis at 3–52.

[76] *Id.* at 3–53.

[77] U.S. Department of Energy. *2015 Solid-State Lighting R&D Plan.* May 2015. (Last accessed July 14, 2015.) *http://energy.gov/sites/prod/files/2015/06/f22/ssl_rd-plan_may2015_0.pdf.*

[78] Ibid.

[79] U.S. Department of Energy. *2015 Project Portfolio: Solid-State Lighting.* January 2015. (Last accessed July 14, 2015.) *http://energy.gov/sites/prod/files/2015/01/f19/2015_ssl-project-portfolio.pdf.*

converters as a viable means of increasing LED lamp efficacy and proposes it as a technology option in this NOPR analysis.

Improved Package Architectures

NEMA noted reliable die attachment methods are needed to enable high temperature operation for improved package architectures. NEMA also commented that there is a need for polymer optical encapsulants to improve color stability and emitter lifetime, and high thermal conductivity to reduce down-converting layer temperatures. Further, NEMA specified that another challenge is the development of high index encapsulants to increase photon extraction. The barriers to improvement differ depending on the architecture approach; NEMA gave the example of mixed color solutions requiring additional controls that would increase the cost of the total package. (NEMA, No. 34 at p. 10)

In the preliminary analysis, DOE presented improved package architecture as a technology option, noting examples of architecture enhancements such as RGB+, hybrid color, and bonding the chip directly on to the heat sink.[80] DOE is aware that die attachment and encapsulation are being continually improved. The challenge with die attachment is that defects can occur in the die if the bonding material requires high temperature. However, there is research regarding bonding materials that can be used at lower temperatures. For example, there is a patent on using a conductive paste as bonding method to allow bonding to occur at a lower temperature.[81] Further, in June 2015, Dow Corning was issued a patent by the Korean Intellectual Property Office (KIPO) for its new LED Optical Silicone Encapsulant Technology, which potentially offers improved light output, improved mechanical protection, and can act as a gas barrier to enhance component reliability.[82] Regarding color mixing, Cree's TrueWhite Technology, which mixes the light from red and unsaturated yellow LEDs to create white light, preserves high color consistency over the life of the product.[83] With respect to cost, as noted earlier, the technology option analysis examines mechanisms that increase efficacy, regardless of cost. Therefore, given that package architectures are continually being improved in GSL products and issues related to further advancing this technology are under research and development, DOE is proposing improved package architecture as a viable means of improving LED lamp efficacy in this NOPR analysis.

Alternative Substrate Materials

NEMA stated that the cost of gallium nitride (GaN) substrates is high for LEDs. Further NEMA stated the performance of Si and GaN-on-Si-based devices is not significantly better than sapphire-based devices and would not warrant a transition to these substrates. (NEMA, No. 34 at p. 10)

In the preliminary analysis DOE presented alternative substrates as a technology option noting certain alternatives to the most commonly used, sapphire substrate material.[84] A greater lattice match between the substrate material and the GaN LED material reduces the likelihood of defects and increases lumen efficacy of the LED. The lattice mismatch of sapphire (16 percent) and silicon (18 percent) are comparable and high. However, the lattice mismatch of silicon carbide (SiC) is 3.5 percent and for GaN is zero.[85] Therefore, DOE agrees that while the use of silicon may not result in better performance compared to sapphire, there are alternative substrates such as SiC and GaN that can enhance the efficacy of LED lamps. Soraa manufactures lamps using GaN on GaN LEDs and recently announced a new LED package reaching 75 percent wall-plug-efficiency.[86] Regarding the cost of GaN material, DOE notes that it does not take cost into consideration when identifying technology options and considers costs in determining the economic justification of any standard levels developed using these technologies. Hence, DOE continues to consider use of alternative substrates as a technology option to improve LED lamp efficacy.

Improved Thermal Interface Materials (TIMs)

NEMA stated that challenges to using improved TIMs include developing TIMs that enable high efficiency thermal transfer for long-term reliability and performance optimization of the LED device and overall lamp product. (NEMA, No. 34 at p. 10)

In the preliminary analysis, DOE presented improved TIMs as a technology option that allows for higher efficiency thermal transfer, which can improve LED efficacy by lowering LED junction temperature.[87] There are also research efforts targeting reliable high efficiency thermal transfer materials such as chemical vapor deposition (CVD) diamond, which provides high thermal conductivity, while allowing for standard methods of attachment (*e.g.,* solders and epoxies).[88] Companies such as Electrolube are focusing on reduced viscosity compounds with higher bulk thermal conductivities to produce TIMs that maximize efficiency in heat dissipation by minimizing thermal resistance.[89] Indium Corporation introduced a Heat-Spring, which is a metal thermal interface material that provides high thermal conductivity and is designed not to bake out or pump out, optimizing long-term performance consistency.[90] Therefore, there is continued development of higher efficiency and longer reliability TIMs. Further, in manufacturer interviews, several manufacturers noted that TIMs are a mechanism used to improve lamp efficacy. Therefore, DOE is continuing to consider improved TIMs as a viable means for increasing LED lamp efficacy.

Optimized Heat Sink Design

NEMA observed that the performance of the heat sink is generally compromised by material cost and geometrical constraints. (NEMA, No. 34 at p. 10)

[80] GSL preliminary analysis at 3–54.

[81] Miyairi, M., Ogashiwa, T., and Shioya, A. (2015) *U.S. Patent No. 2,833,393.* Washington, D.C: U.S. Patent and Trademark Office.

[82] Wright, Maury. *LED business news: Dow Corning IP, new funding, and Eaton management.* June 2015. (Last accessed July 14, 2015.) *http://www.ledsmagazine.com/articles/2015/06/led-business-news-dow-corning-ip-new-funding-and-eaton-management.html.*

[83] Cree. *FAQs about Cree LED Components.* 2015. (Last accessed July 14, 2015.) *http://www.cree.com/led-components-and-modules/tools-and-support/faqs.*

[84] GSL preliminary analysis at 3–58.

[85] Solid State Technology. *Beyond sapphire: LED substrates from GaN to ZnO, SiC, and Si.* May 14, 2012. (Last accessed July 14, 2015.) *http://electroiq.com/blog/2012/05/beyond-sapphire-led-substrates-gan-zno-sic-si/.*

[86] Soraa. *Soraa develops the world's most efficient LED; begins integration into large lamp line.* February 24, 2014. (Last Accessed July 14, 2015.) *http://www.soraa.com/news/soraa-large-lamp-gen3–022414.*

[87] RPI. *Junction temperature in light-emitting diodes assessed by different methods.* (Last accessed June 14, 2015.) *http://www.ecse.rpiscrews.us/~schubert/Reprints/2005%20Chhajed%20et%20al%20%28SPIE%20Photonics%20West%29%20Junction%20temperature%20in%20LEDs.pdf*

[88] Aidala, Dwain A. *CVD Diamond Solves Thermal Challenges.* Solid State Technology. (Last accessed July 14, 2015.) *http://electroiq.com/blog/2006/10/cvd-diamond-solves-thermal-challenges/.*

[89] Electrolube. *Thermal Management of LEDs: Looking Beyond Thermal Conductivity Values.* 2015. (Last accessed July 14, 2015.) *http://www.electrolube.com/technical-articles/thermal-management-of-leds-looking-beyond-thermal-conductivity-values/.*

[90] Indium Corporations. *Indium Corporation Features Heat-Spring for LED Manufacturing at Strategies in Light.* January 8, 2015. (Last accessed on July 14, 2015). *http://www.indium.com/people/marketing-communications/news-releases/heat-spring-for-led-manufacturing-at-strategies-in-light.*

In the preliminary analysis, DOE presented optimized heat sinks as a technology option that improves thermal conductivity and heat dissipation, lowering the temperature at the LED junction and increasing lamp efficacy.[91] DOE determined that geometrical constraints can be addressed in optimized heat sink designs. For example, finned designs made out of materials with high thermal transfer coefficients have been utilized in commercially available A-shape lamps. Further, there are existing patents on optimized heat sinks for LED lamps indicating this is an area of ongoing research. GE developed a heat sink that includes a reflective layer over the heat sink body with a reflectivity greater than 90 percent for light in the visible spectrum. Further is a light transmissive protective layer over the reflective layer that can sufficiently reflect visible and infrared light impinging on the surface of the heat sink, and still transmit heat from the LED lamp to the ambient environment with greater efficacy.[92] Therefore, DOE finds that geometrical constraints can be overcome to improve heat sink designs, and DOE is continuing to consider optimized heat sinks as a technology option that can increase the efficacy of LED lamps in this NOPR analysis.

Active Thermal Management Systems

Regarding active thermal management systems, NEMA commented that reliability and cost are major concerns. (NEMA, No. 34 at p. 10)

In the preliminary analysis, DOE considered active thermal management systems, which are specifically designed to provide cooling to LED components, decreasing the LED junction temperature.[93] Some active thermal management systems take the form of integral fans or vibrating membranes, increasing convection. Additionally, as active thermal management systems are being used in commercially available lamps, such as Philips MASTER LEDspot MR16s, DOE believes reliability concerns can be addressed by manufacturers.[94] Hence, DOE continues to consider active thermal management systems as a technology options that can increase the efficacy of LED lamps.

[91] GSL preliminary analysis at 3–59.

[92] Allen, Gary and Chowdhury, Ashfaqul. GELighting Solutions, LLC. (2014) *U.S. Patent No. 8,672,516.* Washington DC: U.S. Patent and Trademark Office.

[93] GSL preliminary analysis at 3–59.

[94] Philips. *MASTER LEDspot LV—The ideal solution for spot lighting.* July 3, 2015. (Last Accessed July 14, 2015.) *http://download.p4c.philips.com/l4bt/3/322779/master_ledspot_lv_322779_ffs_aen.pdf.*

Improved Driver Design

In terms of improved driver design, NEMA commented that in addition to efficacy, drivers must meet many specifications (such as cost, power quality, flicker, dimmability, isolation, line regulation, and transient protection) and optimizing for specific applications often leads to a compromise in efficacy. (NEMA, No. 34 at p. 11)

In the preliminary analysis, DOE considered improved driver design as a mechanism for increasing overall lamp efficacy.[95] Manufacturer feedback during interviews and DOE's review of catalogs indicate a range of efficiencies associated with drivers. The existence of this range, coupled with historical increases in driver efficiency in commercially available lamps, demonstrates the potential for improvement in driver design, while meeting the functional specifications of the product. Therefore, DOE continues to consider an improved driver design as a technology option for improving LED lamp efficacy.

Reduced Current Density

NEMA stated that current density is only one aspect in the design of an efficient LED die and there are many trade-offs that take place to ensure higher efficacy. Further NEMA asserted that optimization of current density could result in lower overall efficacy. (NEMA, No. 34 at p. 11)

In the preliminary analysis, DOE presented reduced current density as a technology option for improving LED lamp efficacy.[96] DOE notes that increasing current results in a commensurate decrease in LED efficacy. This decrease in efficacy at higher currents is referred to as ''efficacy droop'' and is discussed in further detail in chapter 3 of the NOPR TSD. DOE's research shows that reducing current density within the appropriate package architecture will increase LED lamp efficacy while maintaining practical levels of lumen output per unit area. (See chapter 3 of the NOPR TSD for more information.) For example, chip-on-board (COB) is an LED packaging technology with very compact arrays of LEDs, allowing for greater light intensity and uniformity per unit area.[97] This technology uses many low-powered chips rather than a few high-powered chips to produce the desired lumen output, but at a higher lamp efficacy because the chips can be run at low current. New filament-style LED lamps use strands of as many as 36 low-powered LEDs running at low current (*i.e.,* approximately 15 mA) connected in series, encapsulated on glass or sapphire substrates, and coated in a phosphor resin. Lamps using these filament strands are currently some of the most efficacious on the market according to manufacturer catalogs.[98] A known issue with lower current density is that the each LED die produces fewer lumens. Methods of compact die arrays that allow for more dies per unit area mitigate this issue. Therefore, DOE finds that manufacturers are utilizing reduced current density to increase LED lamp efficacy and continues to consider it as a technology option in this NOPR analysis.

[95] GSL preliminary analysis at 3–60.

[96] *Id.* at 3–61.

[97] Pro Photonix. *Chip-on-Board LED Technology.* 2015. (Last accessed July 14, 2015.) *http://www.prophotonix.com/resources/Technical-Overviews/about-chip-on-board.aspx.*

Device Level Optics

Regarding the use of device level optics, NEMA commented that package size limits the extent of beam-shaping that can be done with reasonable extraction efficacy and that it may not be desirable to integrate application-specific functions at a low system level for complexity management reasons. (NEMA, No. 34 at p. 11)

In the preliminary analysis, DOE presented device level optics as a technology option that involves optimizing optics at the chip level or the primary optic, so that the outer secondary optic can be removed, thereby eliminating losses due to absorption.[99] A primary optic is integrated into the LED package and optimizes light extraction using mechanisms such as reflective structure coatings and integrated lenses. DOE found that there are research efforts addressing issues of optimizing extraction efficiency for small package sizes, as well as improving beam shaping. An existing patent presents 27 different primary optic configurations that achieve more controlled beam shapes while allowing for a more simplified and efficient secondary optic.[100] Another patent discusses LED packages with enhanced mirror reflectivity that improve the overall emissions of the chip by stopping light absorption by the multiple chip layers.[101] Therefore, DOE considers

[98] Tevaja Lighting. *FiLED, Filament LED Bulbs, visual effects of incandescents.* 2015. (Last accessed July 14, 2015.) *http://www.tevaja.com/?page_id=11.*

[99] GSL preliminary analysis at 3–60.

[100] Tars, E., Kellerm, B., Guschl, P., and Negley, G. (2011) *U.S. Patent No. 8,564,004.* Washington DC: U.S. Patent and Trademark Office.

[101] Bergmann, M. et al. and Cree. (2014) *U.S. Patent No. 8,686,429.* Washington DC: U.S. Patent and Trademark Office.

optics as a viable means of increasing LED lamp efficacy in this NOPR analysis.

Further DOE determined that the main mechanism for increasing lamp efficacy through ''device level optics'' is through improvement in primary optics. Therefore, in this NOPR analysis, in order to clearly define this technology option, DOE is proposing to rename ''device level optics'' as ''improved primary optics.'' DOE is also refining the description of the technology option as enhancements to the primary optic of the LED package such as surface etching that would optimize extraction of usable light from the LED package and reduce losses due to light absorption at interfaces. DOE requests comment on its proposed renaming of ''device level optics'' to ''improved primary optics'' and refined description of this technology option. For further details of this technology option see chapter 3 of the NOPR TSD.

Increased Light Utilization

Regarding the increased light utilization technology option, NEMA commented that there is a trade-off between increased light utilization and system level cost. (NEMA, No. 34 at p. 11) In the preliminary analysis, DOE considered increased light utilization as a means for reducing optical losses from housing, diffusion, beam shaping, and color-mixing through mechanisms such as highly reflective coatings inside the lamp, thereby increasing overall luminaire efficacy. DOE does not take cost into consideration when identifying technology options. DOE considers costs in determining the economic justification of any standard levels developed using these technologies.

Further, in the NOPR analysis, DOE determined that the term ''increased light utilization'' can encompass many mechanisms for improving lamp efficacy including use of improved primary optics, improved package architecture, etc. However, the intent of this technology option is to specifically describe how reduction in optical losses is achieved through secondary optics such as diffuse coatings on the lamp. Therefore, in this NOPR analysis, in order to clearly define this technology option, DOE is proposing to replace the term ''increased light utilization'' with ''improved secondary optics.'' Further DOE is refining the description of the technology option as the reduction or elimination of optical losses from the lamp housing, diffusion, beam shaping, and other secondary optics to increase efficacy, using mechanisms such as reflective coatings and improved diffusive coatings. Additionally, DOE finds that because increased lamp efficacy through increased light utilization is a general phenomenon, covered in many proposed technology options, it does not need to be proposed as specific mechanism for achieving LED lamp efficacy. DOE requests comment on its proposal to replace the term ''increased light utilization'' with ''improved secondary optics'' and the refined definition of this technology option. For further details of this technology option see chapter 3 of the NOPR TSD.

c. Summary

In summary, after conducting an update of relevant publications and feedback in manufacturer interviews, DOE is proposing the technology options as shown in Table V–2. For further information on all technology options considered in this NOPR, see chapter 3 of the NOPR TSD. DOE requests comments on the proposed technology options.

TABLE V–2—GSL TECHNOLOGY OPTIONS

Lamp type	Name of technology option	Description
CFL	Highly Emissive Electrode Coatings	Improved electrode coatings allow electrons to be more easily removed from electrodes, reducing lamp power and increasing overall efficacy.
	Higher Efficiency Lamp Fill Gas Composition.	Fill gas compositions improve cathode thermionic emission or increase mobility of ions and electrons in the lamp plasma.
	Higher Efficiency Phosphors	Techniques to increase the conversion of ultraviolet (UV) light into visible light.
	Glass Coatings	Coatings on inside of bulb enable the phosphors to absorb more UV energy, so that they emit more visible light.
	Multi-Photon Phosphors	Emitting more than one visible photon for each incident UV photon.
	Cold Spot Optimization	Improve cold spot design to maintain optimal temperature and improve light output.
	Improved Ballast Components	Use of higher grade components to improve efficiency of integrated ballasts.
	Improved Ballast Circuit Design	Better circuit design to improve efficiency of integrated ballasts.
	Change in Technology	Replace CFL with LED technology.
LED	Efficient Down Converters	New high-efficiency wavelength conversion materials, including optimized phosphor conversion, quantum dots, have the potential for creating warm-white LEDs with improved spectral efficiency, high color quality, and improved thermal stability.
	Improved Package Architectures	Novel package architectures such as color mixing (RGB+) and hybrid architecture to improve package efficacy.
	Improved Emitter Materials	The development of efficient red, green, or amber LED emitters, will allow for optimization of spectral efficiency with high color quality over a range of CCT and which also exhibit color and efficiency stability with respect to operating temperature.
	Alternative Substrate Materials	Alternative substrates such as gallium nitride (GaN), silicon carbide (Si-C) to enable high-quality epitaxy for improved device quality and efficacy.
	Improved Thermal Interface Materials	TIMs that enable high efficiency thermal transfer for long-term reliability and performance optimization of the LED device.
	Optimized Heat Sink Design	Improve thermal conductivity and heat dissipation from the LED chip thus reducing efficacy loss from rises in junction temperature.
	Active Thermal Management Systems	Devices such as internal fans and vibrating membranes to improve thermal dissipation from the LED chip.
	Improved Primary Optics	Enhancements to the primary optic of the LED package such as surface etching that would optimize extraction of usable light from the LED package and reduce losses due to light absorption at interfaces.
	Improved Secondary Optics	Reduce or eliminate optical losses from the lamp housing, diffusion, beam shaping, and other secondary optics to increase efficacy using mechanisms such as reflective coatings and improved diffusive coatings.
	Improved Driver Design	Increase driver efficiency through novel and intelligent circuit design.

TABLE V–2—GSL TECHNOLOGY OPTIONS—Continued

Lamp type	Name of technology option	Description
	AC LEDs	Eliminate the requirements of a driver and therefore reduce efficiency losses from the driver.
	Reduced Current Density	Driving LED chips at lower currents while maintaining light output, and thereby reducing the efficiency losses associated with efficacy droop.

B. Screening Analysis

After DOE identifies the technologies that improve the efficacy of GSLs, DOE conducts the screening analysis. The purpose of the screening analysis is to determine which options to consider further and which options to screen out. DOE consults with industry, technical experts, and other interested parties in developing a list of technology options. DOE then applies the following set of screening criteria to determine which options are unsuitable for further consideration in the rulemaking (10 CFR part 430, subpart C, appendix A at 4(a)(4) and 5(b)):

1. *Technological feasibility.* DOE will consider technologies incorporated in commercially available products or in working prototypes to be technologically feasible.

2. *Practicability to manufacture, install, and service.* If mass production of a technology and reliable installation and servicing of the technology could be achieved on the scale necessary to serve the relevant market at the time the standard comes into effect, then DOE will consider that technology practicable to manufacture, install, and service.

3. *Adverse Impacts on product utility or product availability.* If DOE determines a technology to have significant adverse impact on the utility of the product to significant subgroups of consumers, or to result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not further consider this technology.

4. *Adverse impacts on health or safety.* If DOE determines that a technology will have significant adverse impacts on health or safety, it will not further consider this technology.

Those technology options not screened out by the above four criteria are called ''design options'' and are considered as possible methods of improving efficacy in the engineering analysis. DOE received several comments on the screening analysis presented in the GSL preliminary analysis.

1. CFL Technology Options Screened Out

a. Multi-Photon Phosphors

NEMA commented that multi-photon phosphors have been analyzed in the past and no cost effective improved performance phosphors have been identified, so NEMA agreed with DOE's decision to screen out multi-photon phosphors. (NEMA, No. 34 at p. 9)

In the preliminary analysis, DOE screened out multi-photon phosphor technology based on the first criterion, technological feasibility, because the technology was still in the research phase.[102] DOE finds that the technology remains in research phase and is unaware of any prototypes or commercially available products that incorporate this technology and therefore proposes to continue to screen multi-photon phosphor technology out based on the first criterion, technological feasibility.

2. LED Technology Options Screened Out

a. AC LEDs

NEMA noted that true AC LEDs have less than 50 percent utilization and require external components for, among other things, surge protection and flicker mitigation. Further, for high voltage LEDs there is an efficiency loss due to die segmentation and increased package complexity to sustain the high voltage and wide variety of optimum forward voltages. Therefore, NEMA agreed with DOE's decision to screen out AC LEDs. (NEMA, p. 11)

In the preliminary analysis, DOE presented AC LEDs as a technology option that removed the need for a driver component, potentially reducing efficiency losses.[103] DOE determined that manufacturers are finding solutions to several of the issues noted by NEMA. DOE found that Seoul Semiconductor has a number of high voltage AC LED modules commercially available for integration into lamps. Further, in July 2014, Seoul Semiconductor announced a new line of AC LED modules with improved AC drivers designed specifically for the omnidirectional lamps, improved compatibility with TRIAC dimmers, and mitigated flicker issues with dimming. Regarding utilization issues, DOE found improvements in circuit design can increase LED utilization. For example, Texas Instruments' (TI's) TPS92411 MOSFET switch allows a small capacitor to be placed across each LED segment on a circuit, storing energy to keep all LEDs lit, even when the AC line voltage is too low, thereby increasing LED utilization.

However, at the time of the preliminary analysis, DOE did not find commercially available products that contained this technology, and screened it out based on the first criterion, technological feasibility. During research conducted for the NOPR analysis, DOE found that Eastar Lighting is producing two 5 W G-shaped AC LED lamp models with 330 lumens and 360 lumens that could meet the scope of GSLs. Because only two models are being produced by one manufacturer, it is unclear if these lamps could be produced on a commercial scale. Additionally, the products are not available across a range of lumen packages and limited to the G-shape. Therefore, DOE is proposing to screen out AC LEDs based on the second and third criteria, respectively practicability to manufacture, install, and service and adverse impacts on product utility or product availability.

b. Quantum Dots

NRDC mentioned that new TVs are starting to use quantum dots and have LED back lights. As these technologies are out of the research phase, they could be applicable to general lighting applications. (NRDC, Public Meeting Transcript, No. 29 at p. 60) However, Philips disagreed, commenting that the technology is being very closely monitored within the lighting industry, but it is currently cost prohibitive. (Philips, Public Meeting Transcript, No. 29 at p. 61)

In the preliminary analysis, DOE screened out this technology based on the first criterion, technological

[102] GSL preliminary analysis at 2–61.

[103] *Id.*

feasibility. DOE acknowledges the continued development of quantum dots and their use in TVs and other lighting displays, and notes that in a recent report from Yole Développement, the use of quantum dots in lighting is projected to rise by 2020.[104] However, DOE continues to find no evidence that quantum dot technology is currently used in commercially available lamps. Therefore, DOE proposes to continue to screen out this technology option based on the first criterion, technological feasibility, and will not consider quantum dot technologies as a design option for improving the efficacy of GSLs.

c. Improved Emitter Materials

In the preliminary analysis, DOE screened out improved emitter materials, which can increase the efficiency of LED emitters, the component that generates light output. In particular LED lamp efficacy can be improved with the use of more efficient green emitters. However, because research in this area was ongoing, DOE screened out this technology option based on the first criterion, technological feasibility. In this NOPR analysis, DOE found that improved emitter materials remain in the research phase and proposes to continue to screen them out based on technological feasibility.

3. Summary

In this NOPR, of the technology options identified for improving GSL efficacy, DOE is proposing screening out the following:

CFL Technology Options Screened Out

- Multi-photon phosphors because they could not be proven to be technologically feasible.

LED Technology Options Screened Out

- AC LEDs because they could not be proven to be practicable to manufacture, install and service and had adverse impacts on product utility or product availability;
- Improved emitter materials because they could not be proven to be technologically feasible; and
- Quantum dot technologies because they could not be proven to be technologically feasible.

The following are GSL technologies that DOE has not screened out and is proposing as design options:

[104] I-Micronews. *Phosphors & Quantum Dots 2015: LED Downconverters for Lighting & Displays.* 2015. (Last accessed July14, 2015.) *http://www.i-micronews.com/led-report/product/phosphors-quantum-dots-2015-led-downconverters-for-lighting-displays.html#description.*

CFL Design Options

- Highly Emissive Electrode Coatings
- Higher Efficiency Lamp Fill Gas Composition
- Higher Efficiency Phosphors
- Glass Coatings
- Cold Spot Optimization
- Improved Ballast Components
- Improved Ballast Circuit Design
- Change in Technology

LED Design Options

- Efficient Down Converters (with the exception of quantum dots technologies)
- Improved Package Architectures
- Alternative Substrate Materials
- Improved Thermal Interface Materials
- Optimized Heat Sink Design
- Active Thermal Management Systems
- Improved Primary Optics
- Improved Secondary Optics
- Improved Driver Design
- Reduced Current Density

See chapter 4 of the NOPR TSD for further details on the GSL screening analysis. DOE requests comment on the proposed design options in this NOPR analysis.

C. Engineering Analysis

1. General Approach

The engineering analysis is generally based on commercially available lamps that incorporate the design options identified in the technology assessment and screening analysis. (See chapters 3 and 4 of the NOPR TSD for further information on technology and design options.) The methodology consists of the following steps: (1) Selecting representative product classes, (2) selecting baseline lamps, (3) identifying more efficacious substitutes, and (4) developing ELs by directly analyzing representative product classes and then scaling those ELs to non-representative product classes. The details of the engineering analysis are discussed in chapter 5 of the NOPR TSD. The following discussion summarizes the general steps of the engineering analysis:

Representative product classes: DOE first reviews covered lamps and the associated product classes. When a product has multiple product classes, DOE selects certain classes as ''representative'' and concentrates its analytical effort on these classes. DOE selects representative product classes primarily because of their high market volumes and/or distinct characteristics.

Baseline lamps: For each representative product class, DOE selects a baseline lamp as a reference point against which to measure changes resulting from energy conservation standards. Typically, a baseline model is the most common, least efficacious lamp sold in a given product class. For this NOPR analysis, DOE uses performance data presented in manufacturer catalogs to determine lamp efficacy. DOE also considers other lamp characteristics in choosing the most appropriate baseline for each product class such as wattage, lumen output, CCT, shape, and lifetime.

More efficacious substitutes: DOE selects higher efficacy lamps as replacements for each of the baseline models considered. When selecting higher efficacy lamps, DOE considers only design options that meet the criteria outlined in the screening analysis (see section V.B or chapter 4 of the NOPR TSD). DOE also sought to maintain the baseline lamp's characteristics, such as base type, CCT, and CRI among other specifications, for substitute lamps. For non-integrated GSLs, DOE pairs each lamp with an appropriate ballast because non-integrated GSLs are a component of a system, and their performance is related to the ballast on which they operate.

Efficacy levels: After identifying the more efficacious substitutes for each baseline lamp, DOE develops ELs. DOE bases its analysis on three factors: (1) The design options associated with the specific lamps studied; (2) the ability of lamps across lumen packages to comply with the standard level of a given product class; and (3) the max-tech EL. DOE then scales the ELs of representative product classes to any classes not directly analyzed.

DOE received comments on the general approach to the engineering analysis presented in the preliminary analysis. NEMA and Westinghouse expressed concerns over DOE's use of catalog data. In general, NEMA stated that rated or initial lumens reported in catalogs are long term means and are not necessarily measured values. NEMA especially noted that catalog data for the covered products that are currently without published test procedures would be particularly problematic. Westinghouse commented that manufacturers may be aggressively marketing their product and without supporting test data, it is difficult to determine which numbers are legitimate. Westinghouse further requested that DOE exclude outliers and set standards that allow for differences between specialty and high-volume manufacturing. (NEMA, No. 34 at p. 15; Westinghouse, Public Meeting Transcript, No. 29 at pp. 97–98)

DOE used performance data of commercially available GSLs presented in manufacturer catalogs to identify potential baseline lamps and develop ELs. DOE used catalog data as the basis of its engineering analysis because it is the largest and most comprehensive dataset. However, DOE also used publicly available test data from CEC's Appliance Efficiency Database, DOE's LED Lighting Facts Product List, EPA's ENERGY STAR Certified Light Bulbs Database, and DOE's CCMS Database when possible to verify efficacies calculated from catalog values and to ensure lamps can comply with ELs based on test data. DOE also conducted independent testing, using the LED Test Procedure SNOPR, of representative units and similar lamps to verify performance at the highest levels of efficacy. See section V.C.4 and appendix 5A of the NOPR TSD for more information.

Although certain products included in the scope of this rulemaking do not currently have finalized DOE test procedures (*e.g.,* LED lamps), industry standards for measuring efficacy have been in place for several years for these products. Therefore, manufacturers and the organizations conducting verification testing are likely using existing industry standard test methods to determine performance values. EPCA directs DOE to establish test procedures for covered products in advance of prescribing an energy conservation standard. (42 U.S.C. 6295(o)(3)(A)) Thus, DOE plans to finalize test procedures for all GSLs for which DOE is proposing standards prior to the completion of this rulemaking.

Regarding outliers, DOE identified data outliers in both its collection of lamp performance data from manufacturer catalogs and in its review of efficacy values from DOE's CCMS Database. DOE identified both on the high and low end outliers, and in cases where DOE was unable to verify the value using test data or manufacturer confirmation, DOE maintained its approach from the preliminary analysis of not considering the lamp in the engineering analysis. DOE welcomes comment on the data approach.

2. Representative Product Classes

In the case where a covered product has multiple product classes, DOE identifies and selects certain product classes as ''representative'' and concentrates its analytical effort on those classes. DOE chooses product classes as representative primarily because of their high market volumes and/or unique characteristics. DOE then scales its analytical findings for those representative product classes to other product classes that are not directly analyzed. In the preliminary analysis, DOE considered directly analyzing all product classes for GSLs: Integrated low-lumen GSLs, integrated high-lumen GSLs, and non-integrated GSLs.

In this NOPR analysis, DOE is directly analyzing both the Integrated Low-Lumen and the Integrated High-Lumen product classes because there are technological limitations to producing high-lumen (*i.e.,* 2,000 lumens or greater) GSLs using LED technology and therefore ELs for this product class cannot be scaled from the Integrated Low-Lumen product class. DOE is also continuing to directly analyze the Non-Integrated product class because of observed differences in efficacy trends and maximum technologically feasible levels between integrated and non-integrated lamps. Further, manufacturer feedback indicated that scaling between the integrated and non-integrated products is not appropriate.

As stated in section V.A.1, for this NOPR analysis, DOE is also proposing a product class division based on standby mode functionality for the Integrated Low-Lumen and Integrated High-Lumen product classes. Based on manufacturer feedback and testing conducted, DOE determined that standby power consumption is not negligible and therefore the efficacy of these lamps would be impacted. Because standby mode functionality also offers a consumer utility, DOE is proposing a product class division. Based on manufacturer feedback and testing conducted, DOE determined that integrated lamps with standby mode functionality are typically the same design as integrated lamps without standby mode functionality but with the addition of wireless communication components. Because the technology is fundamentally the same, DOE is proposing to scale from the Integrated Low-Lumen and Integrated High-Lumen product classes without standby mode to the respective product classes capable of operating in standby mode. See section V.C.6 for more information on scaling.

In summary, DOE is proposing to directly analyze the product classes shown (in gray) in Table V–3 as representative in the NOPR analysis. See chapter 5 of the NOPR TSD for further discussion.

TABLE V–3—GENERAL SERVICE LAMPS REPRESENTATIVE PRODUCT CLASSES

Lamp type	Lumen package	Standby mode operation
Integrated GSLs	310 ≤Initial Lumen Output <2,000	No Standby Mode.
		Capable Of Operating In Standby Mode.
	2,000 ≤Initial Lumen Output ≤2,600	No Standby Mode.
		Capable Of Operating In Standby Mode.
Non-Integrated GSLs	310 ≤Initial Lumen Output ≤2,600	

3. Baseline Lamps

Once DOE identifies the representative product classes for analysis, it selects baseline lamps to analyze in each class. Typically, a baseline lamp is the most common, least efficacious lamp that meets existing energy conservation standards. Specific lamp characteristics were used to characterize the most common lamps purchased by consumers (*e.g.,* wattage, CCT, CRI, and light output). Because certain products within the scope of this rulemaking have existing standards, GSLs that fall within the same product class as these lamps must meet the existing standard in order to prevent backsliding. (*See* 42 U.S.C. 6295(o)(1)) Thus, DOE only considered baseline lamps in the Integrated Low-Lumen and Integrated High-Lumen product classes that meet the existing standards for bare MBCFLs. The Non-Integrated product class does not have any applicable existing standards.

a. Integrated Lamps

In the preliminary analysis, DOE identified baseline lamps in the integrated lamps product classes as the most common, least efficacious lamps in those product classes that meet existing standards for MBCFLs.[105] For the Integrated Low-Lumen product class in the preliminary analysis, DOE found that the most common lamps were 60 W equivalent lamps and typically produced lumen output in the range of 700–900 lumens. DOE determined that the baseline lamp for the Integrated Low-Lumen product class was a 14 W, 750 lumen (*i.e.,* 60 W equivalent) A-shape CFL with a lifetime of 10,000

[105] GSL preliminary analysis at 5–4.

hours, a CRI of 80, and a CCT of 2,700 K. For the Integrated High-Lumen product class in the preliminary analysis, DOE found that the most common lamps were 125 W equivalent lamps which typically produce lumen output in the range of 2,000–2,600 lumens. DOE determined that the baseline was a 32 W, 2,000 lumen (*i.e.,* greater than 100 W equivalent) spiral CFL with a lifetime of 10,000 hours, a CRI of 80, and a CCT of 2,700 K.

DOE received comments from stakeholders on the baseline lamps selected for the Integrated Low-Lumen product class. GE, NEMA, and Westinghouse commented that the baseline (CSL 0) and CSL 1 did not represent two ELs for CFLs, but rather two distinct products used for different purposes. Specifically, GE, NEMA, and Westinghouse noted that the baseline in the Integrated Low-Lumen product class was a covered CFL and CSL 1 was a bare CFL, and lamps with covers should not be eliminated because they provide consumer utility. (GE, Public Meeting Transcript, No. 29 at pp. 71–72; NEMA, No. 34 at p. 15; Westinghouse, Public Meeting Transcript, No. 29 at pp. 208–209)

NEMA also commented that because ENERGY STAR requirements are designed for premium products and are not mandatory, DOE should not set the baseline for MBCFLs to align with the ENERGY STAR specification. NEMA further noted that there are energy-efficient MBCFLs currently on the market that do not meet ENERGY STAR requirements. (NEMA, No. 34 at pp. 8, 15)

As stated in section V.A.1, DOE is not proposing a product class division for covered versus bare products because LED lamps are available at higher levels of efficacy with a cover. In addition DOE typically selects a baseline lamp that is the most common, least efficacious lamp that meets existing energy conservation standards. Because spiral lamps are more common than covered lamps, DOE determined a spiral lamp was more representative of the product class. Further, DOE agrees that ENERGY STAR requirements are not mandatory and is therefore not analyzing these requirements as the baseline. The requirements in the current ENERGY STAR specification, ENERGY STAR Lamps Specification V1.1, are higher than the existing energy conservation standards, and DOE typically selects the most common lamp that just meets existing energy conservation standards as the baseline.

NEEA noted a discrepancy in the lumen bins used across the analyses that could result in data inconsistencies. Regarding the Integrated Low-Lumen product class baseline, NEEA noted that the engineering analysis considered replacement options between 700 and 900 lumens for 60 W equivalent replacements, while the LCC and PBP analyses considered a range of 750 to 1,050 lumens. (NEEA, Public Meeting Transcript, No. 29 at p. 231) DOE appreciates the comment from NEEA on the inconsistency of the lumen bin equivalencies. DOE revised the NOPR analysis to consider 60 W equivalent replacements, including the baseline, as lamps with lumen output between 750 and 1,049 lumens, which aligns with the EISA 2007 lumen bins and the downstream analyses. See sections V.G and V.H for more information.

In the NOPR analysis, based on a review of lamps that had the most common characteristics, DOE identified a 14 W, 800 lumen (*i.e.,* 60 W equivalent) spiral CFL with a lifetime of 8,000 hours, a CRI of 82, and a CCT of 2,700 K. Therefore, DOE analyzed a bare spiral CFL with efficacy closest to the existing energy conservation standard as the baseline in the Integrated Low-Lumen product class for the NOPR analysis. DOE did not receive comments on the baseline lamp selected for the Integrated High-Lumen product class. DOE confirmed a 32 W, 2,000 lumen (*i.e.,* greater than 100 W equivalent) spiral CFL with a lifetime of 10,000 hours, a CRI of 80, and a CCT of 2,700 K is the appropriate baseline for the Integrated High-Lumen product class.

DOE is proposing the baseline lamps for the Integrated Low-Lumen and Integrated High-Lumen product classes specified in Table V–4. DOE requests comment on the baseline lamps analyzed in the NOPR analysis, in particular the spiral CFL baseline in the Integrated Low-Lumen product class.

TABLE V–4—INTEGRATED PRODUCT CLASSES' BASELINE LAMPS

Product class	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	Lifetime (hr)	CCT (K)	CRI
Integrated Low-Lumen (310 ≤ Initial Lumen Output < 2,000).	Spiral	E26	CFL	14	800	57.1	8,000	2,700	82
Integrated High-Lumen (2,000 ≤ Initial Lumen Output ≤ 2,600).	Spiral	E26	CFL	32	2,000	62.5	10,000	2,700	80

b. Non-Integrated Lamps

In the preliminary analysis, DOE identified the baseline lamp in the Non-Integrated product class as the most common, least efficacious lamp.[106] The Non-Integrated product class does not have applicable existing standards and therefore the lowest efficacy lamps on the market were considered for the baseline. DOE found that the base types of non-integrated CFLs typically correspond to certain wattages and lumen outputs, and thus DOE concentrated on a common wattage and its associated base type. Based on a review of lamps that had the most common characteristics, DOE determined that the baseline lamp for the Non-Integrated product class was a 26 W, 1,710 lumen double tube[107] G24q–3 base CFL with a lifetime of 10,000 hours and a CCT of 4,100 K in the preliminary analysis.

NEMA expressed concern regarding the baseline lamp selected for the Non-Integrated product class, noting that because CFL pin base lamps have unique base and pin configurations, if the baseline lamp is eliminated, consumers will be forced to replace their fixtures and will be left with stranded assets. (NEMA, No. 34 at p. 15) As stated, DOE selected a common wattage and its associated base type as representative in the Non-Integrated product class and therefore chose a baseline lamp with these characteristics. However, DOE ensured that the vast majority of base types will be available at EL 1. DOE also determined through

[106] *Id.* at 5–12.

[107] The double tube shape for CFLs, that is, a CFL with two U-shaped glass tubes, is also sometimes referred to as quad tube in industry.

manufacturer feedback that non-integrated CFLs replaced with a lamp of the same base type and shape would not require a fixture, socket, or ballast change provided the ballast is compatible with the replacement lamp. Therefore, consumers replacing baseline lamps are not expected to have stranded assets. See section V.C.5 for more information.

In this NOPR analysis, DOE confirmed a 26 W, 1,710 lumen double tube G24q-3 base CFL with a lifetime of 10,000 hours and a CCT of 4,100 K is the appropriate baseline for the Non-Integrated product class. DOE is proposing the baseline lamp for the Non-Integrated product classes specified in Table V–5.

TABLE V–5—NON-INTEGRATED PRODUCT CLASS BASELINE LAMP

Lamp shape	Base type	Lamp type	Nominal wattage (W)	Rated wattage (W)	Initial lumens (lm)	Mean lumens (lm)	Rated efficacy (lm/W)	Lifetime (hr)	CCT (K)	CRI
Double Tube	G24q–3	CFL	26	26	1,710	1,450	65.8	10,000	4,100	82

4. More Efficacious Substitutes

DOE selects a series of more efficacious replacements for the baseline lamps considered within each representative product class. DOE considered only technologies that met all four criteria in the screening analysis. In the preliminary analysis, these selections were made such that potential substitutions maintained light output within 10 percent of the baseline lamp's light output with similar characteristics when possible.[108] In identifying the more efficacious substitutes, DOE utilized a database of commercially available lamps. Further details specific to the more efficacious substitutes of the Integrated Low-Lumen, Integrated High-Lumen, and Non-Integrated product classes are discussed in the following sections.

a. Integrated Lamps

For integrated GSLs, DOE identified more efficacious substitute lamps that saved energy and had light output within 10 percent of the baseline lamp's light output. DOE selected more efficacious substitutes with the same base type as the baseline lamp since replacing an integrated lamp with a lamp of a different base type would potentially require a fixture or socket change and thus is considered an unlikely replacement. For the preliminary analysis, DOE also ensured that the more efficacious substitutes were marketed as omnidirectional, thus maintaining the even light distribution of the baseline lamp. DOE received comments on these requirements and the more efficacious substitutes analyzed for the Integrated Low-Lumen and Integrated High-Lumen product classes.

Omnidirectionality

NEMA agreed that in order to satisfy consumer expectations for replacement lamps, substitutes must be within 10 percent of the lumen output from the baseline lamp. In addition, NEMA commented that more efficacious substitutes should be reasonably omnidirectional in order to serve in general service lamp applications. NEMA noted that ENERGY STAR specifies intensity distribution requirements for omnidirectionality, however CFLs are excluded from testing because they are presumed to be omnidirectional and thus requiring omnidirectionality in a substitute lamp could inadvertently exclude CFLs. (NEMA, No. 34 at p. 15)

DOE agrees that A-shape and spiral CFLs are not typically marketed as omnidirectional despite exhibiting such properties. Therefore, DOE did not require the more efficacious A-shape and spiral CFLs to be explicitly marketed as omnidirectional. However, because A-shape LED lamps are frequently available in both omnidirectional and semi-omnidirectional versions, DOE confirmed that omnidirectional LED lamps were selected in order to maintain omnidirectionality and to ensure that the more efficacious substitutes could be used in the same applications as the lamps being replaced. For the NOPR analysis, DOE maintained the approach of analyzing LED lamps explicitly marketed as omnidirectional and CFLs that are spiral or A-shape as more efficacious substitutes.

Additional CFL More Efficacious Substitutes

Several stakeholders commented that DOE should consider analyzing higher efficacy CFL representative units in the Integrated Low-Lumen product class. CA IOUs and EEAs remarked that CFLs are available in a broad range of efficacies, and there should be more than one CSL corresponding to the different levels of CFL performance. (CA IOUs, No. 33 at p. 4; CA IOUs, Public Meeting Transcript, No. 29 at pp. 88–89; EEAs, No. 32 at p. 4) CEC stated that DOE should consider the existence of more efficacious CFLs at CSLs 2 and 3 and incorporate the wattages, lifetimes, and shipments of those more efficacious CFLs in the NIA. (CEC, No. 31 at p. 2) NRDC commented that they believe the intention was not to eliminate CFLs, and noted there are more efficacious CFLs available than analyzed. (NRDC, Public Meeting Transcript, No. 29 at p. 92) Westinghouse agreed with NRDC, stating that it is preferable to preserve CFLs to allow a wider product assortment, benefiting consumers and industry. (Westinghouse, Public Meeting Transcript, No. 29 at p. 98)

Stakeholders offered specific suggestions on more efficacious CFLs to consider in the analysis. EEA commented that there are 60 W replacement CFLs available today with efficacies up to 69.2 lm/W and 100 W replacements with efficacies that exceed 70 lm/W. (EEAs, No. 32 at p. 4) NRDC encouraged DOE to set a CSL between the current CSL 1 and CSL 2 with the same efficacy as CSL 2 but with a shorter lifetime of 10,000 hours. (NRDC, Public Meeting Transcript, No. 29 at p. 194) CA IOUs noted that the CSLs in the Integrated Low-Lumen product class can have multiple lamp technologies that meet the levels. CA IOUs stated that DOE assumes that only LED lamps can meet EL 2, however CFLs can also meet this level. CA IOUs explained that there are CFLs available on the market with efficacies above 67 lm/W, including products on the ENERGY STAR Qualifying Product List from over 12 manufacturers. (CA IOUs, No. 33 at p. 4; CA IOUs, Public Meeting Transcript, No. 29 at pp. 88–89)

DOE acknowledges that higher efficacy CFLs exist on the market currently. Therefore for this NOPR analysis, DOE also analyzed an energy-saving 11 W CFL with 750 lumens, an efficacy of 68.2 lm/W, and a lifetime of 10,000 hours as a 60 W equivalent replacement at EL 2 in the Integrated

[108] GSL preliminary analysis at 5–13.

Low-Lumen product class. This lamp is modeled based on a commercially available 11 W CFL with the same lifetime and slightly lower lumen output, however DOE believes this efficacy improvement is technologically feasible. In addition, DOE identified other non-energy-saving options including a 13 W CFL with 900 lumens and an efficacy of 69.2 lm/W that can meet EL 2. However, DOE did not analyze this lamp as a representative unit because DOE typically only analyzes energy-saving options in the engineering analysis. DOE did, however, account for the availability of this option in the NIA. See section V.H for more information.

Improvement of LED Lamps

DOE received several comments regarding potential efficacy improvements of LED lamps. NRDC, EEAs, and CEC encouraged DOE to use a forward thinking-approach for LED lamps and to consider even higher levels of efficacy due to recent and future expected market developments. NRDC and EEAs pointed out that as an individual LED becomes more efficient, fewer LEDs are required to produce the same amount of light. This allows an LED lamp to have a smaller heat sink (because there is less heat to dissipate) and smaller components (because there is less power required), leading to an overall smaller form factor. All of these changes lead to an increase in overall lamp efficacy and typically an accompanying decrease in overall lamp cost.[109] NRDC noted that DOE is not predicting improvements in the efficacy of LED lamps besides what is currently commercially available. However, given historical improvements, it is expected such gains will occur by 2020. EEAs urged DOE to consult with EIA and the agency's Solid-State Lighting Program to ensure that expected efficiency trends are captured in the analysis. CEC specifically asked DOE to consider ELs with even greater levels of efficacy to reflect the levels under consideration in California. For example, a 60 W replacement lamp at the most stringent CSL under consideration in the preliminary analysis had a required efficacy of approximately 85 lm/W, whereas CEC is proposing a standard of 98 lm/W with similar quality requirements (such as CRI). (NRDC, Public Meeting Transcript, No. 29 at pp. 98–100; EEAs, No. 32 at p. 4; CEC, No. 31 at p. 1)

DOE agrees that LED lamp technology is rapidly developing and that new products are continuously being introduced. DOE has identified more efficacious commercially available products since the preliminary analysis and has increased the efficacy of the ELs under consideration. For example, the maximum technologically feasible (max-tech) level in the preliminary analysis was represented by a 60 W replacement with an efficacy of 84.2 lm/W (corresponding to an A-value of 91.7), and in this NOPR analysis, DOE identified LED lamps with efficacies in excess of 100 lm/W, as discussed in the following paragraphs. During the course of this rulemaking, DOE will continue to monitor the market for new commercially available products and information on working prototypes and update its analysis as appropriate.

While DOE publishes information on market trends through its Solid-State Lighting Program and reviews publications from other agencies, including the EIA, DOE only considers technologies incorporated in commercially available products or in working prototypes to be technologically feasible. 10 CFR 430, subpart C, appendix A, section 4(a)(4)(i) DOE does, however, use market trends and efficacy projections to inform its assumptions in the national impacts analysis. See section V.H for more information on the efficacy market distributions by product class.

As stated, for the NOPR analysis, DOE found several more efficacious LED lamps at levels of efficacy higher than the max-tech level identified in the preliminary analysis of 84.2 lm/W for a 60 W equivalent replacement in the Integrated Low-Lumen product class. When selecting more efficacious substitutes, DOE identified multiple 8.5 W LED lamps with 800 lumens, efficacy of 94.1 lm/W, and lifetime of 25,000 hours. DOE also identified a few 60 W equivalent replacement LED lamps with even lower wattages and greater efficacies, ranging from about 100 lm/W to 124.6 lm/W. The characteristics of these lamps were typically unique to one manufacturer. Because these lower-wattage products were newly introduced on the market, most of the lamps did not have test data available, and therefore DOE conducted independent testing to confirm the rated performance of these lamps for this NOPR analysis.

DOE conducted efficacy testing in accordance with the LED Test Procedure SNOPR[110] on multiple integrated LED lamps that exceeded the max-tech level identified in the preliminary analysis. Specifically, DOE tested 8.5 W, 8 W, 7 W, and 6.5 W LED lamps with rated lumen output within the range of 750–1,049 lumens (*i.e.,* 60 W equivalent replacements). As noted in appendix 5A of the NOPR TSD, DOE was able to confirm that the tested values of the 8.5 W, 8 W, and 6.5 W LED lamps matched or exceeded the rated performance characteristics with tested efficacies ranging from 94.8 lm/W for an 8.5 W lamp to 113 lm/W for a 6.5 W lamp. The 7 W LED lamp tested below the minimum lumen output DOE considered as suitable for 60 W equivalent replacements and therefore was not considered as a more efficacious substitute. Additionally, in order to maintain more efficacious substitutes across all lumen packages of the Integrated Low-Lumen product class, DOE did not analyze the 6.5 W LED lamp. See section V.C.5 for more information.

DOE notes that the 8 W LED lamp tested was a 3-way lamp tested at its middle setting and resulted in an efficacy of 111.4 lm/W. Based on the testing, DOE has determined that a commercially available 3-way LED lamp when operated at its middle setting demonstrated the potential for a standard, non-3-way, 8 W LED lamp to achieve this EL. Therefore, using the rated performance values, DOE modeled an 8 W LED lamp with 820 lumens and an efficacy of 102.5 lm/W. DOE assumed the modeled lamp would have similar characteristics to the most common commercially available 60 W equivalent LED replacements. Thus, DOE modeled the lamp to have an A19 shape, medium base type, 25,000 hour lifetime, 2,700 K CCT, 80 CRI, and dimming functionality. DOE requests comment on the 3-way lamp used as a basis for the modeled LED lamp and information on whether such a lamp would meet DOE's screening criteria and should be maintained for the final rule analysis.

Based on catalog information and the independent testing conducted for the NOPR analysis, DOE selected an 8.5 W LED lamp with 800 lumens, efficacy of 94.1 lm/W, and lifetime of 25,000 hours as a more efficacious substitute corresponding to EL 3 in the Integrated Low-Lumen product class. DOE also found that for the LED lamps above EL 2, the consumer price decreased as efficacy increased. (See section V.D for more information on product price determination.) Therefore, DOE did not analyze any additional lamps between EL 2 and EL 3 because the 8.5 W was at the lowest incremental first cost for a commercially available product above

[109] See section V.D for discussion of the product price determination methodology and comments related to pricing.

[110] 80 FR 39644 (July 9, 2015).

EL 2. DOE also analyzed the modeled 8 W LED lamp with 820 lumens, efficacy of 102.5, and lifetime of 25,000 hours as a more efficacious substitute at EL 4.

The more efficacious substitutes analyzed in this NOPR analysis for the Integrated Low-Lumen and Integrated High-Lumen product classes are summarized in Table V–6.

TABLE V–6—INTEGRATED PRODUCT CLASSES' REPRESENTATIVE LAMP UNITS

Product class	EL	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	Lifetime (hr)	CCT (K)	CRI
Integrated Low-Lumen (310 ≤ Initial Lumen Output <2,000).	Baseline ...	Spiral	E26 ...	CFL ...	14	800	57.1	8,000	2,700	82
	EL 1	Spiral	E26 ...	CFL ...	13	800	61.5	10,000	2,700	80
	EL 2	A19	E26 ...	LED ...	12	800	66.7	25,000	2,700	83
		Spiral	E26 ...	CFL ...	[111] 11	750	68.2	10,000	2,700	82
	EL 3	A19	E26 ...	LED ...	8.5	800	94.1	25,000	2,700	80
	EL 4	A19	E26 ...	LED ...	[112] 8	820	102.5	25,000	2,700	80
Integrated High-Lumen (2,000 ≤ Initial Lumen Output ≤2,600).	Baseline ...	Spiral	E26 ...	CFL ...	32	2,000	62.5	10,000	2,700	82
	EL 1	Spiral	E26 ...	CFL ...	30	2,000	66.7	10,000	2,700	82
	EL 2	Spiral	E26 ...	CFL ...	29	2,200	75.9	12,000	2,700	82

b. Non-Integrated Lamps

For non-integrated GSLs, DOE considered more efficacious lamps that did not increase energy consumption relative to the baseline and had light output within 10 percent of the baseline lamp-and-ballast system when possible. Due to potential physical and electrical constraints associated with switching base types, DOE selected substitute lamps that had the same base type as the baseline lamp. DOE identified substitute lamps that were the same wattage as the baseline but produced more light and were therefore more efficacious or lamps that were lower wattage than the baseline but produced similar light and were therefore more efficacious. DOE paired each representative lamp with an appropriate ballast because non-integrated GSLs are a component of a system, and their performance is related to the ballast on which they operate. DOE received comments on these requirements and the more efficacious substitutes analyzed for the Non-Integrated product class.

Lumen Output Criterion

DOE received comments regarding the lumen output criterion used for selecting more efficacious substitutes in the Non-Integrated product class. GE commented that consideration must be given to the Occupational Safety and Health Administration (OSHA) safety and minimum light requirements. GE noted that non-integrated CFLs are typically designed to meet certain requirements in commercial spaces and if the lighting level drops, there could be issues meeting safety requirements such as OSHA exit lighting requirements. (GE, Public Meeting Transcript, No. 29 at pp. 84–85)

On the contrary, NEEA observed that most buildings are grossly over lit because the buildings are designed to meet lighting safety requirements when the lamps eventually fall to 70 percent of their initial lumen output. NEEA commented that lumen reductions of 20 to 30 percent are feasible in well-designed spaces and thus a 10 to 11 percent reduction is safe and acceptable. (NEEA, Public Meeting Transcript, No. 29 at pp. 85–86) GE clarified that there are a variety of spaces and their concern is specifically regarding the spaces that are not currently over lit. (GE, Public Meeting Transcript, No. 29 at p. 86)

DOE understands the concern to maintain lumen output. Therefore, for this NOPR analysis, DOE continued to utilize the criterion of maintaining 10 percent of the mean lumen output when possible in developing lamp-and-ballast replacement scenarios. As stated, DOE paired the non-integrated GSLs with representative ballasts because the non-integrated GSLs operate on a ballast in practice. For the NOPR analysis, DOE again paired the non-integrated GSLs with a one-lamp electronic, programmed start ballast to represent the lamp and ballast combinations present in the market. In assessing light output of the representative systems for the Non-Integrated product class, DOE made a distinction between mean and initial lumen output. DOE used catalog initial lumen output to calculate efficacy when determining ELs. As noted by stakeholders, the light output of a lamp decreases over time. To account for this real-world depreciation in lumens, DOE analyzed more efficacious systems that maintain mean lumen output within 10 percent of the baseline system, when possible. Mean lumen output is a measure of light output midway through the rated life of a lamp, and a 10 percent change is a common parameter used by lighting designers to specify acceptable substitute products on the basis of light output.

NEMA commented that the baseline and more efficacious substitutes are 4-pin non-integrated CFLs specifically used in commercial applications. (NEMA, No. 34 at p. 15) NEMA, GE, and Westinghouse further commented that the two CSL 1 choices are problematic because the full wattage lamp has slightly higher lumens but does not offer energy savings and the reduced wattage lamp is not within 10 percent of the baseline lumen output and may not be compatible with the existing ballast or acceptable to consumers. (NEMA, No. 34 at p. 15; GE, Public Meeting Transcript, No. 29 at pp. 72–73; Westinghouse, Public Meeting Transcript, No. 29 at pp. 74–75)

DOE determined the reduced wattage more efficacious substitute is a viable replacement, particularly in the commercial sector where energy savings are prioritized. Although the initial lumen output of the reduced wattage lamp was 11 percent lower than the

[111] Lamp is modeled based on commercially available 11 W CFLs.

[112] Lamp is modeled based on commercially available 3-way lamp with same specifications at middle setting.

baseline lamp, the mean lumen output of the reduced wattage lamp chosen was significantly closer to the baseline lamp's mean lumen output. As stated previously, DOE considers mean lumen output in order to account for lumen deprecation of the system. Therefore, when comparing system mean lumen output of the reduced wattage lamp and baseline lamp, the lumen output of the reduced wattage system was only 5 percent lower than the baseline system. Additionally, DOE acknowledges that the full wattage replacement does not achieve energy savings, however DOE believes this a likely replacement option for consumers in specific applications and therefore maintained this replacement option for scenarios where light output must remain constant for this NOPR analysis.

Compatibility of More Efficacious Substitutes

Westinghouse expressed concern over the expectation that the consumer would understand the lamp-and-ballast-matching process. Westinghouse noted that consumers understand one-to-one wattage replacements, but it cannot be assumed that consumers would know how to select a replacement lamp to operate on an existing ballast if the original wattage is no longer available. Westinghouse observed that consumers return lamps after having tried to fit a replacement on the wrong ballast. Regardless of whether matching the base type was all that was needed to correctly replace a lamp with a new product compatible with the ballast, Westinghouse commented that consumers tended to rely only on matching wattage when replacing lamps. (Westinghouse, Public Meeting Transcript, No. 29 at pp. 79, 80–82)

Conversely, NRDC suggested that DOE reexamine the assumption that more efficacious lamps with different wattages would be incompatible with the installed ballast and socket. Specifically, NRDC pointed out that the more efficacious lamps would have a lower wattage than the lamps they were replacing, and therefore would not impose a safety risk. NRDC noted that wattage equivalency guidance had been successful at educating consumers replacing screw base lamps and similar guidance could be deployed for pin base lamps. In addition, NRDC related that consumers typically bring these lamps to the store when purchasing replacements to ensure a lamp of the proper shape and base type is selected, and therefore a slightly different wattage should not pose an issue. (NRDC, Public Meeting Transcript, No. 29 at pp. 83–84)

DOE agrees that more efficacious substitutes with lower wattages can be suitable replacements for installed lamps. DOE found lamps with the same base type and shape as their higher wattage counterparts that were listed as compatible with the same ballast. Manufacturer feedback also confirmed that non-integrated CFLs replaced with a lamp of the same base type and shape would not require a fixture, socket, or ballast change provided the ballast is compatible with the replacement lamp. Therefore, for this NOPR analysis, DOE maintained the replacement option of a reduced wattage in addition to the full wattage lamp.

The more efficacious substitutes analyzed in this NOPR analysis for the Non-Integrated product class are summarized in Table V–7.

TABLE V–7—NON-INTEGRATED PRODUCT CLASS DESIGN REPRESENTATIVE LAMP UNITS

CSL	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Rated wattage (W)	Initial lumens (lm)	Mean lumens (lm)	Rated efficacy (lm/W)	Lifetime (hr)	CCT (K)	CRI
Baseline.	Double Tube.	G24q–3.	CFL ...	26	26	1,710	1,450	65.8	10,000	4,100	82
EL 1 ...	Double Tube.	G24q–3.	CFL ...	26	26	1,800	1,525	69.2	12,000	4,100	82
EL 1 ...	Double Tube.	G24q–3.	CFL ...	21	21	1,525	1,400	72.6	16,000	4,100	82

5. Efficacy Levels

After identifying more efficacious substitutes for each of the baseline lamps, in the preliminary analysis DOE developed CSLs based on the consideration of several factors, including: (1) the design options associated with the specific lamps being studied (*e.g.,* grades of phosphor for CFLs, improved package architecture for LEDs); (2) the ability of lamps across the applicable lumen range to comply with the standard level of a given product class; and (3) the max-tech level. In the preliminary analysis, DOE considered an equation-based approach to establish CSLs for GSLs reflecting the relationship between efficacy and lumen output. DOE received comments specific to this approach presented in the preliminary analysis.

NEMA expressed concern about how the efficacy curves will translate across the four lumen ranges. NEMA stated that there can be slight discontinuities in efficacy, depending on the technology used in the various ranges. They suggested that each lumen bin be evaluated separately to set the proper EL for that bin and each specific technology. NEMA added that it is likely that the curve will not connect smoothly across all four bins at every CSL, and there will be fewer CSL levels for CFL technology, whether integrated or non-integrated. (NEMA, No. 34 at pp. 16–17)

Conversely, NRDC, EEAs, and CA IOUs expressed support for ELs that are smooth continuous curves rather than the bin approach. (NRDC, Public Meeting Transcript, No. 29 at p. 12; EEAs, No. 32 at pp. 3–4; CA IOUs, Public Meeting Transcript, No. 29 at p. 96) NRDC commented that they were opposed to the current four bin approach because the current standards have four bins which has resulted in gaming and dimmer bulbs. (NRDC, Public Meeting Transcript, No. 29 at pp. 55–56) CA IOUs and EEAs agreed noting that the current step functions used for the GSIL standards had the unintended consequence of encouraging manufacturers to product dimmer bulbs. (CA IOUs, Public Meeting Transcript, No. 29 at p. 96; CA IOUs, No. 33 at p. 3; EEAs, No. 32 at pp. 3–4; EEAs, No. 32 at pp. 3–4) EEAs cited as an example halogen incandescent lamps that are almost 10 percent dimmer than the incandescent lamps they are intended to replace. EEAs concluded that DOE's proposed continuous function results in efficacy requirements that scale with light output, which removes the incentive for manufacturers to market dimmer bulbs as a means to comply with the standards. (EEAs, No. 32 at pp. 3–4)

DOE is continuing to propose an equation-based approach in this NOPR analysis that results in a smooth, continuous curve. DOE is maintaining the continuous function approach based on its assessment that a step function, where efficacy rises significantly at certain increments in lumen output or wattage, is not representative of the technology used in the products covered by this rulemaking. Further, DOE agrees that a step function increases the potential for products to be introduced at the lowest lumen output that is required for a given wattage to comply with the standard.

Regarding NEMA's concern about the impacts of the efficacy curves across the four lumen bins (or packages), DOE has ensured that GSLs across lumen packages are maintained at the highest EL for each product class, including the four lumen packages in the Integrated Low-Lumen product class. DOE does however, agree, that the ELs may not be continuous across product classes. DOE analyzed fewer ELs in the Integrated High-Lumen product class because DOE found that suitable LED replacements lamps were not available and therefore only analyzed CFLs in this product class. Similarly, DOE analyzed fewer ELs in the Non-Integrated product class because suitable LED replacement lamps were not available. DOE also developed unique ELs for the Non-Integrated product class because DOE determined the efficacy-lumen relationship was different for non-integrated GSLs. The specific ELs proposed for each product class are discussed in more detail in the following sections.

CA IOUs also supported DOE's proposal to set standards as a function of light output, rather than wattage because the utility of a bulb is more closely tied to its lumen output than its wattage. Despite consumers historically identifying products by their wattage, there is a much broader range of efficacies and wattages available today. CA IOUs added that it is important to align standards with these changes in the lighting industry and ensure that they are relevant to the new mix of products available on the market. (CA IOUs, No. 33 at pp. 3–4)

DOE agrees that the primary utility provided by a lamp is lumen output, which can be achieved through a wide range of wattages depending on the lamp technology. DOE believes that lamps providing equivalent lumen output and therefore intended for the same applications should be subject to the same minimum efficacy requirements. Therefore, DOE is maintaining its lumens-based approach in this NOPR analysis.

The following sections discuss the ELs developed in the NOPR analysis for the Integrated Low-Lumen, Integrated High-Lumen, and Non-Integrated product classes in more detail.

a. Integrated Lamps

In the preliminary analysis, DOE analyzed CSLs for both the Integrated Low-Lumen and the Integrated High-Lumen product classes. DOE used commercially available lamps and their associated efficacies when possible to determine the design options required to meet each CSL. For the Integrated Low-Lumen and Integrated High-Lumen product classes, DOE used the catalog initial lumen output and the catalog wattage of the lamp to calculate efficacy. To establish final minimum efficacy requirements for each CSL, DOE evaluated whether any adjustments were necessary to the initial CSLs to ensure lamps were available across the entire lumen range represented by the product class and to ensure the CSLs were achievable.

For the Integrated Low-Lumen representative product class, five CSLs were considered in the preliminary analysis.[113] The baseline represented a basic CFL with an efficacy near the existing MBCFL standard level. CSL 1 represented an improved CFL with more-efficient phosphors and improved ballast components. CSL 2 represented a basic LED lamp with an efficacy near the lowest performing LED lamps currently available on the market. CSL 3 represented an improved LED lamp with improved package architecture, high-efficiency driver, and improved optics. CSL 4 represented an advanced LED lamp with further improved package architecture, high-efficiency driver, and improved optics. CSL 5 was the maximum technologically feasible level and represented an LED lamp with the most-efficacious combination of package architecture, driver, and optics available on the market today.

NEMA recommended revisions to the integrated low-lumen CSLs presented in the preliminary analysis. Specifically, NEMA proposed for bare CFLs an EL of 50 lm/W for lamps within 310–749 lumens; 60 lm/W for lamps within 750–1,049 lumens; 61 lm/W for lamps within 1,050–1,489; and 62 lm/W for lamps within 1,490–2,000 lumens. For covered CFLs, NEMA proposed an EL of 45 lm/W for lamps within 310–749 lumens; 50 lm/W for lamps within 750–1,049 lumens; 52 lm/W for lamps within 1,050–1,489; and 55 lm/W for lamps within 1,490–2,000 lumens. For LED lamps, NEMA proposed an EL of 55 lm/W for lamps within 310–749 lumens and 65 lm/W for lamps within 750–2,000 lumens.[114] (NEMA, No. 34 at p. 14)

As discussed in section V.A.1, regarding NEMA's proposed levels, DOE continued to maintain technology-neutral product classes in the NOPR analysis with no division for lamps with a cover. Further, DOE is proposing four levels of efficacy above the baseline. The baseline represents a basic CFL with an efficacy near the existing MBCFL standard level. EL 1 represents an improved CFL with more-efficient phosphors and improved ballast components. EL 2 is represented by a basic LED lamp with an efficacy near the lowest performing LED lamps currently available on the market, and an advanced CFL modeled based on the highest performing commercially available CFLs (see section V.C.4 for more information). EL 3 represents an improved LED lamp with improved package architecture, high-efficiency driver, and improved optics. EL 4 is the maximum technologically feasible level and represents an advanced LED lamp modeled based on the highest performing commercially available LED lamp[115] using the most-efficacious combination of package architecture, driver, reduced current density, and optics (see section V.C.4 for more information).

For the Integrated High-Lumen representative product class, two CSLs were considered in the preliminary analysis.[116] The baseline represented a basic CFL with an efficacy near the existing MBCFL standard level. CSL 1 represented an improved CFL with more-efficient phosphors and improved ballast components. CSL 2 was the maximum technologically feasible level and represented the most-efficacious combination of phosphors and ballast components.

NEMA also recommended revisions to the Integrated High-Lumen CSLs presented in the preliminary analysis. Specifically, NEMA proposed for bare CFLs an EL of 62 lm/W for lamps within 2,000–2,600 lumens. For covered CFLs, NEMA proposed an EL of 55 lm/W for lamps within 2,000–2,600 lumens. For LED lamps, NEMA proposed no standard for lamps with 2,000 lumens or greater. (NEMA, No. 34 at p. 14)

For the NOPR analysis, regarding NEMA's suggested levels, DOE maintained no product class division for

[113] GSL preliminary analysis at 2–73.

[114] NEMA also proposed CSLs for incandescent/halogen lamps. However, DOE cannot consider standards for incandescent/halogen lamps due to the Appropriations Rider.

[115] This lamp is modeled based on a commercially available 3-way lamp that is operating at the middle setting.

[116] GSL preliminary analysis at 2–73.

lamps with a cover for the Integrated High-Lumen product class. Further, DOE is proposing two ELs. The baseline represents a basic CFL with an efficacy near the existing MBCFL standard level. EL 1 represents an improved CFL with more-efficient phosphors and improved ballast components. EL 2 is the maximum technologically feasible level and represents the most-efficacious combination of phosphors and ballast components.

As stated previously, DOE adopted an equation-based approach to establish ELs for GSLs. In the preliminary analysis, DOE developed the general form of the equation by evaluating efficacy trends of integrated GSLs across a range of lumen outputs. The continuous equations specified a minimum lamp efficacy requirement across the lumen output range and represented the efficacy a lamp achieves. DOE determined that adjustments to CSLs considered in the preliminary analysis were necessary. DOE made slight adjustments to capture the efficacy of lamps with those design options across the entire lumen output range. This allowed for continuous CSLs across product classes. DOE also found that compliance and verification testing data supported the CSLs under consideration and therefore did not make any adjustments to CSLs based on this additional data.

Adjustments to Efficacy Levels

DOE received comments suggesting potential adjustments to the CSLs considered in the preliminary analysis due to lumen package availability and testing and verification data. Southern Company expressed concern regarding the availability and size of products with lumen outputs in the upper end of the Integrated Low-Lumen product class range, specifically in the 1,500 to 2,000 lumen range. Southern Company indicated there could be issues with form factor for both CFLs and LED lamps and a separate product class may be warranted to ensure consumer needs are satisfied. (Southern Company, Public Meeting Transcript, No. 29 at pp. 199–200)

For the NOPR analysis, DOE again analyzed the impacts of the ELs across all lumen packages. In the Integrated Low-Lumen product class, DOE confirmed that 40 W, 60 W, 75 W, and 100 W equivalent replacements, which correspond to the four lumen bins of the current GSIL standard, could meet the highest EL proposed (EL 4) in the NOPR analysis. DOE did not consider ELs that were not achievable for all lumen packages within the product class. Regarding Southern Company's concern for replacement lamps in the range of 1,500 to 2,000 lumens, DOE identified several LED lamps in this range (*i.e.,* 100 W equivalent replacements) that meet the max-tech level proposed, EL 4. Further, DOE confirmed that the form factors of the LED lamps at EL 4 (max tech) and the CFLs available at EL 2 (highest level a CFL can meet) are consistent with the lamps they are intended to replace. DOE determined that the majority of the 100 W GSILs in this lumen range are A21 shapes. DOE found that the LED lamps meeting EL 4 are designed in the A21 form factor and the majority of CFLs available at EL 2 are spiral shapes with dimensions that also fit within the A21 form factor. Therefore, DOE concluded that consumers should not experience issues with incompatible length or diameter of replacement lamps.

In addition to lumen package, DOE also analyzed whether the full range of CCTs were available at the highest EL proposed. In the Integrated Low-Lumen product class, DOE made a slight downward adjustment to EL 4 in order to ensure lamps of all CCTs were able to meet the EL. In the Integrated High-Lumen product class, DOE made a slight downward adjustment to EL 2 to ensure lamps of all CCTs were available. Additionally, this adjustment allowed for higher lumen output 100 W equivalent replacements (*e.g.,* 1,800 lumen lamps) to meet EL 2 in the Integrated Low-Lumen product class.

CA IOUs commented that if DOE believes that higher efficacy CFLs would not meet CSL 2, such as if testing showed that their actual efficacies are slightly lower than the values reported in specification sheets or to Energy Star, they recommend that DOE include a CSL that is specifically designed to align with these higher performance CFLs by lowering CSL 2 slightly, or by adding a new CSL between CSLs 1 and 2. (CA IOUs, No. 33 at p. 4; CA IOUs, Public Meeting Transcript, No. 29 at pp. 88–89)

For the NOPR analysis, DOE used publicly available certification data and verification testing from CEC's Appliance Efficiency Database, EPA's ENERGY STAR Certified Light Bulbs Database, and DOE's CCMS Database to confirm that commercially available CFLs are able to meet EL 2. DOE found that DOE's CCMS Database supported the catalog values of numerous lamps, and in some cases the certification and verification data exceeded the catalog values. Thus, DOE determined that EL 2 was achievable for CFLs.

Impacts of Efficacy Levels

In addition, DOE received several comments on the impacts of the CSLs it presented for the Integrated Low-Lumen and Integrated High-Lumen product classes in the preliminary analysis. NEMA commented that placing all integrated lamps into only two categories results in CSLs that only represent one type of technology. They are concerned that this will cause the standards to be set too low thus allowing all technologies, or too high thus allowing only the most efficient LED lamps. NEMA noted that either situation would not be ideal for energy savings, product cost/availability or utility. They recommended that a product class matrix that separates lamps by technology be used to mitigate these issues. (NEMA, No. 34 at p. 16)

As discussed in section V.A.1, DOE is proposing product classes that are not separated by technology because CFLs and LED lamps offer similar utility. Further, two of the four ELs (*i.e.,* EL 1 and EL 2) analyzed by DOE are met by both CFLs and LED lamps. DOE weighed the benefits and burdens of each potential standard in order to select the proposed standard level. See section VI.C.1 for more information.

Westinghouse remarked that the reason they there are efficacy differences between bare and covered CFLs is because the light output from the internal spiral is captured by the covering. Westinghouse noted that the correct level is one that allows covered products to be manufactured because there are applications where those are necessary. (Westinghouse, Public Meeting Transcript, No. 29 at p. 98) As discussed in section V.A.1, DOE was unable to find a consistent correlation between the addition of a cover and efficacy and therefore did not consider a product class division for lamps with covers versus without covers. Further, LED lamps are available at higher levels of efficacy with a cover if an application exists that necessitates a lamp with a cover.

Regarding the standard to be proposed, CEC noted that federal standards could have a preemptive effect and thus if less stringent, could have negative implications on California's energy consumption. (CEC, No. 31 at p. 2) With some exceptions, Federal energy conservation requirements generally supersede state laws or regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297(a)–(c)) However, 42 U.S.C. 6295(i)(6)(A)(vi) states that California or Nevada beginning on or after January 1, 2018 shall not be precluded from adopting: (1) a final rule adopted by the Secretary in accordance with 42 U.S.C. 6295(i)(6)(A)(i)–(iv); (2) the backstop provision of 45 lm/W if no final rule has been adopted; or (3) any California regulations for GSLs adopted pursuant to state statute in effect as of the date of enactment of the Energy Independence and Security Act of 2007 if no final rule is adopted.

Table V–8 summarizes the efficacy requirements at each EL for the Integrated Low-Lumen and Integrated High-Lumen product classes. DOE requests comment on the ELs under consideration for both of the integrated lamp product classes, including the max-tech levels.

TABLE V–8—SUMMARY OF ELS FOR GSL INTEGRATED REPRESENTATIVE PRODUCT CLASSES

Representative product class	Efficacy level	Efficacy lm/W
Integrated Low-Lumen (310 ≤ Initial Lumen Output < 2,000) ...	EL 1	67.6–29.42*0.9983^Initial Lumen Output.
	EL 2	73.4–29.42*0.9983^Initial Lumen Output.
	EL 3	101.6–29.42*0.9983^Initial Lumen Output.
	EL 4	108.6–29.42*0.9983^Initial Lumen Output.
Integrated High-Lumen (2,000 ≤ Initial Lumen Output ≤ 2,600)	EL 1	67.6–29.42*0.9983^Initial Lumen Output.
	EL 2	73.4–29.42*0.9983^Initial Lumen Output.

b. Non-Integrated Lamps

In the preliminary analysis, DOE analyzed CSLs for the Non-Integrated product class. DOE used commercially available lamps and their associated rated efficacies to determine the design options required to meet CSLs. For the Non-Integrated product class, DOE used the catalog initial lumen output and the ANSI rated wattage of the lamp, or nominal wattage if the ANSI rated wattage was not available, to calculate efficacy. To establish final minimum efficacy requirements for each CSL, DOE evaluated whether any adjustments were necessary to the initial CSL to ensure lamps were available across the entire lumen range represented by the product class.[117]

In the preliminary analysis, one CSL was considered for the Non-Integrated representative product class. The baseline represented a basic CFL with an efficacy near the lowest performing non-integrated GSLs currently available on the market. DOE considered two representative lamp units at CSL 1. The first representative unit at CSL 1 was a full wattage, improved CFL with more-efficient phosphors and thus more light output. The second representative unit at CSL 1 was a more efficacious reduced wattage CFL that produced similar lumen output as the baseline unit. The full wattage representative lamp unit was used to set the minimum efficacy requirements of EL 1 because it represented the maximum technologically feasible level that applied across all lumen packages within the product class. The reduced wattage CFL gave consumers the option to replace their current full wattage lamp with one that saves energy. DOE maintained this approach for the NOPR analysis.

As stated previously, DOE adopted an equation-based approach to establish CSLs for GSLs in the preliminary analysis. DOE utilized a similar approach as was used with the other product classes and developed the general form of the equation by evaluating efficacy trends of non-integrated GSLs across a range of lumen outputs. The continuous equation developed specified a minimum lamp efficacy requirement across the lumen output range and represented the efficacy a lamp achieves.

NEMA expressed concern on how the CSL equation for non-integrated GSLs was developed because the lamps are currently unregulated and have no test procedure. NEMA is unaware of databases for these lamps and the veracity of potential data. NEMA stressed that DOE cannot rely upon catalog data to determine the efficacy of pin base CFLs. Nominal and rated wattage are not measured watts and catalog initial lumens represent long-term data, not individual lamp photometric performance. Further, NEMA commented that testing laboratories may not be using the same test methods since there is no defined test procedure for non-integrated lamps and thus the information published in individual manufacturers' catalogs may not be comparable. (NEMA, No. 34 at pp. 15–16)

DOE understands the concern regarding the lack of available test data for non-integrated CFLs; however, industry standards for testing efficacy have been in place for several years for these products. Therefore, manufacturers are likely using existing industry standard test methods to determine performance values published in catalogs. Further, catalog data are the most comprehensive data source currently available for this product class. For these reasons, DOE maintained its approach in the NOPR analysis of using catalog initial lumen output and the ANSI rated wattage of the lamp, or nominal wattage if the ANSI rated wattage was not available, to calculate efficacy and to subsequently determine the EL. DOE notes that EPCA directs DOE to establish test procedures for covered products in advance of prescribing an energy conservation standard. (42 U.S.C. 6295(o)(3)(A)) Thus, DOE plans to finalize test procedures for GSLs for which DOE is proposing standards prior to the completion of this rulemaking.

Base Type and Fixture Compatibility

In the preliminary analysis, as stated, DOE made slight adjustments to capture the efficacy of lamps with those design options across the entire lumen output range. In particular, DOE ensured that lamps of different base types were represented at the CSL. DOE evaluated the impacts of CSL 1 on the individual base types in the Non-Integrated product class. DOE confirmed that the vast majority of base types were still available at CSL 1, and thus consumers would not be forced to switch between lamps with differing base types. Further, DOE concluded that because the different bases are maintained at CSL 1 and base type dictates the required ballast, consumers will not be required to change ballasts. DOE also evaluated whether replacing the baseline lamp with more efficacious substitutes at the higher CSL would require a fixture change. DOE concluded that fixture compatibility would not be an issue for the vast majority of consumers because the fixtures most frequently used with the non-integrated GSLs analyzed were available in configurations for several different lamp types thus indicating flexibility in size.[118]

DOE received several comments pertaining to base type and fixture requirements when replacing non-integrated GSLs. Manufacturers expressed concern over the replacement

[117] *Id.* at 2–75.

[118] *Id.*

of pin base CFL system components. GE commented that pin base lamps and their corresponding ballasts are pinned and keyed in specific ways to deter improper replacement which can potentially result in safety and performance issues. GE stated that due to this sophisticated safety system, there are very few options to save energy in ballasted pin base lamp applications. (GE, Public Meeting Transcript, No. 29 at pp. 77–78) However, NEEA noted that, from their experience, if the base is correct and fits into the socket, and the lumen output is in the desired range, then the correct lamp was chosen and will work with the existing ballast. (NEEA, Public Meeting Transcript, No. 29 at pp. 80–82) GE agreed that if a lamp fits the key way it will likely be compatible for most applications, however GE clarified that even if a more efficacious replacement lamp fits in the socket, performance may be impacted. GE noted that lamp compatibility can be affected if installed on a different system or dimmer. For these reasons, GE stated that pin base CFLs are often sold paired with a compatible ballast. (GE, Public Meeting Transcript, No. 29 at pp. 82–84)

Philips added that particular lamps and ballasts must be installed together, and thus if a lamp needs to be replaced with a more efficacious product, the ballast also could need to be replaced. Philips further noted that because a large percentage of these lamps are operating in recessed can lights, it would be very difficult to access the ballasts for replacement. (Philips, Public Meeting Transcript, No. 29 at p. 78) Westinghouse agreed, noting that as the ballasts are typically not field replaceable, if standards made a certain wattage lamp unavailable, the consumer would be forced to replace the entire fixture. (Westinghouse, Public Meeting Transcript, No. 29 at p. 79) NEMA concluded that if the baseline non-integrated pin base CFL would be eliminated, the unique base and pin configurations would force consumers to replace entire fixtures resulting in stranded assets. (NEMA, No. 34 at p. 15)

DOE understands the concerns regarding lamp and ballast compatibility for non-integrated GSLs. DOE ensured that the more efficacious substitutes analyzed as representative in the Non-Integrated product class were compatible with the existing ballast paired with the baseline lamp. DOE used publicly available ballast specifications published by manufacturers to confirm compatibility and to ensure a ballast replacement would not be required. For the NOPR analysis, DOE also ensured that consumers with non-integrated GSLs installed typically would not be forced to switch to a lamp of a different base type by confirming that the vast majority of base types were still available at EL 1.[119] Additionally, DOE is not aware of a technological reason why the base type of a non-integrated CFL would prevent a lamp from achieving EL 1. Because DOE ensured that the vast majority of base types were available at EL 1 and is not aware of technological limitations for increasing the efficacy of the others, DOE does not believe that consumers would be forced to change fixtures. Therefore, DOE considered fixture replacement to be an unlikely replacement scenario. Consequently, DOE did not evaluate ballast or fixture replacement scenarios for this NOPR analysis. DOE requests comment on the assumption that the efficacy of non-integrated CFLs can be improved for those lamps with base types that potentially cannot meet EL 1.

NEMA also commented that pin base CFLs are available in either 2-pin or 4-pin bases, corresponding to a particular socket and ballast type. NEMA added that 2-pin lamps have an internal starter and are designed for preheat, magnetic operation, while 4-pin lamps are dimmable and designed for electronic ballast operation. NEMA concluded that removing a base type reduces utility. (NEMA, No. 34 at pp. 17–18) Westinghouse commented that there may not be 2-pin reduced wattage replacement options compatible with existing ballasts. Westinghouse noted there is more flexibility with 4-pin non-integrated CFLs because these lamps can be dimmed, however using reduced wattage 2-pin replacement options may not be technically feasible. (Westinghouse, Public Meeting Transcript, No. 29 at pp. 74–75)

As stated previously, DOE ensured that the vast majority of base types were maintained at EL 1, including 2-pin lamps. Further, DOE identified reduced wattage 2-pin replacement lamps. Therefore, it is technologically feasible for a 2-pin reduced wattage lamp to be manufactured and operated with an existing ballast, and consumers have the option to choose reduced wattage lamps in addition to full wattage lamps as replacements for currently installed systems when available.

NEMA further commented that non-integrated lamps must be paired with a unique ballast and a specific socket to electrically and mechanically operate, and noted that DOE selected only one of these systems to analyze despite dozens of other potential lamp and ballast combinations included in the scope. NEMA stated that analyzing different lamp and ballast combinations will produce different results and will likely result in no energy savings in most cases. NEMA also noted that non-integrated CFLs are not acceptable replacements for traditional GSLs, and concluded that DOE should remove these lamps from the scope of the rulemaking due to the complexity, maturity of this product line, and limited energy savings. NEMA further commented that while fixtures are available in configurations for various lamps types, a particular fixture is generally configured for a lamp of a particular base, length, and shape, with the exception or recessed cans. NEMA added that it cannot be assumed that the lamps complying with EL 1 will be the correct shape or have the correct base to fit into an existing fixture. In cases where the lamp no longer fits, consumers need to replace the entire fixture and are subsequently left with stranded assets. NEMA further stated that while many lamps are still available at CSL 1, these products have slightly higher lumen output at the same wattage as the baseline and therefore have no energy savings and the potential for over-illumination. (NEMA, No. 34 at pp. 16–18)

As discussed in section IV.C, DOE determined that the term ''compact fluorescent lamps'' is not limited to MBCFLs. DOE therefore concluded that both integrated and non-integrated CFLs could be considered in the GSL rulemaking. For the Non-Integrated product class, DOE selected the most common lamp type and ballast to analyze as representative in the engineering analysis based on manufacturer feedback and a survey of the market. While DOE agrees that different lamp and ballast combinations may produce varying results, DOE determined the lamp-and-ballast system analyzed is representative of a significant portion of the installed systems. Further, because DOE ensured that the vast majority of base types were available at EL 1 and that the impacts of EL 1 were consistent across lumen packages, DOE concluded the results would be fairly consistent across different lamp and ballast combinations. Regarding size issues, DOE analyzed the dimensions of lamps in the Non-Integrated product class and ensured that lamps that meet EL 1 with the same base type and shape have nearly

[119] DOE identified three base types that are potentially unable to meet EL 1 out of an original 26 base types. DOE believes these lamps were typically used in fixtures, such as desk lamps or fan fixtures, and have already transitioned to more efficacious technologies.

identical dimensions on average as the lamps they are replacing that do not comply with EL 1. Because the vast majority of base types are not being eliminated and the replacements are similar in size, DOE concluded that the comparable form factors of the more efficacious non-integrated GSL replacements will not require consumers to replace entire fixtures. DOE weighs the benefits and burdens of standards in section VI.A.

Table V–9 summarizes the efficacy requirements at EL 1 for the Non-Integrated product class in the NOPR analysis. DOE requests comment on the EL under consideration for the Non-Integrated product class, including the max-tech level.

TABLE V–9—SUMMARY OF ELS FOR GSL NON-INTEGRATED REPRESENTATIVE PRODUCT CLASS

Representative product class	Efficacy level	Efficacy (lm/W)
Non-Integrated (310 ≤ Initial Lumen Output ≤ 2,600)	EL 1	72.6–25.00*0.9989^Initial Lumen Output.

6. Scaling to Other Product Classes

As noted previously, DOE analyzes the representative product classes directly. DOE then scales the levels developed for the representative product classes to determine levels for product classes not analyzed directly. In the preliminary analysis, DOE analyzed all product classes as representative and therefore did not scale. In this NOPR analysis, DOE added a product class division for GSLs with standby mode functionality and did not directly analyze the Integrated Low-Lumen and Integrated High-Lumen product classes with standby mode functionality. Therefore, ELs developed for the Integrated Low-Lumen and Integrated High-Lumen product classes were scaled to obtain levels for the Integrated Low-Lumen Standby-Mode Functionality and Integrated High-Lumen Standby-Mode Functionality product classes.

DOE conducted standby testing and used the test data to calculate the appropriate scaling factor. Based on test data, DOE found that standby power consumption was 0.5 W or less for the vast majority of lamps. (See appendix 5A of the NOPR TSD for more information on the test results.) Therefore, DOE assumed a typical wattage constant for standby mode power consumption of 0.5 W. This wattage was added to the rated wattage of the non-standby mode representative units in the Integrated Low-Lumen product class to calculate the expected efficacy of lamps representative of the same design options but with the addition of standby mode functionality. DOE then applied a ratio of the recalculated efficacies (with standby mode power) divided by the representative units' efficacies (without standby mode power) to the A-values of the ELs for the Integrated Low-Lumen product class without standby mode to determine the scaled ELs. Because DOE selected A-values that resulted in continuous equations across the Integrated Low-Lumen and Integrated High-Lumen product classes, the scaled A-values were applicable for both product classes capable of operating in standby mode. (See Table V–10 for scaling factors and resulting scaled ELs.) DOE determined that for the Integrated Low-Lumen Standby-Mode Functionality product class slight adjustments to EL 1 were necessary to prevent backsliding from existing standard levels. DOE requests comment on the scaling factors determined. Table V–10 shows the ELs proposed for the Integrated Low-Lumen Standby-Mode Functionality and Integrated High-Lumen Standby-Mode Functionality product classes.

TABLE V–10—SUMMARY OF SCALED ELS FOR GSL STANDBY MODE NON-REPRESENTATIVE PRODUCT CLASS

Product class	Efficacy level	Lumens	Efficacy (lm/W)		A-value reduction
			No standby mode	Capable of operating in standby mode	
Integrated-Low Lumen.	EL 1	Initial Lumen Output < 877	67.6–29.42*0.9983^Initial Lumen Output.	65.1–29.42*0.9983^Initial Lumen Output.	3.7
		877 ≤ Initial Lumen Output < 900.	67.6–29.42*0.9983^Initial Lumen Output.	1/15 * Initial Lumen Output	N/A
		900 ≤ Initial Lumen Outputs ≤ 1030.	67.6–29.42*0.9983^Initial Lumen Output.	60	N/A
		1030 < Initial Lumen Output < 2,000.	67.6–29.42*0.9983^Initial Lumen Output.	65.1–29.42*0.9983^Initial Lumen Output.	3.7
	EL 2	310 ≤ Initial Lumen Output < 2,000.	73.4–29.42*0.9983^Initial Lumen Output.	70.5–29.42*0.9983^Initial Lumen Output.	4.0
	EL 3	310 ≤ Initial Lumen Output < 2,000.	101.6–29.42*0.9983^Initial Lumen Output.	96.0–29.42*0.9983^Initial Lumen Output.	5.6
	EL 4	310 ≤ Initial Lumen Output < 2,000.	108.6–29.42*0.9983^Initial Lumen Output.	102.2–29.42*0.9983^Initial Lumen Output.	5.9
Integrated-High Lumen.	EL 1	2,000 ≤ Initial Lumen Output ≤ 2,600.	67.6–29.42*0.9983^Initial Lumen Output.	65.1–29.42*0.9983^Initial Lumen Output.	3.7
	EL 2	2,000 ≤ Initial Lumen Output ≤ 2,600.	73.4–29.42*0.9983^Initial Lumen Output.	70.5–29.42*0.9983^Initial Lumen Output.	4.0

D. Product Price Determination

Typically, DOE develops manufacturing selling prices (MSPs) for covered products and applies markups to create consumer prices to use as inputs to the LCC analysis and NIA. Because GSLs are difficult to reverse-engineer (*i.e.,* not easily disassembled), DOE directly derives consumer prices for the lamps covered in this rulemaking. Consumer price refers to the product price a consumer pays before tax and installation. Because non-integrated CFLs operate with a ballast in practice, DOE also developed prices for ballasts that operate those lamps.

In the preliminary analysis, DOE reviewed and used publicly available retail prices to develop consumer prices for GSLs. In its review, DOE observed a range of consumer prices paid for a lamp, depending on the distribution channel through which the lamp was purchased. Specifically, DOE identified the following four main distribution channels: Small Consumer-Based Distributors (*i.e.,* Internet retailers); Large Consumer-Based Distributors: (*i.e.,* home centers); Electrical Distributors; and State Procurement.[120]

For each distribution channel, DOE calculated an aggregate price for the representative lamp unit at each EL using the average prices for the representative lamp unit and similar lamp models. Because the lamps included in the calculation were equivalent to the representative lamp unit in terms of performance and utility (*i.e.,* had similar wattage, CCT, bulb shape, base type, CRI), DOE considered the pricing of these lamps to be representative of the technology of the EL. DOE developed average consumer prices for the representative lamp units sold in each of the four main distribution channels identified. DOE then calculated an average weighted consumer price using estimated shipments through each distribution channel. To determine prices for CFL ballasts, DOE compared the blue book prices of CFL ballasts to comparable fluorescent lamp ballasts and developed a scaling factor to apply to the consumer prices of the fluorescent lamp ballasts developed in the 2011 Ballast Rule. DOE received several comments on its pricing methodology and results.

1. Price Weightings

DOE received several comments regarding the application of sales weightings and the assessment of lamps sold in multi-packs. NEEA noted that the per-lamp price is lower when lamps are sold in multi-packs and pointed out that if DOE had accounted for the higher shipment volumes of these products, DOE's consumer prices would be lower. (NEEA, Public Meeting Transcript, No. 29 at pp. 153–154) NWPCC and the Appliance Standards Awareness Project (ASAP) agreed that weighting prices using sales volume, instead of averaging prices based on the number of products on store shelves, would result in lower consumer prices. (NWPCC, Public Meeting Transcript, No. 29 at p. 154; ASAP, Public Meeting Transcript, No. 29 at p. 112–113) Westinghouse added that only averaging the prices of lamps sold in single- and multi-packs would allow outliers to disproportionately affect the results. Due to the frequency of large pricing disparities for the same lamp type, Westinghouse stated that outliers would need to be appropriately weighted. (Westinghouse, Public Meeting Transcript, No. 29 at pp. 114–115) EEAs and NRDC recommended that DOE modify its analysis to weight each lamp equally, meaning the cost of an individual lamp sold in a pack of four is counted four times and the cost of a lamp sold singly is counted once. While they did not have specific data, EEAs expected multi-packs to sell in higher volume than single-packs due to their increased value per bulb. (EEAs, No. 32 at p. 12; NRDC, Public Meeting Transcript, No. 29 at pp. 117–118) ASAP requested clarification on how DOE dealt with pricing from single- and multi-packs of the same lamp. (ASAP, Public Meeting Transcript, No. 29 at p. 112–113)

In the preliminary analysis, DOE did not weight the price per lamp by the number of lamps contained in its packaging or by sales data of that lamp. However, DOE agrees with the stakeholders' recommendation regarding package weighting, and in the NOPR analysis, DOE weighed each lamp price by the number of lamps with which it was sold. For example, if a lamp is sold in a single-pack for $1 and is sold also in a multi-pack of four lamps for $3, then one $1 lamp and four $0.75 lamps were used to create an average price. DOE did not include an additional weighting factor to reflect sales volume because the package-weighting factor described above already reflects sales volume; CFLs are most commonly offered in multi-packs, whereas LED lamps are most commonly offered in single-packs.

DOE also received comments on the distribution channel weightings used in the preliminary analysis. GE and CA IOUs agreed with DOE's approach of analyzing typical prices from different sales channels and weighting them according to the portion of the market that uses those channels. GE stated that they have not specifically reviewed distribution channel percentages or exact sales data, but agreed that DOE's estimated percentage of shipments through each channel seemed reasonable. (GE, Public Meeting Transcript, No. 29 at p. 111) CA IOUs agreed with DOE's decision to give the most weighting to the Large Consumer-Based Distributors channel. (CA IOUs, No. 33 at p. 5)

In the preliminary analysis, DOE identified four main distribution channels for GSLs and applied weightings based on estimated shipments through each channel. DOE used different shipment percentages for integrated lamps and non-integrated lamps because integrated lamps are more commonly residential products, while non-integrated lamps are more commonly commercial products. In the preliminary analysis, for the integrated lamps, DOE applied a 10 percent weighting to the Small Consumer-Based Distributors channel, 75 percent to the Large Consumer-Based Distributors channel, 10 percent to the Electrical Distributors channel, and 5 percent to the State Procurement channel.[121] In the NOPR analysis, DOE modified these percentages slightly by applying 80 percent to the Large Consumer-Based Distributors channel and 5 percent to the Electrical Distributors channel. As these lamps are sold mainly to the residential market, DOE determined the electrical distributors likely comprise a lesser share and the large consumer-based distributors likely have a higher share of shipments than estimated in the preliminary analysis.

2. CFL Prices in the Integrated Low-Lumen Product Class

DOE received comments regarding the consumer prices for ELs represented by CFLs in the Integrated Low-Lumen product class. NRDC questioned why DOE's consumer price for the baseline level representing a CFL was $6.00, when the price of such lamps is $1.50 or $2.00 when sold in multi-packs at big box stores, which are part of the highest weighted distribution channel in DOE's analysis. (NRDC, Public Meeting Transcript, No. 29 at p. 107) Southern Company stated that there are differences in utility between a covered and a bare CFL and suggested that DOE establish different product classes for the two lamp types in order to avoid having a baseline level more expensive than CSL1. (Southern Company, Public

[120] GSL preliminary analysis at 6–2.

[121] *Id.* at 6–3.

Meeting Transcript, No. 29 at pp. 108–109)

In the preliminary analysis, the representative lamp unit at the baseline was a 14 W covered CFL, and the representative lamp at CSL 1 was a 13 W bare (spiral) CFL in the Integrated Low-Lumen product class. Covered CFLs are priced higher than bare CFLs, resulting in a higher price in the preliminary analysis at the baseline than at CSL 1. In this NOPR analysis, DOE continued to not establish product classes based on lamp cover but evaluated a 14 W bare CFL as the representative lamp unit at the baseline. (See section V.A.1 for further details regarding product classes and section V.C.4 for further details on representative units.) With this update, in the NOPR analysis the consumer price at the baseline and CSL 1 are, respectively, $2.27 and $2.71.

3. LED Lamp Prices in the Integrated Low-Lumen Product Class

Southern Company suggested that the inclusion of different types of LEDs were causing confusion in the pricing analysis. Specifically, Southern Company noted that directional LED products tend to be more expensive than omnidirectional LED lamps, and comparing their prices directly would be problematic as directional LED lamp products might not be usable in all applications. (Southern Company, Public Meeting Transcript, No. 29 at pp. 154–155)

When determining consumer prices for an EL, DOE used prices for representative lamp units or similar lamps at that EL. DOE ensured that similar lamps had the same characteristics (*e.g.,* wattage, CCT, bulb shape, base type, CRI) that made them equivalent in terms of performance and utility. For the Integrated Low-Lumen product class, all representative lamp units were omnidirectional lamps, and therefore DOE did not use any prices for directional LED lamps in the pricing analysis.

For the Integrated Low-Lumen product class, DOE's preliminary analysis results showed prices of LED lamps decreasing as efficacy increased.[122] Stakeholders provided feedback on this price trend. NRDC and EEAs noted that LED lamps are becoming more efficacious and less expensive at the same time, which is not typical. NRDC explained that as an individual LED package becomes more efficacious, not as many of them are required to produce the needed light output and the size of the heat sink and other components can be reduced, allowing for a smaller form factor and lower overall cost. (NRDC, Public Meeting Transcript, No. 29 at pp. 98–99; EEAs, No. 32 at p. 4)

Several stakeholders pointed out that the rapid turnover in LED product offerings on the market may be affecting the LED price trend presented in the preliminary analysis. Philips stated that it did not make sense that products that were more efficacious would have a lower cost or that consumers would purchase less efficacious products at a higher cost. Philips suggested that because the LED market is so dynamic, robust data cannot be generated and DOE's use of older data points is skewing the analysis. (Philips, Public Meeting Transcript, No. 29 at pp. 188–189) NEMA explained that LED product development results in surges of new products rather than the continuous evolution that is more typical of other technologies. Therefore, even though an abundance of data might be available, lamps that are a year old are already obsolete. (NEMA, Public Meeting Transcript, No. 29 at pp. 155–156) EEAs noted that the prices shown in the examples for CSL 2 and CSL 3 reflected products that were being discontinued and replaced by new, more efficacious products that were also less expensive than the prior versions. (EEAs, No. 32 at p. 12) NRDC commented that the high price at CSL 2 could be because it was an older model. (NRDC, Public Meeting Transcript, No. 29 at pp. 160–161)

DOE uses the most current prices available at the time of analysis to develop average prices for each EL. Based on the data collected for the preliminary and NOPR analyses, DOE has noted a trend showing that lower wattage, more efficacious LED lamps have lower prices than higher wattage, less efficacious LED lamps. As stakeholders indicated, and manufacturers confirmed in interviews, manufacturers begin to phase out their less efficacious LED products as they introduce products that are more efficacious. The low volume and older technology of the less efficacious products likely results in higher prices. Hence, the trend of decreasing prices for more efficacious LED lamps results from the following combination of factors: (1) The ability to make LED lamps more efficacious at a lower cost and (2) the low volume and subsequently higher prices of the less efficacious lamps. DOE consistently found this decreasing LED lamp price trend in the pricing data collected for the preliminary analysis and in the updated pricing data collected for the NOPR analysis.

NEMA stated that the short market exposure and high rate of innovation for LED lamps has resulted in strong price reductions with large technology improvements, such that families of LED lamp products are only now evolving in a linear method similar to other mature lamp technologies. Hence, it is incorrect to compare prices of lamps for sale today with lamps for sale a few years ago because the latest lamp is a new design incomparable to the older version of the lamp. Noting that DOE's typical analysis model examined mature products with incremental improvements, NEMA suggested DOE redesign the price model for LED lamps to recognize this phenomenon. (NEMA, No. 34 at pp. 18–19)

CA IOUs also commented on DOE's pricing model, suggesting that, given the extremely fast rate of price reductions in the LED market, DOE should use forecasted 2020 pricing estimates, rather than utilizing current 2014 pricing. (CA IOUs, No. 33 at p. 5) CA IOUs stated that the prices DOE estimated for LED lamps were too high, especially when considering what the price of the lamps would be in 2020, the first year of compliance. To support this assertion, CA IOUs provided DOE with graphs of online retail price data[123] collected between December 2013 and January 2015 along with projections up to December 2017. CA IOUs stated that according to DOE's findings during the recent GSFL and IRL standards rulemaking (80 FR 4041 [Jan. 26, 2015]), on average, online pricing is generally higher than in-store pricing, suggesting that if anything, those average prices collected by CA IOUs should overestimate the prices for most end users. CA IOUs stated that DOE forecasted the consumer price to be $28.12 ($35.26/kilolumen[124]) for CSL 2,

[122] *Id.*

[123] CA IOUs collected over 40,000 unique price points, for LED replacement lamps over 300 lumens, retrieved at regular intervals between December 2013 and January 2015 from HomeDepot.com, Lowes.com, Acehardware.com, Costco.com, 1000bulbs.com, bulbs.com, and several others. CA IOUs provided three graphs of these data, presenting the average online pricing by EL, along with estimated future pricing developed by applying exponential growth to the data. One graph showed data for all LED replacement lamps over 300 lm (including A, G, PAR, BR, MR, decorative, and downlight lamp shapes), the second showed data for only A-shaped lamps over 300 lumens, and the third showed data for A-shaped lamps between 700 and 1100 lm. CA IOUs also provided a cross-section of price points collected on January 8, 2015, for LED A-shaped lamps between 700 and 1100 lm, with efficacies above 80 lm/W and price data from flikart.com of high and low power factor CFLs. These graphs are available in CA IOUs' public comment on regulations.gov under docket number EERE–2013–BT–STD–0051–0033.

[124] Derived by CA IOUs by dividing the consumer prices developed by DOE in the preliminary analysis by 0.8 based on an 800-lumen lamp.

when CA IOUs' data suggest that such products are currently below $30/kilolumen, and projected prices to be below $10/kilolumen within two years. Similarly, for CSL 3, CA IOUs stated that DOE forecasted the consumer price to be $18.02 ($22.53/kilolumen), when CA IOUs' data suggest that such products are currently approximately $17/kilolumen. For CSL 4 and CSL 5, CA IOUs stated that DOE's forecasted prices were around $13–14 ($17–18/kilolumen), when the CA IOUs' data suggest that they are currently that low. (CA IOUs, No. 33 at p. 8, 11–13) NRDC stated DOE's consumer price of $15.28 (with sales tax) at CSL 4, which hypothetically reflects a typical 60 W LED replacement lamp, is too high and such lamps are $10.00 or less at big box stores. (NRDC, Public Meeting Transcript, No. 29 at pp. 151–152) Further, CA IOUs projected that current prices will drop by 30 to 70 percent in the next two years and the most-efficacious products will see the fastest price reductions. They asked DOE to revisit their assumptions for LED lamp price forecasts and to lower them based on this information. (CA IOUs, No. 33 at p. 8, 11–13)

In the preliminary analysis, DOE did not modify prices in the product price determination based on developments in LED technology that have not yet occurred, but rather used the latest pricing data available at the time of the analysis to determine consumer prices. DOE determined the full price of lamps at each EL rather than pricing incremental design improvements. DOE understands that there may be differences in the design of an LED lamp from one year to the next. However, these changes in design, and the effect they have on the overall lamp price, is unknown. DOE is aware that LED technology is expected to improve over the next several years, but there is no guarantee that a reduction in the price of an LED will be immediately accompanied by a decrease in the price of the lamp in which it is incorporated. Manufacturers may change other aspects of the lamp at the same time, such as improving the light distribution or adding features to enable connectivity. DOE acknowledges that, during interviews, manufacturers indicated they were focusing their development efforts on reducing the price of LED lamps to encourage widespread adoption. To do so, manufacturers expected to eliminate features valued by consumers, such as the ability to dim and long lifetimes. In this rulemaking, DOE analyzes and determines corresponding prices for LED lamps that maintain consumer utility. As described in section V.C.5, DOE has ensured the availability of features valued by consumers at the highest analyzed EL.

DOE updated its pricing analysis for the NOPR using the most recent available prices for actual LED lamps being sold on the market. DOE also reviewed in detail the data and graphs provided by CA IOUs. In comparison to the price data CA IOUs collected, DOE's updated pricing analysis in the NOPR shows lower prices for levels represented by LED lamps. Specifically, DOE determined that the average weighted price for EL 2 (representing a 12 W LED lamp at 66.7 lm/W) is $14.10 (2015$) and the average weighted price decreases at higher efficacy levels with the max-tech lamp at $9.33. DOE also notes that the NIA applies a price-learning factor, which results in even lower prices in future years as shipments of LED lamps increase in volume. (See section V.H for further details.)

E. Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of GSLs at different efficacies in representative U.S. single-family homes, multi-family residences, and commercial buildings, and to assess the energy savings potential of increased GSL efficacy. To develop annual energy use estimates, DOE multiplied GSL input power by the number of hours of use (HOU) per year and a factor representing the impact of controls. The energy use analysis estimates the range of energy use of GSLs in the field (*i.e.,* as they are actually used by consumers) and provides the basis for other analyses DOE performs, particularly assessments of the energy savings and the savings in consumer operating costs that could result from adoption of new or amended standards.[125]

1. Operating Hours

a. Residential Sector

To determine the average HOU of GSLs in the residential sector, DOE collected data from a number of sources. Consistent with the approach taken in the preliminary analysis, DOE used data from various regional field-metering studies of GSL operating hours conducted across the U.S. DOE determined the regional variation in average HOU using average HOU data from the regional metering studies, all of which are listed in the energy use chapter (chapter 7 of the NOPR TSD). DOE determined the average HOU for each EIA Residential Energy Consumption Survey (RECS) reportable domain (*i.e.,* state, or group of states).[126] For regions without HOU metered data, DOE used data from adjacent regions.

In the preliminary analysis, DOE assumed that GSL operating hours do not vary by light source technology.[127] The reasoning was as follows: because section 313 of the Appropriations Rider states that none of the funds made available by the Act may be used to implement or enforce standards for GSILs, intermediate-base incandescent lamps and candelabra base incandescent lamps, DOE did not consider these lamps in its analyses. Furthermore, because these lamps are not included in the scope of this rulemaking, in the preliminary analysis DOE assumed that a potential GSL final rule would not yield sufficient energy savings to avoid triggering the EISA 2007 backstop. Therefore, DOE assumed that the EISA 2007 backstop will go into effect on January 1, 2020. DOE assumed that the compliance date for a potential final GSL rule would be concurrent with the compliance date for the EISA 2007 backstop. (*See* 42 U.S.C. 6295(i)(6)(A)(ii), (i)(6)(A)(iii) and (i)(6)(A)(v)) Thus, during the analysis period, DOE assumed that CFL and LED GSLs would fill all sockets currently filled by GSLs. Although some metering studies have observed higher hours of operation for CFL GSLs compared to incandescent/halogen GSLs—such as NMR Group, Inc.'s Northeast Residential Lighting Hours-of-Use Study[128]—DOE assumed that the higher HOU found for CFL GSLs is based on those lamps currently disproportionately filling sockets with higher HOU. This would not be the case during the analysis period, when CFL and LED GSLs are expected to fill all GSL sockets. This assumption was equivalent to assuming no rebound in operating hours as a result of more efficacious technologies filling sockets currently filled by less efficacious technologies prior to, or as a result of, the EISA 2007 backstop. Additionally, operating hours were assumed to be equivalent for CFL and LED GSLs in the reference scenario. In other words, the reference scenario assumed no rebound

[125] GSL preliminary analysis at 7–1.

[126] U.S. Department of Energy–Energy Information Administration. *2009 RECS Survey Data.* (Last accessed June 9, 2015.) *http://www.eia.gov/consumption/residential/data/2009/.*

[127] GSL preliminary analysis at 7–1.

[128] NMR Group, DNV GL. Northeast Residential Lighting Hours-of-Use Study. May 5, 2014. Prepared for Connecticut Energy Efficiency Board, Cape Light Compact, Massachusetts Energy Efficiency Advisory Council, National Grid Massachusetts, National Grid Rhode Island, New York State Energy Research and Development Authority. (Last Accessed August 22, 2014.)

as a result of a potential GSL energy conservation standard.

Regarding the set of lamps potentially subject to the backstop, Southern Company requested that DOE consider including exemptions for space-constrained products with high-lumen output because consumer utility will be eliminated unless LED technology improves fast enough to cover those applications by the time the backstop takes effect. (Southern Company, Public Meeting Transcript, No. 29 at pp. 131–132) Earthjustice stated that EPCA's backstop requirement applies to all lamps that DOE deems GSLs, even if said lamps are not covered in the scope of this rulemaking (*e.g.,* high-lumen lamps). (Earthjustice, No. 30 at pp. 3–4) EEAs and the California Investor-Owned Utilities (CA IOUs) disagreed with DOE's interpretation of the Appropriations Rider, but agreed with DOE's assumption that not including GSILs in the scope of this rulemaking will cause the backstop to come into effect. (EEAs, No. 32 at p. 2; CA IOUs, No. 33 at pp. 1–2) Conversely, NEMA disagreed with DOE's assumption that the backstop will be triggered, stating that rapid LED adoption and innovation will bring the energy consumption of the mix of GSLs by January 1, 2020 below that of the energy consumption assuming all GSLs at January 1, 2020 had an efficiency of 45 lm/W. (NEMA, No. 34 at pp. 20–21).

As discussed previously, due to the Appropriations Rider, DOE is not considering GSILs, including exclusions or exemptions, in this rulemaking. Under 42 U.S.C. 6295(i)(6)(A)(v), if DOE fails to (1) complete a rulemaking in accordance with clauses (i) through (iv), which includes determining whether the exemptions for certain incandescent lamps should be maintained or discontinued, or (2) publish a final rule that will meet or exceed the energy savings associated with the EISA 2007 45 lm/W backstop, then the backstop will be triggered beginning January 1, 2020. Therefore DOE assumes that the backstop will be triggered beginning January 1, 2020. Thus, as in the preliminary analysis, for the NOPR analysis DOE assumes that the compliance date for a potential final GSL rule would be simultaneous with the compliance date for the EISA 2007 backstop. DOE requests comment on its assumption that the EISA 2007 backstop will be triggered (see issue 25 in section VIII.E).

Southern Company disagreed with DOE's assumption that more efficacious GSLs do not have higher operating hours than less efficacious GSLs. (Southern Company, Public Meeting Transcript, No. 29 at p. 123) NEMA agreed with Southern Company, citing increased consumer convenience in using long-lived, more efficacious lamps in sockets with higher HOU (due to less lamp replacements), as well as the energy savings associated with using lower-wattage lamps in the most-used sockets. (NEMA, No. 34 at pp. 19–20) NRDC highlighted the complexity involved in estimating operating hours for GSLs and supported the 2.3 hours per day average estimated by DOE in the preliminary analysis. (NRDC, Public Meeting Transcript, No. 29 at pp. 130–131)

DOE agrees that, currently, consumers are likely to place more efficacious, longer-lived GSLs in the most-used sockets, especially if the efficacies or lifetimes of the lamps differ greatly. However, DOE does not believe this effect to be substantial in the case of replacing a CFL with an LED lamp. Because DOE's analyses assume no GSLs with efficacy below 45 lm/W are shipped during the analysis period, CFL and LED lamps represent the only GSLs on the market. Therefore, as in the preliminary analysis, for the NOPR analysis DOE assumed that GSL operating hours do not vary by light source technology. Based on the methodology described in this section and in further detail in chapter 7 of the NOPR TSD, DOE estimated the national weighted-average HOU of GSLs in the residential sector to be 2.3 hours per day.

To estimate the variability in GSL HOU by room type, DOE developed HOU distributions for each room type using data from NEEA's Residential Building Stock Assessment Metering Study (RBSAM),[129] a metering study of 101 single-family houses in the Northwest. DOE assumed that the shape of the HOU distribution for a particular room type would be the same across the United States, even if the average HOU for that room type varied by geographic location. To determine the distribution of GSLs by room type, DOE used data from NEEA's 2011 RBSAM for single-family homes,[130] which included GSL room-distribution data for more than 1,400 single-family homes throughout the Northwest.

For more details on the methodology DOE used to estimate the HOU for GSLs in the residential sector, see chapter 7 of the NOPR TSD. DOE requests comment on the data and methodology used to estimate operating hours for GSLs in the residential sector, as well as on the assumption that GSL operating hours do not vary by light source technology (see issue 26 in section VIII.E).

b. Commercial Sector

DOE determined the HOU for GSLs in commercial buildings using lighting data for 15 commercial building types obtained from the 2010 U.S. Lighting Market Characterization (LMC).[131] For each commercial building type presented in the LMC, DOE determined average HOU based on the fraction of installed lamps utilizing each of the light source technologies typically used in GSLs and the HOU for each of these light source technologies. DOE estimated the national-average HOU for the commercial sector by weighting the building-specific HOU for GSLs by the relative floor space of each building type as reported in in the 2003 EIA Commercial Buildings Energy Consumption Survey (CBECS).[132] The national weighted-average HOU for GSLs in the commercial sector were estimated at 10.7 hours per day.

To capture the variability in HOU for individual consumers in the commercial sector, DOE used data from NEEA's 2014 Commercial Building Stock Assessment (CBSA).[133] DOE invites comments and data on its approach to account for variability in HOU in the commercial sector (see issue 27 in section VIII.E). For further details on the commercial sector operating hours, see chapter 7 of the NOPR TSD.

2. Input Power

The input power used in the energy use analysis is the input power presented in the engineering analysis (chapter 5 of the NOPR TSD) for the representative lamps (or lamp-and-ballast systems) at each EL for each of

[129] Ecotope Inc. *Residential Building Stock Assessment: Metering Study.* 2014. Northwest Energy Efficiency Alliance: Seattle, WA. Report No. E14–283. (Last accessed June 15, 2015.) *http://neea.org/docs/default-source/reports/residential-building-stock-assessment—metering-study.pdf?sfvrsn=6.*

[130] Northwest Energy Efficiency Alliance. *2011 Residential Building Stock Assessment Single-Family Database.* (Last accessed June 29, 2015.) *http://neea.org/resource-center/regional-data-resources/residential-building-stock-assessment.*

[131] Navigant Consulting, Inc. *Final Report: 2010 U.S. Lighting Market Characterization.* 2012. U.S. Department of Energy. (Last accessed June 10, 2015.) *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf*

[132] U.S. Department of Energy–Energy Information Administration. *2003 CBECS Survey Data.* (Last accessed June 9, 2015.) *http://www.eia.gov/consumption/commercial/data/2003/index.cfm?view=microdata.*

[133] Northwest Energy Efficiency Alliance. *Commercial Building Stock Assessment 2014.* (Last accessed June 26, 2015.) *http://neea.org/resource-center/regional-data-resources/commercial-building-stock-assessment.*

the three representative product classes considered in this rulemaking: Integrated Low-Lumen, Integrated High-Lumen, and Non-Integrated GSLs.

3. Lighting Controls

For GSLs that operate with controls, DOE assumed an average energy reduction of 30 percent in the preliminary analysis. This estimate was based on a meta-analysis of field measurements of energy savings from commercial lighting controls by Williams, *et al.*[134] Because field measurements of energy savings from controls in the residential sector are very limited, DOE assumed that controls would have the same impact as in the commercial sector.

NEEA suggested that lighting controls do not necessarily translate into real energy savings; however, DOE notes that its energy savings estimate from controls are based on a meta-analysis of commercial building controls studies indicating an average savings of 30 percent for lamps on controlled sockets. (NEEA, Public Meeting Transcript, No. 29 at pp. 125, 138–139)

NRDC contended that DOE's assumption of energy savings from controls in the residential sector should be lower, because DOE based this assumption on data collected on commercial buildings, which have different control systems. (NRDC, Public Meeting Transcript, No. 29 at p. 136) ASAP requested DOE review the data to see if manual and central control types were accounted for separately, and if so, to use the energy savings from manual controls for the residential sector. (ASAP, Public Meeting Transcript, No. 29 at p. 137) General Electric noted that residential dimming is in general much more variable than dimming in the commercial sector, where lights are not dimmed to very low levels. (General Electric Lighting, Public Meeting Transcript, No. 29 at pp. 139–140)

The meta-analysis DOE used to base its assumption of 30-percent energy savings from lighting controls does provide energy savings estimates for individual control types (including manual controls); however, it is unclear that manual lighting controls in commercial buildings would be used in the same manner as manual controls in residences. DOE was able to find a single study that looked at the energy savings of controls in the residential sector,[135] which suggested that energy savings from dimming may be larger than 30 percent in the residential sector. However, because of the very small sample size of this study (the findings were based on metered data from two houses in California), DOE did not base its analysis on the findings of this study.

NEMA supported DOE's assumption of 30-percent energy savings for GSLs on controls in the residential sector, but suggested DOE use 5-percent energy savings for pin base GSLs in the commercial sector. (NEMA, No. 34 at pp. 21–22) DOE found no data indicating the energy savings from controls for commercial pin base fluorescent GSLs is less than 30 percent. DOE also believes that the majority of the lamps measured in the studies considered by the lighting controls meta-analysis were pin base fluorescent lamps. The meta-analysis found an average energy savings from controls of approximately 30 percent; therefore, DOE does not believe the available data indicate only 5-percent energy savings from controls in the commercial sector for pin base fluorescent GSLs. Therefore, DOE has maintained its assumption of 30-percent energy savings from lighting controls in both the residential and commercial sectors for all lamp technologies. DOE requests comment on the energy reduction estimate of 30 percent, as well as data and information on the energy use implications of using dimmers in the residential sector (see issue 28 in section VIII.E).

Southern Company stated that the data on energy savings from controls are likely to come from regions with strong energy efficiency programs, which systematically biases estimated energy savings from controls to be larger than they actually are. (Southern Company, Public Meeting Transcript, No. 29 at pp. 141–142) In response, NEEA indicated that DOE's estimate may be appropriately representative. (NEEA, Public Meeting Transcript, No. 29 at pp. 142–143) The meta-analysis DOE used to estimate savings from controls does not provide information on the geographic representativeness of the analyzed data; however, DOE notes that even if the existence of requirements for controls is linked to regions with strong energy efficiency programs, it is not clear that this would translate into any impact on the usage of controls once installed or indicate that savings from controls in such regions are overestimated.

Philips expressed concern with DOE's assumption that the HOU for GSLs in 2020 will be the same as the current HOU, and highlighted building standards requiring more controls to support this concern. (Philips, Public Meeting Transcript, No. 29 at pp. 123–124) NEMA agreed with DOE's assumption that there are few dimmable CFLs and that the percentage of dimmable LEDs is expected to be higher. (NEMA, No. 34 at p. 21) NEMA added that because of building and energy codes, it is reasonable to assume that most commercial floor space will have controls of various types. (NEMA, No. 34 at p. 27)

In its reference scenario, DOE assumed an increase in commercial floor space utilizing controls, with the increase being driven by building codes. Furthermore, while DOE's reference scenario assumes a constant 14 percent of residential GSLs operate on controls external to the lamp for all light source technologies, DOE has also analyzed an alternative scenario in the LCC and national impact analyses in which the fraction of GSLs operated with such controls[136] increases to 50 percent by the end of the analysis period (see appendices 8B and 10E of the NOPR TSD). Rather than disaggregate the impact of controls between a reduction in HOU and a reduction in input power, DOE has attributed a 30-percent reduction in energy use for all GSLs that operate with controls. DOE also notes that in the NOPR analyses, although it continues to assume that 5 percent of CFLs are dimmable, the fraction of CFLs and LEDs that are used with controls external to the lamp is assumed to be the same (14 percent in the reference case) in the residential sector, due to residential code requirements for non-dimming lighting controls such as vacancy sensors.[137] DOE requests comment on this assumption (see issue 29 in section VIII.E). Chapter 7 of the NOPR TSD provides details on DOE's energy use analysis for GSLs.

F. Life-Cycle Cost and Payback Period Analysis

DOE conducted LCC and PBP analyses to evaluate the economic impacts on individual consumers of potential energy conservation standards

[134] Williams, A., B. Atkinson, K. Garbesi, E. Page, and F. Rubinstein. Lighting Controls in Commercial Buildings. *LEUKOS.* 2012. 8(3): pp. 161–180.

[135] Consortium for Energy Efficiency. Residential Lighting Controls Market Characterization. Available at: *http://library.cee1.org/sites/default/files/library/11458/CEE_LightingMarketCharacterization.pdf.*

[136] In the energy use and LCC analyses, DOE did not consider smart lamps, as the product class containing such lamps is a non-representative product class and DOE presents energy use and LCC results for representative product classes only. Smart lamps are considered in the national impact analysis.

[137] Lutron Electronics Co., Inc. *Illuminating the Title 24 2013 Residential Lighting Requirements.* 2014. (Last accessed June 29, 2015.) *http://www.lutron.com/TechnicalDocumentLibrary/Illuminating_Title_24%20_2013_Resi_Lighting_Requirements.pdf.*

for GSLs. The effect of new or amended energy conservation standards on individual consumers usually involves a reduction in operating cost and an increase in purchase cost. DOE used the following two metrics to measure consumer impacts:

- The LCC is the total consumer expense of an appliance or product over the life of that product, consisting of total installed cost (product price, sales tax, and installation costs) plus operating costs (expenses for energy use, maintenance, and repair) and any applicable disposal costs. When computing operating costs or disposal costs, DOE discounts future costs to the time of purchase and sums them over the lifetime of the product. For products with lifetimes greater than the LCC analysis period (the lifetime of the shortest-lived product in each product class), DOE also accounts for their residual value, which is applied as a credit in the calculation of the LCC.
- The PBP (payback period) is the estimated amount of time (in years) it takes consumers to recover any increased purchase cost (including installation) of a more-efficient product through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost at higher ELs by the change in annual operating cost for the year that amended or new standards are assumed to take effect.

For each EL developed in the engineering analysis, DOE first calculated the average LCC and PBP if a nationally representative consumer sample were to make a purchase at that EL. Separate calculations were conducted for the residential and commercial sectors. DOE developed consumer samples based on the 2009 RECS and the 2003 CBECS, for the residential and commercial sectors, respectively. For each consumer in the sample, DOE determined the energy consumption of the GSL purchased and the appropriate electricity price. By developing consumer samples, the analysis captured the variability in energy consumption and energy prices associated with the use of GSLs.

DOE added sales tax, which varied by state, and installation cost (for the commercial sector) to the cost of the product developed in the product price determination to determine the total installed cost. Inputs to the calculation of operating expenses include annual energy consumption, energy prices and price projections, lamp lifetimes, and discount rates. DOE created distributions of values for lamp lifetimes, discount rates, and sales taxes, with probabilities attached to each value, to account for their uncertainty and variability. For the Integrated Low-Lumen product class, DOE also developed and analyzed two non-representative lamp options for EL 2 (based on common lamp types with significant market share), as well as lamp options across three additional lumen ranges based on the 60 W equivalent lamp options.

For each GSL standards case (*i.e.,* case where a standard would be in place at a particular EL), DOE then measured the LCC savings resulting from the considered standard based on the estimated change in efficacy distribution in the standards case relative to the estimated efficacy distribution in the no-new-standards case. These efficacy distributions include market trends that can result in some lamps with efficacies that exceed the minimum efficacy associated with the standard under consideration. In contrast, the PBP only considers the average time required to recover any increased first cost associated with a purchase at a particular EL relative to the baseline product.

The computer model DOE uses to calculate the LCC and PBP results relies on a Monte Carlo simulation to incorporate uncertainty and variability into the analysis. The Monte Carlo simulations randomly sample input values from the probability distributions and GSL consumer user samples. The model calculated the LCC and PBP for a sample of 10,000 consumers per simulation run.

DOE calculated the LCC and PBP results for all consumers as if each were to purchase a new product in the expected year of compliance with new or amended standards. Any amended standards would apply to GSLs manufactured no earlier than three years after the date on which any amended standard is published. (42 U.S.C. 6295(i)(6)(A)(iii)) DOE assumed that the compliance date for any final GSL rule would be January 1, 2020.

Though DOE assumed the compliance date for any final GSL rule would be January 1, 2020 in the reference scenario, CEC asked DOE to consider phased-in effective dates, whereby the compliance date for a potential final GSL rule would instead be subsequent to the compliance date for the EISA 2007 backstop. (CEC, No. 31 at pp. 2–3) DOE has analyzed an alternative scenario in which the compliance date for a potential final GSL rule is 2022, or two years after the compliance date of the EISA 2007 backstop. This scenario aligns with the suggestion put forth by CEC, and the results can be found in the appendix 10E of this NOPR TSD.

Table V–11 summarizes the approach and data DOE used to derive inputs to the LCC and PBP calculations. The subsections that follow provide further discussion. DOE requests comment on the overall methodology and results of the LCC and PBP analyses (see issue 30 in section VIII.E). Details of the spreadsheet model, and of all the inputs to the LCC and PBP analyses, are contained in chapter 8 of the NOPR TSD and its appendices.

TABLE V–11—SUMMARY OF INPUTS AND METHODS FOR THE LCC AND PBP ANALYSIS*

Inputs	Source/method
Product Cost	Weighted-average consumer price determined in the product price determination. For the Integrated Low-Lumen product class, DOE developed and analyzed two non-representative lamp options for EL 2, as well as lamp options across three additional lumen ranges based on the 60W-equivalent lamp options. To project lamp prices to the compliance year, DOE used a price-learning analysis for both CFLs and LEDs.
Sales Tax	Derived 2019 population-weighted-average tax values for each state based on Census population projections and sales tax data from Sales Tax Clearinghouse.
Installation Costs	Used RSMeans and U.S. Bureau of Labor Statistics data to estimate an installation cost of $1.45 per installed GSL for the commercial sector.
Lumen Range Distribution	Residential sector: Used national sales data from the year 2000 for incandescent lamps. Commercial sector: Used lumen range distribution data from NEEA's 2014 CBSA.
Disposal Cost	Assumed 35 percent of commercial CFLs are disposed of at a cost of $0.70 per CFL. Assumptions based on industry expert feedback and a Massachusetts Department of Environmental Protection mercury lamp recycling rate report.

TABLE V–11—SUMMARY OF INPUTS AND METHODS FOR THE LCC AND PBP ANALYSIS*—Continued

Inputs	Source/method
Energy Use	Derived in the energy use analysis. Varies by geographic location and room type in the residential sector and by building type in the commercial sector.
Energy Prices	Electricity: Based on 2014 average and marginal electricity price data from the Edison Electric Institute. Variability: Electricity prices vary by season, U.S. region, and baseline electricity consumption level.
Energy Price Trends	Based on AEO 2015 price forecasts.
Residual Value	Represents the value of surviving lamps at the end of the LCC analysis period. DOE discounts the residual value to the start of the analysis period and calculates it based on the remaining lamp's lifetime and price at the end of the LCC analysis period.
Product Lifetime	A Weibull survival function is used to provide the survival probability as a function of GSL age, based on the GSL's rated lifetime and sector-specific HOU. On-time cycle length effects are included for residential CFLs.
Discount Rates	Approach involves identifying all possible debt or asset classes that might be used to purchase the considered appliances, or might be affected indirectly. Primary data source was the Federal Reserve Board's Survey of Consumer Finances.
Efficacy Distribution	Estimated by the market-share module of shipments model. See chapter 9 of the NOPR TSD for details.
Assumed Compliance Date	2020

* References for the data sources mentioned in this table are provided in the sections following the table or in chapter 8 of the NOPR TSD.

1. Product Cost

To derive the GSL product cost, DOE used the weighted-average consumer price determined in the product price determination. For the Integrated Low-Lumen product class, DOE also developed and analyzed two additional non-representative lamp options at EL 2 (a CFL and an LED lamp), in order to better reflect the current GSL market at that EL. For the same product class, which is the only product class that includes LED lamps, due to the high variability in LED lamp price by light output, DOE developed and analyzed lamp options across four lumen ranges (310–749 lm, 750–1049 lm, 1050–1489 lm, and 1490–1999 lm). For details on the methodology to derive product prices for the two non-representative lamp options and the lamp options in the three additional lumen ranges, see chapter 8 of the NOPR TSD.

DOE also used a price-learning analysis to account for changes in lamp prices that are expected to occur between the time for which DOE has data for lamp prices (2015) and the assumed compliance date of the rulemaking (2020). For details on the price-learning analysis, see section V.G.1.b.

DOE applied sales tax, which varies by geographic location, to the product cost. DOE collected sales tax data from the Sales Tax Clearinghouse [138] and used population projections from the Census Bureau [139] to develop population-weighted-average sales tax values for each state in 2020.

[138] Sales Tax Clearinghouse, Inc. *State Sales Tax Rates Along with Combined Average City and County Rates.* 2014. (Last accessed June 15, 2015.) *http://thestc.com/STrates.stm.*

[139] U.S. Census Bureau, Population Division, Interim State Population Projections, 2005. Table A1: Interim Projections of the Total Population for the United States and States: April 1, 2000 to July 1, 2030.

2. Installation Cost

In the preliminary analysis, DOE did not consider installation costs in the LCC and PBP analysis. NEMA suggested that many consumers will require an electrician, and therefore incur an installation cost, to replace a failed ballast or fixture on a non-integrated GSL. (NEMA, No. 34 at p. 23) The Northwest Power and Conservation Council agreed with NEMA, adding that installation costs should be included for any commercial lamps. (Northwest Power and Conservation Council, Public Meeting Transcript, No. 29 at p. 151) DOE agrees with NEMA and the Northwest Power and Conservation Council that commercial GSLs are likely to incur an installation cost. Therefore, DOE used RSMeans [140] and U.S. Bureau of Labor Statistics data [141] to estimate a commercial installation cost of $1.45 per installed GSL.

For details on the installation cost calculation, see chapter 8 of the NOPR TSD. DOE has continued to assume zero installation cost for the residential sector. DOE requests comment on the installation cost assumptions used in its analyses (see issue 31 in section VIII.E).

[140] RSMeans. *Facilities Maintenance and Repair Cost Data 2013.* 2012. RSMeans: Norwell, MA.

[141] U.S. Department of Labor. Bureau of Labor Statistics. *May 2014 Occupational Employment Statistics Survey. National Occupational and Wage Estimates.* (Last accessed June 30, 2015.) *http://www.bls.gov/oes/tables.htm.*

3. Lumen Range Distribution

In the preliminary analysis, DOE developed market-share estimates for each lumen range of integrated GSLs (310–749 lm, 750–1049 lm, 1050–1489 lm, and 1490–1999 lm for the Integrated Low-Lumen product class, and 2000–2600 lm for the Integrated High-Lumen product class) in the residential and commercial sectors.[142] In response to the lumen distribution presented in the preliminary analysis, NRDC commented that DOE should update its market estimate and cited available data sources. Specifically, NRDC provided national sales data across lumen ranges for screw base incandescent lamps from 2000 and 2006 and noted that given the relatively stable condition of the lighting market during that period, DOE should consider that CFL and LED replacements for screw base sockets would have similar market shares across lumen ranges. EEAs also pointed out that DOE's market-share estimates may be biased by specific lamp types included in the Cadeo Group data used by DOE in the preliminary analysis. (EEAs, No. 32 at pp. 10–12) NEMA expressed agreement with DOE's assumption that approximately 3 percent of all residential-sector GSLs with integrated ballasts or drivers are brighter than 2,000 lumens. (NEMA, No. 34 at p. 24)

DOE concurs with NRDC's assessment of available lumen-distribution information and thus, in the NOPR analyses, has updated its residential sector lumen-distribution estimate based on the data provided by NRDC. For the residential sector, DOE used

[142] GSL preliminary analysis at 8–18.

national sales data from the year 2000 [143] across lumen ranges for screw base incandescent lamps (because screw base lamps are used predominantly in the residential sector).[144] Based on DOE's updated approach, the fraction of residential-sector GSLs with integrated ballasts or drivers brighter than 2,000 lumens (*i.e.,* those residential-sector GSLs in the Integrated High-Lumen product class) is about 0.5 percent. DOE notes that this updated estimate is based on actual sales data, whereas the preliminary analysis estimate was based on the number of product offerings on the market. For the commercial sector, DOE has also updated its approach from the preliminary analysis and determined the lumen distribution using installed lamp data from NEEA's 2014 CBSA metering study.[145] For more details regarding the lumen range distributions, see chapter 8 of the NOPR TSD. DOE requests comment on the methodology and assumptions used to determine the market share of the lumen range distributions (see issue 32 in section VIII.E).

NEEA expressed concern with the lumen bins DOE used for parts of its analysis, specifically that an approximate range of 700–900 lumens was used in the engineering analysis to select an equivalent representative GSL for a 60 W incandescent bulb, whereas the EISA lumen bins were used to sample lamps for the LCC and PBP analysis. (NEEA, Public Meeting Transcript, No. 29 at pp. 231–232) Of the EISA lumen bins, the 750–1,049 lumen bin is divided between the 700–900 approximate lumen range DOE used in selecting representative units for the preliminary analysis. While DOE agrees with NEEA that using consistent lumen bins across analyses is important for analytical consistency, DOE notes that the discrepancy identified by NEEA has no actual impact on the analysis results. Furthermore, DOE is only aware of market-share data for GSLs broken out across the four EISA lumen bins. Therefore, for the NOPR analysis DOE continued to use the EISA lumen-binned GSL market-share data for its LCC and PBP analysis.

4. Electricity Prices

In the preliminary analysis, DOE used average retail electricity prices to conduct its analyses.[146] For the NOPR analyses, DOE used both marginal and average electricity prices to calculate the operating costs associated with each EL. Specifically, DOE used average electricity prices to characterize the baseline EL and marginal electricity prices to characterize incremental electricity cost savings associated with the other proposed ELs. The electricity prices used in the LCC analysis vary by season, region, and baseline electricity consumption level. DOE estimated these prices using data published with the Edison Electric Institute (EEI) Typical Bills and Average Rates reports for summer and winter 2014.[147] DOE assigned seasonal marginal and average prices to each household or commercial building in the LCC sample based on its location and its baseline monthly electricity consumption for an average summer or winter month. For a detailed discussion of the development of electricity prices, see appendix 8D of the NOPR TSD.

5. Electricity Price Trends

To arrive at electricity prices in future years, DOE multiplied the 2014 electricity prices by the forecast of annual residential or commercial electricity price changes for each Census division from EIA's *AEO 2015,* which has an end year of 2040.[148] To estimate the trends after 2040, DOE used the average rate of change during 2025–2040. For each purchase sampled, DOE applied the projection for the Census division in which the purchase was located. The AEO electricity price trends do not distinguish between marginal and average prices, so DOE used the same (*AEO 2015*) trends for both marginal and average prices. DOE reviewed the EEI data for the years 2007 to 2014 and determined that there is no systematic difference in the trends for marginal vs. average electricity prices in the data.

DOE used the electricity price trends associated with the AEO reference case, which is a business-as-usual estimate, given known market, demographic, and technological trends. DOE also included AEO High Growth and AEO Low-Growth scenarios in the analysis. The high- and low-growth cases show the projected effects of alternative economic growth assumptions on energy prices.

6. Product Lifetime

In the NOPR analyses, as in the preliminary analysis, DOE considered the GSL lifetime to be the service lifetime, *i.e.,* the age at which the GSL is retired from service.[149] In response to the lifetime scenarios presented in the preliminary analysis, Southern Company suggested DOE account for the possibility that some non-dimmable CFL GSLs are placed in dimmable sockets and experience very early failure. (Southern Company, Public Meeting Transcript, No. 29 at p. 170) DOE is unaware of any data indicating that a significant fraction of CFL GSLs experience immediate retirement due to being installed on sockets with dimmer switches. Therefore, in the reference scenario DOE has not assumed any immediate failures of this nature in the NOPR analyses. However, DOE did conduct an alternative NOPR analysis to account for the possibility of 5 percent of GSLs experiencing failure within the first year of use.

General Electric suggested that DOE cannot assume that every bulb of a specific type of GSL will have the same lifetime; some bulbs will be retired earlier than the average lifetime. (General Electric Lighting, Public Meeting Transcript, No. 29 at pp. 35–36) In response, NRDC stated that even if a GSL is retired prior to the average lifetime modeled by DOE, the lamp will most likely be replaced by a more efficacious, lower-cost lamp. (NRDC, Public Meeting Transcript, No. 29 at pp. 36–37) DOE notes that in both its preliminary and NOPR analyses, distributions were used to model GSL lifetimes. Therefore, not all GSLs of a specific type have identical lifetimes and some installed GSLs are retired earlier than indicated by the lamp's modeled median lifetime.

CEC, NEEA, and NRDC all suggested that DOE consider that long-life GSLs in the Early Replacement lifetime scenario will likely get rotated to less-used sockets, rather than being retired outright. (CEC, Public Meeting Transcript, No. 29 at pp. 171–172;

[143] ECOS Consulting, Davis Energy Group, and Energy Solutions. *Codes and Standards Enhancement Initiative for PY2004: Title 20 Standards Development: Analysis of Standards Options for General Service Incandescent Lamps.* 2004. Pacific Gas & Electric Company: San Francisco, CA. (Last accessed June 30, 2015.) *http://www.energy.ca.gov/appliances/2004rulemaking/documents/case_studies/CASE_Gen_Serv_Incand_Lamps.pdf.*

[144] Navigant Consulting, Inc. *Final Report: 2010 U.S. Lighting Market Characterization.* 2012. U.S. Department of Energy. (Last accessed June 10, 2015.) *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.*

[145] Northwest Energy Efficiency Alliance. *Commercial Building Stock Assessment 2014.* (Last accessed June 26, 2015.) *http://neea.org/resource-center/regional-data-resources/commercial-building-stock-assessment.*

[146] GSL preliminary analysis at 8–20.

[147] Edison Electric Institute. Typical Bills and Average Rates Report. Winter 2014 published April 2014, Summer 2014 published October 2014. See *http://www.eei.org/resourcesandmedia/products/Pages/Products.aspx.*

[148] U.S. Energy Information Administration. *Annual Energy Outlook 2015 with Projections to 2040.* 2015. Washington, DC Report No. DOE/EIA–0383(2015). *http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf.*

[149] GSL preliminary analysis at 8–23.

NEEA, Public Meeting Transcript, No. 29 at p. 172; NRDC, Public Meeting Transcript, No. 29 at pp. 173–174) DOE acknowledges that long-lived, efficient lamps may currently be rotated from higher-use sockets, rather than retired outright, when a consumer purchases a new, more-efficient lamp. However, this phenomenon is more likely to occur with the current mix of lighting technologies used by GSLs in homes, and is less likely to occur if the majority of GSLs installed in homes are CFL and LED lamps, because the marginal efficacy increase in the latter case is much smaller than in the former case. Because DOE's analyses assume that CFL and LED lamps are the only GSLs on the market throughout the analysis period, DOE has not assumed that consumers will rotate lamps from higher-use sockets when more efficacious lamps are purchased.

NRDC also commented that the 5-year median lifetime for the Early Replacement lifetime scenario used in the preliminary analysis was too low. (NRDC, Public Meeting Transcript, No. 29 at p. 228) Southern Company and Philips expressed concern with the long GSL lifetimes modeled in the preliminary analysis, with Philips indicating that low-cost electronic components in the lamp may have shorter lifetimes than the lamp's lumen maintenance (for LED GSLs) performance indicates. (Southern Company, Public Meeting Transcript, No. 29 at p. 33; Philips, Public Meeting Transcript, No. 29 at p. 33) NEMA indicated agreement with the lifetime scenarios considered, but found fault with the underlying Weibull function DOE used to model GSL lifetimes, stating that the underlying function was derived for non-integrated linear fluorescent lamps, not CFL and LED GSLs. (NEMA, No. 34 at p. 23)

For the NOPR analysis, DOE made a number of updates to its three lifetime scenario models. In place of 5-year median lifetime used in the Early Replacement lifetime alternative scenario for the preliminary analysis, for the NOPR analyses DOE has assumed a 10-year median lifetime for the ''short lifetime'' alternative scenario. This scenario applies only to LED GSLs and is intended to account for the possibility that the future service lifetime of LED GSLs could be significantly shorter than expected today. DOE has maintained the ''rated lifetime'' and ''renovation-driven lifetime'' scenarios from the preliminary analysis, but DOE has updated the data upon which these models (and the ''short lifetime'' model) are based, in accordance with NEMA's observation. For the NOPR analysis, DOE used a report containing data on the cycle life characteristics of CFL GSLs that was published by the California Public Utilities Commission[150] in place of the underlying Weibull function used in the preliminary analysis. DOE also analyzed a scenario in which the renovation-driven lifetime scenario was modified to assume that five percent of GSLs fail within the first year of use (called ''immediate failures''). Further discussion of and results from these analyses are provided in appendix 8E. DOE invites comment on the three GSL service life scenarios in its analyses, as well as on the lifetime scenario accounting for GSL failure in the first year of use (see issue 33 in section VIII.E).

7. Residual Value

The residual value represents the remaining dollar value of surviving lamps at the end of the LCC analysis period (the lifetime of the shortest-lived GSL in each product class), discounted to the compliance year. To account for the value of any lamps with remaining life to the consumer, the LCC model applies this residual value as a ''credit'' at the end of the LCC analysis period. Because DOE estimates that GSLs undergo price learning, the residual value of these lamps is calculated based on the lamp price at the end of the LCC analysis period.

Philips expressed concern with DOE's residual value calculation in the preliminary analysis, stating that consumers typically dispose of their original lamp and purchase a newer lamp at a comparable price, rather than capturing any value from the original lamp by selling it. (Philips, Public Meeting Transcript, No. 29 at pp. 179–180). To clarify: When comparing products with differing lifetimes, DOE selected a common period over which to evaluate LCCs so that longer-lived lamps were not penalized for continuing to accrue operating costs over a longer operational life. DOE's residual value calculation does not consider the resale value of a lamp; rather, it calculates the value to a consumer of having a lamp that is still operational, instead of a lamp that has failed and must be replaced, at the end of the LCC analysis period.

The Northwest Power and Conservation Council suggested an alternative way for DOE to conduct the residual value analysis, which is to include the replacement cost of the shortest-lived lamp in its LCC. (Northwest Power and Conservation Council, Public Meeting Transcript, No. 29 at p. 181). The CEC commented that DOE needs to consider the remaining value of the energy savings associated with longer-lived lamps. (CEC, Public Meeting Transcript, No. 29 at pp. 193–194) Because consumers of lamps with shorter lives may choose to replace them with longer-lived or more efficacious lamps when they fail, DOE believes that it is inappropriate to make assumptions about the replacement costs borne or relative operating-cost savings accumulated by a consumer after the end of the LCC analysis period.

8. Disposal Cost

Disposal cost is the cost a consumer pays to dispose of their retired GSL. In the preliminary analysis, DOE assumed that 10 percent of commercial consumers pay $1 per lamp to dispose of CFL and LED lamps.[151] General Electric agreed with DOE's assumption that residential consumers do not pay for recycling their CFL lamps; however, General Electric indicated that up to 40 percent of CFL lamps are recycled in the commercial sector, at an average price of approximately $0.50 per lamp. (General Electric Lighting, Public Meeting Transcript, No. 29 at pp. 176–177) Westinghouse Lighting largely agreed with General Electric, stating that the disposal cost for commercial CFL lamps is below $1.00 per lamp, and estimating that the cost may actually be closer to $0.70 per lamp. (Westinghouse Lighting, Public Meeting Transcript, No. 29 at p. 177) NEMA cited the Universal Waste Rule to confirm that the lamp user is responsible for disposal, and also highlighted various approaches to lamp disposal taken by some states and retailers. (NEMA, No. 34 at pp. 23–24)

DOE reviewed the available data and agrees with GE and Westinghouse that a higher percentage of commercial fluorescent lamps are recycled, but at a lower cost than DOE assumed in the preliminary analysis. As discussed in the ceiling fan light kits energy conservation standards NOPR,[152] in 2004 and 2009 the estimated recycling rates for fluorescent lamps were approximately 29 percent and 33 percent, respectively. In the NOPR analyses, DOE assumed that by the

[150] James J. Hirsch and Associates and Erik Page & Associates, Inc. *CFL Laboratory Testing Report: Results from a CFL Switching Cycle and Photometric Laboratory Study.* 2015. California Public Utilities Commission—Energy Division: California. (Last accessed June 18, 2015.) *http://www.energydataweb.com/cpuc/search.aspx?did=1258.*

[151] GSL preliminary analysis at 8–25.

[152] The Ceiling Fan Light Kits Energy Conservation Standards docket can be accessed at: *http://www.regulations.gov/#!docketDetail;dct=FR%252BPR%252BN%252BO%252BSR%252BPS;rpp=25;po=25;D=EERE–2012–BT–STD–0045.*

compliance year 35 percent of CFLs are recycled, and this fraction was assumed to remain constant over the analysis period (for the NIA). DOE also received feedback from a lighting industry consultant indicating a recycling charge of $0.70 per lamp is reasonable; therefore, DOE has assumed for the NOPR analyses that it costs commercial consumers $0.70 per lamp to recycle CFLs. DOE has continued to assume no disposal cost for CFLs in the residential sector. Because LED lamps do not contain mercury, DOE has continued to assume no disposal costs for LED lamps in both the residential and commercial sectors.

DOE requests comment and relevant data on the disposal cost assumptions used in its analyses (see issue 34 in section VIII.E).

9. Discount Rates

In the calculation of LCC, DOE applies discount rates appropriate to consumers to estimate the present value of future operating costs.

To establish residential discount rates for the LCC analysis, DOE estimated a distribution of residential discount rates for GSLs based on consumer financing costs and opportunity cost of funds related to appliance energy cost savings. DOE identified all relevant household debt or asset classes to approximate a consumer's opportunity cost of funds related to GSL energy cost savings. It estimated the average percentage shares of the various types of debt and equity by household income group using data from the Federal Reserve Board's Survey of Consumer Finances [153] (SCF) for 1995, 1998, 2001, 2004, 2007, and 2010. Using the SCF and other sources, DOE developed a distribution of rates for each type of debt and asset by income group to represent the rates that may apply in the year in which amended standards would take effect. DOE assigned each sample household a specific discount rate drawn from one of the distributions. The average rate across all types of household debt and equity and income groups, weighted by the shares of each type, is 4.5 percent.

To establish commercial consumer discount rates for the LCC analysis, DOE estimated the cost of capital for companies that purchase GSLs. The weighted-average cost of capital is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so their cost of capital is the weighted average of the cost to the firm of equity and debt financing, as estimated from financial data for publicly traded firms in the sectors that purchase GSLs. For this analysis, DOE used Damodaran online [154] as the source of information about company debt and equity financing. The average rate across all types of companies that purchase GSLs, weighted by the total number of GSLs associated with each type, is 5.0 percent.

See chapter 8 of the NOPR TSD for further details on the development of consumer discount rates.

10. Efficacy Distributions

To accurately estimate the share of consumers that would be affected by a potential energy conservation standard at a particular EL, DOE's LCC analysis considered the projected distribution (*i.e.,* market shares) of product efficacies that consumers purchase under the no-new-standards case and each of the standards cases (*i.e.,* the cases where a standard would be set at each TSL) in the assumed compliance year. The estimated market shares for the no-new-standards case and each standards case are determined by the shipments analysis and are shown in Table V–12 and Table V–13. See section V.G.1 of this NOPR and chapter 9 of the NOPR TSD for further information on the derivation of the market efficacy distributions.

TABLE V–12—GSL MARKET EFFICACY DISTRIBUTION BY TRIAL STANDARD LEVEL IN 2020 FOR THE RESIDENTIAL SECTOR

Trial Standard Level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	Total (%)
Integrated Low-Lumen GSLs						
No-New-Standards	3.6	4.7	35.9	31.2	24.7	100
TSL 1	0	6.8	36.9	31.4	24.8	100
TSL 2	0	0	43.8	31.4	24.8	100
TSL 3	0	0	0	48.4	51.6	100
TSL 4	0	0	0	0	100	100
Integrated High-Lumen GSLs						
No-New-Standards	25.8	29.1	45.1			100
TSL 1	0	39.2	60.8			100
TSL 2	0	0	100			100
TSL 3	0	0	100			100
TSL 4	0	0	100			100

TABLE V–13—GSL MARKET EFFICACY DISTRIBUTION BY TRIAL STANDARD LEVEL IN 2020 FOR THE COMMERCIAL SECTOR

Trial standard level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	Total (%)
Integrated Low-Lumen GSLs						
No-New-Standards	1.8	3.7	25.7	36.3	32.6	100
TSL 1	0	4.9	26.1	36.4	32.6	100
TSL 2	0	0	31.0	36.4	32.6	100

[153] Board of Governors of the Federal Reserve System. Survey of Consumer Finances. 1995, 1998, 2001, 2004, 2007, and 2010. (Last accessed June 30, 2015.) *http://www.federalreserve.gov/econresdata/scf/scfindex.htm.*

[154] Damodaran, A. *Cost of Capital by Sector.* January 2014. (Last accessed September 25, 2014.) *http://people.stern.nyu.edu/adamodar/New_Home_Page/datafile/wacc.htm.*

TABLE V–13—GSL MARKET EFFICACY DISTRIBUTION BY TRIAL STANDARD LEVEL IN 2020 FOR THE COMMERCIAL SECTOR—Continued

Trial standard level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	Total (%)
TSL 3	0	0	0	43.7	56.3	100
TSL 4	0	0	0	0	100	100
Integrated High-Lumen GSLs						
No-New-Standards	16.9	23.5	59.6			100
TSL 1	0	28.3	71.7			100
TSL 2	0	0	100			100
TSL 3	0	0	100			100
TSL 4	0	0	100			100
Non-Integrated GSLs						
No-New-Standards	31.9	68.1				100
TSL 1	31.9	68.1				100
TSL 2	31.9	68.1				100
TSL 3	31.9	68.1				100
TSL 4	0	100				100

11. LCC Savings Calculation

In the reference scenario, DOE calculated the LCC savings at each TSL based on the change in LCC for each standards case compared to the no-new-standards case, considering the efficacy distribution of products derived by the shipments analysis. This approach allows consumers to choose more-efficient (and sometimes less expensive) products at higher ELs and is intended to more accurately reflect the impact of a potential standard on consumers.

In response to DOE's assumption that in a standards case consumers are assumed to purchase lamps that are at least as efficient as the ones they would purchase in the absence of standards, ASAP and NEEA expressed agreement while NEMA pointed out the possibility of manufacturers producing lamps with increased color rendering, long life, or other metrics, but lower efficiency in the no-new-standards case. (ASAP, Public Meeting Transcript, No. 29 at pp. 191–192; NEEA, Public Meeting Transcript, No. 29 at p. 192; NEMA, No. 34 at p. 22) Incorporating this could mean more consumers start with less efficient lamps in the no-new-standards case, but NEMA understands the difficulty in predicting future product development and acknowledged that DOE's assumption may be the most reasonable approach. (Id.)

DOE clarifies that the statement ''consumers are assumed to purchase lamps that are at least as efficient as the ones they would purchase in the absence of standards'' was not a constraint applied in determining the fraction of purchases made at each EL; rather, it was an attempt to describe how specific consumers in the LCC sample were assigned to ELs when a standard was assumed to be in place, where the fraction of consumers at each EL under a standard was determined by the consumer-choice model in the shipments analysis.

The consumer-choice model determines the fraction of consumers at each EL under a standard, but cannot track the purchasing decision for individual consumers in the LCC sample. Thus, in order to determine the fraction of consumers who experience a net cost, DOE must make a simplifying assumption to relate purchases for a particular consumer in a standards case and in the no-new-standards case. DOE assumed that the rank order of consumers, in terms of the efficacy of the product they purchase, is the same in the no-new-standards case as in the standards cases. In other words, DOE assumed that the consumers who purchased the most-efficacious products in the efficacy distribution in the no-new-standards case would continue to do so in standards cases, and similarly, those consumers who purchased the least efficacious products in the efficacy distribution in the no-new-standards case would continue to do so in standards cases. This assumption is only relevant in determining the fraction of consumers who experience a net cost in the LCC savings calculation, and has no effect on the estimated national impact of a potential standard. DOE has continued to make this simplifying assumption for the NOPR analysis.

CA IOUs indicated DOE should not assume that all products are barely compliant with the efficacy under consideration; instead, DOE should use a ''shift'' approach to model the likelihood of some consumers voluntarily exceeding the minimum efficiency standard. (CA IOUs, No. 33 at p. 8)

To clarify: In both the preliminary and the NOPR analyses, DOE has presented two sets of results in the LCC analysis per product class. The first set are the ''LCC results'', which represent the average costs a consumer is projected to pay for a product purchased at a particular ELs in the compliance year. These results are not intended to represent the impact of a standard. The second set of results are the ''LCC Savings'', which indicate the average change in LCC that consumers are projected to experience if a standard is set at a particular EL. In order to determine the LCC savings, DOE estimated the change to the efficacy distribution that would result from a standard set at each of the ELs under consideration. To do this DOE used a consumer-choice model, which allows for the possibility of consumers purchasing GSLs that exceed a given minimum efficiency standard under consideration.

For details on the LCC savings calculation, see chapter 8 of the NOPR TSD. For details on the consumer-choice model, see chapter 9 of the NOPR TSD.

12. Payback Period Analysis

The payback period is the amount of time it takes the consumer to recover any additional installed cost of more-efficient products, compared to the baseline product, through energy cost savings. Payback periods are expressed in years. Payback periods that exceed the life of the product mean that the increased total installed cost is not recovered in reduced operating expenses.

The inputs to the PBP calculation for each EL are the change in total installed cost of the product and the change in the first year's annual operating expenditures relative to the baseline product. The PBP calculation uses the same inputs as the LCC analysis, except that discount rates and energy price trends are not needed.

As noted previously, EPCA, as amended, establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii)) For each considered EL, DOE determined the value of the first year's energy savings by calculating the energy savings in accordance with the applicable DOE test procedure, and multiplying those savings by the average energy price forecast for the year in which compliance with the amended standards would be required.

G. Shipments Analysis

DOE uses projections of annual product shipments to calculate the national impacts of potential amended energy conservation standards on energy use, NPV, and future manufacturer cash flows.[155] The shipments model takes an accounting approach, tracking market shares of each product class and the vintage of units in the stock. Stock accounting uses product shipments as inputs to estimate the age distribution of in-service product stocks for all years. The age distribution of in-service product stocks is a key input to calculations of both the NES and NPV, because operating costs for any year depend on the age distribution of the stock.

1. Shipments Model

The shipments model projects shipments of GSLs over a thirty-year analysis period for the no-new-standards case and for all standards cases. Separate shipments projections are calculated for the residential sector and for the commercial and industrial sectors. The shipments model used to estimate GSL lamp shipments for this rulemaking has three main interacting elements: (1) A lamp demand module that estimates the demand for GSL lighting for each year of the analysis period; (2) a price-learning module, which projects future prices based on historic price trends; and (3) a market-share module that assigns shipments to the available lamp options.

a. Lamp Demand Module

The lamp demand module first estimates the national demand for GSLs in each year. The demand calculation assumes that sector-specific lighting capacity (maximum lumen output of installed lamps) remains fixed per square foot of floor space over the analysis period. Floor space changes over the analysis period according to the EIA's *AEO 2015* projections of residential and commercial floor space.[156] A lamp turnover calculation estimates demand for new lamps in each year given the growth of floor space in each year, the historical shipments of lamps in each product class, the expected lifetimes of the lamps, and sector-specific assumptions on operating hours and the distribution of per-lamp lumen output desired by consumers. (The assumed operating hours include the effect of rebound in the standards cases for the alternative scenario that includes rebound.) The lamp demand module also accounts for the adoption of integral LED luminaires into lighting applications traditionally served by GSLs; for the possibility that commercial consumers will transition between the non-integrated and integrated GSL product classes in the future; and for consumers' transitioning between GSILs and CFL or LED GSLs during the analysis period, either spontaneously or due to standards. Further details on the assumptions used to model these market transitions are presented in chapter 9 of the NOPR TSD.

CEC asked DOE to update the shipments analysis to reflect market changes that occurred between the preliminary analysis and the NOPR analyses. (CEC, No. 31 at p. 2). The shipments analysis in this NOPR accounted for shipments that occurred through the first calendar quarter of 2015[157] and utilized inputs from the updated engineering analysis that considered 2015 market conditions. DOE requests relevant data on GSL shipments as they become available in order to improve the accuracy of the shipments analysis (see issue 35 in section VIII.E).

The demand module used in the preliminary analysis required assumptions about the breakdown of integrated GSLs between the Integrated Low-Lumen and Integrated High-Lumen product classes, as well as about the rate of transition between non-integrated and integrated GSLs. NEMA disagreed with DOE's assumption that non-integrated CFL GSLs will remain a constant fraction of the installed GSL stock in the commercial sector, indicating that non-integrated CFL GSLs will be significantly replaced by LEDs over the next 30 years (thereby significantly lowering the market share of non-integrated CFL GSLs). (NEMA, No. 34 at p. 24) General Electric and NEEA agreed with NEMA. (General Electric Lighting, Public Meeting Transcript, No. 29 at p. 224; NEEA, Public Meeting Transcript, No. 29 at pp. 225–226) DOE agrees that non-integrated CFL GSLs will have a shrinking market share during the analysis period for the reasons mentioned by the commenters. In the NOPR analysis, DOE has assumed that no non-integrated GSL systems are installed in new construction or in renovations, with systems removed for renovation being replaced either by integrated GSLs or by integrated LED fixtures. Because of this, the total shipments of integrated GSLs fall monotonically over the analysis period and eventually reach zero.

In the preliminary analysis, DOE assumed that some fraction of residential consumers currently utilizing GSILs will spontaneously adopt CFL or LED GSLs in each year before 2020. As discussed previously, DOE assumes that the EISA backstop provision will take effect in 2020; therefore, all GSL shipments in 2020 and after were assumed to be CFL or LED GSLs.

NEMA agreed that in each year prior to 2020 there will be some shift from incandescent lamps to CFL and LED lamps, as well as some shift from CFL lamps to LED lamps, and that these shifts will be increasing over time. (NEMA, No. 34 at p. 26) However, NEMA did not agree with DOE's assumption that a substantial fraction of the GSL market will shift from incandescent to CFL and LED in 2020, indicating that the dramatic sales increase presented in the preliminary analysis shipments results is an impractical assumption. (Id.) Given the

[155] DOE uses data on manufacturer shipments as a proxy for national sales, as aggregate data on sales are lacking. In general one would expect a close correspondence between shipments and sales.

[156] U.S. Energy Information Administration. *Annual Energy Outlook 2015 with Projections to 2040.* 2015. Washington, DC Report No. DOE/EIA–0383(2015). (Last accessed June 5, 2015.) *http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf.*

[157] National Electrical Manufacturers Association. *Lamp Indices.* (Last accessed July 7, 2015.) *http://www.nema.org/Intelligence/Pages/Lamp-Indices.aspx.*

current, significant gap in efficacy between halogen incandescent lamps and the 45 lm/W efficacy level specified by the EISA 2007 backstop requirement, DOE believes that it is very unlikely that GSILs will be able to meet the EISA backstop requirement. Therefore, if the backstop takes effect in 2020, all remaining GSIL demand will shift out of necessity to CFL and LED GSLs. This NOPR modifies the assumptions about this shift that were utilized in the preliminary analysis by assuming that the shift will take place over a period of several years, rather than occurring largely in 2020, since some GSILs have low HOU, and, accordingly, longer lifetimes. DOE requests comment on the assumption that the shift to CFL and LED GSLs during the shipments analysis period will take place over several years (see issue 36 in section VIII.E). NEMA also requested that DOE consider an alternative scenario in which halogen lamps remain on the market. (NEMA, No. 34 at p. 27) As discussed previously, due to the Appropriations Rider, DOE did not analyze GSILs in this NOPR, and thus did not consider halogen lamps.

b. Price-Learning Module

The price-learning module estimates GSL prices in each year of the analysis period using a standard price-learning model,[158] which relates the price of a given technology to its cumulative production, as represented by total cumulative shipments. DOE applied experience curves to CFL and LED lamps separately according to recent studies on price and shipments trends for these technologies.[159] [160] Current cumulative shipments are determined for each technology at the start of the analysis period and are augmented in each subsequent year of the analysis based on the shipments determined for the prior year. New prices for each technology are calculated from the updated cumulative shipments according to the experience curve for each technology. The current year's shipments, in turn, affect the subsequent year's prices. As shown in chapter 9 of the NOPR TSD, because LED GSLs are a relatively young technology, their cumulative shipments increase rapidly and hence they undergo a substantial price decline during the shipments analysis period. By contrast, since CFL technology is more mature, CFL GSL prices decline by a relatively small amount.

CA IOUs indicated that the prices DOE used in the preliminary analysis for integrated low-lumen lamps at each EL in 2020 are too high. (CA IOUs, No. 33 at p. 5) DOE notes that the prices indicated by CA IOUs in their comment were the 2014 prices DOE used in the preliminary analysis, not the prices DOE projected for 2020. Due to price learning, the 2020 prices DOE used in the preliminary analysis were lower than the 2014 prices CA IOUs based their comment on. Discussion of the 2014 prices can be found in V.D.

Westinghouse Lighting stated that DOE should not assume any price learning for CFL lamps. (Westinghouse Lighting, Public Meeting Transcript, No. 29 at p. 209) The California IOUs suggested DOE account for price learning for all LED representative units considered in the analysis. (California IOUs, Public Meeting Transcript, No. 29 at p. 211) DOE believes that price learning will continue for any technologies on the market that are not obsolete and, further, that CFL GSLs are not an obsolete technology in general. Additionally, DOE believes that all of the LED GSL lamp options considered in this analysis represent lamps with an active presence in the current market. Therefore, DOE has assumed that price learning will occur for all lamp options considered in this NOPR. Further discussion on the price learning DOE applied for the NOPR analysis is in chapter 9 of the NOPR TSD. DOE invites comment on its approach to price learning (see issue 37 in section VIII.E).

The preliminary analysis assumed that there was no minimum price difference between lamps with different lumen outputs at a given EL.[161] Southern Company, NRDC, the California IOUs, Westinghouse Lighting, and NEMA suggested DOE ensure that its analyses assume a difference in the incremental price of LED lamps in different lumen bins (*i.e.,* lamps in higher lumen bins will never have exactly the same price as lamps in lower lumen bins). (Southern Company, Public Meeting Transcript, No. 29 at pp. 213–215; NRDC, Public Meeting Transcript, No. 29 at p. 216; California IOUs, Public Meeting Transcript, No. 29 at p. 217; Westinghouse Lighting, Public Meeting Transcript, No. 29 at pp. 218–219; NEMA, No. 34 at p. 25) DOE agrees that lamps in different lumen bins will continue to have a non-zero price difference. In this NOPR, DOE has assumed that lamps in brighter lumen bins have a fixed fractional price increment relative to lamps in dimmer lumen bins. With this approach, the absolute price difference between lumen bins will decline if lamp prices decline, but the difference will always remain greater than zero. DOE requests comment on the assumption that brighter lumen bins have a fixed fractional price increment relative to lamps in dimmer lumen bins (see issue 39 in section VIII.E).

NEMA commented that high efficiency standards could cause lamp prices to remain constant, as manufacturers are forced to focus more on efficiency than cost reduction; alternatively, NEMA believes that setting a lower efficiency standard would allow manufacturers to pursue cost savings, resulting in increased adoption of efficient GSLs. (NEMA, No. 34 at p. 25) DOE has observed that the prices of LED GSLs have fallen rapidly even as the efficacy of such lamps has improved in recent years. The price trends used in this analysis are based on these recent price declines that have occurred in tandem with increased efficacy. Based on this history, DOE believes that it is possible for efficacy to continue to improve even as prices decline for LED GSLs.

c. Market-Share Module

The market-share module apportions the lamp shipments in each year among the different lamp options developed in the engineering and LCC analyses, based on consumer sensitivity to lamp price, lifetime, energy savings, and mercury content, as measured in a recent market study,[162] as well as on consumer preferences for lighting technology (CFL or LED) as revealed in historical shipments data. The market-share module assumes that, when replacing a lamp, consumers will choose from among all of the available lamp options with a similar lumen output to the lamp being replaced. It also assumes that the distribution of lamp lumen outputs

[158] Taylor, M. and S. K. Fujita. *Accounting for Technological Change in Regulatory Impact Analyses: The Learning Curve Technique.* 2013. Lawrence Berkeley National Laboratory: Berkeley, CA. Report No. LBNL–6195E. (Last accessed June 23, 2015.) *http://eetd.lbl.gov/publications/accounting-for-technological-change-0.*

[159] Gerke, B., A. Ngo, A. Alstone, and K. Fisseha. *The Evolving Price of Household LED Lamps: Recent Trends and Historical Comparisons for the US Market.* 2014. Lawrence Berkeley National Laboratory: Berkeley, CA. Report No. LBNL–6854E. (Last accessed June 15, 2015.) *http://eetd.lbl.gov/publications/the-evolving-price-of-household-led-l.*

[160] Gerke, B. F., A. T. Ngo, and K. S. Fisseha. *Recent Price Trends and Learning Curves for Household LED Lamps from a Regression Analysis of Internet Retail Data.* 2015. Lawrence Berkeley National Laboratory: Berkeley, CA. Report No. LBNL–184075. (Last accessed June 24, 2015.) *http://eetd.lbl.gov/publications/recent-price-trends-and-learning-curv.*

[161] GSL preliminary analysis at 2–87.

[162] Krull, S. and D. Freeman. *Next Generation Light Bulb Optimization.* 2012. Pacific Gas and Electric Company. (Last accessed June 23, 2015.) *http://www.etcc-ca.com/sites/default/files/OLD/images/stories/Lighting_Conjoint_Study_v020712f.pdf.*

demanded for new construction and renovations is the same as the average distribution for all shipments. Substitution matrices were developed to specify the product choices available to consumers depending on the lumen output they require. The available options depend on the case under consideration; in each of the standards cases corresponding to the different TSLs, only those lamp options at or above the particular standard level in each product class are considered to be available. The market-share module also incorporates a limit on the diffusion of LED technology into the market using the widely accepted Bass adoption model,[163] the parameters of which are based on historic penetration rates of new lighting technologies into the market. In this way, the module assigns market shares to the different ELs based on observations of consumer preferences.

Westinghouse Lighting and the Northwest Power and Conservation Council highlighted the inverse relationship between GSL life and cost, indicating that GSL cost is a major driver of adoption. (Westinghouse Lighting, Public Meeting Transcript, No. 29 at p. 35; Northwest Power and Conservation Council, Public Meeting Transcript, No. 29 at p. 37) DOE notes that in the shipments analysis, the market-share module accounts for consumer sensitivity to cost, efficiency, and other metrics (see chapter 9 of the NOPR TSD for more details).

2. Rare Earth Oxides

Rare earth oxides (REOs) are used in CFL GSL phosphors to increase luminous efficacy, so affect CFL prices. Large increases in REO prices in 2010 and 2011 raised manufacturer concerns that future price increases could have adverse impacts on the market. DOE developed shipments scenarios in its preliminary analysis to reflect uncertainties in the prices of REOs. DOE's reference case assumed that REO prices would remain constant at the June 2014, level, but DOE acknowledged the uncertainty about prices and included a scenario with much higher REO prices.

Philips indicated that recent reports are suggesting the prices of REOs may increase, due to China's overwhelming control over their production quantities of REOs. (Philips, Public Meeting Transcript, No. 29 at p. 228) NEMA indicated that an increase in rare earth oxide prices impacts the industry as well as consumers. NEMA also referenced the comments they submitted to the GSFL and IRL standards rulemaking,[164] in which NEMA indicated that rare earth oxide prices are more likely to increase in the future than decrease, and that higher efficiency fluorescent lamps have more rare earth oxide contents (by weight). (NEMA, No. 34 at p. 25)

DOE has monitored the price of REOs since the publication of the preliminary analysis and found that their prices have declined over that time period.[165] Additionally, DOE's data show that the price of REOs remained relatively stable over the last half of 2014 and the first half of 2015. Therefore, DOE has maintained its reference scenario assumption from the preliminary analysis: Rare earth oxide prices remain constant at their June 2014 level. Moreover, because REO prices represent a very small portion of the total price of CFL GSLs, the alternative REO price scenario had a minimal impact on the outcome of the preliminary analyses. For this reason, and because REO prices have been stable or declining for several years, DOE did not analyze a scenario with higher REO prices for this NOPR.

H. National Impact Analysis

The NIA assesses the NES and the national NPV from a national perspective of total consumer costs and savings that would be expected to result from new or amended standards at specific ELs.[166] (''Consumer'' in this context refers to consumers of the product being regulated.) DOE calculates the NES and NPV based on projections of annual product shipments and prices, along with the HOU and energy prices from the energy use and LCC analyses.[167] For the present analysis, DOE projected the energy savings, operating-cost savings, product costs, and NPV of consumer benefits over the lifetime of GSLs sold from 2020 through 2049.

DOE evaluates the impacts of new and amended standards by comparing a case without such standards with standards-case projections. The no-new-standards case characterizes energy use and consumer costs for each analyzed product class in the absence of new or amended energy conservation standards. DOE compares the no-new-standards case with projections characterizing the market for each product class if DOE adopted new or amended standards at specific ELs (*i.e.,* the TSLs or standards cases) for that class. For the standards cases, DOE considers how a given standard would likely affect the market shares of products with efficacies greater than the standard.

DOE uses a spreadsheet model to calculate the energy savings and the national consumer costs and savings from each TSL. Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet. The NIA spreadsheet model uses typical values (as opposed to probability distributions) as inputs.

Table V–14 summarizes the inputs and methods DOE used for the NIA analysis for the NOPR. Discussion of these inputs and methods follows the table. See chapter 10 of the NOPR TSD for further details.

TABLE V–14—SUMMARY OF INPUTS AND METHODS FOR THE NATIONAL IMPACT ANALYSIS

Inputs	Method
Shipments	Annual shipments for each lamp option from shipments model for the no-new standards case and each TSL analyzed.
Assumed compliance date of standard	January 1, 2020.
No-new-standards efficacy distribution	Estimated from market-share module of shipments analysis.
Standards-case efficacy distribution	Estimated by the market-share module of the shipments analysis.
Annual energy use per unit	Calculated for each lamp option based on inputs from the Energy Use Analysis.
Total installed cost per unit	Uses lamp prices, and for the commercial sector only, installation costs from the LCC analysis.

[163] Bass, F. M. A New Product Growth Model for Consumer Durables. *Management Science.* 1969. 15(5): pp. 215–227. (Last accessed June 23, 2015.) *http://pubsonline.informs.org/doi/abs/10.1287/mnsc.15.5.215.*

[164] For all materials related to this GSFL and IRL standards rulemaking, see regulations.gov under docket number EERE–2011–BT–STD–0006.

[165] Metal-Pages. *Historical Prices.* 2015. (Last accessed June 23, 2015.) *http://www.metal-pages.com/.*

[166] The NIA accounts for impacts in the 50 States and the U.S. territories.

[167] For the NIA, DOE adjusts the installed cost data from the LCC analysis to exclude sales tax, which is a transfer.

TABLE V–14—SUMMARY OF INPUTS AND METHODS FOR THE NATIONAL IMPACT ANALYSIS—Continued

Inputs	Method
Electricity prices	Estimated marginal electricity prices from the LCC analysis.
Energy price trends	AEO 2015 forecasts (to 2040) and extrapolation thereafter.
Annual operating cost per unit	Calculated for each lamp option using the energy use per unit, and electricity prices and trends.
Energy Site-to-Primary Conversion	A time-series conversion factor based on AEO 2015.
Discount rate	Three and seven percent real.
Present year	2015.

1. National Energy Savings

The NES analysis involves a comparison of national energy consumption of the considered products in each TSL with consumption in the case with no new or amended energy conservation standards. DOE calculated the annual national energy consumption by multiplying the number of units (stock) of each lamp option (by vintage or age) by the unit energy consumption (also by vintage) for each year in the analysis. The NES is based on the difference in annual national energy consumption for the no-new-standards case and each of the standards cases. DOE estimated the energy consumption and savings based on site energy and converted to the electricity consumption and savings at the power plant using annual conversion factors derived from *AEO 2015.* Cumulative energy savings are the sum of NES for each year over the analysis period, taking into account the full lifetime of lamps shipped in 2049.

DOE accounts for the direct rebound effect in its NES analyses. Direct rebound reflects the idea that as appliances become more efficient, consumers use more of their service because their operating cost is reduced. In the case of lighting, the rebound could be manifested in increased HOU or in increased lighting density (lamps per square foot). In the preliminary analysis DOE assumed no rebound in both the residential and commercial sectors. General Electric and Westinghouse Lighting suggested DOE assume some amount of rebound. (General Electric Lighting, Public Meeting Transcript, No. 29 at pp. 236–237; Westinghouse Lighting, Public Meeting Transcript, No. 29 at pp. 238–239) ASAP and NEEA commented that they do not expect a rebound effect associated with moving from a CFL lamp to an LED lamp. (ASAP, Public Meeting Transcript, No. 29 at p. 241; NEEA, Public Meeting Transcript, No. 29 at p. 241) NEMA expects little to no rebound effect in the commercial sector, but foresees an 8.5 percent to 15 percent rebound effect for LED lamps used in the residential sector. (NEMA, No. 34 at p. 27)

While some commenters believed that some degree of rebound would be expected in moving from incandescent GSLs to more efficacious CFL and LED GSLs, most commenters did not anticipate rebound when moving from CFLs to LED lamps (the case considered by this rulemaking) in the residential sector, and none anticipated rebound in the commercial sector. Due to the relatively small incremental increase in efficacy between CFLs and LED GSLs, DOE did not include any rebound in either the residential or commercial sectors in the reference scenario. Additionally, as discussed in more detail in appendix 10D of the NOPR TSD, examining DOE's 2001 and 2010 U.S. LMC studies [168] [169] indicates that there has been reduction in total lamp operating hours in the residential sector concomitant with increases in lighting efficiency. This operating hour reduction was derived from residential usage of incandescent, fluorescent, HID, and solid state GSL lamps and may be explained by a negative rebound effect or other economic factors such as the recent economic downturn.

The daily operating hours for residential incandescent GSL lamps from both 2001 and 2010 LMC reports indicate that incandescent lamps have lower operating hours, 1.9 hours per day when compared to lamps such as CFLs and LED lamps, which were reported to have usage rates as high at 2.2 hours per day. This could be construed to suggest that a positive rebound may result if a significant portion of the market moves from incandescent GSLs to more efficacious CFL or LED lamps. However, DOE's understanding is that the CFL and LED GSLs are currently preferentially installed in sockets with higher operating hours. NEMA's comments on the preliminary analysis corroborate this point. (NEMA, No. 34 at p. 19) The lower overall hours of use in 2010 suggests no positive rebound on a per-socket basis. Therefore DOE assumed that the overall hours of use for all GSLs when CFLs and LEDs fill all sockets during the analysis period will be the same as the current overall hours of use for all GSLs. DOE did consider an alternative scenario, in which there was 15 percent rebound in the residential sector, to illustrate the impact rebound would have. See appendix 10E of the NOPR TSD.

Consistent with what was stated above for the residential sector, DOE does not expect there to be any rebound effect associated with the commercial sector due to the relatively small incremental increase in efficacy between CFL and LED GSLs. NEMA agreed that rebound is not expected for the commercial sector in its response to the preliminary analysis. (NEMA, No. 34 at p. 27) However, DOE requests comment on the rebound assumptions for both the residential and commercial sectors and any data that can be used to further refine the rebound effect assumptions used in the shipments and NIA analyses (see issue 40 in section VIII.E).

In response to the recommendations of a committee on ''Point-of-Use and Full-Fuel-Cycle Measurement Approaches to Energy Efficiency Standards'' appointed by the National Academy of Sciences, DOE announced its intention to use FFC measures of energy use and greenhouse gas and other emissions in the national impact analyses and emissions analyses included in future energy conservation standards rulemakings. 76 FR 51281 (August 18, 2011). After evaluating the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in which DOE explained its determination that EIA's National Energy Modeling System (NEMS) is the most appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701

[168] Navigant Consulting, Inc. *U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate.* 2002. U.S. Department of Energy. (Last accessed June 10, 2015.) *http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/lmc_vol1.pdf.*

[169] Navigant Consulting, Inc. *Final Report: 2010 U.S. Lighting Market Characterization.* 2012. U.S. Department of Energy. (Last accessed June 10, 2015.) *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.*

(August 17, 2012). NEMS is a public domain, multi-sector, partial equilibrium model of the U.S. energy sector that EIA uses to prepare its *AEO.*[170] The approach used for deriving FFC measures of energy use and emissions is described in appendix 10B of the NOPR TSD.

a. Smart Lamps

Integrated GSLs with standby functionality, henceforth referred to as smart lamps, were not explicitly analyzed in the shipments analysis. To account for the additional energy use due to standby for such lamps in the NIA, DOE assumed that smart lamps would make up an increasing fraction of integrated low-lumen lamps following a Bass adoption curve.

In the preliminary analysis, DOE considered a reference scenario in which penetration of smart lamps increased over the analysis period, reaching 50 percent by the end of the analysis period, as well as alternative scenarios in which the smart-lamp penetration in the residential sector never exceeded 0 percent and reached 100 percent by the end of the analysis period to gauge the impact of smart lamp penetration.[171]

NEMA agreed that the penetration of smart lamps into the residential sector will increase, but did not believe the market share for smart lamps will ever reach 100 percent, as there will always be a market for more basic, lower-cost lamps. (NEMA, No. 34 at p. 27) DOE agrees with NEMA that smart lamps are unlikely to ever achieve 100 percent market share in the residential sector, particularly given the existence of lighting controls that are external to the lamp. In the NOPR analyses, DOE considered three lighting-controls scenarios including a smaller range of penetration for smart lamps: 0 percent smart-lamp penetration in the residential sector by 2049, 50 percent penetration (the reference scenario), and a high residential-controls scenario which assumed that externally controlled sockets increase to 50 percent of all sockets in 2049 in addition to a 50 percent penetration of smart lamps in 2049. DOE invites comment on these scenarios (see issue 42 in section VIII.E).

In the preliminary analysis, DOE assumed that there was no standby power associated with smart lamps.[172] In response to this assumption, Westinghouse Lighting stated that smart lamps must have some associated standby power, otherwise they would not function as intended. (Westinghouse Lighting, Public Meeting Transcript, No. 29 at pp. 239–240) NEEA suggested smart lamps may have standby power on the order of 0.5 watts. (NEEA, Public Meeting Transcript, No. 29 at p. 243) For the NOPR analysis, DOE has estimated that smart lamps have a standby power consumption of 0.5 watts due to the receiver. This estimation was based on the findings from a 4E Electronic Devices & Networks Annex report (hereafter referred to as the ''EDNA report'')[173] as well as the maximum standby power allowed in the ENERGY STAR Luminaires Specification V2.0[174] for luminaires with integral motion sensors, occupancy sensors or photosensors, or connected functionality. Furthermore, DOE attributed an additional 0.33 W of standby power for each smart lamp to account for the power draw of the hub for smart lamps that operate with one. This value is based on data indicating smart-lamp hubs consume approximately 2 W of power on average (from the EDNA report), as well as the assumption that 50 percent of smart lamps operate with a hub and three smart lamps, on average, are connected to each hub.

In the preliminary analysis, DOE assumed smart lamps would achieve the same 30 percent energy savings as lamps under other types of controls. NEEA and Southern Company commented that the enhanced convenience associated with smart lamps, even though the lamps are inherently controlled, means these lamps will not necessarily result in real energy savings. (NEEA, Public Meeting Transcript, No. 29 at pp. 240, 243; Southern Company, Public Meeting Transcript, No. 29 at pp. 242–243) DOE is unaware of any data suggesting how HOU or the impact of controls may differ for smart lamps compared to other GSLs that operate with controls; therefore, for the NOPR analysis DOE continued to assume 30 percent energy savings for smart lamps. DOE requests data and information on the assumption of 30 percent energy savings for smart lamps (see issue 43 in section VIII.E).

2. Net Present Value Analysis

The inputs for determining the NPV of the total costs and benefits experienced by consumers are: (1) Total annual installed cost; (2) total annual savings in operating costs; and (3) a discount factor to calculate the present value of costs and savings. DOE calculates net savings each year as the difference between the no-new-standards case and each standards case in terms of total savings in operating costs versus total increases in installed costs. DOE calculates operating-cost savings over the lifetime of each product shipped during the forecast period.

As discussed in section V.G.1.b of this notice, DOE developed GSL prices using a price-learning module incorporated in the shipments analysis. By 2049, which is the end date of the forecast period, the average LED GSL price is projected to drop 83 percent relative to 2015 and the average price of CFL GSLs is projected to drop 13 percent relative to 2015. DOE's projection of product prices is described in chapter 9 of the NOPR TSD.

The operating-cost savings are primarily energy cost savings, which are calculated using the estimated energy savings in each year and the projected price of electricity. To estimate energy prices in future years, DOE multiplied the average national marginal electricity prices by the forecast of annual national-average residential or commercial electricity price changes in the reference case from *AEO 2015,* which has an end year of 2040. To estimate price trends after 2040, DOE used the average annual rate of change in prices from 2020 to 2040.

To evaluate the impact of the economic assumptions used in the NIA, DOE considered two alternative scenarios; a low benefits scenario and a high benefits scenario. The low benefits scenario uses AEO 2015 Low Economic Growth scenario for energy price trends and floorspace growth, coupled with a high price decline rate for LED GSLs. The high benefits scenario uses AEO 2015 High Economic Growth scenario for energy price trends and floorspace growth, coupled with low price decline rate for LED GSLs. The benefits to consumers from GSL standards are lower if LED GSL prices decline faster because consumers convert to LED GSLs more quickly in the no-new-standards case; conversely, the benefits to consumers from GSL standards are higher if LED GSL prices decline slower because consumers are slow to convert to LED GSLs in the no-new-standards

[170] For more information on NEMS, refer to *The National Energy Modeling System: An Overview,* DOE/EIA–0581 (98) (Feb.1998) (Available at: *http://www.eia.gov/oiaf/aeo/overview/*).

[171] GSL preliminary analysis at 10–7.

[172] *Id.* at 10–8.

[173] *Smart Lamp Testing—Initial Results.* 2014. 4E Electronic Devices & Networks Annex. (Last accessed June 25, 2015.) *http://edna.iea-4e.org/files/otherfiles/0000/0100/Smart_Lights_Paper_for_EDNA_Website_v3.pdf.*

[174] ENERGY STAR. *ENERGY STAR Program Requirements: Product Specification for Luminaires (Light Fixtures): Eligibility Criteria, Version 2.0.* 2015. U.S. Environmental Protection Agency: Washington, DC (Last accessed July 7, 2015.) *https://www.energystar.gov/sites/default/files/Luminaires%20V2.0%20Final%20Specification.pdf.*

case. The high and low price trends are based on the 95-percent confidence interval of the learning rate for LED GSLs from a recent study of LED price trends.[175] DOE invites comments on the high and low benefits scenarios considered in its analysis (see issue 44 in section VIII.E). NIA results for the high and low benefits scenarios are presented in appendix 10E of the NOPR TSD.

In addition to the high and low benefits scenarios, DOE considered several other scenarios in its shipments and NIA analyses. DOE invites comments on whether there are other scenarios that should be considered (see issue 45 in section VIII.E). Results for the alternative scenarios can be found in appendix 10E of the NOPR TSD.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this NOPR, DOE estimated the NPV of consumer benefits using both a 3-percent and a 7-percent real discount rate. DOE uses these discount rates in accordance with guidance provided by the Office of Management and Budget (OMB) to federal agencies on the development of regulatory analysis.[176] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the ''social rate of time preference,'' which is the rate at which society discounts future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended standards on consumers, DOE evaluates the impact on identifiable subgroups of consumers that may be disproportionately affected by a new or amended national standard. DOE evaluates impacts on particular subgroups of consumers by analyzing the LCC impacts and PBP for those particular consumers from alternative standard levels. For this NOPR, DOE analyzed the impacts of the considered standard levels on low-income households and small businesses. DOE requests comment on the consumer subgroups selected for analysis in this NOPR (see issue 46 in section VIII.E). Chapter 11 in the NOPR TSD describes the consumer subgroup analysis.

NEMA stated that low-income consumers will be most affected if low-cost halogen or CFL lamps are no longer available in 2020. (NEMA, No. 34 at p. 27) In the NOPR, DOE analyzed the impacts of amended energy efficiency standards on low-income consumers and small businesses. The results of these analyses can be seen in section VI.B.1.b. DOE found that the average LCC savings and PBPs for low-income households at the considered ELs are not substantially different from the averages for all households.

J. Manufacturer Impact Analysis

1. Overview

DOE conducted an MIA for GSLs to estimate the financial impact of proposed standards on manufacturers of GSLs. The MIA has both quantitative and qualitative aspects. The quantitative part of the MIA relies on the GRIM, an industry cash-flow model customized for the GSLs covered in this rulemaking. The key GRIM inputs are data on the industry cost structure, manufacturer production costs (MPCs), shipments, and assumptions about manufacturer markups, and manufacturer conversion costs. The key MIA output is INPV. The GRIM calculates annual cash flows using standard accounting principles. DOE used the GRIM to compare changes in INPV between a no-new-standards case and various TSLs (the standards cases). The difference in INPV between the no-new-standards case and standards cases represents the financial impact of new and amended energy conservation standards on GSL manufacturers. Different sets of assumptions (scenarios) produce different INPV results. The qualitative part of the MIA addresses factors such as manufacturing capacity; characteristics of, and impacts on, any particular subgroup of manufacturers; the cumulative regulatory burden place on the GSL industry; and any impacts on competition.

DOE conducted the MIA for this rulemaking in three phases. In the first phase, DOE prepared an industry characterization based on the market and technology assessment, preliminary manufacturer interviews, and publicly available information. In the second phase, DOE estimated industry cash flows in the GRIM using industry financial parameters derived in the first phase and the shipment scenarios created in the shipment analysis. In the third phase, DOE conducted interviews with a variety of GSL manufacturers that account for the majority of domestic GSL sales covered by this rulemaking. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics specific to each company and obtained each manufacturer's view of the GSL industry as a whole. The interviews provided information that DOE used to evaluate the impacts of new and amended standards on manufacturers' cash flows, manufacturing capacities, and direct domestic manufacturing employment levels. See section VI.B.2.b of this NOPR for the discussion on the estimated changes in the number of domestic employees involved in manufacturing GSLs covered by standards. See section V.J.4 of this NOPR for a description of the key issues that manufacturers raised during manufacturer interviews.

During the third phase, DOE also used the results of the industry characterization analysis in the first phase and feedback from manufacturer interviews to group manufacturers that exhibit similar production and cost structure characteristics. DOE identified one manufacturer subgroup for a separate manufacturer impact analysis—small businesses. DOE determined that GSL manufacturing falls under the North American Industry Classification System (NAICS) code of 335110, electric lamp bulb and part manufacturing. The Small Business Administration (SBA) defines a small business as having less than 1,000 total employees for manufacturers operating under this NAICS code. This threshold includes all employees in a business' parent company and any other subsidiaries. Based on this classification, DOE identified 41 GSL manufacturers that qualify as small businesses. The complete MIA is presented in chapter 12 of the NOPR TSD, and the analysis required by the Regulatory Flexibility Act, 5 U.S.C. 601, *et seq.*, is presented in section VII.B of this NOPR.

2. GRIM Analysis and Key Inputs

DOE uses the GRIM to quantify the changes in cash flows over time due to new and amended energy conservation standards. These changes in cash flows result in either a higher or lower INPV for the standards cases compared to the no-new-standards case. The GRIM uses a standard annual cash-flow analysis that incorporates MPCs, manufacturer markups, shipments, and industry financial parameters as inputs. It then models changes in MPCs, manufacturer investments, and shipments that result from new and amended energy conservation standards. The GRIM uses these inputs to calculate a series of annual cash flows beginning with the

[175] Gerke, et al. (2015), op. cit.

[176] United States Office of Management and Budget. Circular A–4: Regulatory Analysis,'' (Sept. 17, 2003), section E (Available at: *www.whitehouse.gov/omb/memoranda/m03-21.html*).

reference year of the analysis, 2015, and continuing to 2049. DOE computes INPV by summing the stream of annual discounted cash flows during the analysis period. DOE used a real discount rate of 6.1 percent for GSL manufacturers. This initial discount rate estimate was derived from industry corporate annual reports to the Securities and Exchange Commission (SEC 10-Ks). During manufacturer interviews, GSL manufacturers were asked to provide feedback on this discount rate. Most GSL manufacturers agreed that a 6.1 percent discount rate accurately reflected their typical rate of return on their investments.

Many inputs into the GRIM come from the engineering analysis, the shipment analysis, manufacturer interviews, and other research conducted during the MIA. The major GRIM inputs are described in detail in the following sections.

a. Capital and Product Conversion Costs

DOE expects new and amended energy conservation standards to cause manufacturers to incur conversion costs by bringing their tooling and product designs into compliance with new and amended standards. For the MIA, DOE classified these conversion costs into two major groups: (1) Capital conversion costs and (2) product conversion costs. Capital conversion costs are investments in property, plant, and equipment necessary to adapt, change, or expand existing tooling equipment such that new product designs can be fabricated and assembled. Product conversion costs are investments in research, development, testing, marketing, certification, and other non-capitalized costs necessary to make product designs comply with new and amended standards.

Using feedback from manufacturer interviews, DOE conducted a bottom-up analysis to calculate the capital and product conversion costs for GSL manufacturers for each product class at each EL. To conduct this bottom-up analysis, DOE used manufacturer input from manufacturer interviews regarding the types and dollar amounts of discrete capital and product expenditures that would be necessary to convert specific production lines and product designs for each GSL product class at each EL. Manufacturers frequently provided a range of potential conversion costs for each product class at each EL. DOE used this range to create a high and low conversion cost investment scenario due to the uncertainty of these costs across the entire industry. Each conversion cost investment scenario leads to different levels of investment by manufacturers, which, when used in the discounted cash flow model, results in varying free cash flow impacts on GSL manufacturers.

For ELs that can be met with CFLs, DOE assumed that capital conversion costs would be limited to tooling costs, since manufacturers would not need to significantly alter the production equipment used to product more efficacious CFLs. For ELs that require LED lamps, DOE assumed manufacturers would incur larger capital conversion costs since GSL manufacturers would need to make investments in production equipment to further expand their LED lamp manufacturing capacity to meet expected market demand for these products. Product conversion costs at all efficacy levels are based on the number of models that would require redesign, retesting, and recertification due to standards.

In addition to calculating the conversion costs manufacturers would be required to make at each efficacy level, DOE also estimated the capital and product conversion costs GSL manufacturers would have to make due to the implementation of the minimum 45 lm/W backstop stipulated in EISA 2007 in the no-new-standards case. It is assumed GSL manufacturers would be required to make these investments regardless of whether DOE proposes and ultimately sets further GSL standards as a result of this rulemaking. Therefore, these conversion costs caused by the EISA 2007 backstop are included in the no-new-standards case. Conversion costs at higher standards analyzed by this rulemaking are in addition to these no-new-standards case conversion costs.

Once DOE compiled capital and product conversion costs, DOE took average values (*i.e.,* average number of hours or average dollar amounts) based on the range of responses given by manufacturers for each type of capital and product conversion cost at each EL. See chapter 12 of the NOPR TSD for a complete description of DOE's assumptions for the capital and product conversion costs and section VI.B.2.a of this NOPR for the capital and product conversion costs estimates for each TSL.

b. Manufacturer Production Costs

Manufacturing more efficacious GSLs can result in changes in MPCs as a result of varying components and technology types required to meet ELs at each TSL. Changes in MPCs for these more efficacious components can impact the revenue, gross margin, and the cash flows of GSL manufacturers. Typically, DOE develops MPCs for the covered products using reverse-engineering. These costs are used as an input to the LCC analysis and NIA. However, because lamps are difficult to reverse-engineer, DOE directly derived end-user prices and then used those prices in conjunction with average distribution chain markups and manufacturer markups to calculate the MPCs of GSLs.

To determine MPCs of GSLs from the end-user prices, DOE divided the end-user price by the average distribution chain markup and then again by the average manufacturer markup of the representative GSLs at each EL. DOE determined the manufacturer markup by examining the SEC 10-Ks of all publicly traded GSL manufacturers to estimate an average GSL manufacturer markup of 1.55. DOE determined the distribution chain markup by examining the SEC 10–Ks of the major lighting retail manufacturers to estimate a distribution chain markup of 1.52 for all GSLs. Feedback from manufacturer interviews and previous lighting rulemakings (*i.e.,* GSFL and IRL standards rulemaking and CFLK rulemaking) indicated that the respective markups were appropriate for the GSL industry.

DOE requests comment on the use of 1.52 as an average distribution chain markup and 1.55 manufacturer markup for all GSLs. For a complete description of end-user prices, see the product price determination in section V.D of this NOPR.

c. Shipment Scenarios

INPV, which is the key GRIM output, depends on industry revenue, which depends on the quantity and prices of GSLs shipped in each year of the analysis period. Industry revenue calculations require forecasts of: (1) Total annual shipment volume of GSLs; (2) the distribution of shipments across product classes (because prices vary by product class); and, (3) the distribution of shipments across ELs (because prices vary with lamp efficacy).

DOE developed a consumer-choice-based model to estimate shipments of GSLs. The model projects consumer purchases (and hence shipments) based on sector-specific consumer sensitivities to first cost, energy savings, lamp lifetime, and lamp mercury content. For a complete description of the shipments, see the shipments analysis discussion in section V.G of this NOPR.

d. Markup Scenarios

As discussed in the previous manufacturer production costs section, the MPCs for GSLs are the manufacturers' costs for those units. These costs include materials, labor, depreciation, and overhead, which are collectively referred to as the cost of goods sold (COGS). The MSP is the price received by GSL manufacturers from their consumers, typically a distributor, regardless of the downstream distribution channel through which the GSLs are ultimately sold. The MSP is not the cost the end-user pays for GSLs because there are typically multiple sales along the distribution chain and various markups applied to each sale. The MSP equals the MPC multiplied by the manufacturer markup. The manufacturer markup covers all the GSL manufacturer's non-production costs (*i.e.,* selling, general and administrative expenses (SG&A); research and development (R&D); interest) as well as profit. Total industry revenue for GSL manufacturers equals the MSPs at each EL multiplied by the number of shipments at that EL.

DOE only modeled one markup scenario, the preservation of gross margin markup scenario, for the MIA. DOE chose not to model additional manufacturer markup scenarios, since there are already significant market transformations taking place due to the implementation of the EISA 2007 backstop, which is included in the no-new-standards case. DOE finds that higher efficacy standards analyzed in the standards cases, above 45 lm/W, would not significantly alter the manufacturer markup modeled in the no-new-standards case for the GSL market.

The preservation of gross margin markup scenario assumes that the COGS for each product is marked up by a fixed percentage to cover SG&A expenses, R&D expenses, interest expenses, and profit. This allows manufacturers to preserve the same gross margin percentage in the standards cases as in the no-new-standards case. In this markup scenario GSL manufacturers are able to fully pass any additional MPC increase due to standards to their consumers.

To derive the preservation of gross margin markup percentages for GSLs, DOE examined the SEC 10-Ks of all publicly traded GSL manufacturers to estimate the industry average gross margin percentage. Manufacturers were then asked to verify the industry gross margin percentage derived from SEC 10–Ks during manufacturer interviews.

3. Discussion of Comments

During the January 2015 public meeting, interested parties commented on the assumptions and results of the preliminary analysis. These issues included, manufacturer investments, manufacturer subgroups, and ancillary benefits of specific standards.

NEMA stated that regulatory actions that force manufacturers to make incremental investments in mature lighting products that generate only modest energy-saving benefits can make it more difficult for manufacturers to invest in LED lamps. NEMA said it is unlikely that GSL manufacturers would invest in these more mature technologies. NEMA continued saying that mandatory investment in mature lighting technologies can hinder competition and competitiveness. (NEMA, No. 34 at p. 29) DOE understands that the majority of GSL manufacturers are focusing their investments and R&D on LED lamps and are unlikely to make significant investments in CFLs.

DOE acknowledges that for the Integrated High-Lumen and Non-Integrated product classes, any standards proposed for those product classes would require investments in CFL production from GSL manufacturers in order to comply with any potential standards set for those product classes. Since DOE is not proposing standards for the Non-Integrated product class, manufacturers would not be required to make any investments in that product class. DOE also recognizes the opportunity cost associated with any investment in CFLs, and agrees that manufacturers would need to spend capital on their CFL production for the Integrated High-Lumen product class to meet the proposed standards for that product class that they would not have to spend in the no-new-standards case. As a result, manufacturers must determine the extent to which they will balance investment in CFL technologies with investment in LED lamp technologies. GSL manufacturers will have to weigh trade-offs between abandoning CFL production and deploying additional capital to those technologies. DOE also acknowledges that manufacturers will have to make large investments to significantly expand their LED product offerings and production volumes for the Integrated Low-Lumen product class as a result of the proposed standards for this product class. These large investments could significantly strain manufacturers' free cash flow in the years leading up to the effective date of this rulemaking. See section VI.C.1 for a discussion of the benefits and burdens of the proposed TSL.

NRDC commented during the preliminary analysis public meeting that DOE should reach out to a variety of GSL manufacturers, including GSL manufacturers that only make LED lamps and GSL manufacturers that have a large percentage of the CFL market when conducting manufacturer interviews and developing the manufacturer subgroup analysis. (NRDC, Public Meeting Transcript, No. 29 at p. 250) DOE reached out to a variety of GSL manufacturers including manufacturers that exclusively sell LED lamps and manufacturers that have a large share of the CFL market when conducting manufacturer interviews for this NOPR analysis. Non-disclosure agreements (NDAs) were used when conducting these manufacturer interviews, which also cover which manufacturers agreed to participate. DOE was able to interview every GSL manufacturer that expressed a desire to be interviewed for this NOPR analysis.

DOE did not conduct a separate manufacturer subgroup analysis based on the types of GSL technologies that manufacturers produce. Based on DOE market research, DOE was not able to find any GSL manufacturer covered by this rulemaking whose GSL portfolio did not include LED lamps. DOE also did not analyze GSL manufacturers that only produce LED lamps as a separate manufacturer subgroup from GSL manufacturers that produce both LED lamps and CFLs, because manufacturers that only produce LED lamps would not be disproportionally negatively impacted by GSL standards compared to GSL manufacturers that produce both LED lamps and CFLs. DOE only identified one manufacturer subgroup that could be disproportionally impacted by potential standards: small businesses.

During the public meeting, NEEA questioned if the MIA, and specifically the employment impact analysis, would consider some of the potential benefits of standards on the ancillary enabling technology manufacturers associated with more efficacious lighting technologies. (NEEA, Public Meeting Transcript, No. 29 at p. 253) DOE has determined that the MIA, and domestic employment impact analysis, will only examine the direct impacts on GSL manufacturers. DOE will not include any potential ancillary benefits in industries not primarily involved in GSL manufacturing as part of the MIA. Typically, DOE does not examine other manufacturing industries that are not primarily involved in manufacturing of the covered products due to the speculative nature of the potential impacts on those industries.

4. Manufacturer Interviews

DOE conducted additional interviews with manufacturers following the preliminary analysis as part of this NOPR analysis. In these interviews, DOE asked manufacturers to describe their major concerns with this GSL rulemaking. Manufacturers identified two major areas of concern: (1) Testing burden and (2) impacts of technology-neutral standards.

a. Testing Burden

Several manufacturers expressed concern over the testing burden associated with GSL energy conservation standards. Manufacturers expressed concern regarding new testing requirements for LED lamps and expanded scope of CFLs to comply with GSL standards. Instead of spending capital on R&D that could result in an increase in energy savings from these lamps, manufacturers stated that they would need to spend capital on testing and certifying already efficacious lamps to demonstrate compliance with GSL standards. Additionally, manufacturers claimed that standards covering LED lamps could present a barrier to entry for small LED lamp manufacturers due to the increase in testing and certification requirements caused by GSL standards. Manufacturers claim this could result in a potential decrease of product innovation and energy-saving potential for LED lamps.

DOE notes that both large and small LED lamp manufacturers would have to test and certify their products regardless of the standards set for this rulemaking due to the EISA 2007 mandate of 45 lm/W for all GSLs effective January 1, 2020. (42 U.S.C. 6295(i)(6)(A)(v)) Furthermore, DOE performed a separate MIA analysis for small business subgroups to analyze the financial impacts due to the increase in testing and certification requirements. Further discussion on the impacts to small businesses can be found in section VII.B.

b. Impacts of Technology-Neutral Standards

Manufacturers are concerned that technology-neutral standards for GSLs could have a disproportionate effect on the range of technologies covered by standards. If GSL standards are set at the highest ELs, manufacturers are concerned that they may experience a loss of product differentiation among their lighting offerings. Manufacturers claim that as premium products become the baseline offering to consumers, previously offered advantages in lighting utility could be eliminated in an attempt to meet these higher standards. DOE grouped CFLs and LED lamps in the same product classes for this NOPR analysis. The criteria used to create the product classes used in this analysis are discussed in more detail in section V.A.1 of this NOPR.

Several manufacturers also stated they are concerned that GSL standards could be set at unattainable ELs for CFLs. If CFLs are regulated out of the market, it could force CFL manufacturers to either make significant investments in converting their production lines to other lighting technologies, and cause them to incur a significant loss on the stranded assets associated with their existing CFL production, or exit the GSL lighting market altogether. Lastly, manufacturers claim that setting GSL standards at ELs that cannot be attained by CFLs would remove product utility from the market as consumers still value CFLs for certain applications and derive utility from these products due to their lower first cost.

DOE acknowledges that the proposed standards set for the Integrated Low-Lumen product class would eliminate CFLs from the market place. This would cause manufacturers to incur substantial capital and product conversion costs to significantly expand their LED product offerings and production volumes to replace their wide range of non-compliant CFLs product offerings and sales. The methodology for these manufacturer conversion costs are discussed in detail in section V.J.2.a and the values used for each TSL are displayed in section VI.B.2.a.

K. Emissions Analysis

The emissions analysis consists of two components. The first component estimates the effect of potential energy conservation standards on power sector and site (where applicable) combustion emissions of CO_2, NO_X, SO_2, and Hg. The second component estimates the impacts of potential standards on emissions of two additional greenhouse gases, CH_4 and N_2O, as well as the reductions to emissions of all species due to ''upstream'' activities in the fuel production chain. These upstream activities comprise extraction, processing, and transporting fuels to the site of combustion. The associated emissions are referred to as upstream emissions.

The analysis of power sector emissions uses marginal emissions factors that were derived from data in *AEO 2015,* as described in section V.M. The methodology is described in chapter 13 and chapter 15 of the NOPR TSD.

Combustion emissions of CH_4 and N_2O are estimated using emissions intensity factors published by the EPA, GHG Emissions Factors Hub.[177] The FFC upstream emissions are estimated based on the methodology described in chapter 15 of the NOPR TSD. The upstream emissions include both emissions from fuel combustion during extraction, processing, and transportation of fuel, and ''fugitive'' emissions (direct leakage to the atmosphere) of CH_4 and CO_2.

The emissions intensity factors are expressed in terms of physical units per MWh or MMBtu of site energy savings. Total emissions reductions are estimated using the energy savings calculated in the NIA.

For CH_4 and N_2O, DOE calculated emissions reduction in tons and also in terms of units of carbon dioxide equivalent (CO_2eq). Gases are converted to CO_2eq by multiplying each ton of gas by the gas' global warming potential (GWP) over a 100-year time horizon. Based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,[178] DOE used GWP values of 28 for CH_4 and 265 for N_2O.

The *AEO* incorporate the projected impacts of existing air quality regulations on emissions. *AEO 2015* generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of October 31, 2014. DOE's estimation of impacts accounts for the presence of the emissions control programs discussed in the following paragraphs.

SO_2 emissions from affected electric generating units (EGUs) are subject to nationwide and regional emissions cap-and-trade programs. Title IV of the Clean Air Act sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous States and the District of Columbia (DC). (42 U.S.C. 7651 *et seq.*) SO_2 emissions from 28 eastern states and DC were also limited under the Clean Air Interstate Rule (CAIR). 70 FR 25162 (May 12, 2005). CAIR created an allowance-based trading program that operates along with the Title IV program. In 2008, CAIR was remanded to EPA by the U.S. Court of Appeals for the District of Columbia Circuit, but it remained in effect.[179] In 2011, EPA

[177] Available at: *http://www.epa.gov/climateleadership/inventory/ghg-emissions.html.*

[178] Intergovernmental Panel on Climate Change. Chapter 8: Anthropogenic and Natural Radiative Forcing. In *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* T. F. Stocker, D. Qin, G.-K. Plattner, M. M. B. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley, Editors. 2013. Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA. (Last accessed June 22, 2015.) *http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf.*

[179] See *North Carolina* v. *EPA,* 550 F.3d 1176 (D.C. Cir. 2008); *North Carolina* v. *EPA,* 531 F.3d 896 (D.C. Cir. 2008).

issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (August 8, 2011). On August 21, 2012, the D.C. Circuit issued a decision to vacate CSAPR,[180] and the court ordered EPA to continue administering CAIR. On April 29, 2014, the U.S. Supreme Court reversed the judgment of the D.C. Circuit and remanded the case for further proceedings consistent with the Supreme Court's opinion.[181] On October 23, 2014, the D.C. Circuit lifted the stay of CSAPR.[182] Pursuant to this action, CSAPR went into effect (and CAIR ceased to be in effect) as of January 1, 2015.

EIA was not able to incorporate CSAPR into *AEO 2015,* so it assumes implementation of CAIR. Although DOE's analysis used emissions factors that assume that CAIR, not CSAPR, is the regulation in force, the difference between CAIR and CSAPR is not relevant for the purpose of DOE's analysis of emissions impacts from energy conservation standards.

The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. Under existing EPA regulations, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the adoption of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by any regulated EGU. In past rulemakings, DOE recognized that there was uncertainty about the effects of efficiency standards on SO_2 emissions covered by the existing cap-and-trade system, but it concluded that negligible reductions in power sector SO_2 emissions would occur as a result of standards.

Beginning in 2016, however, SO_2 emissions will fall as a result of the Mercury and Air Toxics Standards (MATS) for power plants. 77 FR 9304 (Feb. 16, 2012). In the MATS rule, EPA established a standard for hydrogen chloride as a surrogate for acid gas hazardous air pollutants (HAP), and also established a standard for SO_2 (a non-HAP acid gas) as an alternative equivalent surrogate standard for acid gas HAP. The same controls are used to reduce HAP and non-HAP acid gas; thus, SO_2 emissions will be reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. *AEO 2015* assumes that, in order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed by 2016. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Under the MATS, emissions will be far below the cap established by CAIR, so it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by any regulated EGU.[183] Therefore, DOE believes that energy conservation standards will generally reduce SO_2 emissions in 2016 and beyond.

CAIR established a cap on NO_X emissions in 28 eastern States and the District of Columbia.[184] Energy conservation standards are expected to have little effect on NO_X emissions in those states covered by CAIR because excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions from other facilities. However, standards would be expected to reduce NO_X emissions in the states not affected by the caps, so DOE estimated NO_X emissions reductions from the standards considered in this NOPR for these states.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would likely reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO 2015,* which incorporates the MATS. DOE requests comment on its approach to conducting the emissions analysis for GSLs (see issue 47 in section VIII.E).

L. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this proposed rule, DOE considered the estimated monetary benefits from the reduced emissions of CO_2 and NO_X that are expected to result from each of the TSLs considered. To make this calculation analogous to the calculation of the NPV of consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of products shipped in the forecast period for each TSL. This section summarizes the basis for the monetary values used for each of these emissions and presents the values considered in this NOPR.

For this NOPR, DOE relied on a set of values for the SCC that was developed by a federal interagency process. The basis for these values is summarized in the next section, and a more detailed description of the methodologies used is provided in appendices 14A and 14B of the NOPR TSD. DOE invites input on its approach to estimating monetary benefits associated with emissions reductions (see issue 52 in section VIII.E).

1. Social Cost of Carbon

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) climate-change-related changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. Estimates of the SCC are provided in dollars per metric ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in CO_2 emissions, while a global SCC value is meant to reflect the value of damages worldwide.

Under section 1(b) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), agencies must, to the extent permitted by law, ''assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs.'' The purpose of the SCC estimates presented here is to allow agencies to incorporate the monetized social benefits of reducing CO_2 emissions into cost-benefit analyses of regulatory actions. The estimates are presented with an acknowledgement of the many

---

[180] See *EME Homer City Generation, LP* v. *EPA,* 696 F.3d 7, 38 (D.C. Cir. 2012), *cert. granted,* 81 U.S.L.W. 3567, 81 U.S.L.W. 3696, 81 U.S.L.W. 3702 (U.S. June 24, 2013) (No. 12–1182).

[181] *See EPA* v. *EME Homer City Generation,* 134 S.Ct. 1584, 1610 (U.S. 2014). The Supreme Court held in part that EPA's methodology for quantifying emissions that must be eliminated in certain States due to their impacts in other downwind States was based on a permissible, workable, and equitable interpretation of the Clean Air Act provision that provides statutory authority for CSAPR.

[182] *See Georgia* v. *EPA,* Order *(D.C. Cir. filed October 23, 2014)* (*No. 11–1302).*

[183] DOE notes that the Supreme Court recently remanded EPA's 2012 rule regarding national emission standards for hazardous air pollutants from certain electric utility steam generating units. See *Michigan* v. *EPA* (Case No. 14–46, 2015). DOE has tentatively determined that the remand of the MATS rule does not change the assumptions regarding the impact of energy efficiency standards on SO_2 emissions. Further, while the remand of the MATS rule may have an impact on the overall amount of mercury emitted by power plants, it does not change the impact of the energy efficiency standards on mercury emissions. DOE will continue to monitor developments related to this case and respond to them as appropriate.

[184] CSAPR also applies to NO_X and it would supersede the regulation of NO_X under CAIR. As stated previously, the current analysis assumes that CAIR, not CSAPR, is the regulation in force. The difference between CAIR and CSAPR with regard to DOE's analysis of NO_X emissions is slight.

uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

As part of the interagency process that developed these SCC estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of CO_2 emissions, the analyst faces a number of challenges. A report from the National Research Council [185] points out that any assessment will suffer from uncertainty, speculation, and lack of information about: (1) Future emissions of GHGs; (2) the effects of past and future emissions on the climate system; (3) the impact of changes in climate on the physical and biological environment; and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise questions of science, economics, and ethics and should be viewed as provisional.

Despite the limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing CO_2 emissions. The agency can estimate the benefits from reduced (or costs from increased) emissions in any future year by multiplying the change in emissions in that year by the SCC values appropriate for that year. The NPV of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. In the meantime, the interagency group will continue to explore the issues raised by this analysis and consider public comments as part of the ongoing interagency process.

b. Development of Social Cost of Carbon Values

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across federal agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted. The outcome of the preliminary assessment by the interagency group was a set of five interim values: global SCC estimates for 2007 (in 2006$) of $55, $33, $19, $10, and $5 per metric ton of CO_2. These interim values represented the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules.

c. Current Approach and Key Assumptions

After the release of the interim values, the interagency group reconvened on a regular basis to generate improved SCC estimates. Specially, the group considered public comments and further explored the technical literature in relevant fields. The interagency group relied on three integrated assessment models commonly used to estimate the SCC: the FUND, DICE, and PAGE models. These models are frequently cited in the peer-reviewed literature and were used in the last assessment of the Intergovernmental Panel on Climate Change (IPCC). Each model was given equal weight in the SCC values that were developed.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. A key objective of the interagency process was to enable a consistent exploration of the three models, while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments.

In 2010, the interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth set, which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, was included to represent higher-than-expected impacts from climate change further out in the tails of the SCC distribution. The values grow in real terms over time. Additionally, the interagency group determined that a range of values from 7 percent to 23 percent should be used to adjust the global SCC to calculate domestic effects,[186] although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table V–15 presents the values in the 2010 interagency group report,[187] which is reproduced in appendix 14A of the NOPR TSD.

[185] National Research Council, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use,* National Academies Press: Washington, DC (2009).

[186] It is recognized that this calculation for domestic values is approximate, provisional, and highly speculative. There is no *a priori* reason why domestic benefits should be a constant fraction of net global damages over time.

[187] *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government (February 2010) (Available at: *www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf*).

TABLE V–15—ANNUAL SCC VALUES FROM 2010 INTERAGENCY REPORT, 2010–2050

[2007$ per metric ton CO_2]

Year	Discount rate 5% Average	3% Average	2.5% Average	3% 95th percentile
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC values used for this notice were generated using the most recent versions of the three integrated assessment models that have been published in the peer-reviewed literature, as described in the 2013 update from the interagency working group (revised July 2015).[188] Table V–16 shows the updated sets of SCC estimates from the latest interagency update in 5-year increments from 2010 to 2050. The full set of annual SCC values between 2010 and 2050 is reported in appendix 14B of the NOPR TSD. The central value that emerges is the average SCC across models at the 3-percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance of including all four sets of SCC values.

TABLE V–16—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE (REVISED JULY 2015), 2010–2050

[2007$ per metric ton CO_2]

Year	Discount rate 5% Average	3% Average	2.5% Average	3% 95th percentile
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable because they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Research Council report mentioned previously points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. There are a number of analytical challenges that are being addressed by the research community, including research programs housed in many of the federal agencies participating in the interagency process to estimate the SCC. The interagency group intends to periodically review and reconsider those estimates to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling.

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions, DOE used the values from the 2013 interagency report (revised July 2015), adjusted to 2014$ using the implicit price deflator for gross domestic product (GDP) from the Bureau of Economic Analysis. For each of the four sets of SCC cases specified, the values for emissions in 2015 were $12.2, $40.0, $62.3, and $117 per metric ton avoided (values expressed in 2014$). DOE derived values after 2050 using the relevant growth rates for the 2040–2050 period in the interagency update.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SCC value for that year in each of the four cases. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the four cases using the specific discount rate that had been used to obtain the SCC values in each case.

2. Social Cost of Other Air Pollutants

As noted previously, DOE has estimated how the considered energy conservation standards would reduce site NO_X emissions nationwide and

[188] *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* Interagency Working Group on Social Cost of Carbon, United States Government (May 2013; revised July 2015) (Available at: *http://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.*

decrease power sector NO_X emissions in those 22 States not affected by the CAIR.

DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, ''Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,'' published in June 2014 by EPA's Office of Air Quality Planning and Standards. The report includes high and low values for NO_X (as $PM_{2.5}$) for 2020, 2025, and 2030 discounted at 3 percent and 7 percent,[189] which are presented in chapter 14 of the NOPR TSD. DOE assigned values for 2021–2024 and 2026–2029 using, respectively, the values for 2020 and 2025. DOE assigned values after 2030 using the value for 2030.

DOE multiplied the emissions reduction (tons) in each year by the associated $/ton values, and then discounted each series using discount rates of 3 percent and 7 percent as appropriate. DOE will continue to evaluate the monetization of avoided NO_X emissions and will make any appropriate updates of the current analysis for the final rulemaking.

DOE is evaluating appropriate monetization of avoided SO_2 and Hg emissions in energy conservation standards rulemakings. DOE has not included monetization of those emissions in the current analysis.

NEMA stated that because of the uncertainty in modeling the value of emissions reductions, DOE should use manufacturer impacts, consumer impacts, employment impacts, energy savings, and competition as the sole metrics for justifying an energy efficiency standard. (NEMA, No. 34 at p. 28) DOE acknowledges that there is uncertainty regarding the value of emissions reductions, and it uses a wide range of SCC values to estimate the value of CO_2 emissions reductions. Regarding the inclusion of emissions impacts, the need for national energy and water conservation is one of the factors that DOE must evaluate in determining whether a potential energy conservation standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(VI)) Given the threats posed by global climate change to the economy, public health, and national security, combined with the well-recognized potential of many energy conservation measures to reduce emissions of greenhouse gases, DOE believes that evaluation of the potential benefits from slowing anthropogenic climate change must be part of the consideration of the need for national energy conservation.

M. Utility Impact Analysis

The utility impact analysis estimates several effects on the electric power industry that would result from the adoption of new or amended energy conservation standards. The utility impact analysis estimates the changes in installed electrical capacity and generation that would result for each TSL. The analysis is based on published output from the NEMS associated with *AEO 2015.* NEMS produces the *AEO* reference case, as well as a number of side cases that estimate the economy-wide impacts of changes to energy supply and demand. DOE uses published side cases to estimate the marginal impacts of reduced energy demand on the utility sector. These marginal factors are estimated based on the changes to electricity sector generation, installed capacity, fuel consumption and emissions in the *AEO* reference case and various side cases. Details of the methodology are provided in the appendices to Chapters 13 and 15 of the NOPR TSD.

The output of this analysis is a set of time-dependent coefficients that capture the change in electricity generation, primary fuel consumption, installed capacity and power sector emissions due to a unit reduction in demand for a given end use. These coefficients are multiplied by the stream of electricity savings calculated in the NIA to provide estimates of selected utility impacts of new or amended energy conservation standards. DOE seeks comment on its approach to conducting the utility impact analysis (see issue 53 in section VIII.E).

N. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a proposed standard. Employment impacts from new or amended energy conservation standards include both direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the products subject to standards, their suppliers, and related service firms. The MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, caused by: (1) Reduced spending by end users on energy; (2) reduced spending on new energy supply by the utility industry; (3) increased consumer spending on new products to which the new standards apply; and (4) the effects of those three factors throughout the economy.

One method for assessing the possible effects on the demand for labor of such shifts in economic activity is to compare sector employment statistics developed by the Labor Department's Bureau of Labor Statistics (BLS).[190] BLS regularly publishes its estimates of the number of jobs per million dollars of economic activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. Data from BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.[191] There are many reasons for these differences, including wage differences and the fact that the utility sector is more capital-intensive and less labor-intensive than other sectors. Energy conservation standards have the effect of reducing consumer utility bills. Because reduced consumer expenditures for energy likely lead to increased expenditures in other sectors of the economy, the general effect of efficiency standards is to shift economic activity from a less labor-intensive sector (*i.e.,* the utility sector) to more labor-intensive sectors (*e.g.,* the retail and service sectors). Thus, based on the BLS data alone, DOE believes net national employment may increase due to shifts in economic activity resulting from energy conservation standards.

DOE estimated indirect national employment impacts for the standard levels considered in this NOPR using an input/output model of the U.S. economy

[189] For the monetized NO_X benefits associated with $PM_{2.5}$, the related benefits (derived from benefit-per-ton values) are based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009), which is the lower of the two EPA central tendencies. Using the lower value is more conservative when making the policy decision concerning whether a particular standard level is economically justified so using the higher value would also be justified. If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2012), the values would be nearly two-and-a-half times larger. (See chapter 14 of the NOPR TSD for further description of the studies mentioned above.)

[190] Data on industry employment, hours, labor compensation, value of production, and the implicit price deflator for output for these industries are available upon request by calling the Division of Industry Productivity Studies (202–691–5618) or by sending a request by email to *dipsweb@bls.gov.*

[191] U.S. Department of Commerce: Bureau of Economic Analysis. *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II).* 1992. U.S. Government Printing Office: Washington, DC (Last accessed June 22, 2015.) *https://ia801602.us.archive.org/5/items/regionalmultipl00unit/regionalmultipl00unit.pdf.*

called Impact of Sector Energy Technologies Version 3.1.1 (ImSET).[192] ImSET is a special-purpose version of the ''U.S. Benchmark National Input-Output'' (I–O) model, which was designed to estimate the national employment and income effects of energy-saving technologies. The ImSET software includes a computer-based I–O model having structural coefficients that characterize economic flows among 187 sectors most relevant to industrial, commercial, and residential building energy use.

DOE notes that ImSET is not a general equilibrium forecasting model, and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may overestimate actual job impacts over the long run for this rule. Therefore, DOE generated results for near-term timeframes, where these uncertainties are reduced. DOE welcomes input on its approach to assessing national employment impacts (see issue 54 in section VIII.E). For more details on the employment impact analysis, see chapter 16 of the NOPR TSD.

VI. Analytical Results and Conclusions

The following section addresses the results from DOE's analyses with respect to the considered energy conservation standards for GSLs. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for GSLs, and the standards levels that DOE is proposing to adopt in this NOPR. Additional details regarding DOE's analyses are contained in the NOPR TSD supporting this notice.

A. Trial Standard Levels

DOE analyzed the benefits and burdens of four TSLs for GSLs. These TSLs were developed by combining specific ELs for each of the product classes analyzed by DOE. DOE presents the results for the TSLs in this document, while the results for all efficacy levels that DOE analyzed are in the NOPR TSD. TSL 4 is composed of the max-tech ELs. TSL 3 is composed of the ELs that yield the maximum NPV with any energy savings for products currently available on the market. TSL 2 is composed of the ELs that would minimize manufacturer impacts and allow for a continuous standard for all integrated GSLs. TSL 1 corresponds to the lowest standard level with any energy savings.

DOE used data on the representative product classes from the engineering and pricing analyses described in section V.C.2 to evaluate the benefits and burdens of each of the TSLs. DOE analyzed the benefits and burdens by conducting the analyses described in section III.E.1 for each TSL. Table VI–1 presents the TSLs and the corresponding ELs for GSLs.

TABLE VI–1—COMPOSITION OF TSLS FOR GSLS BY EFFICACY LEVEL

TSL	Representative product class		
	Integrated low-lumen	Integrated high-lumen	Non-integrated
1	EL 1	EL 1	EL 0.
2	EL 2	EL 2	EL 0.
3	EL 3	EL 2	EL 0.
4	EL 4	EL 2	EL 1.

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on GSL consumers by looking at the effects potential new or amended standards at each TSL would have on the LCC and PBP. DOE also examined the impacts of potential standards on consumer subgroups. These analyses are discussed below.

a. Life-Cycle Cost and Payback Period

In general, higher efficiency products affect consumers in two ways: (1) purchase price increases, and (2) annual operating costs decrease. In the case of GSLs, however, DOE projects that higher efficacy GSLs will sometimes have a lower purchase price than less efficacious lamps. Inputs used for calculating the LCC and PBP include total installed costs (*i.e.,* product price plus installation costs), and operating costs (*i.e.,* annual energy use, energy prices, energy price trends, repair costs, and maintenance costs). The LCC calculation also uses product lifetime and a discount rate. Chapter 8 of the NOPR TSD provides detailed information on the LCC and PBP analyses.

Table VI–2 through Table VI–7 show the LCC and PBP results for the ELs considered for each product class. The results in the first of each pair of tables represent the average values if all consumers in the sample make a purchase at the specified EL, and the simple payback for each EL is measured relative to the baseline product (EL 0). In addition, the lifetime operating cost of each EL is calculated for the LCC analysis period, which is the lifetime of the baseline product (EL 0) in each product class. In the second table of each pair, the impact of a potential standard is measured based on the change in the efficacy distribution under the specified TSL in the compliance year compared to the distribution in no-new-standards case (see section V.F.11 of this notice). The savings refer only to consumers who are affected by a standard at a given TSL. Those whose purchasing decision is not affected are not included in the calculation. Consumers for whom the LCC increases under a given TSL experience a net cost.

[192] Scott, M., J. Roop, O. Livingston, R. Schultz, and P. Balducci. *ImSET 3.1: Impact of Sector Energy Technologies Model Description and User's Guide.* 2009. Pacific Northwest National Laboratory: Richland, WA. (Last accessed June 10, 2015.) *http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18412.pdf.*

TABLE VI–2—AVERAGE LCC AND PBP RESULTS BY EFFICACY LEVEL FOR INTEGRATED LOW-LUMEN GSLS

EL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost*	LCC		
Residential Sector						
0	2.55	2.18	3.65	6.19	—	5.5
1	3.04	2.03	3.39	5.95	3.32	6.8
2	5.15	1.62	2.67	5.44	4.59	6.8**, 18.0**
3	4.31	1.36	2.23	4.49	2.14	18.0
4	4.05	1.28	2.10	4.23	1.68	18.0
Commercial Sector						
0	3.94	6.39	10.56	14.71	—	2.6
1	4.42	5.96	9.84	13.79	1.12	3.2
2	6.27	4.58	7.57	11.15	1.29	3.2**, 7.7**
3	5.62	3.99	6.59	9.73	0.70	7.7
4	5.37	3.77	6.23	9.22	0.55	7.7

Note: The results for each EL represent the average value if all purchasers use products at that EL.
The PBP is measured relative to the baseline (EL 0) product.
* Calculated over the LCC analysis period, which is the lifetime of the EL 0 lamp.
** The two lifetimes correspond to the CFL (shorter) and LED (longer) lamp options at each EL.

TABLE VI–3—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR INTEGRATED LOW-LUMEN GSLS

TSL	EL	Average LCC savings* (2014$)	Percent of consumers that experience net cost
Residential Sector			
1	1	0.32	1.4
2	2	0.32	1.4
3	3	0.75	1.3
4	4	0.88	1.0
Commercial Sector			
1	1	1.33	0.2
2	2	1.33	0.2
3	3	1.32	0
4	4	1.40	0

* The savings represent the average LCC for affected consumers.

TABLE VI–4—AVERAGE LCC AND PBP RESULTS BY EFFICACY LEVEL FOR INTEGRATED HIGH-LUMEN GSLS

EL	Average Costs 2014$				Simple payback years	Average lifetime years
	Installed cost	First year's operating cost	Lifetime operating cost *	LCC		
Residential Sector						
0	9.14	3.95	8.42	17.57	—	6.6
1	9.92	3.71	7.89	17.81	3.20	6.6
2	10.55	3.58	7.63	16.79	3.86	7.7
Commercial Sector						
0	10.58	12.53	24.85	35.64	—	3.1
1	11.36	11.77	23.33	34.91	1.02	3.1
2	11.99	11.39	22.58	33.21	1.23	3.8

Note: The results for each EL represent the average value if all purchasers use products at that EL. The PBP is measured relative to the baseline (EL 0) product.
* Calculated over the LCC analysis period, which is the lifetime of the EL 0 lamp.

TABLE VI–5—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR INTEGRATED HIGH-LUMEN GSLS

TSL	EL	Average LCC savings * (2014$)	Percent of consumers that experience net cost
Residential Sector			
1	1	0.24	23.2
2	2	0.94	8.9
3	2	0.96	8.7
4	2	0.96	8.7
Commercial Sector			
1	1	1.13	3.3
2	2	2.00	4.9
3	2	2.02	4.9
4	2	2.02	4.9

* The savings represent the average LCC for affected consumers.

TABLE VI–6—AVERAGE LCC AND PBP RESULTS BY EFFICACY LEVEL FOR NON-INTEGRATED GSLS

EL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost *	LCC		
Commercial Sector						
0	9.00	10.21	20.17	29.38	....	3.1
1	9.69	10.11	19.97	28.44	6.73	3.8 ** 5.0 **

Note: The results for each EL represent the average value if all purchasers use products at that EL. The PBP is measured relative to the baseline (EL 0) product.
* Calculated over the LCC analysis period, which is the lifetime of the EL 0 lamp.
** The two lifetimes correspond to the two different lamp options at this EL.

TABLE VI–7—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR NON-INTEGRATED GSLS

TSL	EL	Average LCC savings* (2014$)	Percent of consumers that experience net cost
Commercial Sector			
4	1	0.95	6.1

* The savings represent the average LCC for affected consumers.

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on low-income households and small businesses. Table VI–8 through Table VI–12 compares the average LCC savings and PBP at each EL for the two consumer subgroups, along with the average LCC savings for the entire sample. In most cases, the average LCC savings and PBPs for low-income households and small businesses at the considered ELs are not substantially different from the averages for all households and all buildings. Chapter 11 of the NOPR TSD presents the complete LCC and PBP results for the subgroups.

TABLE VI–8—COMPARISON OF LCC SAVINGS AND PBP FOR LOW-INCOME HOUSEHOLDS AND ALL HOUSEHOLDS FOR INTEGRATED LOW-LUMEN GSLS

TSL	EL	Average life-cycle cost savings (2014$)		Simple payback period (years)	
		Low-income households	All households	Low-income households	All households
1	1	0.37	0.32	3.28	3.32
2	2	0.37	0.32	4.53	4.59
3	3	0.73	0.75	2.11	2.14

TABLE VI–8—COMPARISON OF LCC SAVINGS AND PBP FOR LOW-INCOME HOUSEHOLDS AND ALL HOUSEHOLDS FOR INTEGRATED LOW-LUMEN GSLS—Continued

TSL	EL	Average life-cycle cost savings (2014$)		Simple payback period (years)	
		Low-income households	All households	Low-income households	All households
4	4	0.85	0.88	1.65	1.68

TABLE VI–9—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESSES AND ALL BUILDINGS FOR INTEGRATED LOW-LUMEN GSLS

TSL	EL	Average life-cycle cost savings (2014$)		Simple payback period (years)	
		Small businesses	All businesses	Small businesses	All businesses
1	1	1.26	1.33	1.10	1.12
2	2	1.26	1.33	1.27	1.29
3	3	1.30	1.32	0.69	0.70
4	4	1.38	1.40	0.54	0.55

TABLE VI–10—COMPARISON OF LCC SAVINGS AND PBP FOR LOW-INCOME HOUSEHOLDS AND ALL HOUSEHOLDS FOR INTEGRATED HIGH-LUMEN GSLS

TSL	EL	Average life-cycle cost savings (2014$)		Simple payback period (years)	
		Low-income households	All households	Low-income households	All households
1	1	0.20	0.24	3.18	3.20
2	2	0.88	0.94	3.84	3.86

TABLE VI–11—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESSES AND ALL BUILDINGS FOR INTEGRATED HIGH-LUMEN GSLS

TSL	EL	Average life-cycle cost savings (2014$)		Simple payback period (years)	
		Small businesses	All businesses	Small businesses	All businesses
1	1	1.06	1.13	1.02	1.02
2	2	1.89	2.00	1.23	1.23

TABLE VI–12—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESSES AND ALL BUILDINGS FOR NON-INTEGRATED GSLS

TSL	EL	Average life-cycle cost savings (2014$)		Simple payback period (years)	
		Small businesses	All businesses	Small businesses	All businesses
4	1	0.93	0.95	6.68	6.73

c. Rebuttable-Presumption Payback

As discussed in section V.F.12, EPCA establishes a rebuttable presumption that an energy conservation standard is economically justified if the increased purchase cost for a product that meets the standard is less than three times the value of the first-year energy savings resulting from the standard. In calculating a rebuttable-presumption payback period for each of the considered ELs, DOE used discrete values, and, as required by EPCA, based the energy use calculation on the DOE test procedure for GSLs. In contrast, the PBPs presented in section VI.B.1.a were calculated using distributions for input values, with energy use based on field studies and RECS data.

Table VI–13 through Table VI–15 presents the rebuttable-presumption payback periods for the considered ELs in each product class. While DOE examined the rebuttable-presumption criterion, it considered whether the standard levels considered for the NOPR are economically justified through a more detailed analysis of the economic impacts of those levels, pursuant to 42

U.S.C. 6295(o)(2)(B)(i), that considers the full range of impacts to the consumer, manufacturer, nation, and environment. The results of that analysis serve as the basis for DOE to definitively evaluate the economic justification for a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification.

TABLE VI–13—REBUTTABLE-PRESUMPTION PAYBACK PERIOD RESULTS FOR INTEGRATED LOW-LUMEN GSLS

EL	Residential sector	Commercial sector
1	3.18	0.95
2	4.39	1.10
3	2.05	0.60
4	1.60	0.47

TABLE VI–14—REBUTTABLE-PRESUMPTION PAYBACK PERIOD RESULTS FOR INTEGRATED HIGH-LUMEN GSLS

EL	Residential sector	Commercial sector
1	3.06	0.87
2	3.69	1.05

TABLE VI–15—REBUTTABLE-PRESUMPTION PAYBACK PERIOD RESULTS FOR NON-INTEGRATED GSLS

EL	Commercial sector
1	5.74

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of new and amended energy conservation standards on manufacturers of GSLs. The following sections describe the expected impacts on manufacturers at each TSL. Chapter 12 of the NOPR TSD explains the analysis in further detail.

a. Industry Cash-Flow Analysis Results

Table VI–16 through Table VI–17 present the estimated financial impacts (represented by changes in INPV) of the analyzed new and amended energy conservation standards on GSL manufacturers, as well as the conversion costs that DOE estimates GSL manufacturers would incur at each TSL. To evaluate the range of cash-flow impacts on the GSL industry, DOE used the preservation of gross margin markup scenarios to estimate the impacts on manufacturers. This preservation of gross margin markup scenario assumes that in the standards cases, manufacturers would be able to pass along any higher production costs required for more efficacious products to their consumers. Specifically, the industry would be able to maintain its average no-new-standards case gross margin (as a percentage of revenue) despite any potential higher production costs in the standards cases.

DOE also modeled a low investment scenario and a high investment scenario for manufacturers that correspond to the range of potential investments manufacturers must make in order to comply with the analyzed new and amended standards. Each investment scenario results in a unique set of cash flows and corresponding industry values at each TSL.

In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and the standards cases that result from the sum of discounted cash flows from the reference year (2015) through the end of the analysis period (2049). The results also discuss the difference in cash flows between the no-new-standards case and the standards cases in the year before the compliance date for proposed standards. This difference in cash flow represents the size of the required conversion costs relative to the cash flow generated by the GSL industry in the absence of new and amended energy conservation standards.

To assess the upper (less severe) end of the range of potential impacts on GSL manufacturers, DOE modeled a low investment conversion cost scenario and to assess the lower (more severe) end of the range of potential impacts on GSL manufacturers, DOE modeled a high investment conversion cost scenario. Table VI–16 and Table VI–17 present the projected range of potential results for GSL manufacture for the low investment and high investment scenarios. DOE examined results for all product classes together.

TABLE VI–16—MANUFACTURER IMPACT ANALYSIS FOR GENERAL SERVICE LAMPS—LOW INVESTMENT SCENARIO

	Units	No-new-standards case	Trial standard levels			
			1	2	3	4
INPV	*2014$ millions*	911.0	894.3	877.3	753.3	731.3
Change in INPV	*2014$ millions*		(16.7)	(33.7)	(157.7)	(179.6)
	%		(1.8)	(3.7)	(17.3)	(19.7)
Product Conversion Costs	*2014$ millions*	50.3	74.2	96.7	178.7	184.8
Capital Conversion Costs	*2014$ millions*	201.4	204.4	205.2	245.5	253.1
Total Conversion Costs	*2014$ millions*	251.7	278.6	301.9	424.1	437.9

TABLE VI–17—MANUFACTURER IMPACT ANALYSIS FOR GENERAL SERVICE LAMPS—HIGH INVESTMENT SCENARIO

	Units	No-new-standards case	Trial standard levels			
			1	2	3	4
INPV	*2014$ millions*	911.0	886.6	862.2	690.0	665.9
Change in INPV	*2014$ millions*		(24.4)	(48.8)	(221.0)	(245.1)
	%		(2.7)	(5.4)	(24.3)	(26.9)
Product Conversion Costs	*2014$ millions*	50.3	85.9	119.6	242.6	250.8
Capital Conversion Costs	*2014$ millions*	201.4	204.8	206.0	266.4	274.1
Total Conversion Costs	*2014$ millions*	251.7	290.7	325.7	509.0	525.0

For the no-new-standards case DOE typically assumes conversion costs are zero, because manufacturers typically do not need to make additional investments beyond their normal capital expenditures and investments in research and development if no-new-standards are prescribed by a rulemaking. However, DOE included conversion costs in the no-new-standards case since manufacturers would have to make significant one-time investments to comply with the EISA 2007 45 lm/W backstop. DOE estimates manufacturers will incur product conversion costs of $50.3 million and capital conversion costs of $201.4 million to comply with the efficacy requirements prescribed by the EISA 2007 backstop. Product conversion costs include investments in research, development, testing, marketing, and certification that manufacturers must make to create new GSL designs intended to replace the product offering eliminated by the EISA 2007 backstop efficacy requirements. Capital conversion costs include investments in production equipment that GSL manufacturers would be required to make in order to significantly expand their LED manufacturing capacity to meet expected market demand for LED lamps caused by the EISA 2007 backstop.

TSL 1 sets the efficacy level at baseline for the Non-Integrated product class and EL 1 for Integrated Low-Lumen and Integrated High-Lumen product classes. At TSL 1, DOE estimates impacts on INPV to range from −$24.4 million to −$16.7 million, or a change in INPV of −2.4 percent to −1.8 percent. At TSL 1, industry free cash flow (operating cash flow minus capital expenditures) is expected to range from −$37.4 million to −$33.3, which is a decrease of approximately $13.5 million and $9.4 million respectively, compared to the no-new-standards case value of −$24.0 million in 2019, the year leading up to standards.

Percentage impacts on INPV are slightly negative at TSL 1. DOE estimates that 96 percent of integrated low-lumen shipments, 78 percent of integrated high-lumen shipments, and 100 percent of non-integrated shipments will meet the ELs required at TSL 1 in 2020, the expected compliance year of standards.

DOE expects product conversion costs will rise from $50.3 million at the no-new-standards case to $74.2 million in the low investment scenario and to $85.9 million in the high investment scenario at TSL 1. Product conversion costs are driven primarily by manufacturers redesigning CFLs to meet standards. DOE expects capital conversion costs to increase from $201.4 million in the no-new-standards case to $204.4 million in the low investment scenario and to $204.8 million in the high investment scenario at TSL 1. The additional capital conversion consists of minor retooling costs necessary to accommodate the redesigned CFLs. DOE does not estimate any manufacturers would be required to make any additional major production equipment expenditures not made in the no-new-standards case, since manufacturers would either simply remove product offering of non-compliant CFLs or make minor modifications requiring retooling expenditures to existing CFL production lines to comply with standards set at this TSL.

At TSL 1, the shipment-weighted average MPC increases by 1 percent relative to the no-new-standards case MPC in 2020, the expected year of compliance. In both the high and low investment scenarios, manufacturers are not able to recover their conversion costs through the slight increase in MPC over the course of the analysis period resulting in a slightly negative INPV for each investment scenario.

TSL 2 sets the efficacy level at baseline for the Non-Integrated product class and EL 2 for Integrated Low-Lumen and Integrated High-Lumen product classes. EL 2 represents max tech for the Integrated High-Lumen product class. At TSL 2, DOE estimates impacts on INPV to range from −$48.8 million to −$33.7 million, or a change in INPV of −5.4 percent to −3.7 percent. At TSL 2, industry free cash flow is expected to range from −$49.3 million to −$41.3, which is a decrease of approximately $25.4 million to $17.3 million respectively, compared to the no-new-standards case value of −$24.0 million in 2019, the year leading up to standards.

Percentage impacts on INPV range from slightly negative to moderately negative at TSL 2. DOE estimates that 94 percent of integrated low-lumen shipments, 52 percent of integrated high-lumen shipments, and 100 percent of non-integrated shipments will meet the ELs required at TSL 2 in 2020.

DOE expects product conversion costs will rise from $74.2 million at TSL 1 to $96.7 million at TSL 2 in the low investment scenario and from $85.9 million at TSL 1 to $119.6 million at TSL 2 in the high investment scenario. This increase is primarily driven by more CFL models needing to be redesigned to meet this analyzed TSL. DOE expects capital conversion costs to increase from $204.4 million at TSL 1 to $205.2 million at TSL 2 in the low investment scenario and from $204.8 million at TSL 1 to $206.0 million at TSL 2 in the high investment scenario. This increase is driven by an expected increase in the number of CFL models that would require new tooling due to their redesign. Again, DOE does not estimate any manufacturers would be required to make any additional major production equipment expenditures at this TSL that are not made in the no-new-standards case.

At TSL 2, the shipment-weighted average MPC increases by 1 percent relative to the no-new-standards case MPC in 2020. In both the high and low investment scenarios, manufacturers are not able to recover their conversion costs through the slight increase in MPC over the course of the analysis period resulting in a slightly negative INPV for the low investment scenario and a moderately negative INPV for the high investment scenario.

TSL 3 sets the efficacy level at baseline for the Non-Integrated product class, EL 2 for the Integrated High-Lumen product class, and EL 3 for the Integrated Low-Lumen product class. EL 3 is the first efficacy level to require the use of LED lamps for the Integrated Low-Lumen product class. At TSL 3, DOE estimates impacts on INPV to range from −$221.0 million to −$157.7 million, or a change in INPV of −24.3 percent to −17.3 percent. At TSL 3, industry free cash flow is expected range from −$126.4 million to −$88.8, which is a decrease of approximately $102.4 million and $64.8 million respectively, compared to the no-new-standards case value of −$24.0 million in 2019, the year leading up to standards.

Percentage impacts on INPV are moderately negative at TSL 3. DOE estimates that 57 percent of integrated low-lumen shipments, 52 percent of integrated high-lumen shipments, and 100 percent of non-integrated shipments will meet the ELs required at TSL 3 in 2020.

DOE expects product conversion costs will significantly rise from $96.7 million at TSL 2 to $178.7 million at TSL 3 in the low investment scenario and from $119.6 million at TSL 2 to $242.6 million at TSL 3 in the high investment scenario. At this TSL, manufacturers would have to abandon CFL production for the Integrated Low-Lumen product class and spend a considerable amount of R&D to introduce replacement LED lamps for those CFLs being removed from the market. DOE expects capital conversion costs to significantly increase from $205.2 million at TSL 2 to $245.5 million at TSL 3 in the low investment scenario and from $206.0 million at TSL 2 to $266.4 million at TSL 3 in the high investment scenario. This increase is driven by an expected increase in the number of production lines for LED lamps to accommodate the increase in demand for LED lamps.

At TSL 3, the shipment-weighted average MPC decreases by 1 percent relative to the no-new-standards case MPC in 2020. The slight decrease in MPC and increase in conversion costs incurred by manufacturers result in a moderately negative INPV in the low investment scenario and a significantly negative INPV in the high investment scenario at TSL 3.

TSL 4 sets the efficacy level at EL 1 for the Non-Integrated product class, EL 2 for the Integrated High-Lumen product class, and EL 4 for the Integrated Low-Lumen product class. TSL 4 represents max tech for all product classes. At TSL 4, DOE estimates impacts on INPV to range from −$245.1 million to −$179.6 million, or a change in INPV of −26.9 percent to −19.7 percent. At TSL 4, industry free cash flow is expected to range from −$133.5 million to −$94.9, which is a decrease of approximately $109.5 million and $70.9 million respectively, compared to the no-new-standards case value of −$24.0 million in 2019, the year leading up to standards.

Percentage impacts on INPV range from moderately negative to significantly negative at TSL 4. DOE estimates that 25 percent of integrated low-lumen shipments, 52 percent of integrated high-lumen shipments, and 68 percent of non-integrated shipments will meet the ELs required at TSL 4 in 2020.

DOE expects product conversion costs will slightly rise from $178.7 million at TSL 3 to $184.8 million at TSL 4 in the low investment scenario and from $242.6 million at TSL 3 to $250.8 million at TSL 4 in the high investment scenario. At this TSL, manufacturers would have to improve the efficacy of CFLs in the Non-Integrated product class, which would result in an increase in R&D, testing, and certification costs. DOE expects capital conversion costs to slightly increase from $245.5 million at TSL 3 to $253.1 million at TSL 4 in the low investment scenario and from $266.4 million at TSL 3 to $274.1 million at TSL 4 in the high investment scenario. DOE does not expect manufacturers to have to make significant additional production equipment expenditures at TSL 4 compared to the production equipment expenditures made at TSL 3 to make the more efficacious non-integrated CFLs required at TSL 4. DOE only assumes that there would be some increase in tooling costs associated with the redesign of some LED models for the Integrated Low-Lumen product classes as well as some increase in tooling costs associated with the redesign of some of the CFL models for the Non-Integrated product class required at TSL 4 that would not be incurred at TSL 3.

At TSL 4, the shipment-weighted average MPC decreases by 3 percent relative to the no-new-standards case MPC in 2020. The slight decrease in MPC and increase in conversion costs incurred by manufacturers result in a moderately negative INPV in the low investment scenario and a significantly negative INPV in the high investment scenario at TSL 4.

b. Impacts on Employment

DOE determined that there was only one GSL manufacturer that manufactured lamps or lamp components covered by this rulemaking domestically. During manufacturing interviews, manufacturers stated that the vast majority of LED manufacturing, and all CFL manufacturing, is done abroad. Some of these facilities are owned by the GSL manufacturer and others outsource their GSL production to original equipment manufacturers located primarily in Asia. However, several CFL manufacturers have domestic employees responsible for the R&D, marketing, sales, and distribution of CFLs.

Based on manufacturer interviews, DOE estimates that there are approximately 100 domestic employees dedicated to the non-production aspects of CFLs. Since the majority of CFLs are in the Integrated Low-Lumen product class, DOE believes there would be a sizable reduction in this number of domestic non-production employees at the proposed TSL. Manufacturers claim that the market disruption caused by eliminating CFLs from the Integrated Low-Lumen product class, would cause some manufacturers to reduce the number of domestic non-production employees.

DOE also limited the employment impact analysis to the domestic production of CFLs and LED lamps covered by this rulemaking and did not analyze the impact of the EISA 2007 45 lm/W backstop on the domestic production of other lamps, since they are outside the scope of this rulemaking.

Overall, based on DOE's market research, manufacturer feedback, and the scope of the employment impact analysis, DOE anticipates a limited impact on domestic employment, due to the elimination of domestic employees responsible for R&D, marketing, sales, and distribution of CFLs, caused by the proposed standard in this NOPR.

DOE seeks comment on the assumption that there is only one GSL manufacturer with domestic production of LED lamps and none with domestic production of CFLs. DOE also requests comment on the assumption that approximately 100 employees are involved in the R&D, marketing, sales, and distribution of CFLs. Additionally, DOE seeks comment on any potential domestic employment impacts as a result of the proposed new and amended energy conservation standards for GSLs in this NOPR.

c. Impacts on Manufacturing Capacity

During manufacturer interviews several GSL manufacturers expressed concern over the potential LED manufacturing capacity of any standards that could only be met by LED lamps for the Integrated Low-Lumen product class. These manufacturers stated that as other countries and regions adopt more-stringent lighting efficiency standards, especially Europe, around the compliance date of this rulemaking, worldwide LED manufacturing capacity would be severely strained if LED lamps are required to meet DOE's GSL energy conservation standards.

Manufacturers stated that if DOE sets energy conservation standards that only LED lamps could meet (*i.e.,* TSL 3 or 4), the demand for LED lamps would increase by 2 or 3 times over the course of a single year. This is supported by DOE shipment analysis which projects Integrated Low-Lumen LED shipments rising from approximately 242 million units in 2019 in the no-new-standards case to over 675 million units in 2020 at TSLs 3 and 4. Manufacturers further claimed that they would not be willing to invest significantly to increase LED manufacturing capacity, because the LED market would shrink over the following 10 years since LED lamps have extremely long lifetimes. This is again supported by DOEs shipment analysis which projects Integrated Low-Lumen LED shipments declining from over 675 million units in 2020 to approximately 172 million units in 2030 at TSLs 3 and 4.

Manufacturers stated that any manufacturer that significantly increased their LED manufacturing capacity could face the possibility of going out of business before they were able to recover their investments required to increase their LED manufacturing capacity due to this decline in future LED shipments. Therefore, it would be difficult for GSL manufacturers to meet the GSL demand for any standards that could only be met by using LED lamps for the Integrated Low-Lumen product class.

DOE is proposing standards that require the use of LED lamps to meet the Integrated Low-Lumen product class and acknowledges that manufacturers would have to face a difficult decision of whether to invest in the required production equipment necessary to supply the market with LED lamps in the compliance year and the years immediately following that, given that they may not be able to recover all of those investments due to the long-term drop in LED lamp shipments. DOE also acknowledges that as other nations and regions implement their own general service lighting regulations that require the use of LED lamps there could be a potential global supply chain shortage of LEDs around the effective date of this rulemaking. However, DOE believes that GSL manufacturers are capable of meeting the U.S. demand for LED lamps at proposed standard, TSL 3, given the three year time frame between the announcement of a final rule and the implementation of that final rule.

d. Impacts on Subgroups of Manufacturers

Using average cost assumptions to develop an industry cash-flow estimate may not be adequate for assessing differential impacts among manufacturer subgroups. Small manufacturers, niche product manufacturers, and manufacturers exhibiting cost structures substantially different from the industry average could be disproportionately affected. DOE only identified one manufacturer subgroup that it believes could be disproportionally impacted by energy conservation standards and would require a separate analysis in the MIA, small businesses. DOE analyzes the impacts on small businesses in a separate analysis in section VII.B of this NOPR as part of the Regulatory Flexibility Analysis. DOE did not identify any other adversely impacted manufacturer subgroups for GSLs for this rulemaking based on the results of the industry characterization. DOE seeks comment on any other potential manufacturer subgroups that could be disproportionally impacted by new and amended energy conservation standards for GSLs.

e. Cumulative Regulatory Burden

While any one regulation may not impose a significant burden on manufacturers, the combined effects of recent or impending regulations may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Assessing the impact of a single regulation may overlook this cumulative regulatory burden. Multiple regulations affecting the same manufacturer can strain profits and lead companies to abandon product lines or markets with lower expected future returns than competing products. For these reasons, DOE conducts a cumulative regulatory burden analysis as part of its rulemakings for GSLs.

DOE identified a number of requirements, in addition to new and amended energy conservation standards for GSLs, that GSL manufacturers will face for products they manufacture approximately three years prior to and three years after the estimated compliance date of these new and amended standards. The following section addresses key related concerns that manufacturers raised during interviews regarding cumulative regulatory burden.

Manufacturers raised concerns about other DOE energy conservation standards that lighting manufacturers must comply with. In addition to the proposed new and amended energy conservation standards on GSLs, several other existing and pending federal regulations may apply to other products produced by GSL manufacturers. These lighting regulations include the finalized metal halide lamp fixture standards (79 FR 7746 [Feb. 10, 2014]), the finalized GSFL standards (80 FR 4042 [Jan. 26, 2015]), the finalized ceiling fan light kit standards (81 FR 580 [Jan. 6, 2016]), and the ongoing fluorescent lamp ballast standards (80 FR 35886 [Jun. 23, 2015]).

DOE acknowledges that each regulation can impact a manufacturer's financial operations. Multiple regulations affecting the same manufacturer can strain manufacturers' profit and possibly cause them to exit particular markets. Table VI–18 lists other DOE energy conservation standards that could also affect GSL manufacturers in the three years leading up to and after the estimated compliance date of the new and amended energy conservation standards for GSLs. On December 9, 2015 DOE published a final determination for high-intensity discharge lamps that determined standards were not technologically feasible or economically justified based in part on manufacturers concerns regarding costs asscociated to meet more stringent efficacy levels. (80 FR 76355)

TABLE VI–18—OTHER DOE REGULATIONS POTENTIALLY AFFECTING GENERAL SERVICE LAMP MANUFACTURERS

Regulation	Approximate compliance date	Estimated industry total conversion expenses
Metal Halide Lamp Fixtures	2017	$25 million (2012$).[193]
General Service Fluorescent Lamps	2018	$26.6 million (2013$).[194]
Ceiling Fan Light Kits	2019	$17.0–$18.9 million (2014$).[195]
Fluorescent Lamp Ballast	*2022	N/A†.
Candelabra Base Incandescent Lamps and Intermediate-Base Incandescent Lamps	βN/A	N/A†.
Other Incandescent Reflector Lamps	βN/A	N/A†.

* The dates listed are an approximation. The exact dates are pending final DOE action.

† For energy conservation standards for rulemakings awaiting DOE final action, DOE does not have a finalized estimated total industry conversion cost.

β These rulemakings are placed on hold due to the Consolidated and Further Continuing Appropriations Act, 2015 (Public Law 113–235, Dec. 16, 2014).

Manufacturers also stated that they must comply with other Federal and state regulations and certifications, separate from DOE's energy conservation standards, which cover the GSLs they manufacture. These include California Title 20, which has energy conservation standards identical to DOE's existing medium base CFL standards, but requires an additional certification; Interstate Mercury Education and Reduction Clearinghouse (IMERC) labeling requirements for CFLs; FTC's labeling requirements for all GSLs; and the Federal Communications Commission's electromagnetic interference verification for LEDs. Lastly, as described in EISA 2007, all lamps classified as GSL, regardless of whether standards are set for those products in this rulemaking, will have to meet a minimum of 45 lm/W by January 1, 2020. (42 U.S.C. 6295(i)(6)(A)(v)) DOE included the significant conversion costs that GSL manufacturers would have to make to comply with the EISA 2007 backstop in the no-new-standards case to more accurately reflect the total investments GSL manufacturers would have to make at the analyzed standard levels. These EISA 2007 backstop conversion costs are included in the cash flow analyses described in section VI.B.2.a.

Manufacturers also stated that several of their models sold in the U.S. are also sold in other international markets and therefore must also comply with a handful of other international standards. Manufacturers stated that there are standards that GSLs must comply with in order to be sold in Canada and Mexico.

DOE discusses these and other requirements in chapter 12 of the NOPR TSD. DOE seeks comment on the compliance costs of any other regulations GSL manufacturers must make, especially if compliance with those regulations is required three years before or after the estimated compliance date of these proposed standards (2020).

3. National Impact Analysis

a. Significance of Energy Savings

To estimate the energy savings attributable to potential standards for GSLs, DOE compared the energy consumption of those products under the no-new-standards case to their anticipated energy consumption under each TSL. The savings are measured over the entire lifetime of products purchased in the 30-year period that begins in the year of anticipated compliance with amended standards (2020–2049). Table VI–19 present DOE's projections of the NES for each TSL considered for GSLs. The savings were calculated using the approach described in section V.H of this NOPR.

TABLE VI–19—CUMULATIVE NATIONAL ENERGY SAVINGS FOR GSLS SHIPPED IN 2020–2049

	Trial standard level (quads)			
	1	2	3	4
Primary Energy	0.039	0.055	0.81	1.05
FFC Energy	0.041	0.058	0.85	1.09

OMB Circular A–4 [196] requires agencies to present analytical results, including separate schedules of the monetized benefits and costs that show the type and timing of benefits and costs. Circular A–4 also directs agencies to consider the variability of key elements underlying the estimates of benefits and costs. For this rulemaking, DOE undertook a sensitivity analysis using nine, rather than 30, years of product shipments. The choice of a nine-year period is a proxy for the timeline in EPCA for the review of certain energy conservation standards and potential revision of and compliance with such revised standards.[197] The review timeframe established in EPCA is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to GSLs. Thus, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology. The NES sensitivity analysis results based on a nine-year analytical period are presented in Table VI–20. The impacts are counted over the lifetime of GSLs purchased in 2020–2028.

TABLE VI–20—CUMULATIVE NATIONAL ENERGY SAVINGS FOR GSLS; NINE YEARS OF SHIPMENTS (2020–2028)

	Trial standard level (quads)			
	1	2	3	4
Primary Energy	0.023	0.027	0.444	0.562
FFC Energy	0.024	0.028	0.464	0.587

[193] Estimated industry conversion expenses were published in the TSD for the February 2014 metal halide lamp fixtures final rule. 79 FR 7746 The TSD for the 2014 metal halide lamp fixture final rule can be found at *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/16.*

[194] Estimated industry conversion expenses were published in the TSD for the January 2015 general service fluorescent lamps final rule. 80 FR 4042 The TSD for the 2015 general service fluorescent lamps final rule can be found at *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/24.*

[195] Estimated industry conversion expenses were published in the TSD for the January 2016 celing fan light kit final rule. 81 FR 580 The TSD for the 2016 ceiling fan light kit final rule can be found at *https://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/66.*

[196] U.S. Office of Management and Budget. *Circular No. A–4, Regulatory Analysis.* 2003. Washington, DC (Last accessed June 15, 2015.) *http://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/a-4.pdf.*

[197] Section 325(m) of EPCA requires DOE to review its standards at least once every 6 years, and requires, for certain products, a 3-year period after any new standard is promulgated before compliance is required, except that in no case may any new standards be required within 6 years of the compliance date of the previous standards. While adding a 6-year review to the 3-year compliance period adds up to 9 years, DOE notes that it may undertake reviews at any time within the 6 year period and that the 3-year compliance date may yield to the 6-year backstop. A 9-year analysis period may not be appropriate given the variability that occurs in the timing of standards reviews and the fact that for some consumer products, the compliance period is 5 years rather than 3 years.

b. Net Present Value of Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for consumers that would result from the TSLs considered for GSLs. In accordance with OMB's guidelines on regulatory analysis,[198] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table VI–21 shows the consumer NPV results with impacts counted over the lifetime of products purchased in 2020–2049. Table VI–21 implicitly includes a negative total incremental installed cost of $0.9 billion and $1.4 billion dollars at seven and three percent discount rates, respectively. The negative total cost increment is explained by the reduction in product costs that occurs because (1) more efficacious lamps have longer average lifetimes than less efficacious lamps, resulting in fewer replacement purchases, (2) the purchase price of more efficacious LED lamps is lower than the price of less efficacious LED lamps, and (3) the purchase price of LED lamps declines faster than the price of CFLs during the analysis period, resulting in LED lamps becoming less expensive than CFLs. However, negative compliance costs run counter an economic theory that assumes a perfect capital market with perfect rationality of agents having complete information. In such a market, because the more efficacious GSLs are less expensive and longer lived than the baseline product, consumers would have an incentive to purchase them even in the absence of standards. For these reasons, DOE requests comment on various aspects of the inputs to the installed cost analysis, such as assumptions about consumers' response to first cost versus long-term operating cost, the price structure developed for LED lamps, the application of learning curves that yield declining prices over the analysis period, the increased lifetime of the more efficacious products, assumptions for manufacturer capital and product conversion costs, and other factors. In addition, DOE requests comment and information on any other factors that might be more difficult to quantify, such as any lessening of utility of the more efficient product or consumer welfare losses due to the more stringent standards.

TABLE VI–21—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR GSLS SHIPPED IN 2020–2049

	Trial standard level (billion 2014$)			
	1	2	3	4
3%	0.34	0.53	9.05	11.66
7%	0.15	0.24	4.41	5.69

The NPV results based on the aforementioned 9-year analytical period are presented in Table VI–22. The impacts are counted over the lifetime of products purchased in 2020–2028. As mentioned previously, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology or decision criteria.

TABLE VI—22 CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR GSLS; NINE YEARS OF SHIPMENTS (2020–2028)

Discount rate	Trial standard level (billion 2014$)			
	1	2	3	4
3%	0.23	0.27	5.75	7.33
7%	0.12	0.15	3.36	4.31

The above results utilize the reference economic and price assumptions in the shipments and NIA analyses. DOE also conducted a number of alternative analyses, results of which can be found in appendix 10E of the NOPR TSD.

c. Indirect Impacts on Employment

DOE expects energy conservation standards for GSLs to reduce energy bills for consumers of those products, with the resulting net savings being redirected to other forms of economic activity. These expected shifts in spending and economic activity could affect the demand for labor. As described in section V.N of this document, DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered in this rulemaking. DOE understands that there are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Therefore, DOE generated results for near-term timeframes (2020–2025), where these uncertainties are reduced.

The results suggest that the proposed standards are likely to have a negligible impact on the net demand for labor in the economy. The net change in jobs is so small that it would be imperceptible in national labor statistics and might be offset by other, unanticipated effects on employment. Chapter 16 of the NOPR TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

DOE has tentatively concluded that the standards proposed in this NOPR would not reduce the utility or performance of GSLs under consideration in this rulemaking. Manufacturers of these products currently offer units that meet or exceed the proposed standards.

[198] U.S. Office of Management and Budget, ''Circular A–4: Regulatory Analysis,'' section E, (Sept. 17, 2003) (Available at: *http://www.whitehouse.gov/omb/circulars_a004_a-4/*).

5. Impact of Any Lessening of Competition

As discussed in section III.E.1.e, the Attorney General determines the impact, if any, of any lessening of competition likely to result from a proposed standard, and transmits such determination in writing to the Secretary, together with an analysis of the nature and extent of such impact. To assist the Attorney General in making such determination, DOE has provided DOJ with copies of this NOPR and the accompanying TSD for review. DOE will consider DOJ's comments on the proposed rule in determining whether to proceed to a final rule. DOE will publish and respond to DOJ's comments in that document.

6. Need of the Nation To Conserve Energy

Enhanced energy efficiency, where economically justified, improves the Nation's energy security, strengthens the economy, and reduces the environmental impacts (costs) of energy production. Reduced electricity demand due to energy conservation standards is also likely to reduce the cost of maintaining the reliability of the electricity system, particularly during peak-load periods. As a measure of this reduced demand, chapter 15 in the NOPR TSD presents the estimated reduction in generating capacity, relative to the no-new-standards case, for the TSLs that DOE considered in this rulemaking.

Energy conservation from new or amended standards for GSLs is expected to yield environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases. Table VI–23 provides DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this rulemaking. The table includes both power sector emissions and upstream emissions. The emissions were calculated using the multipliers discussed in section V.K. DOE reports annual emissions reductions for each TSL in chapter 13 of the NOPR TSD.

TABLE VI–23—CUMULATIVE EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2020–2049

	Trial standard level			
	1	2	3	4
Power Sector Emissions				
CO_2 (*million metric tons*)	2.390	3.334	49.043	63.306
SO_2 (*thousand tons*)	1.496	2.060	30.593	39.457
NO_X (*thousand tons*)	2.594	3.634	53.280	68.795
Hg (*tons*)	0.006	0.008	0.114	0.147
CH_4 (*thousand tons*)	0.213	0.294	4.362	5.627
N_2O (thousand tons)	0.030	0.042	0.619	0.798
Upstream Emissions				
CO_2 (*million metric tons*)	0.129	0.182	2.670	3.449
SO_2 (*thousand tons*)	0.024	0.034	0.497	0.642
NO_X (*thousand tons*)	1.848	2.609	38.234	49.394
Hg (*tons*)	0.000	0.000	0.001	0.001
CH_4 (*thousand tons*)	10.190	14.395	210.958	272.547
N_2O (thousand tons)	0.001	0.002	0.025	0.032
Total FFC Emissions				
CO_2 (*million metric tons*)	2.520	3.517	51.713	66.755
SO_2 (*thousand tons*)	1.521	2.094	31.090	40.099
NO_X (*thousand tons*)	4.442	6.244	91.514	118.189
Hg (*tons*)	0.006	0.008	0.115	0.148
CH_4 (*thousand tons*)	10.403	14.689	215.319	278.173
CH_4 (thousand *tons* CO_{2eq}) *	291.287	411.299	6028.941	7788.852
N_2O (thousand tons)	0.031	0.043	0.643	0.830
N_2O (*thousand tons* CO_2eq) *	8.327	11.491	170.517	219.961

* CO_2eq is the quantity of CO_2 that would have the same GWP.
Negative values refer to an increase in emissions.

As part of the analysis for this proposed rule, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 and NO_X that DOE estimated for each of the considered TSLs for GSLs. As discussed in section V.L of this document, for CO_2, DOE used the most recent values for the SCC developed by an interagency process. The four sets of SCC values for CO_2 emissions reductions in 2015 resulting from that process (expressed in 2014$) are represented by $12.2/metric ton (the average value from a distribution that uses a 5-percent discount rate), $40.0/metric ton (the average value from a distribution that uses a 3-percent discount rate), $62.3/metric ton (the average value from a distribution that uses a 2.5-percent discount rate), and $117/metric ton (the 95th-percentile value from a distribution that uses a 3-percent discount rate). The values for later years are higher due to increasing damages (public health, economic and environmental) as the projected magnitude of climate change increases.

Table VI–24 presents the global value of CO_2 emissions reductions at each TSL. For each of the four cases, DOE calculated a present value of the stream of annual values using the same discount rate as was used in the studies upon which the dollar-per-ton values are based. DOE calculated domestic values as a range from 7 percent to 23 percent of the global values; these results are presented in chapter 14 of the NOPR TSD.

TABLE VI–24 ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR PRODUCTS SHIPPED IN 2020–2049

TSL	SCC case* (million 2014$)			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th ercentile
Power Sector Emissions				
1	16.9	76.5	121	232
2	23.3	106	168	323
3	344	1562	2478	4747
4	443	2017	3200	6130
Upstream Emissions				
1	0.89	4.1	6.5	12.3
2	1.2	5.7	9.1	17.4
3	18.2	83.8	133.32	255
4	23.6	108	172.29	330
Total FFC Emissions				
1	17.8	80.5	128	244
2	24.6	112	178	340
3	362	1646	2612	5002
4	467	2125	3372	6459

*For each of the four cases, the corresponding SCC value for emissions in 2015 is $12.2, $40.0, $62.3, and $117 per metric ton (2014$). The values are for CO_2 only (i.e., not CO_{2eq} of other greenhouse gases).

DOE is well aware that scientific and economic knowledge about the contribution of CO_2 and other GHG emissions to changes in the future global climate and the potential resulting damages to the world economy continues to evolve rapidly. Thus, any value placed on reduced CO_2 emissions in this rulemaking is subject to change. DOE, together with other federal agencies, will continue to review various methodologies for estimating the monetary value of reductions in CO_2 and other GHG emissions. This ongoing review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues. However, consistent with DOE's legal obligations, and taking into account the uncertainty involved with this particular issue, DOE has included in this proposed rule the most recent values and analyses resulting from the interagency review process.

DOE also estimated the cumulative monetary value of the economic benefits associated with NO_X emissions reductions anticipated to result from the considered TSLs for GSLs. The dollar-per-ton value that DOE used is discussed in section V.L of this document. Table VI–25 presents the cumulative present values for NO_X emissions for each TSL calculated using 7-percent and 3-percent discount rates.

TABLE VI–25—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2020–2049

TSL	Million 2014$	
	3% discount rate	7% discount rate
Power Sector Emissions		
1	8.66	3.90
2	12.00	5.22
3	176.27	76.68
4	227.63	98.76
Upstream Emissions		
1	6.02	2.62
2	8.43	3.55
3	123.78	52.22
4	159.99	67.35
Total FFC Emissions		
1	14.67	6.52
2	20.43	8.77
3	300.06	128.90
4	387.62	166.11

7. Other Factors

The Secretary of Energy, in determining whether a standard is economically justified, may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) No other factors were considered in this analysis.

8. Summary of National Economic Impacts

The NPV of the monetized benefits associated with emissions reductions can be viewed as a complement to the NPV of the consumer savings calculated for each TSL considered in this rulemaking. Table VI–26 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced CO_2 and NO_X emissions in each of four valuation scenarios to the NPV of consumer savings calculated for each TSL considered in this rulemaking, at both a 7-percent and 3-percent discount rate. The CO_2 values used in the columns of each table correspond to the four sets of SCC values discussed above.

TABLE VI–26—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS

TSL	Billion 2014$ Consumer NPV at 3% Discount Rate added with:			
	SCC Case $12.2/metric ton and 3% NO_X value	SCC Case $40.0/metric ton and 3% NO_X value	SCC Case $62.3/metric ton and 3% NO_X value	SCC Case $117/metric ton and 3% NO_X value
1	0.372	0.434	0.481	0.598
2	0.579	0.667	0.732	0.895
3	9.715	10.999	11.964	14.355
4	12.519	14.177	15.424	18.511
TSL	Consumer NPV at 7% Discount Rate added with:			
	SCC Case $12.2/metric ton and 7% NO_X value	SCC Case $40.0/metric ton and 7% NO_X value	SCC Case $62.3/metric ton and 7% NO_X value	SCC Case $117/metric ton and 7% NO_X value
1	0.176	0.239	0.286	0.402
2	0.269	0.356	0.421	0.584
3	4.904	6.189	7.154	9.545
4	6.320	7.979	9.225	12.312

In considering the above results, two issues are relevant. First, the national operating-cost savings are domestic U.S. monetary savings that occur as a result of market transactions, while the value of CO_2 reductions is based on a global value. Second, the assessments of operating-cost savings and the SCC are performed with different methods that use different time frames for analysis. The national operating-cost savings is measured for the lifetime of products shipped in 2020 to 2049. Because CO_2 emissions have a very long residence time in the atmosphere,[199] the SCC values in future years reflect future CO_2-emissions impacts that continue beyond 2100.

C. Conclusion

When considering proposed standards, the new or amended energy conservation standards that DOE adopts for any type (or class) of covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens by, to the greatest extent practicable, considering the seven statutory factors discussed previously. (42 U.S.C. 6295(o)(2)(B)(i)) The new or amended standard must also result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B))

For this NOPR, DOE considered the impacts of amended standards for GSLs at each TSL, beginning with the maximum technologically feasible level, to determine whether that level was economically justified. Where the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficacy level that is both technologically feasible and economically justified and saves a significant amount of energy.

To aid the reader as DOE discusses the benefits and/or burdens of each TSL, tables in this section present a summary of the results of DOE's quantitative analysis for each TSL. In addition to the quantitative results presented in the tables, DOE also considers other burdens and benefits that affect economic justification. These include the impacts on identifiable subgroups of consumers who may be disproportionately affected by a national standard and impacts on employment.

DOE also notes that the economics literature provides a wide-ranging discussion of how consumers trade off upfront costs and energy savings in the absence of government intervention. Much of this literature attempts to explain why consumers appear to undervalue energy efficiency improvements. There is evidence that consumers undervalue future energy savings as a result of: (1) A lack of information; (2) a lack of sufficient salience of the long-term or aggregate benefits; (3) a lack of sufficient savings to warrant delaying or altering purchases; (4) excessive focus on the short term, in the form of inconsistent weighting of future energy cost savings relative to available returns on other investments; (5) computational or other difficulties associated with the evaluation of relevant trade-offs; and (6) a divergence in incentives (for example, between renters and owners, or builders and purchasers). Having less than perfect foresight and a high degree of uncertainty about the future, consumers may trade off these types of investments at a higher-than-expected rate between current consumption and uncertain future energy cost savings.

In DOE's current regulatory analysis, potential changes in the benefits and costs of a regulation due to changes in consumer purchase decisions are included in two ways. First, if consumers forego the purchase of a product in the standards case, this decreases sales for product manufacturers, and the impact on manufacturers attributed to lost revenue is included in the MIA. Second, DOE accounts for energy savings attributable only to products actually used by consumers in the standards case; if a regulatory option decreases the number of products purchased by consumers, this decreases the potential energy savings from an energy conservation standard. DOE provides estimates of shipments and changes in the volume of product purchases in chapter 9 of the NOPR TSD. However, DOE's current analysis does not explicitly control for

[199] The atmospheric lifetime of CO_2 is estimated of the order of 30–95 years. Jacobson, MZ, ''Correction to 'Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming,''' *J. Geophys. Res.* 110. pp. D14105 (2005).

heterogeneity in consumer preferences, preferences across subcategories of products or specific features, or consumer price sensitivity variation according to household income.[200]

While DOE is not prepared at present to provide a fuller quantifiable framework for estimating the benefits and costs of changes in consumer purchase decisions due to an energy conservation standard, DOE is committed to developing a framework that can support empirical quantitative tools for improved assessment of the consumer welfare impacts of appliance standards. DOE has posted a paper that discusses the issue of consumer welfare impacts of appliance energy conservation standards, and potential enhancements to the methodology by which these impacts are defined and estimated in the regulatory process.[201] DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and how to quantify this impact in its regulatory analysis in future rulemakings (see issue 55 in section VIII.E).

1. Benefits and Burdens of TSLs Considered for GSL Standards

Table VI–27 and Table VI–28 summarize the quantitative impacts estimated for each TSL for GSLs. The national impacts are measured over the lifetime of GSLs purchased in the 30-year period that begins in the anticipated year of compliance with amended standards (2020–2049). The energy savings, emissions reductions, and value of emissions reductions refer to FFC results. The ELs contained in each TSL are described in section VI.A of this NOPR.

TABLE VI–27—SUMMARY OF ANALYTICAL RESULTS FOR GSL TSLS: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4
Cumulative FFC National Energy Savings (*quads*)				
	0.041	0.058	0.847	1.093
NPV of Consumer Costs and Benefits (*2014$ billion*)				
3% discount rate	0.339	0.53	9.05	11.66
7% discount rate	0.151	0.235	4.41	5.69
Cumulative FFC Emissions Reduction (Total FFC Emission)				
CO_2 (*million metric tons*)	2.520	3.517	51.713	66.755
SO_2 (*thousand tons*)	1.521	2.094	31.090	40.099
NO_X (*thousand tons*)	4.442	6.244	91.514	118.189
Hg (*tons*)	0.006	0.008	0.115	0.148
CH_4 (*thousand tons*)	10.403	14.689	215.319	278.173
CH_4 (*thousand tons CO_2eq*) *	291.287	411.299	6028.941	7788.852
N_2O (*thousand tons*)	0.031	0.043	0.643	0.830
N_2O (*thousand tons CO_2eq*) *	8.327	11.491	170.517	219.961
Value of Emissions Reduction (Total FFC Emissions)				
CO_2 (*2014$ billion*) **	0.018 to 0.244	0.025 to 0.340	0.362 to 5.002	0.467 to 6.459
NO_X—3% discount rate (*2014$ million*)	14.7 to 32.9	20.4 to 45.6	300.1 to 669.8	387.6 to 865.0
NO_X—7% discount rate (*2014$ million*)	6.5 to 14.5	8.8 to 19.5	128.9 to 287.2	166.1 to 370.1

Parentheses indicate negative (−) values.
* CO_2eq is the quantity of CO_2 that would have the same GWP.
** Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.

TABLE VI–28—SUMMARY OF ANALYTICAL RESULTS FOR GSL TSLS: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1 *	TSL 2 *	TSL 3 *	TSL 4 *
Manufacturer Impacts				
Industry NPV (2014$ million) (No-new-standards case INPV = $911.0 million)	886.6–894.3	862.2–877.3	690.0–753.3	665.9–731.3
Industry NPV (*% change*)	(2.7)–(1.8)	(5.4)–(3.7)	(24.3)–(17.3)	(26.9)–(19.7)
Residential Sector				
Consumer Average LCC Savings (*2014$*):				
Integrated Low-Lumen	0.32	0.32	0.75	0.88
Integrated High-Lumen	0.24	0.94	0.96	0.96
Consumer Simple PBP (*years*):				
Integrated Low-Lumen	3.32	4.59	2.14	1.68
Integrated High-Lumen	3.20	3.86	3.86	3.86
Percentage of Consumers that Experience Net Cost:				
Integrated Low-Lumen	1.4	1.4	1.3	1.0

[200] P.C. Reiss and M.W. White, Household Electricity Demand, Revisited, *Review of Economic Studies* (2005) 72, 853–883.

[201] Alan Sanstad, Notes on the Economics of Household Energy Consumption and Technology Choice. Lawrence Berkeley National Laboratory (2010) (Available online at: *www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf*).

TABLE VI–28—SUMMARY OF ANALYTICAL RESULTS FOR GSL TSLS: MANUFACTURER AND CONSUMER IMPACTS—Continued

Category	TSL 1 *	TSL 2 *	TSL 3 *	TSL 4 *
Integrated High-Lumen	23.2	8.9	8.7	8.7
Commercial Sector				
Consumer Average LCC Savings (*2014$*):				
Integrated Low-Lumen	1.33	1.33	1.32	1.40
Integrated High-Lumen	1.13	2.00	2.02	2.02
Non-Integrated	0	0	0	0.95
Consumer Simple PBP (*years*)				
Integrated Low-Lumen	1.12	1.29	0.70	0.55
Integrated High-Lumen	1.02	1.23	1.23	1.23
Non-Integrated	....	....	....	6.73
Percentage of Consumers that Experience Net Cost				
Integrated Low-Lumen	0.2	0.2	0	0
Integrated High-Lumen	3.3	4.9	4.9	4.9
Non-Integrated	0	0	0	6.1

* Parentheses indicate negative (−) values. The entry "n.a." means not applicable because there is no change in the standard at certain TSLs.

DOE first considered TSL 4, which represents the max-tech EL. TSL 4 would save 1.1 quads of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer benefit would be 5.7 billion using a discount rate of 7 percent, and 11.7 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 4 are 66.8 Mt of CO_2, 40.1 thousand tons of SO_2, 118.2 thousand tons of NO_X, 0.15 ton of Hg, 278 thousand tons of CH_4, and 0.83 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 4 ranges from 476 million to 6,459 million.

At TSL 4, the average LCC impact in the residential sector is a savings of $0.88 in the Integrated Low-Lumen product class and savings of $0.96 in the Integrated High-Lumen product class. In the commercial sector, the average LCC impact is a savings of $1.40 in the Integrated Low-Lumen product class, a savings of $2.02 in Integrated High-Lumen product class, and a savings of $0.95 in the Non-Integrated product class. The simple payback period in the residential sector is 1.68 years in the Integrated Low-Lumen product class and 3.86 years in the Integrated High-Lumen product class. The simple payback period in the commercial sector is 0.55 years in the Integrated Low-Lumen product class, 1.23 years in the Integrated High-Lumen product class, and 6.73 in the Non-Integrated product class. The fraction of consumers experiencing a net LCC cost in the residential sector is 1.0 percent in the Integrated Low-Lumen product class and 8.7 percent in the Integrated High-Lumen product class. The fraction of consumers experiencing a net LCC cost in the commercial sector is 0 percent in the Integrated Low-Lumen product class, 4.9 percent in the Integrated High-Lumen product class, and 6.1 percent in the Non-Integrated product class.

At TSL 4, the projected change in INPV ranges from a decrease of $245.1 million to a decrease of $179.6 million, which represent decreases of 26.9 percent and 19.7 percent, respectively. As discussed in section V.C.4, the representative lamp unit at TSL 4 in the Integrated Low-Lumen product class is a modeled LED lamp. DOE modeled the lamp based on a commercially available 3-way LED lamp that, when tested at its middle setting of 8 W, was more efficacious than other commercially available LED lamps that could be considered an adequate replacement for the baseline lamp. DOE concluded that the efficacy achieved by the 8 W setting of this lamp demonstrated the potential for a standard, non 3-way 8 W LED lamp to achieve the same efficacy level. Because TSL 4 is based on a modeled product, a commercially available lamp suitable for a direct lamp replacement that complies with TSL 4 is not currently commercially available. Although new LED products are introduced into the market at a rapid pace, DOE is uncertain as to whether such a lamp would be commercially available at the time manufacturers must comply with the proposed standard.

Additionally, DOE identified only one level of efficacy for the Non-Integrated product class. TSL 4, which represents the max-tech level, proposes a standard for the Non-Integrated product class. Although there are LCC savings associated with the efficacy level for the Non-Integrated product class, the simple payback period is longer than the lifetime of the representative units. Further, DOE anticipates minimal energy savings for the product class based on the choices consumers are expected to make when purchasing at a higher level of efficacy.

The Secretary tentatively concludes that at TSL4 for GSLs, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the potential reduction in industry value, the potentially limited availability of compliant lamps in the Low-Lumen Integrated product class, and the long payback period and limited energy savings associated with the Non-Integrated product class. Consequently, the Secretary has tentatively concluded that TSL 4 is not justified.

DOE then considered TSL 3 which would save an estimated 0.85 quads of energy, an amount DOE considers significant. Under TSL 3, the NPV of consumer benefit would be 4.4 billion using a discount rate of 7 percent, and 9.1 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 3 are 51.7 Mt of CO_2, 31.1 thousand tons of SO_2, 91.5 thousand tons of NO_X, 0.12 ton of Hg, 215 thousand tons of CH_4, and 0.64 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 3 ranges from 362 million to 5,002 million.

At TSL 3, the average LCC impact in the residential sector is a savings of $0.75 in the Integrated Low-Lumen product class and savings of $0.96 in the

Integrated High-Lumen product class. In the commercial sector, the average LCC impact is a savings of $1.32 in the Integrated Low-Lumen product class and a savings of $2.02 in Integrated High-Lumen product class. The simple payback period in the residential sector is 2.14 years in the Integrated Low-Lumen product class and 3.86 years in the Integrated High-Lumen product class. The simple payback period in the commercial sector is 0.70 years in the Integrated Low-Lumen product class and 1.23 years in the Integrated High-Lumen product class. The fraction of consumers experiencing a net LCC cost in the residential sector is 1.3 percent in the Integrated Low-Lumen product class and 8.7 percent in the Integrated High-Lumen product class. The fraction of consumers experiencing a net LCC cost in the commercial sector is 0 percent in the Integrated Low-Lumen product class and 4.9 percent in the Integrated High-Lumen product class.

At TSL 3, the projected change in INPV ranges from a decrease of $221.0 million to a decrease of $157.7 million, which represent decreases of 24.3 percent and 17.3 percent, respectively. For the Integrated Low-Lumen product class, the largest product class by volume, manufacturers would have to abandon CFL production for LED lamps. This would cause manufacturers to spend a considerable amount of R&D to introduce replacement LED lamps for those CFLs being removed from the market and make a sizable investment to increase their production equipment required to significantly expand their existing LED capacity.

After considering the analysis and weighing the benefits and burdens, the Secretary has tentatively concluded that at TSL 3 for GSLs, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, the estimated monetary value of the emissions reductions, and positive average LCC savings would outweigh the reduction in industry value, the size of manufacturer investments, and the potentially limited availability of LED lamps due to manufacturer capacity constraints. Accordingly, the Secretary has tentatively concluded that TSL 3 would offer the maximum improvement in efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy.

Therefore, based on the above considerations, DOE proposes to adopt the energy conservation standards for GSLs at TSL 3. The proposed amended energy conservation standards for GSLs are shown in Table VI–29.

TABLE VI–29—PROPOSED ENERGY CONSERVATION STANDARDS FOR GSLS

Representative product class	Efficacy level	Efficacy (lm/W)
Integrated Low-Lumen (310 ≤ Initial Lumen Output < 2,000)	EL 3	101.6–29.42*0.9983^Initial Lumen Output.
Integrated High-Lumen (2,000 ≤ Initial Lumen Output ≤ 2,600 lumens).	EL 2	73.4–29.42*0.9983^Initial Lumen Output.
Non-Integrated (310 ≤ Initial Lumen Output ≤ 2,600)	EL 0	N/A.

2. Summary of Annualized Benefits and Costs of the Proposed Standards

The benefits and costs of the proposed standards can also be expressed in terms of annualized values. The annualized net benefit is the sum of: (1) The annualized national economic value (expressed in 2014$) of the benefits from operating products that meet the proposed standards (consisting primarily of operating-cost savings from using less energy, minus increases in product purchase costs, and (2) the annualized monetary value of the benefits of CO_2 and NO_X emission reductions.[202]

Table VI–30 shows the annualized values for GSLs under TSL 3, expressed in 2014$. The results under the primary estimate are as follows.

Using a 7-percent discount rate for benefits and costs other than CO_2 reductions (for which DOE used a 3-percent discount rate along with the average SCC series corresponding to a value of $40.0/ton in 2015 (2014$)), the estimated cost of the proposed standards for GSLs is $ − 93 million per year in increased equipment costs, while the estimated benefits are $373 million per year in reduced equipment operating costs, $95 million per year in CO_2 reductions, and $13.6 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $574 million per year.

Using a 3-percent discount rate for all benefits and costs and the average SCC series corresponding to a value of $40.0/ton in 2015 (2014$), the estimated cost of the proposed standards for GSLs is $-82 million per year in increased equipment costs, while the estimated annual benefits are $438 million in reduced operating costs, $95 million in CO_2 reductions, and $17.2 million in reduced NO_X emissions. In this case, the net benefit amounts to $632 million per year.

TABLE VI–30—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GENERAL SERVICE LAMPS (TSL 3)

	Discount rate	Million 2014$/year		
		Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Benefits				
Consumer Operating-Cost Savings	7%	373	334	404
	3%	438	386	481

[202] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2014, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (2020, 2030, *etc.*), and then discounted the present value from each year to 2015. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates. Using the present value, DOE then calculated the fixed annual payment over a 30-year period, starting in the compliance year that yields the same present value.

TABLE VI–30—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GENERAL SERVICE LAMPS (TSL 3)—Continued

	Discount rate	Million 2014$/year		
		Primary estimate *	Low net benefits estimate *	High net benefits estimate *
CO_2 Reduction Value ($12.2/t) **	5%	29	26	31
CO_2 Reduction Value ($40.0/t) **	3%	95	86	101
CO_2 Reduction Value ($62.3/t) **	2.5%	138	125	148
CO_2 Reduction Value ($117/t) **	3%	287	262	308
NO_X Reduction Value †	7%	13.6	12.6	32.2
	3%	17.2	15.8	41.1
Total Benefits ††	7% plus CO_2 range	415 to 674	373 to 608	467 to 744
	7%	481	433	537
	3% plus CO_2 range	483 to 742	428 to 663	552 to 829
	3%	549	488	623
Costs				
Consumer Incremental Product Costs ‡	7%	−93	−81	−105
	3%	−82	−70	−95
Total ††	7% plus CO_2 range	508 to 767	453 to 689	571 to 849
	7%	574	513	642
	3% plus CO_2 range	566 to 824	498 to 733	647 to 924
	3%	632	558	718

* This table presents the annualized costs and benefits associated with GSLs shipped in 2020–2049. These results include benefits to consumers which accrue after 2049 from the products purchased in 2020–2049. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule.

The primary estimate assumes the reference case electricity prices and floorspace growth projections from *AEO 2015* and decreasing product prices for both CFL and LED GSLs, due to price learning. The Low Benefits Estimate uses the Low Economic Growth electricity prices and floorspace growth from *AEO 2015* and a faster decrease in product prices for LED GSLs. The High Benefits Estimate uses the High Economic Growth electricity prices and floorspace growth from *AEO 2015* and a slower decrease in product prices for LED GSLs. The methods used to derive projected price trends are explained in section V.G.1.b.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5-percent, 3-percent, and 2.5-percent discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3-percent discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section V.L. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, ''Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,'' published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) See section V.L.2 for further discussion. For DOE's Primary Estimate and Low Net Benefits Estimate, the agency is presenting a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3-percent and 7-percent cases are derived using the series corresponding to the average SCC with a 3-percent discount rate ($40.0/t case). In the rows labeled ''7% plus CO_2 range'' and ''3% plus CO_2 range,'' the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

‡ This reduction in product costs occurs because (1) more efficacious lamps have longer average lifetimes than less efficacious lamps, resulting in fewer replacement purchases, (2) the purchase price of more efficacious LED lamps is lower than the price of less efficacious LED lamps, and (3) the purchase price of LED lamps declines faster than the price of CFLs during the analysis period, resulting in LED lamps becoming less expensive than CFLs.

VII. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Section 1(b)(1) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), requires each agency to identify the problem that it intends to address, including, where applicable, the failures of private markets or public institutions that warrant new agency action, as well as to assess the significance of that problem. The problems that the proposed standards set forth in this NOPR are intended to address are as follows:

(1) Insufficient information and the high costs of gathering and analyzing relevant information leads some consumers to miss opportunities to make cost-effective investments in energy efficiency.

(2) In some cases, the benefits of more-efficient equipment are not realized due to misaligned incentives between purchasers and users. An example of such a case is when the equipment purchase decision is made by a building contractor or building owner who does not pay the energy costs.

(3) There are external benefits resulting from improved energy efficiency of appliances and equipment that are not captured by the users of such products. These benefits include externalities related to public health, environmental protection, and national energy security that are not reflected in energy prices, such as reduced emissions of air pollutants and greenhouse gases that impact human health and global warming. DOE attempts to quantify some of the external benefits through use of social cost of carbon values.

The Administrator of the Office of Information and Regulatory Affairs (OIRA) in the OMB has determined that the proposed regulatory action is a significant regulatory action under section (3)(f) of Executive Order 12866.

Accordingly, pursuant to section 6(a)(3)(B) of the Order, DOE has provided to OIRA: (i) The text of the draft regulatory action, together with a reasonably detailed description of the need for the regulatory action and an explanation of how the regulatory action will meet that need; and (ii) An assessment of the potential costs and benefits of the regulatory action, including an explanation of the manner in which the regulatory action is consistent with a statutory mandate. DOE has included these documents in the rulemaking record.

In addition, the Administrator of OIRA has determined that the proposed regulatory action is an ''economically'' significant regulatory action under section (3)(f)(1) of Executive Order 12866. Accordingly, pursuant to section 6(a)(3)(C) of the Order, DOE has provided to OIRA an assessment, including the underlying analysis, of benefits and costs anticipated from the regulatory action, together with, to the extent feasible, a quantification of those costs; and an assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation, and an explanation why the planned regulatory action is preferable to the identified potential alternatives. These assessments can be found in the NOPR TSD for this rulemaking.

DOE has also reviewed this regulation pursuant to Executive Order 13563, issued on January 18, 2011. 76 FR 3281 (Jan. 21, 2011). Executive Order 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in Executive Order 12866. To the extent permitted by law, agencies are required by Executive Order 13563 to: (1) Propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.

DOE emphasizes as well that Executive Order 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, OIRA has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, DOE believes that this NOPR is consistent with these principles, including the requirement that, to the extent permitted by law, benefits justify costs and that net benefits are maximized.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's Web site (*http://energy.gov/gc/office-general-counsel*). DOE has prepared the following IRFA for the products that are the subject of this rulemaking.

1. Description on Estimated Number of Small Entities Regulated

For manufacturers of GSLs, the SBA has set a size threshold, which defines those entities classified as ''small businesses'' for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule See 13 CFR part 121. The size standards are listed by NAICS code and industry description and are available at *http://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf.* Manufacturing of GSLs is classified under NAICS 335110, ''Electric Lamp Bulb and Part Manufacturing.'' The SBA sets a threshold of 1,000 employees or less for an entity to be considered as a small business for this category.

To estimate the number of companies that could be small businesses that sell GSLs covered by this rulemaking, DOE conducted a market survey using publicly available information. DOE's research involved information provided by trade associations (*e.g.,* NEMA [203]) and information from DOE's Compliance Certification Management System (CCMS) Database,[204] EPA's ENERGY STAR Certified Light Bulbs Database,[205] LED Lighting Facts Database,[206] previous rulemakings, individual company Web sites, SBA's database, and market research tools (*e.g.,* Hoover's reports [207]). DOE also asked stakeholders and industry representatives if they were aware of any small businesses during manufacturer interviews and DOE public meetings. DOE used information from these sources to create a list of companies that potentially manufacture or sell GSLs and would be impacted by this rulemaking. DOE screened out companies that do not offer products covered by this rulemaking, do not meet the definition of a ''small business,'' or are completely foreign owned and operated.

DOE identified approximately 118 small businesses that sell GSLs in the United States that are covered by this rulemaking. However, DOE estimates that approximately 65 of these potential small businesses are rebranders who typically purchase fully assembled lamps from original equipment manufacturers and are not involved in the product development or manufacturing of those lamps. Subsequently, DOE determined that 53 companies were small businesses that are involved in the product development and/or manufacturing of GSLs covered by this rulemaking.

[203] National Electric Manufacturers Association | Member Products | Lighting Systems | Related Manufacturers, *http://www.nema.org/Products/Pages/Lighting-Systems.aspx* (last accessed July 13, 2015).

[204] DOE's Compliance Certification Database | Lamps—Bare or Covered (No Reflector) Medium Bas Compact Fluorescent, *http://www.regulations.doe.gov/certification-data* (last accessed July 13, 2015).

[205] ENERGY STAR Qualified Lamps Product List, *http://downloads.energystar.gov/bi/qplist/Lamps_Qualified_Product_List.xls?dee3-e997* (last accessed July 13, 2015).

[206] LED Lighting Facts Database, *http://www.lightingfacts.com/products* (last accessed July 13, 2015).

[207] Hoovers | Company Information | Industry Information | Lists, *http://www.hoovers.com* (last accessed July 13, 2015).

DOE was able to interview five small GSL businesses as part of the NOPR manufacturer interviews. DOE seeks comments, information, and data on the number of small businesses, including the number of rebranders, in the GSL industry that DOE identified, including their estimated market share.

2. Description and Estimate of Compliance Requirements

DOE assumed that LED manufacturers would be required to test and certify their LED lamps in the absence of DOE setting energy conservation standards for this GSL rulemaking, since the EISA 2007 45 lm/W backstop would be triggered and would include LED lamps. This backstop would require LED manufacturers to test and certify their LED lamps using the same DOE test procedure that these manufacturers would use if DOE sets energy conservation standards for this GSL rulemaking.

DOE assumes that the proposed standards would not increase the regulatory burden on GSL manufacturers that are making compliant products compared to the no-new-standards case regulatory burden. Additionally, DOE assumes that the GSL small businesses that are not responsible for the product development or manufacturing of the lamps they sell (*i.e.,* rebranders) have significantly less conversion costs and compliance costs for any products that would need to be redesigned because of the proposed standards compared to GSL manufacturers who do either their own product development or manufacturing. DOE assumes that while rebranders are responsible for certifying their lamps to DOE's energy conservation standards, typically the original equipment manufacturers provide the rebranders with the test data necessary for certification. Therefore, DOE assumes these certification costs will not significantly impact these small businesses.

According to DOE's analysis, of the 118 GSL small businesses, approximately 84 exclusively sell LED lamps and do not sell lamps using other technologies (*i.e.,* CFLs). Of those 84 small businesses exclusively selling LEDs, DOE estimates that approximately half are rebranders and half are involved in the product development and/or the manufacturing of the LEDs they sell.

DOE anticipates that in 2020 approximately 63 percent of all LED lamps covered by this rulemaking would meet the standards required at TSL 3. Also, given the short product development lifetime of LEDs, DOE anticipates that most, if not all, LED lamps that fail to meet the proposed standards would have experienced a product redesign during the three year compliance period in the absence of GSL energy conservation standards. So while DOE assumes that small businesses exclusively selling LED lamps would incur additional R&D investments to increase the efficacy of some of their products to meet the proposed standards, DOE also assumes that a portion of the testing and certification costs would be incurred by these small businesses in the no-new standards case.

Additionally, DOE does not assume small businesses exclusively selling LED lamps will incur additional investment in production equipment (*i.e.,* capital conversion costs) due to the proposed standards, since most LED small businesses either do not own their LED production equipment or could use their existing LED production equipment to manufacture more efficacious LED lamps that meet the proposed standards. Lastly, DOE assumes that original equipment manufacturers frequently produce the same LEDs for a variety of rebranders. Therefore, original equipment manufacturers would not pass on all of these R&D and testing costs caused by the proposed standards, to an individual rebrander. Instead the original equipment manufacturer would most likely spread these R&D and testing costs over a variety of rebranders that purchase an LED lamp from this original equipment manufacturer. Overall, DOE does not anticipate a significant impact to the majority of small businesses that exclusively sell LED lamps, especially for the rebranders, based on the proposed standards, TSL 3.

DOE estimates that there are approximately 29 small businesses that sell both CFLs and LEDs. These small businesses could be disproportionally impacted by the proposed energy conservation standards compared to large GSL manufacturers. The impact on each individual small business will depend on the portion of sales that CFLs, and to a lesser extent LED lamps that are not compliant with proposed standards, make up of a small business' total revenue and the number of CFL models that would need to be removed and LED lamp models that would need to be redesigned due to the proposed standards. The proposed standards would likely create a large shift in the market share of GSL manufacturers, and therefore some small businesses selling CFLs may not be able to replace that lost revenue with an increase in their additional LED lamp revenue.

Lastly, there are approximately five small businesses that exclusively sell CFLs and do not sell any LED lamps. These small businesses would be the most severely impacted by the proposed standards. Because their products would no longer meet the proposed standards, these small busineses would have to discontinue their CFL product lines and replace their portfolio with compliant LED lamps to stay in business. This would require using a completely different technology for all their products and finding new component suppliers (for the two manufacturers) or original equipment manufacturers (for the three rebranders).

DOE calculated the conversion costs that typical small and large general service lamp manufacturers would need to make in order to comply with standards set at each TSL. DOE presents a range of conversion costs for a typical small and large general service lamp manufacturer to account for both the low and high investment scenarios used at each TSL.

TABLE VII–1 COMPARISON OF TYPICAL SMALL AND LARGE MANUFACTURER'S TOTAL CONVERSION COSTS

Trial standard level	Total conversion costs for typical small manufacturer (2014$ millions)	Total conversion costs for typical large manufacturer (2014$ millions)
TSL 1	1.3—1.4	4.7—4.9
TSL 2	1.5—1.6	4.8—5.2
TSL 3	2.2—2.6	6.4—7.7
TSL 4	2.3—2.7	6.5—7.8

3. Duplication, Overlap, and Conflict With Other Rules and Regulations

DOE is not aware of any rules or regulations that duplicate, overlap, or conflict with the proposed new and amended standards. DOE seeks comment on any rules or regulations that could potentially duplicate, overlap, or conflict with the proposed new and amended standards.

4. Significant Alternatives to the Rule

The discussion in the previous section analyzes impacts on small businesses that would result from DOE's proposed rule, TSL 3. In reviewing alternatives to the proposed rule, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1 and TSL 2 would reduce the impacts on small business manufacturers, it would come at the expense of a reduction in energy savings. TSL 1 achieves 95 percent percent lower energy savings compared to the energy savings at TSL 3. TSL 2 achieves 93 percent percent lower energy savings compared to the energy savings at TSL 3.

DOE believes that establishing standards at TSL 3 balances the benefits of the energy savings at TSL 3 with the potential burdens placed on GSL manufacturers, including small business manufacturers. Accordingly, DOE is declining to adopt one of the other TSLs considered in the analysis, or the other policy alternatives detailed as part of the regulatory impacts analysis included in Chapter 17 of this NOPR TSD.

DOE does not have the capability of extending the compliance date for small businesses beyond January 1, 2020 due to the statutory requirement in 42 U.S.C. 6295(i)(6)(A)(iii); however, additional compliance flexibilities may be available through other means. For example, individual manufacturers may petition for a waiver of the applicable test procedure. (See 10 CFR 430.27) Further, EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8 million may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. Additionally, section 504 of the Department of Energy Organization Act, 42 U.S.C. 7194, provides authority for the Secretary to adjust a rule issued under EPCA in order to prevent ''special hardship, inequity, or unfair distribution of burdens'' that may be imposed on that manufacturer as a result of such rule. Manufacturers should refer to 10 CFR part 430, subpart E, and 10 CFR part 1003 for additional details.

DOE requests any available data or reports that would contribute to the analysis of alternatives to standards for GSLs. In particular, DOE seeks information on the effectiveness of existing or past efficiency improvement programs for these products (see issue 57 in section VIII.E).

NEMA indicated that depending on the energy efficiency standard set by the rulemaking, utilities may decide to forego their lamp rebate programs, which may actually result in slower GSL adoption rates. (NEMA, No. 34 at p. 29) DOE notes that it did not assume the continued existence of utility rebate programs for GSLs in its analysis of the considered TSLs. DOE did consider policy alternatives, including consumer rebates, to energy efficiency standards and determined that the energy savings of these alternatives are significantly smaller than those that would be expected to result from adoption of the proposed standard levels.

C. Review Under the Paperwork Reduction Act

Manufacturers of GSLs must certify to DOE that their products comply with any applicable energy conservation standards. In certifying compliance, manufacturers must test their products according to the DOE test procedures for GSLs, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment. 76 FR 12422 (March 7, 2011). The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910–1400. DOE requested OMB approval of an extension of this information collection for three years, specifically including the collection of information proposed in the present rulemaking, and estimated that the annual number of burden hours under this extension is 30 hours per company. In response to DOE's request, OMB approved DOE's information collection requirements covered under OMB control number 1910–1400 through November 30, 2017. 80 FR 5099 (January 30, 2015).

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB control number.

D. Review Under the National Environmental Policy Act of 1969

Pursuant to the National Environmental Policy Act (NEPA) of 1969, DOE has determined that the proposed rule fits within the category of actions included in Categorical Exclusion (CX) B5.1 and otherwise meets the requirements for application of a CX. See 10 CFR part 1021, App. B, B5.1(b); 1021.410(b) and App. B, B(1)–(5). The proposed rule fits within this category of actions because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, and for which none of the exceptions identified in CX B5.1(b) apply. Therefore, DOE has made a CX determination for this rulemaking, and DOE does not need to prepare an Environmental Assessment or Environmental Impact Statement for this proposed rule. DOE's CX determination for this proposed rule is available at *http://cxnepa.energy.gov/*.

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism,'' 64 FR 43255 (August 10, 1999), imposes certain requirements on federal agencies formulating and implementing policies or regulations that preempt state law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the states and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by state and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this proposed rule and has tentatively determined that it would not have a substantial direct effect on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes federal preemption of state regulations as to energy conservation for the products that are the subject of this proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297)

Therefore, no further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' imposes on federal agencies the general duty to adhere to the following requirements: (1) Eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general standard; and (4) promote simplification and burden reduction. 61 FR 4729 (Feb. 7, 1996). Regarding the review required by section 3(a), section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this proposed rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each federal agency to assess the effects of federal regulatory actions on state, local, and tribal governments and the private sector. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by state, local, and tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a federal agency to develop an effective process to permit timely input by elected officers of state, local, and tribal governments on a proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. DOE's policy statement is also available at *http://energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf*.

Although this proposed rule does not contain a federal intergovernmental mandate, it may require expenditures of $100 million or more in any one year by the private sector. Such expenditures may include: (1) Investment in R&D and in capital expenditures by GSL manufacturers in the years between the final rule and the compliance date for the new standards, and (2) incremental additional expenditures by consumers to purchase more efficacious GSLs.

Section 202 of UMRA authorizes a federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the proposed rule. (2 U.S.C. 1532(c)) The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The SUPPLEMENTARY INFORMATION section of this NOPR and the TSD for this proposed rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. (2 U.S.C. 1535(a)) DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the proposed rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6295(d), (f), and (o), 6313(e), and 6316(a), this proposed rule would establish new and amended energy conservation standards for GSLs that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified. A full discussion of the alternatives considered by DOE is presented in the ''Regulatory Impact Analysis'' section of the TSD for this proposed rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

Pursuant to Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (March 15, 1988), DOE has determined that this proposed rule would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under the Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for federal agencies to review most disseminations of information to the public under information quality guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed this NOPR under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use,'' 66 FR 28355 (May 22, 2001), requires federal agencies to prepare and submit to OIRA at OMB, a Statement of Energy Effects for any proposed significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of

OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has tentatively concluded that this regulatory action, which proposes new and amended energy conservation standards for GSLs, is not a significant energy action because the proposed standards are not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as such by the Administrator at OIRA. Accordingly, DOE has not prepared a Statement of Energy Effects on this proposed rule.

L. Review Under the Information Quality Bulletin for Peer Review

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy (OSTP), issued its Final Information Quality Bulletin for Peer Review (the Bulletin). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the federal government, including influential scientific information related to agency regulatory actions. The purpose of the Bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are ''influential scientific information,'' which the Bulletin defines as ''scientific information the agency reasonably can determine will have, or does have, a clear and substantial impact on important public policies or private sector decisions.'' *Id.* at FR 2667.

In response to OMB's Bulletin, DOE conducted formal in-progress peer reviews of the energy conservation standards development process and analyses and has prepared a Peer Review Report pertaining to the energy conservation standards rulemaking analyses. Generation of this report involved a rigorous, formal, and documented evaluation using objective criteria and qualified and independent reviewers to make a judgment as to the technical/scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects. The ''Energy Conservation Standards Rulemaking Peer Review Report'' dated February 2007 has been disseminated and is available at the following Web site: *www1.eere.energy.gov/buildings/appliance_standards/peer_review.html.*

M. Description of Materials Incorporated by Reference

In this NOPR, DOE proposes to incorporate by reference the standard published by UL, titled ''Standard for Light-Emitting Diode Retrofit Luminaire Conversion Kits,'' First Edition, dated January 16, 2014, UL 1598C–2014. UL 1598C–2014 is an industry accepted standard that describes the requirements for LED retrofit luminaire conversion kits intended to replace existing incandescent, fluorescent, induction, and HID systems that comply with existing requirements for luminaires. The standard proposed in this NOPR references UL 1598C–2014 for the definition of the term ''LED Downlight Retrofit Kit.'' UL 1598C–2014 is readily available on *http://ulstandards.ul.com/standards-catalog/.*

VIII. Public Participation

A. Attendance at the Public Meeting

The time, date, and location of the public meeting are listed in the **DATES** and **ADDRESSES** sections at the beginning of this NOPR. If you plan to attend the public meeting, please notify Ms. Brenda Edwards at (202) 586–2945 or *Brenda.Edwards@ee.doe.gov.*

Please note that foreign nationals visiting DOE Headquarters are subject to advance security screening procedures which require advance notice prior to attendance at the public meeting. If a foreign national wishes to participate in the public meeting, please inform DOE of this fact as soon as possible by contacting Ms. Regina Washington at (202) 586–1214 or by email (*Regina.Washington@ee.doe.gov*) so that the necessary procedures can be completed.

DOE requires visitors to have laptops and other devices, such as tablets, checked upon entry into the Forrestal Building. Any person wishing to bring these devices into the building will be required to obtain a property pass. Visitors should avoid bringing these devices, or allow an extra 45 minutes to check in. Please report to the visitor's desk to have devices checked before proceeding through security.

Due to the REAL ID Act implemented by the Department of Homeland Security (DHS), there have been recent changes regarding identification (ID) requirements for individuals wishing to enter federal buildings from specific states and U.S. territories. As a result, driver's licenses from several states or territory will not be accepted for building entry, and instead, one of the alternate forms of ID listed below will be required. DHS has determined that regular driver's licenses (and ID cards) from the following jurisdictions are not acceptable for entry into DOE facilities: Alaska, American Samoa, Arizona, Louisiana, Maine, Massachusetts, Minnesota, New York, Oklahoma, and Washington. Acceptable alternate forms of Photo-ID include: U.S. Passport or Passport Card; an Enhanced Driver's License or Enhanced ID-Card issued by the States of Minnesota, New York, or Washington (Enhanced licenses issued by these states are clearly marked Enhanced or Enhanced Driver's License); a military ID or other federal-government-issued photo ID-card.

In addition, you can attend the public meeting via webinar. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's Web site at: *https://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=83.* Participants are responsible for ensuring their systems are compatible with the webinar software.

B. Procedure for Submitting Prepared General Statements for Distribution

Any person who has plans to present a prepared general statement may request that copies of his or her statement be made available at the public meeting. Such persons may submit requests, along with an advance electronic copy of their statement in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format, to the appropriate address shown in the **ADDRESSES** section at the beginning of this NOPR. The request and advance copy of statements must be received at least one week before the public meeting and may be emailed, hand-delivered, or sent by mail. DOE prefers to receive requests and advance copies via email. Please include a telephone number to enable DOE staff to make follow-up contact, if needed.

C. Conduct of the Public Meeting

DOE will designate a DOE official to preside at the public meeting and may also use a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with section 336 of EPCA. (42 U.S.C. 6306) A court reporter will be present to record the proceedings and prepare a transcript. DOE reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the public meeting. There shall not be discussion of proprietary information, costs or prices, market share, or other commercial matters regulated by U.S. anti-trust laws. After the public meeting, interested parties may submit further comments on the proceedings, as well as on any aspect of the rulemaking, until the end of the comment period.

The public meeting will be conducted in an informal, conference style. DOE will present summaries of comments received before the public meeting, allow time for prepared general statements by participants, and encourage all interested parties to share their views on issues affecting this rulemaking. Each participant will be allowed to make a general statement (within time limits determined by DOE), before the discussion of specific topics. DOE will allow, as time permits, other participants to comment briefly on any general statements.

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly and comment on statements made by others. Participants should be prepared to answer questions by DOE and by other participants concerning these issues. DOE representatives may also ask questions of participants concerning other matters relevant to this rulemaking. The official conducting the public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the public meeting.

A transcript of the public meeting will be included in the docket, which can be viewed as described in the *Docket* section at the beginning of this notice and will be accessible on the DOE Web site. In addition, any person may buy a copy of the transcript from the transcribing reporter.

D. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule before or after the public meeting, but no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this NOPR.

Submitting comments via *www.regulations.gov*. The *www.regulations.gov* Web page will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment itself or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Otherwise, persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to *www.regulations.gov* information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as confidential business information or CBI). Comments submitted through *www.regulations.gov* cannot be claimed as CBI. Comments received through the Web site will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section below.

DOE processes submissions made through *www.regulations.gov* before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that *www.regulations.gov* provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery/courier, or mail. Comments and documents submitted via email, hand delivery/courier, or mail also will be posted to *www.regulations.gov*. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via mail or hand delivery/courier, please provide all items on a CD, if feasible, in which case it is not necessary to submit printed copies. No telefacsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, that are written in English, and that are free of any defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery/courier two well-marked copies: One copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1) A description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person that would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

E. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. DOE requests comment on its consideration to exclude from the scope of the GSL rulemaking lamps that are addressed in other rulemakings. See section IV.B.2.

2. DOE requests comment on the energy savings potential of standards for GSLs greater than 2,600 lumens. See section IV.B.3.

3. DOE requests comment on the revised definitions proposed for general service LED lamp, OLED lamp, and light fixture. See sections IV.C.1, IV.C.2, and IV.C.6.

4. DOE requests comment on the definition proposed for LED downlight retrofit kit. See section IV.C.7.

5. DOE requests comment on if there are any other lamp types that do not serve in general lighting applications and should be exempted from general service lamp standards. See section IV.D.

6. DOE welcomes comment on the exemptions proposed for non-incandescent lamps of certain shapes, in particular on the proposal to exempt B-shape lamps (including blunt shape), C- and CA-shape lamps (including candle shape), F-shape lamps (including flame or flame tip shape), S-shape lamps, and torpedo or torpedo tip shape lamps with diameters of 1.875 inches or less, G-shape lamps with diameters of 2.0625 or less, and A15 lamps with diameter of 2.185 or less. See section IV.D.2.e.

7. DOE welcomes comment on including non-IRLs in the definition of GSLs. See section IV.D.2.a.

8. DOE requests comment on the various definitions based on GSIL exemptions proposed to better delineate the GSL definition, especially in regards to determining the possible GSLs that use technologies other than incandescent and operate in applications equivalent to those of the lamps exempted from the GSIL definition. See section IV.D.

9. DOE requests comments on its assessments of GSLs for which standards should be proposed. See section IV.E.4.

10. DOE requests information on start times available on the CFL market. See section IV.F.2.c.

11. DOE requests comment on its proposal to require integrated LED lamps to meet a power factor of 0.7 or some other value. See section IV.F.3.

12. DOE requests any comments regarding proposed metrics for GSLs in this NOPR analysis. See section IV.F.4.

13. DOE requests comments on the proposed product classes. See section V.A.1.

14. DOE requests comment on its proposed renaming of ''device level optics'' to ''improved primary optics'' and refined description of this technology option. See section V.A.2.b.

15. DOE requests comment on its proposal to replace the term ''increased light utilization'' with ''improved secondary optics'' and the refined definition of this technology option. See section V.A.2.b.

16. DOE requests comments on the proposed technology options. See section V.A.2.c.

17. DOE requests comment on the proposed design options in this NOPR analysis. See section V.B.3.

18. In its collection of lamp performance data, DOE did not consider high and low end outliers in the engineering analysis where DOE was unable to verify values using test data or manufacturer confirmation. DOE welcomes comment on the data approach. See section V.C.1.

19. DOE requests comment on the baseline lamps analyzed in the NOPR analysis, in particular the spiral CFL baseline in the Integrated Low-Lumen product class. See section V.C.3.a.

20. DOE requests comment on the 3-way lamp used as a basis for the modeled LED lamp and information on whether such a lamp would meet DOE's screening criteria and should be maintained for the final rule analysis. See section V.C.4.

21. DOE requests comment on the ELs under consideration for both of the integrated lamp product classes, including the max-tech levels. See section V.C.5.a.

22. DOE requests comment on the assumption that the efficacy of non-integrated CFLs can be improved for those lamps with base types that potentially cannot meet EL 1. See section V.C.5.b.

23. DOE requests comment on the EL under consideration for the Non-Integrated product class, including the max-tech level. See section V.C.5.b.

24. DOE requests comment on the scaling factors determined. See section V.C.6.

25. DOE requests comment on its assumption that the EISA 2007 backstop will be triggered. See section V.E.1.a.

26. DOE requests comment on the data and methodology used to estimate operating hours for GSLs in the residential sector, as well as on the assumption that GSL operating hours do not vary between CFLs and LED GSLs. See section V.E.1.a.

27. DOE invites comments and data on its approach to account for variability in HOU in the commercial sector. See section V.E.1.b.

28. DOE requests comment on the energy reduction estimate of 30 percent, as well as data and information on the energy use implications of using dimmers in the residential sector. See section V.E.3.

29. DOE requests comment on the assumption that, although in the NOPR analyses DOE continues to assume that 5 percent of CFLs are dimmable, the fraction of CFLs and LEDs that are used with controls external to the lamp is assumed to be the same (14 percent in the reference case) in the residential sector. See section V.E.3.

30. DOE requests comment on the overall methodology and results of the LCC and PBP analyses. See section V.F.

31. DOE requests comment on the installation cost assumptions used in its analyses. See section V.F.2.

32. DOE requests comment on the methodology and assumptions used to determine the market share of the lumen range distributions. See section V.F.3.

33. DOE invites comment on the three GSL service life scenarios in its analyses. DOE also invites comment on the lifetime scenario accounting for GSL failure in the first year of use. See section V.F.6.

34. DOE requests comment and relevant data on the disposal cost assumptions used in its analyses. See section V.F.8.

35. DOE requests relevant data on GSL shipments as they become available in order to improve the accuracy of the shipments analysis. See section V.G.1.a.

36. DOE requests comment on the assumption that the shift to CFL and LED GSLs during the shipments analysis period will take place over several years. See section V.G.1.a.

37. DOE requests comment on whether there are data, in the lighting sector, showing that consumers might purchase, in quantity, existing products on the market prior to compliance of a new, more efficient standard.

38. DOE invites comments on its approach to price learning for LED GSLs. See section V.G.1.b.

39. DOE requests comment on the assumption that brighter lumen bins have a fixed fractional price increment relative to lamps in dimmer lumen bins. See section V.G.1.b.

40. DOE has assumed zero rebound effect in the reference scenario for consumers switching from CFLs to LED lamps in both the commercial and residential sectors. In an alternative scenario, DOE has assumed 15 percent rebound in the residential sector for consumers switching from CFLs to LED lamps, and zero rebound in the commercial sector. DOE requests comment on these assumptions and any data that can be used to further refine the rebound effect assumptions used in the shipments and NIA analyses. See section V.H.1.

41. DOE estimated a reduction in product costs at the proposed standard level because (1) more efficacious lamps have longer average lifetimes than less efficacious lamps, resulting in fewer replacement purchases, (2) the purchase price of more efficacious LED lamps is lower than the price of less efficacious LED lamps, and (3) the purchase price of LED lamps declines faster than the price of CFLs during the analysis period, resulting in LED lamps becoming less expensive than CFLs. DOE requests comment on the cost reduction estimate. See section VI.C.2.

42. DOE considered three lighting-controls scenarios including a smaller range of penetration for smart lamps: 0 percent smart-lamp penetration in the residential sector by 2049, 50 percent penetration (the reference scenario), and a high residential-controls scenario which assumed that externally controlled sockets increase to 50 percent of all sockets in 2049 in addition to a 50 percent penetration of smart lamps in 2049. DOE invites comment on these scenarios. See section V.H.1.a.

43. DOE requests data and information on the assumption of 30 percent energy savings for smart lamps. See section V.H.1.a.

44. DOE invites comment on the low and high benefits scenarios considered in its analysis. See section V.H.2.

45. In addition to the high and low benefits scenarios, DOE considered several other scenarios in its shipments and NIA analyses. DOE invites comments on whether there are other scenarios that should be considered. See section V.H.2.

46. DOE requests comment on the consumer subgroups selected for analysis in this NOPR. See section V.I.

47. DOE requests comment on its approach to conducting the emissions analysis for GSLs. See section V.K.

48. DOE requests comment on the use of 1.52 as an average distribution chain markup and 1.55 as the manufacturer markup for all GSLs. See section V.J.2.b.

49. DOE seeks comment on the assumption that there is only one GSL manufacturer with domestic production of CFLs or LED lamps. Additionally, DOE seeks comment on any potential domestic employment impacts as a result of the proposed new and amended energy conservation standards for GSLs in this NOPR. See section VI.B.2.b.

50. DOE seeks comment on any other potential manufacturer subgroups that could be disproportionally impacted by new and amended energy conservation standards for GSLs. See section VI.B.2.d.

51. DOE seeks comment on the compliance costs of any other regulations GSL manufacturers must make, especially if compliance with those regulations is required three years before or after the estimated compliance date of these proposed standards (2020). See section VI.B.2.e.

52. DOE invites input on its approach to estimating monetary benefits associated with emissions reductions. See section V.L.

53. DOE seeks comment on its approach to conducting the utility impact analysis. See section V.M.

54. DOE welcomes input on its approach to assessing national employment impacts. See section V.N.

55. DOE requests comment on its assumption that there will be no lessening of utility or performance such that the performance characteristics, including physical constraints, diameter, lumen package, color quality, lifetime, and ability to dim, would be adversely affected for the GSL efficacy levels. See sections VI.B.4, V.A, V.B, and V.C.

56. DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and how to quantify this impact in its regulatory analysis in future rulemakings. See section VI.C.

57. DOE requests any available data or reports that would contribute to the analysis of alternatives to standards for GSLs. In particular, DOE seeks information on the effectiveness of existing or past efficiency improvement programs for these products. See section VII.B.4.

IX. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this notice of proposed rulemaking.

List of Subjects

10 CFR Part 429

Confidential business information, Energy conservation, Household appliances, Imports, Reporting and recordkeeping requirements.

10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Issued in Washington, DC, on February 12, 2016.

David T. Danielson,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE proposes to amend parts 429 and 430 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 429—CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291–6317.

■ 2. Section 429.12 is amended by revising paragraph (d) to read as follows:

§ 429.12 General requirements applicable to certification reports.

* * * * *

(d) *Annual filing.* All data required by paragraphs (a) through (c) of this section shall be submitted to DOE annually, on or before the following dates:

Product category	Deadline for data submission
Fluorescent lamp ballasts, Incandescent reflector lamps, General service fluorescent lamps, General service lamps, Residential ceiling fans, Residential ceiling fan light kits, Residential showerheads, Residential faucets, Residential water closets, and Residential urinals.	Mar. 1.
Residential water heater, Residential furnaces, Residential boilers, Residential pool heaters, Commercial water heaters, Commercial hot water supply boilers, Commercial unfired hot water storage tanks, Commercial packaged boilers, Commercial warm air furnaces, Commercial unit heaters and Residential furnace fans.	May 1.
Residential dishwashers, Commercial prerinse spray valves, Illuminated exit signs, Traffic signal modules, Pedestrian modules, and Distribution transformers.	June 1.
Room air conditioners, Residential central air conditioners, Residential central heat pumps, Small duct high velocity system, Space constrained products, Commercial package air-conditioning and heating equipment, Packaged terminal air conditioners, Packaged terminal heat pumps, and Single package vertical units.	July 1.
Residential refrigerators, Residential refrigerators-freezers, Residential freezers, Commercial refrigerator, freezer, and refrigerator-freezer, Automatic commercial automatic ice makers, Refrigerated bottled or canned beverage vending machine, Walk-in coolers, and Walk-in freezers.	Aug. 1.
Torchieres, Residential dehumidifiers, Metal halide lamp fixtures, External power supplies, and Pumps.	Sept. 1.
Residential clothes washers, Residential clothes dryers, Residential direct heating equipment, Residential cooking products, and Commercial clothes washers.	Oct. 1.

* * * * *

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

■ 3. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291–6309; 28 U.S.C. 2461 note.

■ 4. Section 430.2 is amended by:

■ a. Adding in alphabetical order the definitions of ''Black light lamp,'' ''Bug lamp,'' ''Colored lamp,'' ''General service light-emitting diode LED lamp,'' ''GU24 base,'' ''Infrared lamp,'' ''Integrated lamp,'' ''LED Downlight Retrofit Kit,'' ''Light fixture,'' ''Marine signal service lamp,'' ''Mercury vapor lamp,'' ''Mine service lamp,'' ''Non-integrated lamp,'' ''Non-reflector lamp,'' ''OLED lamp,'' ''Pin base lamp,'' ''Plant light lamp,'' ''Reflector lamp,'' ''Showcase Lamp,'' ''Sign service lamp,'' ''Silver bowl lamp,'' and ''Traffic signal lamp;'' and

■ b. Revising the definitions of ''designed and marketed'' and ''general service lamp.''

The additions and revisions read as follows:

§ 430.2 Definitions.

* * * * *

Black light lamp means a lamp that is designed and marketed as a black light lamp and is an ultraviolet lamp with the highest radiant power peaks in the UV–A band (315 to 400 nm) of the electromagnetic spectrum.

* * * * *

Bug lamp means a lamp that is designed and marketed as a bug lamp, has radiant power peaks above 550 nm on the electromagnetic spectrum, and has a visible yellow coating.

* * * * *

Colored lamp means a colored fluorescent lamp, a colored incandescent lamp, or a lamp designed and marketed as a colored lamp and not designed and marketed for general lighting applications with either of the following characteristics (if multiple modes of operation are possible [such as variable CCT], either of the below characteristics must be maintained throughout all modes of operation):

(1) A CRI less than 40, as determined according to the method set forth in CIE Publication 13.3 (incorporated by reference; see § 430.3); or

(2) A correlated color temperature less than 2,500 K or greater than 7,000 K as determined according to the method set forth in IES LM–66 or IES LM–79 as appropriate (incorporated by reference; see § 430.3).

* * * * *

Designed and marketed means that the product is specifically designed to fulfill the indicated application and, when distributed in commerce, is designated and marketed for the intended application, with the designation on the packaging and all publicly available documents (*e.g.*, product literature, catalogs, and packaging labels) indicating the intended application. This definition is applicable to terms related to the following covered lighting products: Fluorescent lamp ballasts; fluorescent lamps; general service fluorescent lamps; general service incandescent lamps; general service lamps; incandescent lamps; incandescent reflector lamps; medium base compact fluorescent lamps; and specialty application mercury vapor lamp ballasts.

* * * * *

General service lamp means a lamp that has an ANSI base, operates at any voltage, has an initial lumen output of 310 lumens or greater (or 232 lumens or greater for modified spectrum general service incandescent lamps), is not a light fixture, is not an LED downlight retrofit kit, and is used in general lighting applications. General service lamps include, but are not limited to, general service incandescent lamps, compact fluorescent lamps, general service light-emitting diode lamps, and general service organic light-emitting diode lamps, but do not include general service fluorescent lamps; incandescent reflector lamps; mercury vapor lamps; appliance lamps; black light lamps; bug lamps; colored lamps; infrared lamps; marine signal lamps; mine service lamps; plant light lamps; sign service lamps; traffic signal lamps; and medium screw base incandescent lamps that are left-hand thread lamps, marine lamps, reflector lamps, rough service lamps, shatter-resistant lamps (including a shatter-proof lamp and a shatter-protected lamp), silver bowl lamps, showcase lamps, 3-way incandescent lamps, vibration service lamps, G shape lamps as defined in ANSI C78.20 (incorporated by reference; see § 430.3) and ANSI C79.1–2002 (incorporated by reference; see § 430.3) with a diameter of 5 inches or more, T shape lamps as defined in ANSI C78.20 and ANSI C79.1–2002 and that use not more than 40 watts or have a length of more than 10 inches, and B, BA, CA, F, G16–1/2, G–25, G30, S, or M–14 lamps as defined in ANSI C79.1–2002 and ANSI C78.20 of 40 watts or less.

General service light-emitting diode (LED) lamp means an integrated or non-integrated LED lamp designed for use in general lighting applications (as defined in § 430.2) and that uses light-emitting diodes as the primary source of light.

* * * * *

GU24 base means the GU24 base standardized in ANSI C81.61 (incorporated by reference; see § 430.3).

* * * * *

Infrared lamp means a lamp that is designed and marketed as an infrared lamp, has its highest radiant power peaks in the infrared region of the electromagnetic spectrum (770 nm to 1 mm), and which has a primary purpose of providing heat.

Integrated lamp means a lamp that contains all components necessary for the starting and stable operation of the lamp, does not include any replaceable or interchangeable parts, and is connected directly to a branch circuit through an ANSI base and corresponding ANSI standard lamp-holder (socket).

* * * * *

LED Downlight Retrofit Kit means a product intended to install into an existing downlight, replacing the existing light source and related electrical components, typically employing an ANSI standard lamp base, either integrated or connected to the downlight retrofit by wire leads, and is a retrofit kit classified or certified to UL 1598C (incorporated by reference; see § 430.3). LED downlight retrofit kit does not include integrated lamps or non-integrated lamps.

* * * * *

Light fixture means a complete lighting unit consisting of light source(s) and ballast(s) (when applicable) together with the parts designed to distribute the light, to position and protect the light source, and to connect the light source(s) to the power supply.

* * * * *

Marine signal service lamp means a lamp that is designed and marketed for marine signal service applications.

* * * * *

Mercury vapor lamp means a high intensity discharge lamp, including clear, phosphor-coated, and self-ballasted screw base lamps, in which the major portion of the light is produced by radiation from mercury typically operating at a partial vapor pressure in excess of 100,000 pascal (approximately 1 atmosphere).

* * * * *

Mine service lamp means a lamp that is designed and marketed for mine service applications.

* * * * *

Non-integrated lamp means a lamp that is not an integrated lamp.

Non-reflector lamp means a lamp that is not a reflector lamp.

* * * * *

OLED lamp means an integrated or non-integrated lamp designed for use in general lighting applications that uses OLEDs as the primary source of light.

* * * * *

Pin base lamp means a base type designated as a single pin base or multiple pin base system in Table 1 of ANSI C81.61, Specifications for Electrics Bases (incorporated by reference; see § 430.3).

* * * * *

Plant light lamp means a lamp that is designed to promote plant growth by emitting its highest radiant power peaks in the regions of the electromagnetic spectrum that promote photosynthesis: Blue (440 nm to 490 nm) and/or red (620 to 740 nm). Plant light lamps must be designed and marketed for plant growing applications.

* * * * *

Reflector lamp means a lamp that has an R, PAR, BPAR, BR, ER, MR, or similar bulb shape as defined in ANSI C78.20 (incorporated by reference; see § 430.3) and ANSI C79.1–2002 (incorporated by reference; see § 430.3) and is used to direct light.

* * * * *

Showcase lamp means a lamp that has a T-shape as specified in ANSI C78.20 (incorporated by reference; see § 430.3) and ANSI C79.1–2002 (incorporated by reference; see § 430.3), is designed and marketed as a showcase lamp, and has a maximum rated wattage of 75 watts.

* * * * *

Sign service lamp means a vacuum type or gas-filled lamp that has sufficiently low bulb temperature to permit exposed outdoor use on high-speed flashing circuits, is designed and marketed as a sign service lamp, and has a maximum rated wattage 15 watts.

Silver bowl lamp means a lamp that has a reflective coating applied directly to part of the bulb surface that reflects light toward the lamp base and that is designed and marketed as a silver bowl lamp.

* * * * *

Traffic signal lamp means a lamp that is designed and marketed for traffic signal applications.

* * * * *

■ 5. Section 430.3 is amended by adding paragraph (u)(4) to read as follows:

§ 430.3 Materials incorporated by reference.

* * * * *

(u) * * *

(4) UL 1598C–2014 (''UL 1598C''), Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits, First Edition, dated January 16, 2014, IBR approved for § 430.2.

* * * * *

■ 6. Section 430.32 is amended by removing and reserving paragraphs (u) and (x), and adding paragraph (z) to read as follows:

§ 430.32 Energy and water conservation standards and their compliance dates.

* * * * *

(u) Removed and Reserved.

* * * * *

(x) Removed and Reserved.

* * * * *

(z) *General service lamps.* (1) Energy conservation standards for general service lamps:

(i) General service incandescent lamps manufactured after the dates specified in the tables below, except as described in paragraph (z)(1)(ii) of this section, shall have a rated wattage no greater than the values shown in the table in this paragraph:

GENERAL SERVICE INCANDESCENT LAMPS

Rated lumen ranges	Maximum rate wattage	Compliance date
1490–2600	72	1/1/2012
1050–1489	53	1/1/2013
750–1049	43	1/1/2014
310–749	29	1/1/2014

(ii) Modified spectrum general service incandescent lamps manufactured after the dates specified in the table in this paragraph shall have a rated wattage no greater than the values shown in the table in this paragraph:

MODIFIED SPECTRUM GENERAL SERVICE INCANDESCENT LAMPS

Rated lumen ranges	Maximum rate wattage	Compliance date
1118–1950	72	1/1/2012
788–1117	53	1/1/2013
563–787	43	1/1/2014
232–562	29	1/1/2014

(iii) Each candelabra base incandescent lamp shall not exceed 60 rated watts.

(iv) Each intermediate base incandescent lamp shall not exceed 40 rated watts.

(v) A bare or covered (no reflector) medium base compact fluorescent lamp manufactured on or after January 1, 2006, must meet or exceed the following requirements:

Factor	Requirements
Labeled Wattage (Watts) & Configuration *	Minimum initial lamp efficacy (lumens per watt) must be at least:
Bare Lamp:	
Labeled Wattage <15	45.0
Labeled Wattage ≥15	60.0
Covered Lamp (no reflector):	
Labeled Wattage <15	40.0
15≤ Labeled Wattage <19	48.0
19≤ Labeled Wattage <25	50.0
Labeled Wattage ≥25	55.0

* Use labeled wattage to determine the appropriate efficacy requirements in this table; do not use measured wattage for this purpose.

(vi) Except as provided in paragraph (z)(3) of this section, each general service lamp manufactured on or after [DATE 3 YEARS AFTER *DATE OF* PUBLICATION IN THE **Federal Register** OF FINAL RULE] that:

(A) Is an integrated, non-reflector lamp with a medium screw base and an initial lumen output between 310 and 2,600 lumens; or

(B) Is an integrated or non-integrated non-reflector lamp with a GU24 base and an initial lumen output between 310 and 2,600 lumens; shall have:

(*1*) A power factor greater than or equal to 0.7 for integrated LED lamps (as defined in § 430.2) and 0.5 for integrated compact fluorescent lamps (as defined in appendix W of subpart B); and

(*2*) A lamp efficacy greater than or equal to the values shown in the table in this paragraph:

Lamp type	Lumen package (*lumens*)	Standby mode operation	Minimum lamp efficacy (*lm/W*)
Integrated GSLs	310 ≤ Initial Lumen Output <2,000	No standby mode	101.6 − 29.42*0.9983^Initial Lumen Output.
		Capable of operating in standby mode.	96.0—29.42*0.9983^Initial Lumen Output.
	2,000 ≤ Initial Lumen Output ≤ 2,600	No standby mode	73.4 − 29.42*0.9983^Initial Lumen Output.
		Capable of operating in standby mode.	70.5 − 29.42*0.9983^Initial Lumen Output.

(vii) Effective beginning January 1, 2020, each general service lamp sold shall meet a minimum efficacy standard of 45.0 lumens per watt.

(2) Other standards for general service lamps:

(i) General service incandescent lamps manufactured after the dates specified in the tables below, except as described in paragraph (z)(2)(ii) of this section, shall have a color rendering index greater than or equal to 80 and shall have a rated lifetime not less than the values shown in the table in this paragraph:

GENERAL SERVICE INCANDESCENT LAMPS

Rated lumen ranges	Minimum rate life-time (hrs)	Compliance date
1490–2600	1,000	1/1/2012
1050–1489	1,000	1/1/2013
750–1049	1,000	1/1/2014
310–749	1,000	1/1/2014

(ii) Modified spectrum general service incandescent lamps manufactured after the dates specified shall have a color rendering index greater than or equal to 75 and shall have a rated lifetime not less than the values shown in the table in this paragraph:

MODIFIED SPECTRUM GENERAL SERVICE INCANDESCENT LAMPS

Rated lumen ranges	Minimum rate life-time (hrs)	Compliance date
1118–1950	1,000	1/1/2012
788–1117	1,000	1/1/2013
563–787	1,000	1/1/2014
232–562	1,000	1/1/2014

(iii) Medium base CFLs (as defined in § 430.2) manufactured on or after the dates specified in the table below shall meet or exceed the following standards:

Metrics	Requirements for MBCFLs manufactured on or after January 1, 2006	Requirements for MBCFLs manufactured on or after [DATE 3 YEARS AFTER PUBLICATION OF FINAL RULE]
Lumen Maintenance at 1,000 Hours	≥ 90.0%	
Lumen Maintenance at 40 Percent of Lifetime*	≥ 80.0%	
Rapid Cycle Stress Test	At least 5 lamps *must meet or exceed* the minimum number of cycles.	
	All MBCFLs: Cycle once per every two hours of lifetime.*	MBCFLs with start time > 100 ms: Cycle once per hour of lifetime* or a maximum of 15,000 cycles. MBCFLs with a start time of ≤ 100 ms: Cycle once per every two hours of lifetime.*
Lifetime*	≥ 6,000 hours	≥ 10,000 hours.
CRI	No requirement	80.
Start time	No requirement	The time needed for a MBCFL to become fully illuminated must be within one second of application of electrical power.

*Lifetime refers to lifetime of a compact fluorescent lamp as defined in 10 CFR 430.2.

(3) The standards described in paragraph (z)(1)(vi) of this section do not apply to:

(i) Non-integrated CFLs with a pin base;

(ii) Non-integrated LED lamps with a pin base;

(iii) Lamps that have initial lumen outputs greater than 2600 lumens;

(iv) Reflector lamps;

(v) OLED lamps;

(vi) General service incandescent lamps;

(vii) The following medium screw base lamps that are not incandescent lamps:

(*A*) A15 lamps (as defined in ANSI 79.1–2002 (incorporated by reference; see § 430.3)) with lamp diameter when measured at the widest point of less than or equal to 2.185 inches.

(B) Any of the following shapes with lamp diameter when measured at the widest point of less than or equal to 2.0625 inches: G lamps (as defined in ANSI 79.1–2002) and lamps specifically designed and marketed as a globe shape.

(C) Any of the following shapes with lamp diameter when measured at the widest point of less than or equal to 1.875 inches: B lamps (as defined in ANSI 79.1–2002); C lamps (as defined in ANSI 79.1–2002); CA lamps (as defined in ANSI 79.1–2002); F lamps (as defined in ANSI 79.1–2002); S lamps (as defined in ANSI 79.1–2002); and lamps specifically designed and marketed as a blunt, candle, flame, flame tip, torpedo, or torpedo tip shape.

[FR Doc. 2016–04813 Filed 3–16–16; 8:45 am]

BILLING CODE 6450–01–P