DEPARTMENT OF ENERGY

10 CFR Part 430

[EERE–2022–BT–STD–0022]

RIN 1904–AF43

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 and announcement of public meeting.

SUMMARY: The Energy Policy and Conservation Act, as amended (EPCA), directs the U.S. Department of Energy (DOE) to initiate two rulemaking cycles for general service lamps (GSLs) that, among other requirements, determine whether standards in effect for GSLs should be amended. EPCA also requires DOE to periodically determine whether more-stringent, standards would be technologically feasible and economically justified, and would result in significant energy savings. In this notice of proposed rulemaking (NOPR), DOE proposes amended standards for GSLs pursuant to its statutory authority in EPCA, and also announces a webinar to receive comments on its proposal and associated analyses and results.

DATES:

Comments: DOE will accept comments, data, and information regarding this NOPR no later than March 27, 2023.

Comments regarding the likely competitive impact of the proposed standard should be sent to the Department of Justice contact listed in the **ADDRESSES** section on or before February 10, 2023.

Meeting: DOE will hold a public meeting via webinar on Wednesday, February 1, 2023, from 1 p.m. to 4 p.m. See section IX, ''Public Participation,'' for webinar registration information, participant instructions, and information about the capabilities available to webinar participants.

ADDRESSES: Interested persons are encouraged to submit comments using the Federal eRulemaking Portal at *www.regulations.gov,* under docket number EERE–2022–BT–STD–0022. Follow the instructions for submitting comments. Alternatively, interested persons may submit comments, identified by docket number EERE–2022–BT–STD–0022, by any of the following methods:

Email: GSL2022STD0022@ee.doe.gov. Include the docket number EERE–2022–BT–STD–0022 in the subject line of the message.

Postal Mail: Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Office, Mailstop EE–5B, 1000 Independence Avenue SW, Washington, DC 20585–0121. Telephone: (202) 287–1445. If possible, please submit all items on a compact disc (CD), in which case it is not necessary to include printed copies.

Hand Delivery/Courier: Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Office, 950 L'Enfant Plaza SW, 6th Floor, Washington, DC 20024. Telephone: (202) 287–1445. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

No telefacsimiles (faxes) will be accepted. For detailed instructions on submitting comments and additional information on the rulemaking process, see section IX of this document.

Docket: The docket for this activity, which includes **Federal Register** notices, 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, not all documents listed in the index may be publicly available, such as information that is exempt from public disclosure.

The docket web page can be found at *www.regulations.gov/docket/EERE-2022-BT-STD-0022.* The docket web page contains instructions on how to access all documents, including public comments, in the docket. See section IX of this document for information on how to submit comments through *www.regulations.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* on or before the date specified in the **DATES** section. Please indicate in the ''Subject'' line of your email the title and Docket Number of this proposed rule.

FOR FURTHER INFORMATION CONTACT:

Mr. Bryan Berringer, 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) 586–0371. Email: *ApplianceStandardsQuestions@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 the Appliance and Equipment Standards Program staff at (202) 287–1445 or by email: *ApplianceStandardsQuestions@ee.doe.gov.*

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

Underwriters Laboratories (UL) 1598C, ''UL 1598C Standard for Safety Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits,'' approved January 12, 2017.

Copies of UL 1598C can be obtained by going to *https://www.shopulstandards.com/Default.aspx.*

For a further discussion of this standard, see section VIII.M of this document.

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I. Synopsis of the Proposed Rule

Title III, Part B [1] of the EPCA,[2] established the Energy Conservation Program for Consumer Products Other Than Automobiles. (42 U.S.C. 6291–6309) These products include GSLs, the subject of this proposed rulemaking.

DOE is issuing this NOPR pursuant to multiple provisions in EPCA. First, EPCA requires that DOE must 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 energy conservation standards and if the exemptions for certain incandescent lamps should be maintained or discontinued. For this second review of energy conservation standards, the scope of rulemaking is not limited to incandescent technologies. (42 U.S.C. 6295(i)(6)(B)(ii))

[1] For editorial reasons, upon codification in the U.S. Code, part B was redesignated part A. All references to part B in this document refer to the redesignated part A.

[2] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Public Law 116–260 (Dec. 27, 2020), which reflect the last statutory amendments that impact parts A and A–1 of EPCA.

Second, 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 including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)) Third, pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that DOE determines 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)) Lastly, 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))

In accordance with these and other statutory provisions discussed in this document, DOE proposes energy conservation standards for GSLs. This is the second rulemaking cycle for GSLs. As a result of the first rulemaking cycle, there is currently a sales prohibition on the sale of any GSLs that do not meet a minimum efficacy standard of 45 lumens per watt. There are existing DOE energy conservation standards higher than 45 lumens per watt for medium base compact fluorescent lamps (MBCFLs), which are types of GSLs. 70 FR 60407 (Oct. 18, 2005). The standards proposed in this rulemaking, which are expressed in minimum lumens (lm) output per watt (W) of a lamp or lamp efficacy (lm/W), are shown in Table I.1. These proposed standards, if adopted, would apply to all GSLs listed in Table I.1 manufactured in, or imported into, the United States beginning on the effective date for the standard.

Table I.1 Proposed Energy Conservation Standards for GSLs

Product Class	Efficacy Equation (lm/W)
Integrated Omnidirectional Short GSLs, No Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + A$
Integrated Omnidirectional Short GSLs, With Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + A$
Integrated Directional GSLs, No Standby Power	$\text{Efficacy} = \frac{73}{0.5 + e^{-0.0021(\text{Lumens}+1000)}} - A$
Integrated Directional GSLs, With Standby Power	$\text{Efficacy} = \frac{73}{0.5 + e^{-0.0021(\text{Lumens}+1000)}} - A$
Integrated Omnidirectional Long GSLs	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + A$
Non-integrated Omnidirectional Long GSLs	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + A$
Non-integrated Omnidirectional Short GSLs	$\text{Efficacy} = \frac{122}{0.55 + e^{-0.003(\text{Lumens}+250)}} - A$
Non-integrated Directional GSLs	$\text{Efficacy} = \frac{67}{0.45 + e^{-0.00176(\text{Lumens}+1310)}} - A$

* Initial lumen output as determined in accordance with the DOE test procedure at 10 CFR part 430, subpart B, appendix W or appendix BB and applicable sampling plans.

A. Impact on Manufacturers

The industry net present value (INPV) is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2022–2058). 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 $2,014 million in 2021$. Under the proposed new and amended standards, the change in INPV is estimated to range from −13.5 percent to −7.2 percent, which is approximately −$271 million to −$145 million. In order to bring products into compliance with new and amended standards, it is estimated that the industry would incur total conversion costs of $407 million.

DOE's analysis of the impacts of the proposed standards on manufacturers is described in section VI.J of this document. The analytic results of the manufacturer impact analysis (MIA) are presented in section VII.B.2 of this document.

B. 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

[3] The average LCC savings refer to consumers that are affected by a standard and are measured relative to the efficiency distribution in the no-new-standards case, which depicts the market in the first full year of compliance in the absence of new or amended standards (see section VI.F.11 of this document). The simple PBP, which is designed to

are positive for all product classes, and the PBP is less than the average lifetime of GSLs, which varies by product class and efficiency level (see section VI.F.5 of this document).

TABLE I.2—IMPACTS OF PROPOSED ENERGY CONSERVATION STANDARDS ON CONSUMERS OF GSLS

Product class	Average LCC savings (2021$)	Simple payback period (years)
Residential:		
Integrated Omnidirectional Short	0.59	0.8
Integrated Omnidirectional Long	1.82	5.4
Integrated Directional	3.01	0.0
Non-integrated Omnidirectional *	....	....
Non-integrated Directional	0.28	4.2
Commercial:		
Integrated Omnidirectional Short	1.11	0.5
Integrated Omnidirectional Long	4.74	2.9
Integrated Directional	3.86	0.0
Non-integrated Omnidirectional	6.62	2.1
Non-integrated Directional	0.69	2.8

* Non-integrated Omnidirectional GSLs were only analyzed for the commercial sector.

DOE's analysis of the impacts of the proposed standards on consumers is described in section VII.B.1 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 without new or amended standards, the lifetime energy savings for GSLs purchased in the 30-year period that begins in the anticipated first full year of compliance with the amended standards (2029–2058) amount to 4.0 quadrillion British thermal units (Btu), or quads.[5] This represents a savings of 48 percent relative to the energy use of these products in the case without amended standards (referred to as the ''no-new-standards case'').

The cumulative net present value (NPV) of total consumer benefits of the proposed standards for GSLs ranges from $7.29 billion (at a 7-percent discount rate) to $20.37 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product costs for GSLs purchased in 2029–2058.

In addition, the proposed standards for GSLs are projected to yield significant environmental benefits. DOE estimates that the proposed standards would result in cumulative emission reductions (over the same period as for energy savings) of 130.63 million metric tons (Mt) [6] of carbon dioxide (CO_2), 59.27 thousand tons of sulfur dioxide (SO_2), 203.05 thousand tons of nitrogen oxides (NO_X), 902.76 thousand tons of methane (CH_4), 1.36 thousand tons of nitrous oxide (N_2O), and 0.39 tons of mercury (Hg).[7]

DOE estimates the value of climate benefits from a reduction in greenhouse gases (GHG) using four different estimates of the social cost of CO_2 (SC–CO_2), the social cost of methane (SC–CH_4), and the social cost of nitrous oxide (SC–N_2O). Together these represent the social cost of GHG (SC–GHG). DOE used interim SC–GHG values developed by an Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).[8] The derivation of these values is discussed in section VI.L of this document. For presentational purposes, the climate benefits associated with the average SC–GHG at a 3-percent discount rate are estimated to be $5.9 billion. DOE does not have a single central SC–GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates.[9]

DOE estimated the monetary health benefits of SO_2 and NO_X emissions reductions, also discussed in section VI.L of this document. DOE estimated the present value of the health benefits would be $3.6 billion using a 7-percent discount rate, and $10.1 billion using a 3-percent discount rate.[10] DOE is currently only monetizing (for SO_2 and NO_X) particulate matter $(PM)_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will

compare specific efficiency levels, is measured relative to the baseline product (see section VI.F.13 of this document).

[4] All monetary values in this document are expressed in 2021 dollars.

[5] 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 VI.H.1 of this document.

[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 2022* (*AEO2022*). *AEO2022* represents current federal and state legislation and final implementation of regulations as of the time of its preparation. See section VI.K of this document for further discussion of *AEO2022* assumptions that effect air pollutant emissions.

[8] *See* Interagency Working Group on Social Cost of Greenhouse Gases, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Interim Estimates Under Executive Order 13990, Washington, DC, February 2021. *https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.*

[9] On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. As reflected in this proposed rule, DOE has reverted to its approach prior to the injunction and presents monetized greenhouse gas abatement benefits where appropriate and permissible under law.

[10] DOE estimates the economic value of these emissions reductions resulting from the considered TSLs for the purpose of complying with the requirements of Executive Order 12866.

continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions.

Table I.3 summarizes the economic benefits and costs expected to result from the proposed standards for GSLs. There are other important unquantified effects, including certain unquantified climate benefits, unquantified public health benefits from the reduction of toxic air pollutants and other emissions, unquantified energy security benefits, and distributional effects, among others.

TABLE I.3—SUMMARY OF ECONOMIC BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GSLS (TSL 6)

	Billion 2021$
3% discount rate	
Consumer Operating Cost Savings	25.0
Climate Benefits *	5.9
Health Benefits **	10.1
Total Benefits †	41.0
Consumer Incremental Product Costs ‡	4.6
Net Benefits	36.4
7% discount rate	
Consumer Operating Cost Savings	9.7
Climate Benefits * (3% discount rate)	5.9
Health Benefits **	3.6
Total Benefits †	19.1
Consumer Incremental Product Costs ‡	2.4
Net Benefits	16.7

Note: This table presents the costs and benefits associated with GSLs shipped in 2029–2058. These results include benefits to consumers which accrue after 2058 from the products shipped in 2029–2058.

* Climate benefits are calculated using four different estimates of the social cost of carbon (SC–CO_2), methane (SC–CH_4), and nitrous oxide (SC–N_2O) (model average at 2.5 percent, 3 percent, and 5 percent discount rates; 95th percentile at 3 percent discount rate) (see section VI.L of this rulemaking). Together these represent the global SC–GHG. For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but DOE does not have a single central SC–GHG point estimate. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. As reflected in this proposed rule, DOE has reverted to its approach prior to the injunction and presents monetized greenhouse gas abatement benefits where appropriate and permissible under law.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for NO_X and SO_2) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. See section VI.L of this document for more details.

† Total benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, but the Department does not have a single central SC–GHG point estimate. DOE emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates. See Table VII.27 for net benefits using all four SC–GHG estimates.

† Costs include incremental equipment costs as well as installation costs.

The benefits and costs of the proposed standards can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are (1) the reduced consumer operating costs, minus (2) the increase in product purchase prices and installation costs, plus (3) the value of climate and health benefits of emission reduction, all annualized.[11] The national operating savings are domestic private U.S. consumer monetary savings that occur as a result of purchasing the covered products and are measured for the lifetime of GSLs shipped in 2029–2058. The benefits associated with reduced emissions achieved as a result of the proposed standards are also calculated based on the lifetime of GSLs shipped in 2029–2058. Total benefits for both the 3-percent and 7-percent cases are presented using the average social costs with 3-percent discount rate. Estimates of SC–GHG values are presented for all four discount rates in section VII.B.8 of this document. Table I.4 presents the total estimated monetized benefits and costs associated with the proposed standard, expressed in terms of annualized values.

[11] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2022, 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.,*2030), and then discounted the present value from each year to 2022. 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 I.4—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GSLS (TSL 6)

	Million 2021$/year		
	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
3% discount rate			
Consumer Operating Cost Savings	1,521.4	1,469.8	1,586.0
Climate Benefits *	358.1	357.7	358.5
Health Benefits **	615.6	615.0	616.3
Total Benefits †	2,495.1	2,442.5	2,560.8
Consumer Incremental Product Costs ‡	280.3	291.0	270.0
Net Benefits	2,214.8	2,151.6	2,290.7
7% discount rate			
Consumer Operating Cost Savings	1,171.5	1,135.9	1,215.2
Climate Benefits * (3% discount rate)	358.1	357.7	358.5
Health Benefits **	432.0	431.7	432.4
Total Benefits †	1,961.6	1,925.3	2,006.1
Consumer Incremental Product Costs ‡	289.4	299.4	279.8
Net Benefits	1,672.2	1,625.9	1,726.3

Note: This table presents the costs and benefits associated with GSLs shipped in 2029–2058. These results include benefits to consumers which accrue after 2058 from the products shipped in 2029–2058. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the AEO2022 Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, LED lamp prices reflect a higher price learning rate in the Low Net Benefits Estimate, and a lower price learning rate in the High Net Benefits Estimate. See section VII.B.3.b for discussion. The methods used to derive projected price trends are explained in section VI.G.1.b of this document. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

* Climate benefits are calculated using four different estimates of the global SC–GHG (see section VI.L of this rulemaking). For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate, and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. As reflected in this proposed rule, DOE has reverted to its approach prior to the injunction and presents monetized greenhouse gas abatement benefits where appropriate and permissible under law.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. See section VI.L of this document for more details.

† Total benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, but the Department does not have a single central SC–GHG point estimate.

‡ Costs include incremental equipment costs as well as installation costs

DOE's analysis of the national impacts of the proposed standards is described in sections VI.H of this document.

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. With regards to technological feasibility, products achieving these standard levels are already commercially available for all product classes covered by this proposal. As for economic justification, DOE's analysis shows that the benefits of the proposed standard exceed, to a great extent, the burdens of the proposed standards. Using a 7-percent discount rate for consumer benefits and costs and NO_X and SO_2 reduction benefits, and a 3-percent discount rate case for GHG social costs, the estimated cost of the proposed standards for GSLs is $289.4 million per year in increased product costs, while the estimated annual benefits are $1.17 billion in reduced product operating costs, $358.1 million in climate benefits, and $432.0 million in health benefits. The net benefit amounts to $1.67 billion per year.

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking.[12] For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand. Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis.

As previously mentioned, the standards are projected to result in estimated national FFC energy savings of 4.0 quads, the equivalent of the primary annual energy use of 43.0 million homes. In addition, they are projected to reduce CO_2 emissions by 130.63 Mt. Based on these findings, DOE has initially determined the energy savings from the proposed standard levels are ''significant'' within the meaning of 42 U.S.C. 6295(o)(3)(B). A

[12] Procedures, Interpretations, and Policies for Consideration in New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Commercial/Industrial Equipment, 86 FR 70892, 70901 (Dec. 13, 2021).

more detailed discussion of the basis for these tentative conclusions is contained in the remainder of this document and the accompanying TSD.

DOE also considered less-stringent energy efficiency levels as potential standards, and is still considering them in this rulemaking. However, DOE has tentatively concluded that TSL 6 achieves the maximum improvement in energy efficiency that is technologically feasible and economically justified.

Based on consideration of the public comments DOE receives in response to this document and related information collected and analyzed during the course of this rulemaking effort, DOE may adopt energy efficiency levels presented in this document that are lower than the proposed standards, or some combination of level(s) that incorporate the proposed standards in part.

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

EPCA authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. Title III, Part B of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles. These products include GSLs, the subject of this document. 42 U.S.C. 6295(i)(6))

EPCA directs 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 directed DOE to initiate a rulemaking process prior to January 1, 2014, to determine whether: (1) to amend energy conservation standards for GSLs and (2) the exemptions for certain incandescent lamps should be maintained or discontinued. (42 U.S.C. 6295(i)(6)(A)(i)) The rulemaking was not to be limited to incandescent lamp technologies and was required to include a consideration of a minimum standard of 45 lm/W for GSLs. (42 U.S.C. 6295(i)(6)(A)(ii)) EPCA provides that if the Secretary determined that the standards in effect for GSILs should be amended, a final rule must be published by January 1, 2017, with a compliance date at least 3 years after the date on which the final rule is published. (42 U.S.C. 6295(i)(6)(A)(iii)) The Secretary was also required to consider phased-in effective dates after considering certain manufacturer and retailer impacts. (42 U.S.C. 6295(i)(6)(A)(iv)) If DOE failed to complete a rulemaking in accordance with 42 U.S.C. 6295(i)(6)(A)(i)–(iv), or if a final rule from the first rulemaking cycle did not produce savings greater than or equal to the savings from a minimum efficacy standard of 45 lm/W, the statute provides a ''backstop'' under which DOE was required to prohibit sales of GSLs that do not meet a minimum 45 lm/W standard. (42 U.S.C. 6295(i)(6)(A)(v)). As a result of DOE's failure to complete a rulemaking in accordance with the statutory criteria, DOE codified this backstop requirement in a rule issued on May 9, 2022. 87 FR 27439 (May 2022 Backstop Final Rule)

EPCA further directs DOE to initiate a second rulemaking cycle by January 1, 2020, to determine whether standards in effect for GSILs (which are a subset of GSLs)) should be amended with more stringent maximum wattage requirements than EPCA specifies, and whether the exemptions for certain incandescent lamps should be maintained or discontinued. (42 U.S.C. 6295(i)(6)(B)(i)) As in the first rulemaking cycle, the scope of the second rulemaking is not limited to incandescent lamp technologies. (42 U.S.C. 6295(i)(6)(B)(ii)) As previously stated in Section I of this document, DOE is publishing this NOPR pursuant to this second cycle of rulemaking, as well as section (m) of 42 U.S.C. 6295.

The energy conservation program under EPCA consists essentially of four parts: (1) testing, (2) labeling, (3) the establishment of Federal energy conservation standards, and (4) certification and enforcement procedures. Relevant provisions of EPCA specifically include definitions (42 U.S.C. 6291), test procedures (42 U.S.C. 6293), labeling provisions (42 U.S.C. 6294), energy conservation standards (42 U.S.C. 6295), and the authority to require information and reports from manufacturers (42 U.S.C. 6296).

Federal energy efficiency requirements for covered products established under EPCA generally supersede State laws and 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 EPCA. (See 42 U.S.C. 6297(d))

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 42 U.S.C. 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 GSLs appear at title 10 of the Code of Federal Regulations (CFR) part 430, subpart B, appendices R, W, BB, and DD.

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 the Secretary of Energy determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and 42 U.S.C. 6295(o)(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 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 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, EPCA 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))

Finally, pursuant to the amendments contained in the Energy Independence and Security Act of 2007 (EISA), Public Law 110–140, 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 feasible 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 commercially available GSLs that operate in standby mode. DOE's current test procedures for GSLs address standby mode and off mode energy use. In this rulemaking, DOE intends to incorporate such energy use into any amended energy conservation standards that it may adopt.

B. Background

1. History of Standards Rulemaking for General Service Lamps

Pursuant to its statutory authority to complete the first cycle of rulemaking for GSLs, DOE published a notice of proposed rulemaking (NOPR) on March 17, 2016, that addressed the first question that Congress directed it to consider—whether to amend energy conservation standards for GSLs (March 2016 NOPR). 81 FR 14528, 14629–14630 (Mar. 17, 2016). In the March 2016 NOPR, DOE stated that it would be unable to undertake any analysis regarding GSILs and other incandescent lamps because of a then-applicable congressional restriction (the Appropriations Rider). *See* 81 FR 14528, 14540–14541. The Appropriations Rider prohibited 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 (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 incandescent reflector lamps (IRLs). Under the Appropriations Rider, DOE was restricted from undertaking the analysis required to address the first question presented by Congress, but was not so limited in addressing the second question—that is, DOE was not prevented from determining whether the exemptions for certain incandescent lamps should be maintained or discontinued. To address that second question, DOE published a Notice of Proposed Definition and Data Availability (NOPDDA), which proposed to amend the definitions of GSIL, GSL, and related terms (October 2016 NOPDDA). 81 FR 71794, 71815 (Oct. 18, 2016). The Appropriations Rider, which was originally adopted in 2011 and readopted and extended continuously in multiple subsequent legislative actions, expired on May 5, 2017, when the Consolidated Appropriations Act, 2017 was enacted.[13]

On January 19, 2017, DOE published two final rules concerning the definitions of GSL, GSIL, and related terms (January 2017 Definition Final Rules). 82 FR 7276; 82 FR 7322. The January 2017 Definition Final Rules amended the definitions of GSIL and GSL by bringing certain categories of lamps that had been excluded by statute from the definition of GSIL within the definitions of GSIL and GSL. DOE determined to use two final rules in 2017 to amend the definitions of GSIL and GSLs in order to address the majority of the definition changes in one final rule and the exemption for IRLs in the second final rule. These two rules were issued simultaneously, with the first rule eschewing a determination regarding the existing exemption for IRLs in the definition of GSL and the second rulemaking discontinuing that exemption from the GSL definition. 82 FR 7276, 7312; 82 FR 7322, 7323. As in the October 2016 NOPDDA, DOE stated that the January 2017 Definition Final Rules related only to the second question that Congress directed DOE to consider, regarding whether to maintain or discontinue ''exemptions'' for certain incandescent lamps. 82 FR 7276, 7277; 82 FR 7322, 7324 (See also 42 U.S.C. 6295(i)(6)(A)(i)(II)). That is, neither of the two final rules issued on January 19, 2017, established energy conservation standards applicable to GSLs. DOE explained that the Appropriations Rider prevented it from establishing, or even analyzing, standards for GSILs. 82 FR 7276, 7278. Instead, DOE explained that it would either impose standards for GSLs in the future pursuant to its authority to develop GSL standards, or

[13] See Consolidated Appropriations Act of 2017 (Pub. L. 115–31, div. D, tit. III); see also Consolidated Appropriations Act, 2018 (Pub. L. 115–141).

apply the backstop standard prohibiting the sale of lamps not meeting a 45 lm/W efficacy standard. 82 FR 7276, 7277–7278. The two final rules were to become effective as of January 1, 2020.

On March 17, 2017, the National Electrical Manufacturer's Association (NEMA) filed a petition for review of the January 2017 Definition Final Rules in the U.S. Court of Appeals for the Fourth Circuit. *National Electrical Manufacturers Association* v. *United States Department of Energy,* No. 17–1341. NEMA claimed that DOE ''amend[ed] the statutory definition of 'general service lamp' to include lamps that Congress expressly stated were 'not include[d]' in the definition'' and adopted an ''unreasonable and unlawful interpretation of the statutory definition.'' Pet. 2. Prior to merits briefing, the parties reached a settlement agreement under which DOE agreed, in part, to issue a notice of data availability requesting data for GSILs and other incandescent lamps to assist DOE in determining whether standards for GSILs should be amended (the first question of the rulemaking required by 42 U.S.C. 6295(i)(6)(A)(i)).

With the removal of the Appropriations Rider in the Consolidated Appropriations Act, 2017, DOE was no longer restricted from undertaking the analysis and decision-making required to address the first question presented by Congress, *i.e.,* whether to amend energy conservation standards for GSLs, including GSILs. Thus, on August 15, 2017, DOE published a notice of data availability and request for information (NODA) seeking data for GSILs and other incandescent lamps (August 2017 NODA). 82 FR 38613.

The purpose of the August 2017 NODA was to assist DOE in determining whether standards for GSILs should be amended. (42 U.S.C. 6295(i)(6)(A)(i)(I)) Comments submitted in response to the August 2017 NODA also led DOE to re-consider the decisions it had already made with respect to the second question presented to DOE—whether the exemptions for certain incandescent lamps should be maintained or discontinued. 84 FR 3120, 3122 (See also 42 U.S.C. 6295(i)(6)(A)(i)(II)) As a result of the comments received in response to the August 2017 NODA, DOE also re-assessed the legal interpretations underlying certain decisions made in the January 2017 Definition Final Rules. *Id.*

On February 11, 2019, DOE published a NOPR proposing to withdraw the revised definitions of GSL, GSIL, and the new and revised definitions of related terms that were to go into effect on January 1, 2020 (February 2019 Definition NOPR). 84 FR 3120. In a final rule published September 5, 2019, DOE finalized the withdrawal of the definitions in the January 2017 Definition Final Rules and maintained the existing regulatory definitions of GSL and GSIL, which are the same as the statutory definitions of those terms (September 2019 Withdrawal Rule). 84 FR 46661. The September 2019 Withdrawal Rule revisited the same primary question addressed in the January 2017 Definition Final Rules, namely, the statutory requirement for DOE to determine whether ''the exemptions for certain incandescent lamps should be maintained or discontinued.'' 42 U.S.C. 6295(i)(6)(A)(i)(II) (*See* also 84 FR 46661, 46667). In the rule, DOE also addressed its interpretation of the statutory backstop at 42 U.S.C. 6295(i)(6)(A)(v) and concluded the backstop had not been triggered. 84 FR 46661, 46663–46664. DOE reasoned that 42 U.S.C. 6295(i)(6)(A)(iii) ''does not establish an absolute obligation on the Secretary to publish a rule by a date certain.'' 84 FR 46661, 46663. ''Rather, the obligation to issue a final rule prescribing standards by a date certain applies if, and only if, the Secretary makes a determination that standards in effect for GSILs need to be amended.'' *Id.* DOE further stated that, since it had not yet made the predicate determination on whether to amend standards for GSILs, the obligation to issue a final rule by a date certain did not yet exist and, as a result, the condition precedent to the potential imposition of the backstop requirement did not yet exist and no backstop requirement had yet been triggered. *Id.* at 84 FR 46664.

Similar to the January 2017 Definition Final Rules, the September 2019 Withdrawal Rule clarified that DOE was not determining whether standards for GSLs, including GSILs, should be amended. DOE stated it would make that determination in a separate rulemaking. *Id.* at 84 FR 46662. DOE initiated that separate rulemaking by publishing a notice of proposed determination (NOPD) on September 5, 2019, regarding whether standards for GSILs should be amended (September 2019 NOPD). 84 FR 46830. In conducting its analysis for that notice, DOE used the data and comments received in response to the August 2017 NODA and relevant data and comments received in response to the February 2019 Definition NOPR, and DOE tentatively determined that the current standards for GSILS do not need to be amended because more stringent standards are not economically justified. *Id.* at 84 FR 46831. DOE finalized that tentative determination on December 27, 2019 (December 2019 Final Determination). 84 FR 71626. DOE also concluded in the December 2019 Final Determination that, because it had made the predicate determination not to amend standards for GSILs, there was no obligation to issue a final rule by January 1, 2017, and, as a result, the backstop requirement had not been triggered. *Id.* at 84 FR 71636.

Two petitions for review were filed in the U.S. Court of Appeals for the Second Circuit challenging the September 2019 Withdrawal Rule. The first petition was filed by 15 States,[14] New York City, and the District of Columbia. See *New York* v. *U.S. Department of Energy,* No. 19–3652 (2d Cir., filed Nov. 4, 2019). The second petition was filed by six organizations [15] that included environmental, consumer, and public housing tenant groups. See *Natural Resources Defense Council* v. *U.S. Department of Energy,* No. 19–3658 (2d Cir., filed Nov. 4, 2019). The petitions were subsequently consolidated. Merits briefing has been concluded, but the case has not been argued or submitted to the Circuit panel for decision. The case has been in abeyance since March 2021, pending further rulemaking by DOE.

Additionally, in two separate petitions also filed in the Second Circuit, groups of petitioners that were essentially identical to those that filed the lawsuit challenging the September 2019 Withdrawal Rule challenged the December 2019 Final Determination. See *Natural Resources Defense Council* v. *U.S. Department of Energy,* No. 20–699 (2d Cir., filed Feb, 25, 2020); *New York* v. *U.S. Department of Energy,* No. 20–743 (2d Cir., filed Feb. 28, 2020). On April 2, 2020, those cases were put into abeyance pending the outcome of the September 2019 Withdrawal Rule petitions.

On January 20, 2021, President Biden issued Executive Order (E.O.) 13990, ''Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis.'' 86 FR 7037 (Jan. 25, 2021). Section 1 of that Order lists a number of policies related to the

[14] The petitioning States are the States of New York, California, Colorado, Connecticut, Illinois, Maryland, Maine, Michigan, Minnesota, New Jersey, Nevada, Oregon, Vermont, and Washington and the Commonwealth of Massachusetts.

[15] The petitioning organizations are the Natural Resource Defense Council, Sierra Club, Consumer Federation of America, Massachusetts Union of Public Housing Tenants, Environment America, and U.S. Public Interest Research Group.

protection of public health and the environment, including reducing greenhouse gas emissions and bolstering the Nation's resilience to climate change. *Id.* at 86 FR 7041. Section 2 of the Order instructs all agencies to review ''existing regulations, orders, guidance documents, policies, and any other similar agency actions promulgated, issued, or adopted between January 20, 2017, and January 20, 2021, that are or may be inconsistent with, or present obstacles to, [these policies].'' *Id.* Agencies are then directed, as appropriate and consistent with applicable law, to consider suspending, revising, or rescinding these agency actions and to immediately commence work to confront the climate crisis. *Id.*

In accordance with E.O. 13990, on May 25, 2021, DOE published a request for information (RFI) initiating a re-evaluation of its prior determination that the Secretary was not required to implement the statutory backstop requirement for GSLs. 86 FR 28001 (May 2021 Backstop RFI). DOE solicited information regarding the availability of lamps that would satisfy a minimum efficacy standard of 45 lm/W, as well as other information that may be relevant to a possible implementation of the statutory backstop. *Id.* On December 13, 2021, DOE published a NOPR proposing to codify in the CFR the 45 lm/W backstop requirement for GSLs. 86 FR 70755 (December 2021 Backstop NOPR). On May 9, 2022, DOE published the May 2022 Backstop Final Rule codifying the 45 lm/W backstop requirement. 87 FR 27439. In the May 2022 Backstop Final Rule, DOE determined the backstop requirement applies because DOE failed to complete a rulemaking for GSLs in accordance with certain statutory criteria in 42 U.S.C. 6295(i)(6)(A).

On August 19, 2021, DOE published a NOPR to amend the current definitions of GSL and GSIL and adopt associated supplemental definitions to be defined as previously set forth in the January 2017 Definition Final Rules. 86 FR 46611. (August 2021 Definition NOPR). On May 9, 2022, DOE published a final rule adopting definitions of GSL and GSIL and associated supplemental definitions as set forth in the August 2021 Definition NOPR. 87 FR 27461 (May 2022 Definition Final Rule).

Upon issuance of the May 2022 Backstop Final Rule and the May 2022 Definition Final Rule, DOE concluded the first cycle of GSL rulemaking required by 42 U.S.C. 6295(i)(6)(A). This NOPR initiates the second cycle of GSL rulemaking under 42 U.S.C. 6295(i)(6)(B). As detailed above, EPCA directs DOE to initiate this rulemaking procedure no later than January 1, 2020. However, DOE is delayed in initiating this second cycle because of the Appropriations Rider, DOE's evolving position under the first rulemaking cycle, and the associated delays that resulted in DOE certifying the backstop requirement for GSLs two years after the January 1, 2020, date specified in the statute.

2. Current Standards

This is the second cycle of energy conservation standards rulemakings for GSLs. As noted in section II.B of this document, in the May 2022 Backstop Final Rule, DOE codified the statutory backstop requirement prohibiting sales of GSLs that do not meet a 45 lm/W requirement. Because incandescent and halogen GSLs would not be able to meet the 45 lm/W requirement, they are not being considered in this analysis. The analysis does take into consideration existing standards for MBCFLs by ensuring that proposed levels do not decrease the existing minimum required energy efficiency of MBCFLs in violation of EPCA's anti-backsliding provision, which precludes DOE from amending an existing energy conservation standard to permit greater energy use or a lesser amount of energy efficiency (*see* 42 U.S.C. 6295(o)(1)). The current standards for MBCFLs are summarized in Table II.1. 10 CFR 430.32(u).

TABLE II.1—EXISTING 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	[16] 45.0
	15≥ amp power <19	48.0
	19≥ amp 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.	

MBCFLs fall within the Integrated Omnidirectional Short product class (*see* section VI.A.1 for further details on product classes). Because DOE determined that lamp cover (*i.e.,* bare or covered) is not a class-setting factor in the product class structure established in this analysis, the baseline efficacy requirements are determined by lamp

[16] The MBCFL energy conservation standards at 10 CFR 430.42(u)(1) are subject to the sales prohibition in paragraph (dd) of this same section.

wattage. Therefore, for products with wattages less than 15 W, which fall into the Integrated Omnidirectional Short product class, DOE set the baseline efficacy at 45 lm/W (the highest of the existing standards for that wattage range) to prevent increased energy usage in violation of EPCA's anti-backsliding provision. For products with wattages greater than or equal to 15 W, which fall into the Integrated Omnidirectional Short product class, DOE set the baseline efficacy at 60 lm/W to prevent increased energy usage in violation of EPCA's anti-backsliding provision. Table II.2 shows the baseline efficacy requirements for the Integrated Omnidirectional Short product class.

TABLE II.2—INTEGRATED OMNIDIRECTIONAL SHORT CURRENT STANDARD EFFICACY REQUIREMENTS

Product class	Lamp power (W)	Minimum efficacy (lm/W)
Integrated GSLs	<15 ≥15	45.0 60.0

C. Deviation From Appendix A

In accordance with section 3(a) of 10 CFR part 430, subpart C, appendix A (appendix A), DOE notes that it is deviating from the provisions in appendix A regarding the pre-NOPR stages for an energy conservation standards rulemaking. Section 6(a)(1) specifies that as the first step in any proceeding to consider establishing or amending any energy conservation standard, DOE will publish a document in the **Federal Register** announcing that DOE is considering initiating a rulemaking proceeding. Section 6(a)(1) states that as part of that document, DOE will solicit submission of related comments, including data and information on whether DOE should proceed with the rulemaking, including whether any new or amended rule would be cost effective, economically justified, technologically feasible, or would result in a significant savings of energy. Section 6(a)(2) of appendix A states that if the Department determines it is appropriate to proceed with a rulemaking, the preliminary stages of a rulemaking to issue or amend an energy conservation standard that DOE will undertake will be a framework document and preliminary analysis, or an advance notice of proposed rulemaking (ANOPR). DOE finds it necessary and appropriate to deviate from this step in Appendix A and to publish this NOPR without conducting these preliminary stages. Completion of the second cycle of GSL rulemaking is overdue under the January 1, 2020 statutory deadline in 42 U.S.C. 6295(i)(6)(B), so DOE seeks to complete its statutory obligations as expeditiously as possible. Under the requirements of 42 U.S.C. 6295(i)(6)(B)(i), DOE is to initiate a second rulemaking procedure by January 1, 2020, to determine whether standards in effect for GSILs should be amended. The scope of this rule is not limited to incandescent lamp technologies and thus includes GSLs. (42 U.S.C. 6295(i)(6)(B)(ii)) Further, as discussed in section II.B.1 of this document, in settling the lawsuit filed by NEMA following the January 2017 Definition Final Rules (Petition for Review, *Nat'l Elec. Mfrs. Ass'n* v. *U.S. Dep't of Energy,* No. 17–1341 (4th Cir.)), DOE agreed to use its best efforts to issue a supplemental notice of proposed rulemaking regarding whether to amend or adopt standards for general service light-emitting diode (LED) lamps, that may also address whether to adopt standards for compact fluorescent lamps (CFLs), by May 2018. Given this context, DOE has determined that proceeding with this rulemaking as expeditiously as is reasonably practical is the appropriate approach. Additionally, while DOE is not publishing pre-NOPR documents, DOE has tentatively found that the methodologies used for the March 2016 NOPR continue to apply to the current market for GSLs. DOE has updated analytical inputs in its analysis from the March 2016 NOPR where appropriate and welcomes submission of additional data, information, and comments.

III. General Discussion

DOE developed this proposal after considering data and information from interested parties that represent a variety of interests.

A. Product Classes and Scope of Coverage

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 VI.A.1 of this document 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 energy conservation standards and to quantify the efficiency of their product. DOE will finalize a test procedure establishing methodologies used to evaluate proposed energy conservation standards prior to publication of a NOPR proposing new or amended energy conservation standards. Section 8(d)(1) of appendix A.

DOE's test procedures for GSILs and IRLs are set forth at 10 CFR part 430, subpart B, appendix R. DOE's test procedure for CFLs is set forth at 10 CFR part 430, subpart B, appendix W. DOE's test procedure for LED lamps is set forth at 10 CFR part 430, subpart B, appendix BB. DOE's test procedure for GSLs that are not GSILs, IRLs, CFLs, or integrated LED lamps is set forth at 10 CFR part 430, subpart B, appendix DD.

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. Sections 6(b)(3)(i) and 7(b)(1) of appendix A.

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; (3) adverse impacts on health or safety, and (4) unique-pathway proprietary technologies. Sections 6(b)(3)(ii) through (v) and 7(b)(2) through (5) of appendix A. Section VI.B of this document 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 VI.C.4.e of this proposed rule and in chapter 5 of the NOPR TSD.

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 first full year of compliance with the proposed standards (2029–2058).[17] The savings are measured over the entire lifetime of GSLs purchased in the previous 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 amended energy conservation standards.

DOE used its national impact analysis (NIA) spreadsheet model to estimate national energy savings (NES) from potential amended or new standards for GSLs. The NIA spreadsheet model (described in section VI.H of this document) calculates energy savings in terms of site energy, which is the energy directly consumed by products at the locations where they are used. For electricity, DOE reports national energy savings in terms of primary energy savings, which is the savings in the energy that is used to generate and transmit the site electricity. DOE also calculates NES in terms of 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.[18] 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 VI.H.1 of this document.

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))

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking. For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand. In evaluating the significance of energy savings, DOE considers differences in primary energy and FFC effects for different covered products and equipment when determining whether energy savings are significant. Primary energy and FFC effects include the energy consumed in electricity production (depending on load shape), in distribution and transmission, and in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and thus present a more complete picture of the impacts of energy conservation standards.

Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis. As mentioned previously, the proposed standards are projected to result in estimated national FFC energy savings of 4.0 quads, the equivalent of the electricity use of 43 million homes in one year. DOE has initially determined the energy savings from the proposed standard levels are ''significant'' within the meaning of 42 U.S.C. 6295(o)(3)(B).

E. Economic Justification

1. Specific Criteria

As noted previously, 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 proposed rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of a potential amended standard on manufacturers, DOE conducts an MIA, as discussed in section VI.J of this document. 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 PBP associated with new or amended standards. These measures are discussed further in the following

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

[18] 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).

section. For consumers in the aggregate, DOE also calculates the national net present value 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 attached 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 full year of compliance with new or amended standards. The LCC savings for the considered efficiency levels are calculated relative to the case that reflects projected market trends in the absence of new or amended standards. DOE's LCC and PBP analysis is discussed in further detail in section VI.F of this document.

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 VI.H of this document, DOE uses the NIA spreadsheet model to project national energy savings.

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. DOE invites comment from the public regarding the competitive impacts that are likely to result from this proposed rule. In addition, stakeholders may also provide comments separately to DOJ regarding these potential impacts. See the **ADDRESSES** section for information to send comments to DOJ.

f. Need for National Energy Conservation

DOE also considers the need for national energy and water 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 VI.M of this document.

DOE maintains that environmental and public health benefits associated with the more efficient use of energy are important to take into account when considering the need for national energy conservation. The proposed standards are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases (GHGs) associated with energy production and use. DOE conducts an emissions analysis to estimate how potential standards may affect these emissions, as discussed in section VI.K; the estimated emissions impacts are reported in section VII.B.6 of this document. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section VI.L of this document.

g. Other Factors

In determining whether an energy conservation standard is economically justified, DOE may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) To the extent DOE identifies any relevant information regarding economic justification that does not fit into the other categories described previously, 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 VI.F.11 of this proposed rule.

IV. Scope of Coverage

This section addresses the scope of coverage of this rulemaking. 42 U.S.C. 6295(i)(6)(B)(ii) of EPCA provides that this rulemaking scope shall not be limited to incandescent technologies. In accordance with this provision, the scope of this rulemaking encompasses other GSLs in addition to GSILs. Additionally, 42 U.S.C. 6295(i)(6)(B)(i)(II) of EPCA directs DOE to consider whether the exemptions for certain incandescent lamps should be maintained or discontinued. In this NOPR, DOE reviews the regulatory definitions of GSL, GSIL and supporting definitions adopted in the May 2022 Definition Final Rule and tentatively determines that no amendments are needed with regards to maintenance or discontinuation of exemptions. DOE is proposing minor updates to clarify certain supplemental definitions adopted in the May 2022 Definition Final Rule.

A. Definitions of General Service Lamp, Compact Fluorescent Lamp, General Service LED Lamp, General Service OLED Lamp, General Service Incandescent Lamp

In the September 2019 Definition Final Rule, DOE withdrew the definitions adopted in the January 2017 Definition Final Rules and maintained the existing regulatory definitions of GSL and GSIL, which are the same as the statutory definitions of those terms. 84 FR 46661, 46662. As noted in section II.B.1 of this document, in the August 2021 Definition NOPR, DOE revisited its conclusions in the September 2019 Definition Final Rule and proposed to amend the definitions of GSL and GSIL and associated supplemental definitions to be defined as previously set forth in the January 2017 Definition Final Rules. In the May 2022 Definition Final Rule, DOE discussed comments received regarding the August 2021 Definition NOPR and adopted the GSL and GSIL definitions and associated supplemental definitions as proposed in the August 2021 Definition NOPR. 87 FR 27461. The current regulatory definitions for GSL, CFL, general service LED lamp, general service OLED lamp, and GSIL are described in the following paragraphs.

A general service lamp has the following characteristics: (1) an ANSI base; (2) able to operate at a voltage of 12 volts or 24 volts, at or between 100 to 130 volts, at or between 220 to 240 volts, or of 277 volts for integrated lamps or is able to operate at any voltage for non-integrated lamps; (3) has an initial lumen output of greater than or equal to 310 lumens (or 232 lumens for modified spectrum general service incandescent lamps) and less than or equal to 3,300 lumens; (4) is not a light fixture; (5) is not an LED downlight retrofit kit; and (6) 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. General service lamps do not include: (1) Appliance lamps; (2) Black light lamps; (3) Bug lamps; (4) Colored lamps; (5) G shape lamps with a diameter of 5 inches or more as defined in ANSI C79.1–2002 (incorporated by reference; see § 430.3); (6) General service fluorescent lamps; (7) High intensity discharge lamps; (8) Infrared lamps; (9) J, JC, JCD, JCS, JCV, JCX, JD, JS, and JT shape lamps that do not have Edison screw bases; (10) Lamps that have a wedge base or prefocus base; (11) Left-hand thread lamps; (12) Marine lamps; (13) Marine signal service lamps; (14) Mine service lamps; (15) MR shape lamps that have a first number symbol equal to 16 (diameter equal to 2 inches) as defined in ANSI C79.1–2002 (incorporated by reference; see § 430.3), operate at 12 volts, and have a lumen output greater than or equal to 800; (16) Other fluorescent lamps; (17) Plant light lamps; (18) R20 short lamps; (19) Reflector lamps (as defined in this section) that have a first number symbol less than 16 (diameter less than 2 inches) as defined in ANSI C79.1–2002 (incorporated by reference; see § 430.3) and that do not have E26/E24, E26d, E26/50x39, E26/53x39, E29/28, E29/53x39, E39, E39d, EP39, or EX39 bases; (20) S shape or G shape lamps that have a first number symbol less than or equal to 12.5 (diameter less than or equal to 1.5625 inches) as defined in ANSI C79.1–2002 (incorporated by reference; see § 430.3); (21) Sign service lamps; (22) Silver bowl lamps; (23) Showcase lamps; (24) Specialty MR lamps; (25) T-shape lamps that have a first number symbol less than or equal to 8 (diameter less than or equal to 1 inch) as defined in ANSI C79.1–2002 (incorporated by reference; see § 430.3), nominal overall length less than 12 inches, and that are not compact fluorescent lamps (as defined in this section); (26) Traffic signal lamps. 87 FR 27461, 27480–27481.

A compact fluorescent lamp is an integrated or non-integrated single-base, low-pressure mercury, electric-discharge source. In this lamp a fluorescing coating transforms some of the ultraviolet energy generated by the mercury discharge into light. The term does not include circline or U-shaped lamps. 10 CFR 430.2.

A general service light-emitting diode (LED) lamp is an integrated or non-integrated LED lamp designed for use in general lighting applications. It uses light-emitting diodes as the primary source of light. 87 FR 27461, 27481.

A general service organic light-emitting diode (OLED) lamp is an integrated or non-integrated OLED lamp designed for use in general lighting applications. It uses organic light-emitting diodes as the primary source of light. 87 FR 27461, 27481.

A general service incandescent lamp is a standard incandescent or halogen type lamp that is intended for general service applications. It has the following characteristics: (1) medium screw base; (2) lumen range of not less than 310 lumens and not more than 2,600 lumens or, in the case of a modified spectrum lamp, not less than 232 lumens and not more than 1,950 lumens; and (3) capable of being operated at a voltage range at least partially within 110 and 130 volts. This definition does not apply to the following incandescent lamps—(1) An appliance lamp; (2) A black light lamp; (3) A bug lamp; (4) A colored lamp; (5) A G shape lamp with a diameter of 5 inches or more as defined in ANSI C79.1–2002 (incorporated by reference; see § 430.3); (6) An infrared lamp; (7) A left-hand thread lamp; (8) A marine lamp; (9) A marine signal service lamp; (10) A mine service lamp; (11) A plant light lamp; (12) An R20 short lamp; (13) A sign service lamp; (14) A silver bowl lamp; (15) A showcase lamp; and (16) A traffic signal lamp. 87 FR 27461, 27480.

As stated, this rulemaking is being conducted in accordance with 42 U.S.C. 6295(i)(6)(B). Under this provision, DOE must determine whether exemptions for certain incandescent lamps should be maintained or discontinued based, in part, on exempted lamp sales data collected by the Secretary from manufacturers.

As part of the first rulemaking cycle for GSLs, in the January 2017 Definition Final Rules and May 2022 Definition Final Rule, DOE also determined whether exemptions for certain incandescent lamps should be maintained or discontinued based, in part, on exempted lamp sales data collected by the Secretary from manufacturers under 42 U.S.C. 6295(i)(6)(A)(i)(II). DOE conducted this analysis with the understanding that the purpose was to ensure that a given exemption would not impair the effectiveness of GSL standards by leaving available a convenient substitute that was not regulated as a GSL. Therefore, DOE based its decision for each exemption on an assessment of whether the exemption encompassed lamps that could provide general illumination and could functionally be a ready substitute for lamps already covered as GSLs. The technical characteristics of lamps in a given exemption and the volume of sales of those lamps were also considered. 82 FR 7276, 7288; 87 FR 27461, 27465–27467. Subsequently, in the May 2022 Definition Final Rule, DOE reaffirmed its conclusions in the January 2017 Definition Final Rules and discontinued the exemptions from the GSIL definition for rough service lamps; shatter-resistant lamps; three-way incandescent lamps; vibration service lamps; reflector lamps; T-shape lamps of 40 W or less or length of 10 inches or more; and B, BA, CA, F, G16–1/2, G25, G30, S, M–14 lamps of 40 W or less. 87 FR 27461, 27480–27481.

DOE has reviewed the remaining exemptions from the GSIL and GSL definitions. DOE's review of lamp specifications indicates that the exempted lamps continue to have features that do not make them suitable as substitutes for GSLs. Further review of the market indicates that they remain niche products. Hence, DOE finds that the lamps exempted in the May 2022 Definition Final Rule have not acquired technical characteristics that make them ready substitutes for GSLs or have not increased in sales. Therefore, DOE has tentatively determined that no amendments are needed to the definitions of GSIL and GSL as determined in the May 2022 Definition Final Rule.

B. Supporting Definitions

In the May 2022 Definition Final Rule, DOE adopted supporting definitions for GSLs and GSILs as proposed in the August 2021 Definition NOPR and set forth in the January 2017 Definition Final Rules. 87 FR 27461. These included definitions for ''black light lamp,'' ''bug lamp,'' ''colored lamp,'' ''infrared lamp,'' ''left-hand thread lamp,'' ''light fixture,'' ''marine lamp,'' ''marine signal service lamp,'' ''mine service lamp,'' ''non-integrated lamp,'' ''pin base lamp, ''plant light lamp,'' ''reflector lamp,'' ''showcase lamp,'' ''sign service lamp,'' ''silver bowl lamp,'' ''specialty MR lamp,'' and ''traffic signal lamp.''

In this NOPR, DOE is proposing minor updates to certain supplemental definitions adopted in the May 2022 Definition Final Rule. Specifically, DOE is proposing to add an industry reference to the definition of LED downlight retrofit kit by specifying that it must be a retrofit kit classified or certified to UL 1598C–2014.[19] Additionally, DOE is proposing to update the industry standards referenced in the definitions of ''Reflector lamp'' and ''Showcase lamp.'' The current definitions for ''Showcase lamp'' and ''Reflector lamp'' reference ANSI C78.20–2003 [20] and ANSI C79.1–2002.[21] In this NOPR, DOE is proposing to remove the reference to ANSI C78.20–2003 from the definitions of ''Showcase lamp'' and ''Reflector lamp.'' ANSI C78.20–2003 is an industry standard for A, G, PS, and similar shapes with E26 bases and therefore is not relevant to these lamp types. Further, ANSI has replaced ANSI C79.1–2002 with ANSI C78.79–2014 (R2020).[22] ANSI 79.1–2002 is referenced in the: (1) ''Specialty MR lamp'' definition; (2) ''Reflector lamp'' definition; (3) ''General service incandescent lamp'' definition with respect to a G shape lamp with a diameter of 5 inches or more; and (4) ''General service lamp'' definition with respect to G shape lamps with a diameter of 5 inches or more; MR shape lamps that have a first number symbol equal to 16; Reflector lamps that have a first number symbol less than 16; S shape or G shape lamps that have a first number symbol less than or equal to 12.5; T shape lamps that have a first number symbol less than or equal to 8. Accordingly, DOE proposes to revise the references to ANSI C79.1–2002 to ANSI C78.79–2014 (R2020) in all the aforementioned definitions.

DOE requests comments on the proposed updates to industry references in the definitions of ''General service incandescent lamp,'' ''General service lamp,'' ''LED downlight retrofit kit'', ''Reflector lamp,'' ''Showcase lamp,'' and ''Specialty MR lamp.'' *See* section IX.E for a list of issues on which DOE seeks comment.

In this NOPR, DOE is proposing a new supporting term, ''Circadian-friendly integrated LED lamp'' and its definition. This lamp type will be excluded from the GSL definition. DOE has identified commercially available integrated LED lamps that are marketed as aiding in the human sleep-wake (*i.e.,* circadian) cycle by changing the light spectrum. For example, the Soraa HEALTHY™ lamp and the NorbSLEEP lamp specify decrease or removal of blue light from the light spectrum emitted by the lamp to ensure proper melatonin production for better sleep.[23] DOE observed that these were integrated LED lamps with efficacies ranging from 47.8 lm/W to 85.7 lm/W. Because these lamps offer a utility to consumers and do not have high efficacies, DOE is proposing to exempt them from standards. Hence, DOE is proposing to define the exempt lamp type, circadian-friendly integrated LED lamp, as an integrated LED lamp that

(1) Is designed and marketed for use in the human sleep-wake (circadian) cycle;

(2) Is designed and marketed as an equivalent replacement for a 40 W or 60 W incandescent lamp;

(3) Has at least one setting that decreases or removes standard spectrum radiation emission in the 440 nm to 490 nm wavelength range; and

(4) Is sold in packages of two lamps or less.

The first criterion specifies the application of the lamp. For the second criterion, because these lamps are mainly available in the 500 to 800 lumen range, DOE is specifying the equivalent incandescent wattages. For the third criterion, because these lamps provide a better sleep-wake cycle by removing blue light, DOE has specified that the lamp must decrease or remove emission in the 440 to 490 nm wavelength range. In verifying a luminaire to have a certain amount of blue light content, the Underwriters Laboratories' verification method consisted of determining the amount of blue light radiation in the 440–490 nm wavelength range.[24] The fourth criterion

[19] UL, UL1598C Standard for Safety Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits. Approved January 12, 2017.

[20] American National Standards Institute, ANSI C78.20–2003 American National Standard for Electric Lamps—A, G, PS, and Similar Shapes with E26 Medium Screw Bases. Approved October 30, 2003.

[21] American National Standards Institute, ANSI C79.1–2002 American National Standard For Electric Lamps—Nomenclature for Glass Bulbs Intended for Use with Electric Lamps. Approved September 16, 2002.

[22] American National Standards Institute, ANSI C 78.79–2014 (R2020) American National Standard for Electric Lamps—Nomenclature for Envelope Shapes Intended for Use with Electric Lamps. Approved January 17, 2020.

[23] Soraa HEALTHY™, available at *https://www.soraa.com/products/52-Soraa-Healthy-A19-A60.php#;* NorbSLEEP, available at *https://norblighting.com/sleep/;* accessed June 29, 2020.

[24] Ian Ashdown, Melanopic Green The Other Side of Blue, available at *https://www.ies.org/fires/melanopic-green-the-other-side-of-blue/.* Accessed

limits how many lamps are sold per package to ensure that lamps are not sold in bulk. This type of lamp offers a specific feature to consumers. To prevent the use of the lamp in general applications for common use, and thereby create a loophole to GSL standards, DOE is proposing the fourth criterion, which is consistent with the vibration service lamp definition intended for a specialty lamp type.

DOE requests comments on the proposed definition for ''Circadian-friendly integrated LED lamp,'' including the packaging criterion. DOE also requests comments on the consumer utility and efficacy potential of lamps marketed to improve the sleep-wake cycle. *See* section IX.E for a list of issues on which DOE seeks comment.

C. GSLs Evaluated for Potential Standards in This NOPR

DOE is not assessing standards for general service OLED lamps and incandescent lamps, types of GSLs, in this NOPR analysis. OLED means a thin-film light-emitting device that typically consists of a series of organic layers between 2 electrical contacts (electrodes). 10 CFR 430.2. OLEDs can create diffuse light sources with direct emitters and are also thin and bendable, allowing for new form factors. DOE reviewed product offerings of manufacturers and retailers marketing OLED lighting technology and did not find any that offered integrated or non-integrated OLED lamps. Most OLED light sources are embedded within a light panel that can range from approximately 100 to 300 lumens.[25] The panels are being used in light fixtures such as desk lamps, hanging ceiling light fixtures and troffers emitting lumens ranging from 75 to 1,800 lumens (depending on the number of panels used per fixture). Due to the lack of commercially available GSLs that use OLED technology, it is unclear whether the efficacy of these products can be increased. Therefore, DOE is not evaluating standards for general service OLED lamps because DOE has tentatively determined that standards for these lamps would not be technologically feasible at this time.

As noted in section II.B.1 of this document, in the May 2022 Backstop Final Rule, DOE codified the 45 lm/W requirement for GSLs, which cannot be met by incandescent and halogen lamps. Therefore, DOE is also not analyzing standards for incandescent and halogen lamps in this proposal.

DOE is analyzing CFLs and general service LED lamps that have a lumen output within the range of 310–3,300 lumens; an input voltage of 12 volts or 24 volts, at or between 100 to 130 volts, at or between 220 to 240 volts, or of 277 volts for integrated lamps, or are able to operate at any voltage for non-integrated lamps; and do not fall into any exclusion from the GSL definition at 10 CFR 430.2 (*see* section IV.A of this document).

V. Scope of Metrics

In this section DOE discusses its proposal to use minimum lumens per watt as the metric for measuring lamp efficiency. DOE also discusses proposed updates to existing metrics and proposed addition of new metrics for GSLs.

Because CFLs are included in the definition of GSL, this proposed rulemaking satisfies the requirements under 42 U.S.C 6295(m)(1) to review existing standards for MBCFLs. The Energy Policy Act of 2005 (EPAct 2005) amended EPCA by establishing energy conservation standards for MBCFLs, which were codified by DOE in an October 2005 final rule. 70 FR 60413. 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 color rendering index (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))

For MBCFLs, in this NOPR, DOE is proposing to update the existing requirements for rapid cycle stress test and lifetime and add minimum requirements for power factor, CRI, and start time. For integrated LED lamps, DOE is also proposing to add a minimum requirement for power factor and for medium screw base GSLs a minimum requirement for CRI. These proposals are discussed in the following sections.

1. Lumens per Watt (Lamp Efficacy)

As stated in section II.A, this proposed rulemaking is being conducted under 42 U.S.C. 6295(i)(6)(B). Under 42 U.S.C. 6295(i)(6)(B)(i)(I), DOE is required to determine whether standards in effect for GSILs should be amended to reflect lumen ranges with more stringent maximum wattage than the standards specified in paragraph (1)(A) [*i.e.,* standards enacted by section 321(a)(3)(A)(ii) of EISA [26]]. The scope of this analysis is not limited to incandescent lamp technologies and thus encompasses GSLs. The May 2022 Backstop Final Rule codified the statutory backstop requirement in 42 U.S.C. 6295(i)(6)(A)(v) prohibiting sales of GSLs that do not meet a 45 lm/W efficacy standard. Because incandescent and halogen GSLs would not be able to meet the 45 lm/W requirement, they are not being considered in this analysis. Regarding the efficiency metric, DOE is assessing the efficiency of GSLs based on minimum lumens per watt (*i.e.,* lamp efficacy) rather than maximum wattage of a lamp. Because the lamps covered by the scope of this rulemaking span different lighting technologies, GSLs designed to satisfy the same applications are available in a variety of wattages. 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 has tentatively determined that lamps providing equivalent lumen output, and therefore intended for the same applications, should be subject to the same minimum efficacy requirements. Thus, DOE is proposing to use lumens per watt as a metric to evaluate standards in this NOPR. DOE is also proposing an equation-based approach to establish ELs so that lamps that provide the same utility (*i.e.,* lumen output) are subject to the same standard. To ensure there would be no backsliding in violation of EPCA with this approach, DOE

June 29, 2020; Circadian ZircLight, Inc. UL Verification Mark, available at *https://verify.ul.com/verifications/117.*

[25] U.S. Department of Energy, 2019 Lighting R&D Opportunities, January 2020. Available at *https://www.energy.gov/sites/prod/files/2020/01/f70/ssl-rd-opportunities2-jan2020.pdf.*

[26] This provision was to be codified as an amendment to 42 U.S.C. 6295(i)(1)(A). But because of an apparent conflict with section 322(b) of EISA, which purported to ''strik[e] paragraph (1)'' of 6295(i) and replace it with a new paragraph (1), neither this provision nor other provisions of section 321(a)(3)(A)(ii) of EISA that were to be codified in 42 U.S.C. 6295(i)(1) were ever codified in the U.S. Code. *Compare* EISA 321(a)(3)(A)(ii), *with* 42 U.S.C. 6295(i)(1). It appears, however, that Congress's intention in section 322(b) was to replace the existing paragraph (1), not paragraph (1) as amended in section 321(a)(3). Indeed, there is no reason to believe that Congress intended to strike these new standards for GSILs. DOE has thus issued regulations implementing these uncodified provisions. *See, e.g.,* 10 CFR 430.32(x) (implementing standards for GSILs, as set forth in section 321(a)(3)(A)(ii) of EISA).

converted the maximum wattage standards for GSILs in paragraph (1)(A) [*i.e.,* the EISA enacted standards for GSILs] and 10 CFR 430.32(x)(1) to be expressed in terms of lumens per watt. For each lumen output, DOE used the corresponding maximum wattage to calculate the equivalent lumens-per-watt requirement and determined that the 45 lm/W sales prohibition for GSLs exceeds all maximum wattage requirements specified in paragraph (1)(A) and 10 CFR 430.32(x)(1). Thus, standards considered in this proposal that are in terms of lumens per watt would not decrease the existing minimum required energy efficiency of GSLs and do not result in backsliding.

2. Power Factor

In this NOPR DOE is proposing minimum power factor requirements for MBCFLs (see 42 U.S.C. 6295(bb)(2)–(3)) and integrated LED lamps. DOE considered ENERGY STAR Lamps Specification V2.1 [27] requirements, industry standards, and characteristics of lamps in the current market when selecting power factor requirements for MBCFL and integrated LED lamps. DOE found 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 Lamps Specification V2.1 (latest ENERGY STAR lamp specification) and ANSI C82.77–10–2020 [28] requirement of a minimum power factor of 0.5 for integrated CFLs. Similarly, DOE found the vast majority of the U.S. market reports power factors greater than 0.7 for integrated LED lamps. DOE notes that ENERGY STAR Lamps Specification V2.1 requires a power factor of 0.6 for omnidirectional lamps with rated/reported input power of less than or equal to 10 watts and 0.7 for all other solid-state lamps. ANSI C82.77–10–2020 requires a minimum power factor of 0.57 for input powers between 5 W and 25 W (inclusive); and 0.86 for input powers greater than 25 W. DOE reviewed the lamps database developed for this analysis and determined that of integrated LED lamps with power factor data, 99.9 percent (about 16,700 lamps) had a power factor of 0.7 or greater. Further, of integrated LED lamps with wattage less than or equal to 10 W and power factor data, 99.5 percent had a power factor 0.7 or greater. Therefore, because the vast majority of LED lamps have a power factor of 0.7 or greater, DOE is proposing a minimum 0.7 power factor for integrated LED lamps.

DOE also conducted testing of low-cost LED products that have been increasing in popularity on the market to determine if there was a relationship between cost and power factor. In an assessment conducted in 2016, DOE tested the power factor of 25 LED lamps with a per-lamp cost of $5 or less. Of the 25 lamp models tested, 14 lamps had a power factor of 0.7 or higher. Because greater than half of the lamp models complied with a power factor requirement of 0.7, DOE tentatively concluded that low power factor is not a requirement for a low-cost LED lamp. DOE also reviewed the DOE product database developed for this analysis and found 25 integrated LED lamps with a published power factor and price of $5 or less. Of these 25 lamps, 21 lamps had a power factor of 0.7 or higher. Thus, DOE has tentatively determined the proposed power factor requirements are achievable and would not result in higher costs, nor pose physical challenges. DOE is proposing a minimum power factor for integrated lamps being analyzed for potential standards in this NOPR of 0.7 for integrated LED lamps and 0.5 for MBCFLs.

3. Lifetime

In this NOPR, DOE is proposing to update the minimum lifetime standard for MBCFLs pursuant to the authority under 42 U.S.C 6295(m)(1) to review existing MBCFL standards. Specifically, DOE is proposing to update the existing minimum 6,000-hour requirement to 10,000 hours. Based on a review of the market DOE has determined that the majority of MBCFLs on the market have lifetimes of at least 10,000 hours. Further, of the MBCFLs submitted to DOE in DOE's compliance certification database, about 94 percent have a lifetime of at least 10,000 hours.

4. Start Time

In this NOPR, DOE is proposing a minimum start time requirement for MBCFLs (*see* 42 U.S.C. 6295(bb)(2)–(3)). Specifically, DOE is proposing that an MBCFL with standby mode power must meet a one second start time requirement and an MBCFL without standby mode power must meet a 750 millisecond start time requirement.

This requirement aligns with the ENERGY STAR Lamps Specification V2.1, the latest ENERGY STAR specifications regarding lamps. In ENERGY STAR Lamps Specification V2.1, the start time for connected MBCFLs is full illumination within one second of application of electrical power, and for non-connected MBCFLs it is within 750 milliseconds. ENERGY STAR defines a connected lamp as a lamp that ''includes elements (hardware and software or firmware) or instructions required to enable communication in response to consumer-authorized energy or performance related commands.'' Based on this description, a connected lamp would have standby mode power.

5. CRI

Section 321(a) of EISA established CRI requirements for lamps that are intended for a general service or general illumination application (whether incandescent or not); have a medium screw base or any other screw base not defined in ANSI C81.61–2006; are capable of being operated at a voltage at least partially within the range of 110 to 130 volts; and are manufactured or imported after December 31, 2011. For such lamps, section 321(a) of EISA specifies a minimum CRI of 80 for nonmodified spectrum lamps and 75 for modified spectrum lamps. Because MBCFLs meet these criteria, as they are GSLs and used in general service applications, have a medium screw base and a rated input voltage range of 115 to 130 volts (see definition of ''medium base compact fluorescent lamp'' at 10 CFR 430.2), they are subject to section 321(a) of EISA.

In this NOPR, DOE is proposing to codify the CRI requirements in section 321(a) of EISA. Specifically, DOE is proposing to specify that lamps with a medium screw base or any other screw base not defined in ANSI C81.61–2006; intended for a general service or general illumination application (whether incandescent or not); and capable of being operated at a voltage at least partially within the range of 110 to 130 volts, must have a minimum CRI of 80 (for non-modified spectrum lamps) and 75 (modified spectrum lamps). Because MBCFLs meet these specifications they would also be subject to the minimum CRI requirements in section 321(a) of EISA.

6. Summary of Metrics

Table V.1 summarizes the non-efficacy metrics proposed in this rulemaking (efficacy metrics are discussed in the engineering analysis; see section VI.C of this document). DOE has determined that these proposed new metrics for MBCFLs, integrated LED lamps, and medium base GSLs will provide consumers with increased

[27] ENERGY STAR Lamps Specification V2.1, ENERGY STAR Program Requirements for Lamps (Light Bulbs), January 2, 2017. Available at *https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf.*

[28] American National Standards Institute, ANSI C82.77–10–2020, ''American National Standard for Lighting Equipment-Harmonic Emission Limits-Related Power Quality Requirements,'' approved January 9, 2020.

energy savings and consumer satisfaction for those products capable of achieving the proposed standard level. DOE has existing test procedures for the metrics being proposed. (See section III.B for more information on test procedures for GSLs.) Further, DOE has tentatively concluded that the new proposed metrics will not result in substantial testing burden, as many manufacturers already test their products according to these metrics. DOE requests comments on the non-efficacy metrics proposed for GSLs. *See* section IX.E for a list of issues on which DOE seeks comment.

TABLE V.1—NON-EFFICACY METRICS FOR CERTAIN GSLS

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: (1) one second of application of electrical power for lamp with standby mode power. (2) 750 milliseconds of application of electrical power for lamp without standby mode power.
Integrated LED Lamps	Power factor	0.7.
Non-modified spectrum lamps with a medium screw base or any other screw base not defined in ANSI C81.61–2006; intended for a general service or general illumination application (whether incandescent or not); capable of being operated at a voltage at least partially within the range of 110 to 130 volts.	CRI	80.
Modified spectrum lamps with a medium screw base or any other screw base not defined in ANSI C81.61–2006; intended for a general service or general illumination application (whether incandescent or not); capable of being operated at a voltage at least partially within the range of 110 to 130 volts.	CRI	75.

* Lifetime refers to lifetime of a CFLs as defined in 10 CFR 430.2.

VI. Methodology and Discussion

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 NIA uses a second spreadsheet set that provides shipments projections 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 website for this rulemaking: *https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4.* Additionally, DOE used output from the latest version of the Energy Information Administration's (EIA's) *Annual Energy Outlook* (*AEO*), a widely known energy projection for the United States, for the emissions and utility impact analyses.

In this NOPR, DOE anticipates compliance in the second half of 2028 and uses 2029 as the first full compliance year for purposes of conducting the analysis based on the requirement in 42 U.S.C. 6295(m)(4)(B) that DOE shall not require new standards for a product within 6 years of the compliance date of the previous standard. Since compliance with the statutory backstop requirement for GSLs commenced on July 25, 2022 a July 25, 2028 compliance date for any GSL standard would provide a 6-year spread between GSL compliance dates consistent with 42 U.S.C. 6295(m)(4)(B). A compliance date of July 25, 2028, is also consistent with the timespan described in 42 U.S.C. 6295(i)(6)(B), which contemplates at least a 5-year time period between any GSL rule arising out of the first cycle of rulemaking under 42 U.S.C. 6295(i)(6)(A) and the effective date of a final rule for the second cycle of rulemaking under 42 U.S.C. 6295(i)(6)(B). However, per 42 U.S.C. 6295(i)(6)(B)(iv)(I)–(II), for this proposed rulemaking, the Secretary shall consider phased-in effective dates after considering the impact of any amendments on manufacturers (*e.g.,* retiring, repurposing equipment, stranded investments, labor contracts, workers and raw materials) and the time needed to work with retailers/lighting designers to revise sales/marketing strategies. As is evident in this analysis, DOE is collecting information and evaluating the industry and market with respect to potential standards for GSLs.

DOE will be in a better position to determine whether phased-in effective dates are necessary once it receives comments from stakeholders on the potential standards for GSLs presented in this NOPR. DOE requests comments on whether or not phased-in effective dates are necessary for this rulemaking. *See* section IX.E for a list of issues on which DOE seeks comment.

A. Market and Technology Assessment

DOE develops information in the market and technology assessment that provides an overall picture of the market for the products concerned, including the purpose of the products, the industry structure, manufacturers, market characteristics, and technologies used in the products. This activity includes both quantitative and qualitative assessments, based primarily on publicly-available information. The subjects addressed in the market and technology assessment for this rulemaking include (1) a determination of the scope of the rulemaking and product classes, (2) manufacturers and industry structure, (3) existing efficiency programs, (4) shipments information, (5) market and industry trends; and (6) technologies or design options that could improve the energy efficiency of GSLs. The key findings of DOE's market assessment are summarized in the following sections. See chapter 3 of the NOPR TSD for further discussion of the market and technology assessment.

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. In this analysis, DOE reviewed several factors including lamp component location, standby mode operation, base type, bulb shape, CRI, correlated color temperature (CCT), lumens, and length. In this NOPR, DOE proposes product class divisions based on lamp component location (*i.e.,* location of ballast/driver) and capability of operating in standby mode; directionality (*i.e.,* omnidirectional versus directional) and lamp length (*i.e.,* 45 inches or longer [''long''] or less than 45 inches [''short''] as product class setting factors. In the section below, DOE discusses its proposed product class setting factors. In chapter 3 of the NOPR TSD, DOE discusses features it considered but determined to not be valid product class setting factors including lamp technology, lumen package, lamp cover, dimmability, base type, lamp spectrum, CRI and CCT. *See* chapter 3 of the NOPR TSD for further discussion.

a. Lamp Component Location

Lamp component location refers to the position of the ballast or driver. Integrated lamps have these components enclosed within the lamp, whereas non-integrated lamps have them external to the lamp. Due to the additional components and circuity enclosed within it, an integrated lamp will have an inherent difference in efficacy compared to a lamp that utilizes external components. For consumers using an integrated lamp, there is also the utility of requiring replacement of one lamp unit rather than two separate components. In certain cases, integrated lamps are also generally more compact and thus can be used in applications with size constraints. For these reasons, DOE is proposing a product class based on lamp component location.

b. Standby Mode Operation

DOE observed that some integrated lamps have standby mode functionality and conducted an analysis to determine its impact on lamp efficacy. Because this functionality seems to be increasingly incorporated in LED lamps compared to CFLs, DOE focused on LED lamps. DOE conducted active mode and standby mode testing per DOE's integrated LED lamp test procedure (see appendix BB). These lamps were designed with varying communication methods, including Zigbee, Bluetooth, Wi-Fi, and radio frequency remote controls. Almost half of the lamps tested were operated using a central hub for communication between the end-user and the lamp itself. DOE's test results, as presented in appendix 5a of the NOPR TSD, indicate that the tested standby power generally varied between 0.2 W and 0.5 W. 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.

c. Directionality

In this analysis, DOE assessed whether directionality should be a product class setting factor—that is, whether a lamp designed to direct light should be subject to separate standards from a lamp that is not. DOE compared pairs of integrated LED lamps from the same manufacturer with the same lumens, lifetime, range of CCT and CRI, except one was directional (*e.g.,* parabolic aluminized reflector [''PAR'']) and the other omnidirectional (*e.g.,* A-shape). DOE also ensured the pairs were of comparable size. For example, a PAR30 was compared with an A19—the numbers indicate the diameter in inches when divided by 8. DOE determined that in over 80 percent of cases, omnidirectional lamps had a higher efficacy. Additionally, by directing or not directing light, directional and omnidirectional each provide a unique consumer utility. DOE was unable to compare the efficacy impact from directionality for the non-integrated lamps due to difference in size. The non-integrated directional lamps are predominantly MR16 shape lamps and the non-integrated omnidirectional lamps are longer tube, pin base CFLs and their LED replacements, or linear LED lamps. However, based on the analysis of integrated lamps, DOE has tentatively concluded that lamps differing only in directionality, all other attributes held constant, will likely differ in lamp efficacy. Due to the impact of directionality on efficacy and consumer utility, DOE is proposing directionality as a product class setting factor in this analysis.

d. Lamp Length

Efficacy tends to increase with length. GSLs span a range of lengths. A-shape or reflector shape lamps typically have a maximum overall length (MOL) of about 1.8–7 inches. Pin base CFLs and their LED replacements typically have a MOL of about 3.7–23 inches. Linear LED lamps are 2-, 3-, 4- and 8-foot lamps. In general, of these lamps, regardless of whether compared to integrated or non-integrated lamps, DOE found a considerable jump in efficacy for the 4-foot (about 45 inches) linear T8 LED lamps. Further, because consumers must change a lamp fixture to substitute lamps of different geometries for one another, lamp length affects utility. Due to the impact of length on efficacy and utility, DOE is proposing lamp length as a product class setting factor—specifying the product class division between lamps of 45 inches or longer length (long) and less than 45 inches (short).

DOE did observe that 4-foot T5 and 8-foot T8 linear LED lamps were not reaching the same efficacies as 4-foot T8 linear LED lamps. DOE has tentatively concluded that this is not due to a technical constraint due to diameter but rather lack of product development of 4-

foot T5 and 8-foot T8 linear LED lamps. DOE requests comments and data on the impact of diameter on efficacy for linear LED lamps. Finally, DOE observed that pin base LED lamp replacements with 2G11 bases and lengths close to two feet are less efficacious than 2-foot linear LED lamps. DOE requests comments on all attributes the same, how the efficacy of pin base LED lamp replacements and linear LED lamps compare. *See* section IX.E for a list of issues on which DOE seeks comment.

e. Product Class Summary

Table VI.1 shows the product classes DOE is proposing in this NOPR. DOE requests comments on the proposed product classes. *See* section IX.E for a list of issues on which DOE seeks comment.

TABLE VI.1—PROPOSED GSL PRODUCT CLASSES

Lamp type	Lamp component location	Directionality	Lamp length	Standby mode operation
GSLs	Integrated	Omnidirectional	Short (<45 inches)	Standby.
				Non-Standby.
			Long (≥45 inches)	Non-Standby.
		Directional	All Lengths	Standby.
				Non-Standby.
	Non-Integrated	Omnidirectional	Short (<45 inches)	N/A.
			Long (≥45 inches).	
		Directional	All Lengths.	

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 this NOPR, DOE identified 21 technology options that would be expected to improve GSL efficacy, as measured by the applicable DOE test procedure. The technology options are differentiated by those that improve the efficacy of CFLs versus those that improve the efficacy of LED lamps. Table VI.2 provides a list of technology options being proposed in this NOPR. 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. *See* section IX.E for a list of issues on which DOE seeks comment.

TABLE VI.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	Use of higher efficiency phosphors to increase the conversion of ultraviolet (UV) light into visible light.
	Glass Coatings	Coatings on inside of bulb reflect UV radiation passing through the phosphor back onto the phosphor, allowing a greater portion of UV to be absorbed, and thereby emit more visible light.
	Multi-Photon Phosphors	Emitting more than one visible photon for each incident UV photon absorbed.
	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.
	Higher Efficiency Reflector Coatings.	Alternative reflector coatings such as silver, with higher reflectivity to increase the amount of directed light.
	Change to LEDs	Replace CFL with LED technology.
LED	Efficient Down Converters	New wavelength conversion materials, such as novel phosphor composition and quantum dots, have the potential for creating warm-white LEDs with improved spectral efficiency, high color quality, and improved thermal stability.
	Improved Package Architectures.	Arrangements of color mixing and phosphor coating LEDs on the LED array that improve package efficacy.
	Improved Emitter Materials	The development of efficient red, green, or amber LED emitters that 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	Emerging alternative substrates that enable high-quality epitaxy for improved device quality and efficacy.
	Improved Thermal Interface Materials (TIMs).	TIMs enable high efficiency thermal transfer to reduce efficacy loss from rises in junction temperature and optimize for long-term reliability of the device.
	Improved LED Device Architectures.	Novel architectures for integrating LED chip(s) into a lamp, such as surface mount device and chip-on-board that improve efficacy.
	Optimized Heat Sink Design	Heat sink design to improve thermal conductivity and heat dissipation from the LED package, 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.

TABLE VI.2—GSL TECHNOLOGY OPTIONS—Continued

Lamp type	Name of technology option	Description
	Improved Primary Optics	Enhancements to the primary optics of the LED package, such as surface etching, novel encapsulant formulations, and flip chip design that improve light extraction 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	Novel and intelligent circuit design to increase driver efficiency.
	AC LEDs	LEDs that operate on AC voltage, eliminating the requirement for and 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

DOE uses the following five screening criteria to determine which technology options are suitable for further consideration in an energy conservation standards rulemaking:

(1) *Technological feasibility.* Technologies that are not incorporated in commercial products or in working prototypes will not be considered further.

(2) *Practicability to manufacture, install, and service.* If it is determined that mass production and reliable installation and servicing of a technology in commercial products could not be achieved on the scale necessary to serve the relevant market at the time of the projected compliance date of the standard, then that technology will not be considered further.

(3) *Impacts on product utility or product availability.* If it is determined that a technology would have a significant adverse impact on the utility of the product for significant subgroups of consumers or would 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 be considered further.

(4) *Adverse impacts on health or safety.* If it is determined that a technology would have significant adverse impacts on health or safety, it will not be considered further.

(5) *Unique-Pathway Proprietary Technologies.* If a design option utilizes proprietary technology that represents a unique pathway to achieving a given efficiency level, that technology will not be considered further due to the potential for monopolistic concerns.

10 CFR part 430, subpart C, appendix A, sections 6(b)(3) and 7(b).

In summary, if DOE determines that a technology, or a combination of technologies, fails to meet one or more of the listed five criteria, it will be excluded from further consideration in the engineering analysis. The reasons for eliminating any technology are discussed in the following sections.

The subsequent sections include comments from interested parties pertinent to the screening criteria, DOE's evaluation of each technology option against the screening analysis criteria, and whether DOE determined that a technology option should be excluded (screened out) based on the screening criteria.

1. Screened-Out Technologies

In this NOPR, DOE is proposing to screen out multi-photon phosphors for CFLs, and quantum dots and improved emitter materials for LED lamps based on the first criterion on technological feasibility. In its review of technologies for this analysis, DOE did not find evidence that multi-photon phosphors, quantum dots, or improved emitter materials are being used in commercially available products or prototypes.

In this NOPR, 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. The only commercially available AC LED lamps that DOE found were G-shapes between 330 and 360 lumens or candle shapes between 220 and 400 lumens. Therefore, it is unclear whether the technology could be made for a wide range of products on a commercial scale and in particular for those being considered in this document.

2. Remaining Technologies

Through a review of each technology, DOE tentatively concludes that all of the other identified technologies listed in section VI.A.2 of this document met all five screening criteria and are examined further as design options in this analysis. In summary, DOE did not screen out the following technology options:

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
- Higher Efficiency Reflector Coatings
- Change to LEDs

LED Design Options

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

DOE has initially determined that these technology options are technologically feasible because they are being used or have previously been used in commercially-available products or working prototypes. DOE also finds that all of the remaining technology options meet the other screening criteria (*i.e.,* practicable to manufacture, install, and service and do not result in adverse impacts on consumer utility, product availability, health, or safety, unique-pathway proprietary technologies). For additional details, see chapter 4 of the NOPR TSD. DOE requests comments on the design options it has identified. *See* section IX.E for a list of issues on which DOE seeks comment.

C. Engineering Analysis

The purpose of the engineering analysis is to establish the relationship between the efficiency and cost of GSLs. There are two elements to consider in the engineering analysis; the selection of efficiency levels to analyze (*i.e.,* the ''efficiency analysis'') and the determination of product cost at each efficiency level (*i.e.,* the ''cost analysis''). In determining the performance of higher-efficiency products, DOE considers technologies and design option combinations not eliminated by the screening analysis. For each product class, DOE estimates the baseline cost, as well as the incremental cost for the product at efficiency levels above the baseline. The output of the engineering analysis is a set of cost-efficiency ''curves'' that are used in downstream analyses (*i.e.,* the LCC and PBP analyses and the NIA).

1. Efficiency Analysis

DOE typically uses one of two approaches to develop energy efficiency levels for the engineering analysis: (1) relying on observed efficiency levels in the market (*i.e.,* the efficiency-level approach), or (2) determining the incremental efficiency improvements associated with incorporating specific design options to a baseline model (*i.e.,* the design-option approach). Using the efficiency-level approach, the efficiency levels established for the analysis are determined based on the market distribution of existing products (in other words, based on the range of efficiencies and efficiency level ''clusters'' that already exist on the market). Using the design option approach, the efficiency levels established for the analysis are determined through detailed engineering calculations and/or computer simulations of the efficiency improvements from implementing specific design options that have been identified in the technology assessment. DOE may also rely on a combination of these two approaches. For example, the efficiency-level approach (based on actual products on the market) may be extended using the design option approach to ''gap fill'' levels (to bridge large gaps between other identified efficiency levels) and/or to extrapolate to the max-tech level (particularly in cases where the max-tech level exceeds the maximum efficiency level currently available on the market).

In this NOPR, DOE relies on an efficiency-level approach. For GSLs, efficiency levels (ELs) are determined as lumens per watt which is also referred to as the lamp's efficacy (*see* section V.1 of this document). DOE derives ELs in the engineering analysis and end-user prices in the cost analysis. DOE estimates the end-user price of GSLs directly because reverse-engineering a lamp is impractical as the lamps are not easily disassembled. By combining the results of the engineering analysis and the cost analysis, DOE derives typical inputs for use in the LCC and NIA. Section VI.D discusses the cost analysis (*see* chapter 5 of the NOPR TSD for further details).

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. The baseline model in each product class represents the characteristics of a product typical of that class (*e.g.,* wattage, lumen output, CCT, CRI, shape, and lifetime). Generally, a baseline model is one that just meets current energy conservation standards, or, if no standards are in place, the baseline is typically the most common or least efficient unit on the market.

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 VI.B or chapter 4 of the NOPR TSD). DOE also seeks to maintain the baseline lamp's characteristics, such as base type, CCT, and CRI among other specifications, for substitute lamps. To calculate efficacy, DOE uses the ANSI rated wattage of the lamp, or nominal wattage if the ANSI rated wattage is not available. For the Non-integrated product classes, DOE pairs each lamp with an appropriate ballast because these lamps are a component of a system, and their performance is related to the ballast on which they operate.

Efficiency levels (ELs): 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. As part of DOE's analysis, the maximum available efficacy level is the most efficacious unit currently available on the market. DOE also defines a ''max-tech'' efficacy level to represent the maximum possible efficacy for a given product.

For engineering analysis, DOE developed a lamps database using data from manufacturer catalogs, ENERGY STAR Certified Light Bulbs database,[29] DOE's compliance certification database,[30] and retailer websites. DOE used performance data of lamps from one of these sources in the following general order of priority: DOE's compliance certification database, manufacturer catalog, ENERGY STAR database, and retailer websites. In addition, DOE reviewed applicable lamps in the CEC's Appliance Efficiency Database.[31]

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 this NOPR, DOE is proposing to establish eight product classes: (1)

[29] The most recent ENERGY STAR Certified Light Bulbs database can be found at *https://www.energystar.gov/productfinder/product/certified-light-bulbs/results.* Last accessed June 17, 2020.

[30] DOE's compliance certification database can be found at *https://www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A*.* Last accessed by June 17, 2020.

[31] The most recent CEC Appliance Efficiency Database can be found at *https://www.energy.ca.gov/appliances/.* Last accessed June 17, 2020.

Integrated Omnidirectional Short Standby Mode, (2) Integrated Omnidirectional Short Non-standby Mode, (3) Integrated Directional Standby Mode, (4) Integrated Directional Non-standby Mode, (5) Integrated Omnidirectional Long, (6) Non-integrated Omnidirectional Short, (7) Non-integrated Omnidirectional Long, and (8) Non-integrated Directional. With the exception of the Non-integrated Omnidirectional Long product class and all the Standby Mode product classes, DOE directly analyzed all other proposed product classes.

DOE directly analyzed Directional and Omnidirectional product classes. The Directional product classes consist of reflector lamps and lamps with MRX and AR shapes. Reflector lamp is defined by DOE as a lamp that has an R, PAR, BPAR, BR, ER, MR, or similar bulb shape and is used to provide directional light. (See proposed updates to industry references in the reflector lamp definition in section IV.B) The Omnidirectional product classes consist of shapes designed to output light in a non-directional manner such as the A, B, BA, CA, F, G, T shapes. Because of the distinctive difference in design, the Directional and Omnidirectional product classes cannot be scaled from each other and were directly analyzed.

DOE also directly analyzed the Long (45 inches or longer) and Short (shorter than 45 inches) product classes. The lamps in the Short product classes are mainly the A, B, BA, CA, F, G, R, PAR, BPAR, BR, ER, MR shapes or configurations of short multiple tubes (*e.g.,* pin base CFLs). The lamps in the Long product classes are linear single tubes (*e.g.,* 4-foot T8 linear LED lamps). Because of the distinctive difference in shape and size, the Short and Long product classes cannot be scaled from each other and were directly analyzed.

As noted in section VI.A.1.a of this document, integrated lamps contain all the components necessary for operation within the lamp, whereas non-integrated lamps have components such as a ballast or driver external to the lamp. Due to this distinction in design, DOE directly analyzed both the Integrated and Non-integrated product classes with the exception of the Non-integrated Omnidirectional Long product class.

In this analysis, DOE scales the Non-integrated Omnidirectional Long product class from the Integrated Omnidirectional Long product class. There are three main types of linear LED lamps and LED lamps that are replacements for pin base CFLs: (1) Type A lamps have an internal driver and connect to the existing fluorescent lamp ballast; (2) Type B lamps have an internal driver and connect to the main line voltage; and (3) Type C lamps connect to an external, remote driver. In this analysis, DOE considers Type A and Type C lamps as non-integrated lamps because they require an external component to operate, whereas Type B lamps are integrated lamps as they can be directly connected to the main line voltage. There are also hybrid lamps that are both Type A and B. DOE classifies these lamps as integrated as they can be operated without an external component. Hence, the Non-integrated Omnidirectional Long product class consists of Type A and Type C linear LED lamps and the Integrated Omnidirectional Long product class consists of Type B and Type A/B linear LED lamps. DOE determined that lamps in both these product classes are the same in shape and size, and tentatively concluded the internal versus external components would not preclude them from being scaled from or to one another. Based on manufacturer feedback, Type B lamps are a more robust replacement solution, and the professional and consumer markets are moving away from the Type A and Type C replacements. Hence, DOE directly analyzed the Integrated Omnidirectional Long product class (containing Type B, A/B lamps) and scaled the resulting ELs to derive ELs for the Non-integrated Omnidirectional Long product class (containing Type A and C lamps).

Finally, DOE is also directly analyzing product classes without standby mode functionality and scaling to product classes that have this functionality. DOE observed only integrated lamps to have standby mode functionality. Because integrated lamps with standby functionality are fundamentally the same as lamps without standby functionality but with the addition of wireless communication components, DOE did not directly analyze the integrated product classes capable of operating in standby mode, but rather scaled from the integrated lamps without standby functionality. DOE chose to directly analyze lamps without standby mode as they remain representative of the majority of the market.

In summary, DOE directly analyzed the product classes shown in grey shading in Table VI.3 as representative in this NOPR. See chapter 5 of the NOPR TSD for further discussion. DOE requests comments on the representative product classes (*i.e.,* product classes directly analyzed) identified for this analysis. *See* section IX.E for a list of issues on which DOE seeks comment.

TABLE VI.3—GENERAL SERVICE LAMPS REPRESENTATIVE PRODUCT CLASSES

Lamp type	Lumen package	Directionality	Lamp length	Standby mode operation
GSLs	Integrated	Omnidirectional	Short (<45 inches)	Standby.
				Non-Standby.
			Long (≥45 inches)	Non-Standby.
		Directional (reflector lamps)	All Lengths	Standby.
				Non-Standby.
	Non-Integrated	Omnidirectional	Short (<45 inches)	N/A.
			Long (≥45 inches)	
		Directional (reflector lamps)	All Lengths.	

3. Baseline Lamps

Once DOE identifies 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 lumen 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 of current standards in violation of EPCA. (*See* 42 U.S.C. 6295(o)(1)) Specifically, the Integrated Omnidirectional Short product class consists of MBCFLs for which there are existing DOE standards. The other product classes do not have existing DOE standards but are subject to the statutory backstop requirement of 45 lm/W. DOE requests comments on the baseline lamps selected for each representative product class (*i.e.,* Integrated Omnidirectional Short Non-standby Mode, Integrated Directional Non-standby Mode, Integrated Omnidirectional Long, Non-integrated Omnidirectional Short, and Non-integrated Directional). See section IX.E for a list of issues on which DOE seeks comment.

a. Integrated Omnidirectional Short Product Class

The Integrated Omnidirectional Short product class consists of the A, B, BA, CA, F, G, T shapes as well as linear and U-shape tubular LED lamps (Type B, A/B) that are less than 45 inches (*e.g.,* 2-foot linear or U-shape, 3-foot linear LED lamps). Based on common characteristics of lamps in this product class, DOE identified the baseline lamp as a 15 W, 900-lumen (*i.e.,* 60 W equivalent) spiral CFL with lifetime of 10,000 hours, CRI of 82, and CCT of 2,700 K. The baseline lamp for the Integrated Omnidirectional Short product class identified in this analysis is specified in Table VI.4.

TABLE VI.4—BASELINE LAMPS FOR INTEGRATED OMNIDIRECTIONAL SHORT PRODUCT CLASS

Representative product class	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	Lifetime (hr)	CCT (K)	CRI
Integrated Omnidirectional Short	Spiral	E26	CFL	15	900	60.0	10,000	2,700	82

b. Integrated Omnidirectional Long Product Class

The Integrated Omnidirectional Long product class consists of linear tubular LED lamps. These are Type B or Type A/B lamps that contain an internal driver and can be connected directly to the main line voltage. Based on common characteristics of lamps in this product class, DOE identified a 15 W 4-foot T8 Linear LED lamp with a medium bipin base, 1,800 lumens, lifetime of 50,000 hours, CRI of 80, and CCT of 4,000 K as the baseline lamp. The baseline lamp for the Integrated Omnidirectional Long product class identified in this analysis is specified in Table VI.5.

TABLE VI.5—BASELINE LAMPS FOR INTEGRATED OMNIDIRECTIONAL LONG PRODUCT CLASS

Representative product class	Lamp shape	Lamp length	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	Lifetime (hr)	CCT (K)	CRI
Integrated Omnidirectional Long	T8	4-Foot	Medium Bipin	LED	15	1,800	120.0	50,000	4,000	80

c. Integrated Directional Product Class

The Integrated Directional product class consists of reflector shape lamps. Based on common characteristics of lamps in this product class, DOE identified a 23 W, PAR38 shape CFL with an E26 base, 1,100 lumens, lifetime of 10,000 hours, CRI of 82, and CCT of 2,700 K as the baseline lamp. The baseline lamp for the Integrated Directional product class identified in this analysis is specified in Table VI.6.

TABLE VI.6—BASELINE LAMPS FOR INTEGRATED DIRECTIONAL PRODUCT CLASS

Representative product class	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	Lifetime (hr)	CCT (K)	CRI
Integrated directional	PAR38	E26	CFL	23	1,100	47.8	10,000	2,700	82

d. Non-Integrated Omnidirectional Short Product Class

The Non-integrated Omnidirectional Short product class mainly consists of pin base CFLs and their LED replacements as well as linear and U-shape tubular LED lamps (Type A, C) less than 45 inches (*e.g.,* 2-foot linear or U-shape, and 3-foot linear LED lamps). DOE determined that base types of non-integrated lamps 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 identified the baseline lamp as a 26 W, 1,700-lumen double tube G24q–3 CFL with lifetime of 10,000 hours, CRI of 82, and CCT of 4,100 K.

The baseline lamp for the Non-integrated Omnidirectional Short product class identified in this analysis is specified in Table VI.7.

TABLE VI.7—BASELINE LAMPS FOR NON-INTEGRATED OMNIDIRECTIONAL SHORT PRODUCT CLASS

Product class	Base type	Lamp shape	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	Lifetime (hr)	CCT (K)	CRI
Non-Integrated Omnidirectional Short	G24q–3	Double Tube	CFL	26.0	1,700	65.4	10,000	4,100	82

e. Non-Integrated Directional Product Class

The Non-integrated Directional product class consists of reflector shape lamps that mainly operate at 12 V. Based on common characteristics of lamps in this product class, DOE identified an 8 W MR16 shape LED with a GU5.3 base, 500 lumens, lifetime of 25,000 hours, CRI of 80, and CCT of 2,700 K as the baseline lamp. The baseline lamp for the Non-integrated Directional product class identified in this analysis is specified in Table VI.8.

TABLE VI.8—BASELINE LAMPS FOR NON-INTEGRATED DIRECTIONAL PRODUCT CLASS

Product class	Base type	Lamp shape	Lamp type	Nominal wattage (*W*)	Initial lumens (*lm*)	Rated efficacy (*lm/W*)	Lifetime (*hr*)	CCT (*K*)	CRI
Non-Integrated Directional	GU5.3	MR16	LED	8.0	500	62.5	25,000	2,700	80

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 five criteria in the screening analysis. These selections were made such that the more efficacious substitute lamp saved energy and had light output within 10 percent of the baseline lamp's light output, when possible. DOE also sought to keep characteristics of substitute lamps, such as CCT, CRI, and lifetime, as similar as possible to the baseline lamps. 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. In identifying the more efficacious substitutes, DOE utilized the lamps database of commercially available GSLs it developed for this analysis (see section VI.C.1). Further details specific to the more efficacious substitutes of the representative product classes are discussed in the following sections. DOE requests comments on the more efficacious substitutes selected for each representative product class (*i.e.,* Integrated Omnidirectional Short Non-standby Mode, Integrated Directional Non-standby Mode, Integrated Omnidirectional Long, Non-integrated Omnidirectional Short, and Non-integrated Directional). See section IX.E for a list of issues on which DOE seeks comment.

a. Integrated Omnidirectional Short Product Class

For the Integrated Omnidirectional Short product class, DOE's survey of the market showed the number of 15,000-hour LED lamps were comparable to 25,000-hour LED lamps. Additionally, ENERGY STAR Lamps Specification V2.1, effective January 2, 2017, requires LED lamps to have a lifetime of at least 15,000 hours. Hence, for the Integrated Omnidirectional Short product class, DOE analyzed more efficacious substitutes with 25,000-hour lifetimes and 15,000-hour lifetimes at ELs where lamps with both lifetimes were available (*i.e.,* EL 3, EL 4). DOE analyzed lamps with each lifetime as more efficacious substitutes because they are both readily available alternatives that are part of a growing market and have unique life-cycle costs and payback periods associated with them. For the Integrated Omnidirectional Short product class, DOE also ensured that the more efficacious substitutes were marketed as omnidirectional, thus maintaining the even light distribution of the baseline lamp.

As noted, the Integrated Omnidirectional Short product class consists of the A, B, BA, CA, F, G, T shapes as well as linear and U-shape tubular LED lamps (Type B, A/B) that are less than 45 inches (*e.g.,* 2-foot linear and U-shape, 3-foot linear LED lamps). The more efficacious substitutes analyzed in this NOPR for the representative Integrated Omnidirectional Short product class are summarized in Table VI.9.

TABLE VI.9—REPRESENTATIVE LAMP UNITS IN THE INTEGRATED OMNIDIRECTIONAL SHORT PRODUCT CLASS

Product class	EL	Lifetime (hr)	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	A-value *	CCT (K)	CRI
Integrated Omnidirectional Short.	Baseline	10,000	Spiral	E26	CFL	15.0	900	60.0	−40.0	2,700	82
	EL 1	10,000	Spiral	E26	CFL	14.0	900	64.3	−35.7	2,700	82
	EL 2	10,000	Spiral	E26	CFL	13.0	900	69.2	−30.8	2,700	83
	EL 3	15,000	A19	E26	LED	10.0	800	80.0	−18.5	2,700	80
		25,000	A19	E26	LED	10.0	800	80.0	−18.5	2,700	84
	EL 4	15,000	A19	E26	LED	9.0	800	88.9	−9.6	2,700	80
		25,000	A19	E26	LED	9.0	800	88.9	−9.6	2,700	80
	EL 5	15,000	A19	E26	LED	8.0	800	100.0	1.5	2,700	81
	EL 6	15,000	A19	E26	LED	7.0	800	114.3	15.8	2,700	82
	EL 7	15,000	A19	E26	LED	6.5	810	124.6	25.9	2,700	80

* The A-value is a variable in the equation form (a curve) being proposed to specify the minimum efficacy standard for GSLs. The A-value specifies the height of the equation form and thereby indicates the level of efficacy (see section VI.C.5.a).

b. Integrated Omnidirectional Long Product Class

The Integrated Omnidirectional Long product class consists of linear tubular LED lamps 45 inches or longer that are Type B or Type A/B. DOE identified more efficacious substitutes that save energy, have light output within 10 percent of baseline lamp, and have characteristics similar to the baseline lamp. The more efficacious substitutes analyzed in this analysis for the representative Integrated Omnidirectional Long product class are summarized in Table VI.10. DOE requests comments on whether any characteristics (*e.g.,* diameter [T5, T8]) may prevent or allow a linear LED lamp to achieve high efficacies. See section IX.E for a list of issues on which DOE seeks comment.

TABLE VI.10—REPRESENTATIVE LAMP UNITS IN THE INTEGRATED OMNIDIRECTIONAL LONG PRODUCT CLASS

Product class	El	Lifetime (hr)	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	A-value	CCT (K)	CRI
Integrated Omnidirectional Long.	Baseline	50,000	T8 Linear	Medium Bipin.	LED	15.0	1,800	120.0	17.5	4,000	80
	EL 1	50,000	T8 Linear	Medium Bipin.	LED	14.0	1,800	128.6	26.1	4,000	82
	EL 2	50,000	T8 Linear	Medium Bipin.	LED	12.5	1,750	140.0	37.5	4,000	83
	EL 3	50,000	T8 Linear	Medium Bipin.	LED	12.0	1,800	150.0	47.5	4,000	82
	EL 4	50,000	T8 Linear	Medium Bipin.	LED	11.5	1,800	156.5	54.0	4,000	82
	EL 5	50,000	T8 Linear	Medium Bipin.	LED	10.5	1,700	161.9	59.4	4,000	82
	EL 6	50,000	T8 Linear	Medium Bipin.	LED	9.2	1,625	176.6	74.1	4,000	83

c. Integrated Directional Product Class

The Integrated Directional product class consists of reflector shapes. While the baseline lamp for the Integrated Directional product class is a CFL, the more efficacious substitutes are integrated LED lamps. Because there is a considerable difference in lifetimes between CFL and LED technology, the more efficacious substitutes have lifetimes of 25,000 hours rather than the baseline 10,000 hours. The most common lifetime among the LED lamps in this product class is 25,000 hours. Aside from technology and lifetime, the more efficacious substitutes have characteristics similar to the baseline lamp, have light output within 10 percent of the baseline lamp, and save energy. The more efficacious substitutes analyzed for the representative Integrated Directional product class are summarized in Table VI.11.

TABLE VI.11—REPRESENTATIVE LAMP UNITS IN THE INTEGRATED DIRECTIONAL PRODUCT CLASS

Product class	EL	Lifetime (hr)	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	A-value	CCT (K)	CRI
Integrated Directional	Baseline	10,000	PAR38	E26	CFL	23.0	1,100	47.8	94.7	2,700	82
	EL 1	25,000	PAR38	E26	LED	17.0	1,200	70.6	72.6	2,700	80
	EL 2	25,000	PAR38	E26	LED	16.0	1,200	75.0	68.2	2,700	80
	EL 3	25,000	PAR38	E26	LED	15.0	1,200	80.0	63.2	2,700	83
	EL 4	25,000	PAR38	E26	LED	14.0	1,200	85.7	57.5	2,700	82
	EL 5	25,000	PAR38	E26	LED	12.5	1,200	96.0	47.2	2,700	83

d. Non-Integrated Omnidirectional Short Product Class

The Non-integrated Omnidirectional Short product class mainly consists of pin base CFLs and their LED replacements as well as linear and U-shape tubular LED lamps (Type A, C) less than 45 inches (*e.g.,* 2-foot linear and U-shape, 3-foot linear LED lamps). For non-integrated GSLs that operate on a ballast, DOE considered more efficacious lamps that did not increase energy consumption relative to the baseline and had light output approximately 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 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.

LED Lamp Replacements for Non-Integrated CFLs

DOE conducted a thorough analysis of the LED replacements for non-integrated CFLs and found varied product offerings of efficacies, lumens, wattages, and bases. DOE also found that a little more than half of LED replacements include ballast compatibility lists. DOE was able to identify more efficacious non-integrated LED lamp substitutes for the 26 W non-integrated CFL baseline lamp. DOE notes that while these non-integrated LED lamps are marketed as replacements for the 26 W non-integrated CFL, they have much lower lumens than the CFL they are intended to replace. Hence, the more efficacious non-integrated LED lamps selected have lumens about 30–35 percent lower than the 26 W non-integrated CFL baseline lumens of 1,700. DOE confirmed with several manufacturers' product support that these lamps are indeed equivalent replacements for the 26 W CFLs. DOE learned that because these LED lamps are designed to emit light in one direction, they emit fewer lumens than their CFL counterparts which are designed to emit light in all directions (*i.e.,* omnidirectional). Therefore, in a fixture the 26 W CFL and its equivalent LED lamp emit similar lumen outputs, as some of the CFL omnidirectional light is lost within the fixture.

The more efficacious non-integrated LED substitutes identified have a PL shape, a G24q base, 4,000K CCT, and 50,000-hour lifetime. These characteristics differ from the baseline 26 W CFL which has a double tube shape, a G24q–3 base, 4,100K CCT, and 10,000-hour lifetime (see section VI.C.3.d). Regarding shape, DOE found that most LED replacement lamps for non-integrated CFLs are marketed as having a PL shape which denotes plug-in or PLL shape which denotes a plug-in that is a longer lamp. The more efficacious non-integrated LED substitutes identified have a PL shape. The double tube shape of the CFL comprises of two tubes each bent in a U-shape, set side by side, while the PL shape of the LED is a singular tube with no bends. However, due to similar overall diameter and length, the PL shape lamp can serve as a suitable replacement for the double tube shape lamp. Regarding base type, DOE determined that non-integrated LED lamp replacements for non-integrated CFLs do not include a number identification at the end of the base type, *i.e.* they are labeled as G24q rather than G24q–3. This is because the ''–#'' identification number correlates to the CFL wattage. Non-integrated LED replacements can be compatible with multiple CFL wattages and therefore, the ''–#'' is not required. Additionally, a non-integrated LED lamp with a G24q base can adequately replace G24q–1, G24q–2, G24q–3 bases of a non-integrated CFL. DOE confirmed that at the highest levels of efficacy, the vast majority of base types were available and thus consumers would not be forced to change base types in most scenarios. Consumers may need to change a base type if that base type is paired with a lamp that does not have a high efficacy. However, because the vast majority of base types do meet the highest ELs, this scenario would not be very common. Further, for the few, uncommon base types that are typically paired with less efficacious lamps and are not meeting the highest ELs, the base type should not pose a technological limitation for increasing lamp efficacy.

Regarding the difference in CCT, very few non-integrated LED replacements for non-integrated CFLs have a CCT of 4,100K. Therefore, DOE chose more efficacious non-integrated LED lamps with a 4,000K CCT, which is the most popular CCT closest to 4,100K. Regarding lifetime, there is a considerable difference in lifetimes between CFL and LED technology, and almost all non-integrated LED replacements for non-integrated CFLs have a lifetime of 50,000 hours. DOE also confirmed that there is an even split of non-integrated LED lamp replacements for non-integrated CFLs that operate in the horizontal, vertical or universal orientation. DOE ensured that there were both horizontal and vertical orientation options at each proposed EL.

Ballast Luminous Efficiency

DOE compiled catalog data of non-integrated CFL ballasts in order to estimate the system power ratings and initial lumen outputs of the representative lamp-and-ballast systems in the Non-integrated product class. A lamp-and-ballast system input power depends on the total lamp arc power operated by the ballast and the ballast's efficiency, or BLE. Because BLE specifications were not commonly listed in ballast catalogs, DOE instead used catalog ballast efficacy factor (BEF) data to convert to BLE for ballasts paired with full wattage lamps. DOE then determined an estimated BLE for ballasts paired with reduced wattage lamps, because ballast specifications when operating reduced wattage lamps are not published. DOE used BLE instead of BEF because the market has been shifting towards the BLE metric due to the fluorescent lamp ballast (FLB) final rule published on November 14, 2011 (76 FR 70548), and a simple, accurate method for converting BEF to BLE existed. (See chapter 5 of the NOPR TSD for more information on the determination of BLE and system input power.) The more efficacious non-integrated LED lamps identified in this analysis are Type A LEDs that can be used with the existing CFL ballast. Hence, DOE used the same ballast parameters for the non-integrated CFL and LED lamp units.

Same-Wattage Substitute

DOE identified more efficacious CFLs that were lower wattage than the baseline but produced similar light and were therefore more efficacious. DOE also identified substitute CFLs that were the same wattage as the baseline but produced more light and were therefore more efficacious. The difference in lumens between full-wattage EL 1 representative unit and the same-wattage baseline unit is 100 lumens, which is small. Thereby, the more efficacious, full wattage substitute at EL 1 is close in efficacy to the baseline. However, the more efficacious substitutes identified are likely replacement options for consumers in specific applications where light output must remain constant and thus a reduced wattage lamp with lower lumen output could not be used.

The more efficacious substitutes for the Non-integrated Omnidirectional Short product class are summarized in Table VI.12.

TABLE VI.12—REPRESENTATIVE LAMP UNITS IN THE NON-INTEGRATED OMNIDIRECTIONAL SHORT PRODUCT CLASS

Product class	EL	Lifetime (hr)	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	A-value	CCT *(K)*	CRI
Non-integrated Omnidirectional Short.	Baseline	10,000	Double Tube.	G24q–3 ..	CFL	26.0	1,700	65.4	155.3	4,100	82
	EL 1	10,000	Double Tube.	G24q–3 ..	CFL	26.0	1,800	69.2	151.8	4,100	82
		16,000	Double Tube.	G24q–3 ..	CFL	21.0	1,525	72.6	147.3	4,100	82
	EL 2	50,000	PL	G24q	LED	12.0	1,100	91.7	123.4	4,000	80
	EL 3	50,000	PL	G24q	LED	9.0	1,200	133.3	83.4	4,000	80

e. Non-Integrated Directional Product Class

As noted, the Non-integrated Directional product class consists of reflector shapes that mainly operate at 12 V. DOE identified more efficacious substitutes that save energy, have light output within 10 percent of the baseline lamp, and have characteristics similar to the baseline lamp. The more efficacious substitutes analyzed in this NOPR for the representative Non-integrated Directional product class are summarized in Table VI.13.

TABLE VI.13—REPRESENTATIVE LAMP UNITS IN THE NON-INTEGRATED DIRECTIONAL PRODUCT CLASS

Product class	EL	Lifetime (hr)	Lamp shape	Base type	Lamp type	Nominal wattage (W)	Initial lumens (lm)	Rated efficacy (lm/W)	A-value	CCT (K)	CRI
Non-integrated Directional	Baseline	25,000	MR16	GU5.3	LED	8.0	500	62.5	73.9	2,700	80
	EL 1	25,000	MR16	GU5.3	LED	7.0	500	71.4	65.0	2,700	82
	EL 2	25,000	MR16	GU5.3	LED	6.5	500	76.9	59.5	2,700	83
	EL 3	25,000	MR16	GU5.3	LED	6.0	500	83.3	53.1	2,700	84

5. Efficacy Levels

After identifying more efficacious substitutes for each of the baseline lamps, DOE developed ELs 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 LED lamps); (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. DOE requests comments on the ELs analyzed for each representative product class (*i.e.,* Integrated Omnidirectional Short Non-standby Mode, Integrated Directional Non-standby Mode, Integrated Omnidirectional Long, Non-integrated Omnidirectional Short, and Non-integrated Directional). See section IX.E for a list of issues on which DOE seeks comment.

a. Equation Form

In this NOPR, using the lamps database of commercially available GSLs it developed for this analysis (*see* section VI.C.1 of this document), DOE conducted regression analyses to identify the equation form that best fits the GSL data. DOE determined a sigmoid equation is the best fit equation form to capture the relationship between wattage and lumens across all ranges for GSLs. DOE ensured that the equation forms employed in this analysis capture product performance at both the high and low end of the lumen range. The equation determines the minimum efficacy based on the measured lumen output of the lamp. The A-value in the equations is a value that can be changed to move the equation curve up or down and thereby change the minimum required efficacy. The constants of the equations were the same for the Integrated Omnidirectional Short and Integrated Omnidirectional Long product classes. The equations for each representative product class are shown in Table VI.14. These equations were scaled for the non-representative product classes (*see* section VI.C.6 of this document).

Table VI.14 GSL Equations

Representative Product Class	Equation*
Integrated Omnidirectional Short	$Efficacy = \frac{123}{1.2 + e^{-0.005(Lumens-200)}} + A$
Integrated Omnidirectional Long	$Efficacy = \frac{123}{1.2 + e^{-0.005(Lumens-200)}} + A$
Integrated Directional	$Efficacy = \frac{73}{0.5 + e^{-0.0021(Lumens+1000)}} - A$
Non-integrated Omnidirectional Short	$Efficacy = \frac{122}{0.55 + e^{-0.003(Lumens+250)}} - A$
Non-integrated Directional	$Efficacy = \frac{67}{0.45 + e^{-0.00176(Lumens+1310)}} - A$

**Efficacy* = minimum efficacy requirement, *Lumens* = measured lumen output, and *A* = an adjustment variable (the "A-value").

b. Integrated Omnidirectional Short Product Classes

In this NOPR, DOE identified seven ELs for the Integrated Omnidirectional Short product class. The baseline represents a basic CFL with an efficacy representative of the most common least efficacious product on the market. EL 1 represents an improved CFL with more-efficient phosphors and improved ballast components. EL 2 represents an advanced CFL with more-efficient phosphors, improved ballast components, and higher efficiency coatings. EL 3 represents an improved LED lamp with improved package architecture and high-efficiency driver design. EL 4 represents a more improved LED lamp with improved package architecture, high-efficiency driver design, and improved optics. EL 5 represents an advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, and reduced current density. EL 6 represents a more advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, reduced current density, and improved heat sink/thermal management. EL 7 represents the maximum technologically feasible LED lamp with improved package architecture, high-efficiency driver design, improved optics, reduced current density, improved heat sink/thermal management, and improved alternative substrate materials.

To establish final minimum efficacy requirements for each EL, DOE evaluated whether any adjustments were necessary to the initial ELs to ensure lamps were available across the entire lumen range and maintained consumer utility. DOE confirmed that a range of lamp characteristics such as lumens, CCT, and CRI would be available at the highest levels of efficacy. Because the Integrated Omnidirectional Short product class consists of MBCFLs which have existing standards, DOE assessed whether the initial ELs are equal to or more stringent to the existing standards (*i.e.,* that backsliding is not occurring). DOE determined that for products with lumens less than 424, the initial EL 1 equation would result in an efficacy requirement less than the 45 lm/W MBCFL standard. Similarly, for products with lumens less than 371, the initial EL 2 equation would result in an efficacy requirement less than the 45 lm/W MBCFL standard. Hence, DOE is proposing at EL 1 and EL 2 products with respectively, lumens less than 424 and lumens less than 371 must meet a minimum efficacy requirement of 45 lm/W. Regarding other lumen ranges, DOE is proposing at EL 1 products with lumens equal to 424 and less than or equal 3,300 meet the minimum efficacy requirement based on the equation line of EL 1; and at EL 2 products with lumens equal to 371 and less than or equal to 3,300 lumens meet the minimum efficacy requirement based on the equation line of EL 2.

c. Integrated Omnidirectional Long Product Class

In this NOPR, DOE identified six ELs for the Integrated Omnidirectional Long product class. The baseline represents a basic LED with an efficacy representative of the most common least efficacious product on the market. EL 1 represents an improved LED lamp with improved package architecture. EL 2 represents a more improved LED lamp with improved package architecture and high-efficiency driver design. EL 3 represents an advanced LED lamp with improved package architecture, high-efficiency driver design, and improved optics. EL 4 represents an advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, and reduced current density. EL 5 represents a more advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, reduced current density, and improved heat sink/thermal management. EL 6 represents the maximum technologically feasible LED lamp with improved package architecture, high-efficiency driver design, improved optics, reduced current density, improved heat sink/thermal management, and improved alternative substrate materials.

To establish final minimum efficacy requirements for each EL, DOE evaluated whether any adjustments were necessary to the initial ELs to ensure lamps were available across the entire lumen range and maintained consumer utility. DOE confirmed that a range of lamp characteristics such as lumens, CCT, and CRI would be available at the highest levels of efficacy. After reviewing these characteristics, DOE determined that an adjustment to the max tech level was necessary to allow for lamps with lower CCTs to meet the max tech levels. DOE recognizes that LED technology may be less efficacious at lower CCTs. Therefore, DOE decided to lower the max tech level by adjusting the A-value from 74.1 to 71.7, and thereby the minimum lm/W required at that EL.

d. Integrated Directional Product Class

In this NOPR, DOE identified five ELs for the Integrated Directional product class. The baseline represents a basic CFL with an efficacy representative of the most common least efficacious product on the market. EL 1 represents an improved LED lamp with improved package architecture and high-efficiency driver design. EL 2 represents a more improved LED lamp with improved package architecture, high-efficiency driver design, and improved optics. EL 3 represents an advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, and reduced current density. EL 4 represents a more advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, reduced current density, and improved heat sink/thermal management. EL 5 represents the maximum technologically feasible with improved package architecture, high-efficiency driver design, improved optics, reduced current density, improved heat sink/thermal management, and improved alternative substrate materials.

To establish final minimum efficacy requirements for each EL, DOE evaluated whether any adjustments were necessary to the initial ELs to ensure lamps were available across the entire lumen range and maintained consumer utility. DOE confirmed that a range of lamp characteristics such as lumens, CCT, and CRI would be available at the highest levels of efficacy. Hence, DOE found no reason to make adjustments to the initials ELs developed in this NOPR.

e. Non-Integrated Omnidirectional Short Product Class

As previously noted, the Non-integrated Omnidirectional Short product class comprises products with a wide range of base types (*see* section VI.C.4.d of this document). DOE confirmed that at the highest levels of efficacy, the vast majority of base types were available and thus consumers would not be forced to change base types in most scenarios. For the few, uncommon base types that are typically paired with less efficacious lamps and are not meeting the highest ELs, the base type should not pose a technological limitation for increasing lamp efficacy.

In this NOPR, DOE identified three ELs for the Non-integrated Omnidirectional Short product class. The baseline represents a basic CFL with an efficacy representative of the most common least efficacious product on the market. EL 1 represents a full wattage, improved CFL with more-efficient phosphors and thus more light output and a more efficacious reduced wattage CFL that produces 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 represents the technologically feasible level that applied across all lumen packages within the product class. EL 2 represents an advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, and reduced current density. EL 3 represents the maximum technologically feasible level with improved package architecture, high-efficiency driver design, improved optics, reduced current density, improved heat sink/thermal management, and improved alternative substrate materials.

To establish final minimum efficacy requirements for each EL, DOE evaluated whether any adjustments were necessary to the initial ELs to ensure lamps were available across the entire lumen range and also maintained consumer utility. Specifically, DOE considered the impacts on lumen package, CCT, CRI, lamp shapes, and lamp bases. DOE found lamps with a range of lumens available at the highest levels of efficacy. DOE also confirmed that a range of lamp characteristics such as CCT, CRI, shape, and base would be available at the highest levels of efficacy. Hence, DOE found no reason to make adjustments to the initial ELs developed in this NOPR.

f. Non-Integrated Directional Product Class

In this NOPR, DOE identified three ELs for the Non-integrated Directional product class. The baseline represents a basic LED with an efficacy representative of the most common least efficacious product on the market. EL 1 represents an advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, and reduced current density. EL 2 represents a more advanced LED lamp with improved package architecture, high-efficiency driver design, improved optics, reduced current density, and improved heat sink/thermal management. EL 3 represents the maximum technologically feasible with improved package architecture, high-efficiency driver design, improved optics, reduced current density, improved heat sink/thermal management, and improved alternative substrate materials.

To establish final minimum efficacy requirements for each EL, DOE evaluated whether any adjustments were necessary to the initial ELs to ensure lamps were available across the entire lumen range and also maintained consumer utility. Specifically, DOE considered the impacts on lumen package, CCT, CRI, lamp shapes, and lamp bases. DOE found lamps with a range of lumens available at the highest levels of efficacy. DOE also confirmed that a range of lamp characteristics such as CCT, CRI, shape, and base would be available at the highest levels of efficacy. Hence, DOE found no reason to make adjustments to the initial ELs developed in this NOPR.

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 this NOPR, DOE scaled the Integrated Omnidirectional Short Standby product class from the Integrated Omnidirectional Short Non-Standby product class. DOE scaled the Integrated Directional Standby product class from the Integrated Directional Non-Standby product class. DOE scaled the Non-integrated Omnidirectional Long product class from Integrated Omnidirectional Long product class. The scaling for the non-representative product classes is discussed in the following sections. DOE requests comment on its approach to scaling non-representative product classes in this NOPR. *See* section IX.E for a list of issues on which DOE seeks comment.

a. Scaling of Integrated Standby Mode Product Classes

DOE did not observe standby mode functionality in lamps in the Non-integrated product classes or the Integrated Omnidirectional Long product class, and therefore is proposing standby mode product classes only for the Integrated Omnidirectional Short and Integrated Directional Standby Mode products. DOE requests comments on its tentative determination that lamps such as Type B or Type A/B linear LED lamps do not have standby mode functionality. *See* section IX.E for a list of issues on which DOE seeks comment.

Based on test data, DOE found that standby power consumption was 0.5 W or less for the vast majority of lamps available. (*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 and added this wattage to the rated wattage of the non-standby mode representative units to calculate the expected efficacy of lamps with the addition of standby mode functionality. DOE then used the expected efficacy of the lamps with the addition of standby mode functionality at each EL to calculate the corresponding A-value. DOE assumed the lumens for a lamp with the addition of standby mode functionality were the same as for the non-standby mode representative units.

DOE has tentatively determined that this is the most appropriate approach for establishing ELs for standby mode product classes. DOE test procedures to measure efficacy in active mode of integrated LED lamps, CFLs and GSLs include the measurement of any standby mode power a lamp may have (*see* respectively, appendix BB, appendix W, and appendix DD of 10 CFR part 430, subpart B). DOE is proposing a standard based on the integrated measure of active mode and standby mode efficiency. For GSLs with standby mode functionality, the energy efficiency standards proposed in this NOPR set an assumed power consumption attributable to standby mode. It is possible for a lamp with standby mode power consumption greater than the assumed value to comply with the applicable energy efficiency standard, but only if the decreased efficiency of standby mode was offset by an increased efficiency in active mode. This ability for manufacturers to trade off efficiency between active mode efficiency and standby mode efficiency is a function of integrating the efficiencies into a single standard and is consistent with EPCA. EPCA directs DOE to incorporate, if feasible, standby mode and active mode into a single standard. (42 U.S.C. 6295(gg)(3)(A)) The integration of efficacies of multiple modes into a single standard allows for this type of trade-off. The combined energy consumption of a GSL in active mode and standby mode must result in an efficiency that is equal to or less than the applicable standard.

b. Scaling of Non-Integrated Long Product Class

In this NOPR, DOE scaled the Non-integrated Omnidirectional Long product class from the representative Integrated Omnidirectional Long product class. Both classes consist of linear and U-shape tubular LED lamps. The Non-integrated Omnidirectional Long product class consists of Type A and Type C lamps which require an external component to operate. The Integrated Omnidirectional Long product class consists of Type B or Type A/B lamps which can be directly connected to the main line voltage. DOE determined that because the lamps in these product classes are the same in shape and size, they could be scaled from or to one another.

Because the linear shapes are substantively more prevalent than the U-shape lamps, DOE identified linear tubular LED lamp pairs that had the same manufacturer, initial lumen output, length, CCT, lifetime, CRI range in the 80s and differed only in being integrated (Type B) or non-integrated (Type A). Using 13 lamp pairs identified, DOE determined an average 10.7 percent efficacy increase and applied it to the efficacy at each EL of the Integrated Omnidirectional Long product class to calculate the efficacies of ELs for the Non-integrated Omnidirectional Long product class. The scaled efficacies of the ELs were then used to calculate the corresponding A-values.

7. Summary of All Efficacy Levels

Table VI.15 displays the efficacy requirements for each level analyzed by product class. Note that the non-standby and standby Integrated Omnidirectional Short product classes EL 1 and EL 2 have different requirements for lower and higher lumens. This is to ensure that lamps in the Integrated Omnidirectional Short product classes already subject to an existing standard are not subject to a less stringent standard, *i.e.,* that backsliding in violation of 42 U.S.C. 6295(o)(1) is not occurring (*see* section VI.C.5.b for further information). The representative product classes are shown in gray, and all others are scaled product classes.

TABLE VI.15—PROPOSED EFFICACY LEVELS OF GSLs

Representative product class	Efficacy level	Efficacy (lm/W)
Integrated Omnidirectional Short (Not Capable of Operating in Standby Mode)	EL 1	45 (for lumens less than 424) $123/(1.2+e^{-0.005*(Lumens-200)})-35.7$ (for lumens 424–3,300)
	EL 2	45 (for lumens less than 371) $123/(1.2+e^{-0.005*(Lumens-200)})-30.8$ (for lumens 371–3,300)
	EL 3	$123/(1.2+e^{-0.005*(Lumens-200)})-18.5$

TABLE VI.15—PROPOSED EFFICACY LEVELS OF GSLS—Continued

Representative product class	Efficacy level	Efficacy (lm/W)
	EL 4	$123/(1.2+e^{-0.005*(Lumens-200)}))-9.6$
	EL 5	$123/(1.2+e^{-0.005*(Lumens-200)}))+1.5$
	EL 6	$123/(1.2+e^{-0.005*(Lumens-200)}))+15.8$
	EL 7	$123/(1.2+e^{-0.005*(Lumens-200)}))+25.9$
Integrated Omnidirectional Long (Not Capable of Operating in Standby Mode)	EL 1	$123/(1.2+e^{(-0.005*(Lumens-200))})+26.1$
	EL 2	$123/(1.2+e^{(-0.005*(Lumens-200))})+37.5$
	EL 3	$123/(1.2+e^{(-0.005*(Lumens-200))})+47.5$
	EL 4	$123/(1.2+e^{(-0.005*(Lumens-200))})+54.0$
	EL 5	$123/(1.2+e^{(-0.005*(Lumens-200))})+59.4$
	EL 6	$123/(1.2+e^{(-0.005*(Lumens-200))})+74.1$
Integrated Directional (Not Capable of Operating in Standby Mode)	EL 1	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-72.6$
	EL 2	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-68.2$
	EL 3	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-63.2$
	EL 4	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-57.5$
	EL 5	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-47.2$
Non-integrated Omnidirectional Short (Not Capable of Operating in Standby Mode)	EL 1	$122/(0.55+e^{(-0.003*(Lumens+250))})-151.8$
	EL 2	$122/(0.55+e^{(-0.003*(Lumens+250))})-123.4$
	EL 3	$122/(0.55+e^{(-0.003*(Lumens+250))})-83.4$
Non-integrated Directional (Not Capable of Operating in Standby Mode)	EL 1	$67/(0.45+e^{(-0.00176*(Lumens+1310))})-65.0$
	EL 2	$67/(0.45+e^{(-0.00176*(Lumens+1310))})-59.5$
	EL 3	$67/(0.45+e^{(-0.00176*(Lumens+1310))})-53.1$
Integrated Omnidirectional Short (Capable of Operating in Standby Mode)	EL 1	45 (for lumens less than 452) $123/(1.2+e^{(-0.005*(Lumens-200))})-37.9$ (for lumens 452–3,300)
	EL 2	45 (for lumens less than 399) $123/(1.2+e^{(-0.005*(Lumens-200))})-33.3$ (for lumens 399–3,300)
	EL 3	$123/(1.2+e^{(-0.005*(Lumens-200))})-22.2$
	EL 4	$123/(1.2+e^{(-0.005*(Lumens-200))})-14.2$
	EL 5	$123/(1.2+e^{(-0.005*(Lumens-200))})-4.3$
	EL 6	$123/(1.2+e^{(-0.005*(Lumens-200))})+8.2$
	EL 7	$123/(1.2+e^{(-0.005*(Lumens-200))})+17.1$
Integrated Directional (Capable of Operating in Standby Mode)	EL 1	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-74.6$
	EL 2	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-70.5$
	EL 3	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-65.8$
	EL 4	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-60.4$
	EL 5	$73/(0.5+e^{(-0.0021*(Lumens+1000))})-50.9$
Non-integrated Omnidirectional Long (Not Capable of Standby Mode)	EL 1	$123/(1.2+e^{(-0.005*(Lumens-200))})+39.8$
	EL 2	$123/(1.2+e^{(-0.005*(Lumens-200))})+52.4$
	EL 3	$123/(1.2+e^{(-0.005*(Lumens-200))})+63.5$
	EL 4	$123/(1.2+e^{(-0.005*(Lumens-200))})+70.7$
	EL 5	$123/(1.2+e^{(-0.005*(Lumens-200))})+76.6$
	EL 6	$123/(1.2+e^{(-0.005*(Lumens-200))})+93.0$

D. Cost Analysis

The cost analysis portion of the engineering analysis is conducted using one or a combination of cost approaches. The selection of cost approach depends on a suite of factors, including the availability and reliability of public information, characteristics of the regulated product, the availability and timeliness of purchasing the GSLs on the market. The cost approaches are summarized as follows:

• *Physical teardowns:* Under this approach, DOE physically dismantles a commercially available product, component-by-component, to develop a detailed bill of materials for the product.

• *Catalog teardowns:* In lieu of physically deconstructing a product, DOE identifies each component using parts diagrams (available from manufacturer websites or appliance repair websites, for example) to develop the bill of materials for the product.

• *Price surveys:* If neither a physical nor catalog teardown is feasible (for example, for tightly integrated products such as fluorescent lamps, which are infeasible to disassemble and for which parts diagrams are unavailable) or cost-prohibitive and otherwise impractical (*e.g.,* large commercial boilers), DOE conducts price surveys using publicly available pricing data published on major online retailer websites and/or by soliciting prices from distributors and other commercial channels.

In the present case, DOE conducted the analysis using the price survey approach. Typically, DOE develops manufacturing selling prices (MSPs) for covered products and applies markups to create end-user 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 end-user prices for the lamps covered in this rulemaking. The end-user 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.

DOE reviewed and used publicly available retail prices to develop end-user prices for GSLs. In its review, DOE observed a range of end-user prices paid for a lamp, depending on the distribution channel through which the lamp was purchased. DOE identified the following four main distribution channels: Small Consumer-Based Distributors (*i.e.,* internet retailers); Large Consumer-Based Distributors: (*i.e.,* home centers, mass merchants, and hardware stores); Electrical Distributors; and State Procurement.

In this NOPR, 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, shape, base type, CRI), DOE considered the pricing of these lamps to be representative of the technology of the EL. DOE developed average end-user prices for the representative lamp units sold in each of the four main distribution channels analyzed. DOE then calculated an average weighted end-user price using estimated shipments through each distribution channel.

DOE used one set of shipment percentages reflecting commercial products for the Non-integrated Omnidirectional Short, Non-integrated Directional, and Integrated Omnidirectional Long product classes and another set of shipment percentages reflecting residential products for the Integrated Omnidirectional Short and Integrated Directional product classes. DOE grouped the Integrated Omnidirectional Long product class in the commercial product categories as these are mainly linear tubular LED lamps used as replacements for linear fluorescents in commercial spaces. Table VI.16 shows the shipment weightings used for each distribution channel.

TABLE VI.16—SHIPMENT WEIGHTINGS USED PER DISTRIBUTION CHANNEL

	Small consumer-based distributors (%)	Large consumer-based distributors (%)	Electrical distributors (%)	State procurement (%)
Residential (Integrated Omnidirectional Short and Integrated Directional)	20	70	5	5
Commercial (Non-Integrated Omnidirectional, Non-integrated Directional, Integrated Omnidirectional Long)	20	8	62	10

DOE also determined prices for CFL ballasts by comparing the blue book prices of CFL ballasts with comparable fluorescent lamp ballasts and developing a scaling factor to apply to the end-user prices of the fluorescent lamp ballasts developed for the final rule that was published on November 14, 2011. 76 FR 70548. See chapter 5 of the NOPR TSD for shipment percentages and ballast prices.

The end-user prices determined in this NOPR are detailed in chapter 5 of the NOPR TSD. These end-user prices are used to determine an MSP using a distribution chain markup. DOE developed an average distribution chain markup by examining the annual Securities and Exchange Commission (SEC) 10–K reports filed by publicly traded retail stores that sell GSLs. See section VI.J for further details. DOE requests comments on its methodology for determining end-user prices and the resulting prices. *See* section IX.E for a list of issues on which DOE seeks comment.

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. The energy use analysis estimates the range of energy use of GSLs in the field (*i.e.,* as they are actually used by consumers). The energy use analysis provides the basis for other analyses DOE performed, particularly assessments of the energy savings and the savings in consumer operating costs that could result from adoption of amended or new standards. 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.

DOE analyzed energy use in the residential and commercial sectors separately but did not explicitly analyze GSLs installed in the industrial sector. This is because far fewer GSLs are installed in that sector compared to the commercial sector, and the average operating hours for GSLs in the two sectors were assumed to be approximately equal. In the energy use and subsequent analyses, DOE analyzed these sectors together (using data specific to the commercial sector), and refers to the combined sector as the commercial sector.

1. Operating Hours

a. Residential Sector

To determine the average HOU of Integrated Omnidirectional Short GSLs in the residential sector, DOE collected data from a number of sources. Consistent with the approach taken in the December 2019 Final Determination, DOE used data from various regional field-metering studies of GSL operating hours conducted across the U.S. (84 FR 71626–71671) DOE determined the regional variation in average HOU using average HOU data from the regional metering studies, which are listed in the energy use chapter (chapter 6 of the NOPR TSD). Specifically, DOE determined the average HOU for each EIA 2015 Residential Energy Consumption Survey (RECS) reportable domain (*i.e.,* state, or group of states).[32]

[32] U.S. Department of Energy–Energy Information Administration. *2015 Residential Energy Consumption Survey (RECS).* 2015. (Last accessed

Continued

For regions without HOU metered data, DOE used data from adjacent regions. DOE estimated the national weighted-average HOU of Integrated Omnidirectional Short GSLs in the residential sector to be 2.3 hours per day.

For lamps in the other GSL product classes, DOE estimated average HOU by scaling the average HOU from the Integrated Omnidirectional Short product class. Scaling factors were developed based on the distribution of room types that particular lamp types (*e.g.,* reflector or linear) are typically installed in, and the associated HOU for those room types. Room-specific average HOU data came from NEEA's 2014 *Residential Building Stock Assessment Metering Study* (RBSAM) [33] and room distribution data by lamp type came from a 2010 KEMA report.[34] See chapter 6 of this NOPR TSD for more detail. DOE notes that this approach assumes that the ratio of average HOU for reflector or linear lamps to A-line lamps will be approximately the same across the United States, even if the average HOU varies by geographic location. DOE estimated the national weighted-average HOU of Integrated Directional and Non-integrated Directional GSLs to be 2.9 hours per day and Integrated Omnidirectional Long GSLs to be 2.1 hours per day in the residential sector.

DOE assumes that operating hours do not vary by light source technology. Although some metering studies have observed higher hours of operation for CFL GSLs compared to all GSLs—such as NMR Group, Inc.'s *Northeast Residential Lighting Hours-of-Use Study* [35] and the *Residential Lighting End-Use Consumption Study* (RLEUCS) [36]—DOE assumes that the higher HOU found for CFL GSLs is based on those lamps disproportionately filling sockets with higher HOU at the time of the studies. This would not be the case during the analysis period, when CFL and LED GSLs were expected to fill all GSL sockets. DOE assumes that it is appropriate to apply the HOU estimate for all GSLs to CFLs and LEDs, as only CFLs and LEDs will be available during the analysis period, consistent with DOE's approach in the March 2016 NOPR. This assumption is equivalent to assuming no rebound in operating hours as a result of more efficacious technologies filling sockets currently filled by less efficacious technologies.

The operating hours of lamps in actual use are known to vary significantly based on the room type the lamp is located in; therefore, DOE estimated this variability by developing HOU distributions for each room type using data from NEEA's 2014 RBSAM, 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 U.S., 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 2016–2017 RBSAM for single-family homes, [37] which included GSL room-distribution data for more than 700 single-family homes throughout the Northwest.

DOE requests comment on the data and methodology used to estimate operating hours for GSLs in the residential sector. See section IX.E for a list of issues on which DOE seeks comment.

b. Commercial Sector

For each commercial building type presented in the *2015 U.S. Lighting Market Characterization* (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 for Integrated Omnidirectional Short, Integrated Directional, Non-integrated Directional, and Non-integrated Omnidirectional GSLs.[38] For Integrated Omnidirectional Long GSLs, DOE used the data from the 2015 LMC pertaining to linear fluorescent lamps. DOE estimated the national-average HOU for the commercial sector by mapping the LMC building types to the building types used in CBECS 2012, [39] and then weighting the building-specific HOU for GSLs by the relative floor space of each building type as reported in the 2015 LMC. The national weighted-average HOU for Integrated Omnidirectional Short, Integrated Directional, Non-integrated Directional, and Non-integrated Omnidirectional GSLs in the commercial sector were estimated at 11.5 hours per day. The national weighted-average HOU for Integrated Omnidirectional Long GSLs in the commercial sector were estimated at 8.1 hours per day.

To capture the variability in HOU for individual consumers in the commercial sector, DOE used data from NEEA's *2019 Commercial Building Stock Assessment* (CBSA).[40] Similar to the residential sector, DOE assumed that the shape of the HOU distribution from the CBSA was similar for the U.S. as a whole.

DOE requests comment on the data and methodology used to estimate operating hours for GSLs in the commercial sector. *See* section IX.E for a list of issues on which DOE seeks comment.

2. Input Power

The input power used in the energy use analysis is the input power presented in the engineering analysis (section VI.C.4 of this document) for the representative lamps considered in this proposed rulemaking.

3. Lighting Controls

For GSLs that operate with controls, DOE assumed an average energy reduction of 30 percent, which is based on a meta-analysis of field measurements of energy savings from commercial lighting controls by

February 1, 2022.) *https://www.eia.gov/consumption/residential/data/2015/.*

[33] Ecotope Inc. *Residential Building Stock Assessment: Metering Study.* 2014. Northwest Energy Efficiency Alliance: Seattle, WA. Report No. E14–283. (Last accessed February 23, 2022.) *https://neea.org/data/residential-building-stock-assessment.*

[34] KEMA, Inc. *Final Evaluation Report: Upstream Lighting Program: Volume 2.* 2010. California Public Utilities Commission, Energy Division: Sacramento, CA. Report No. CPU0015.02. (Last accessed August 5, 2021.) *https://www.calmac.org/publications/FinalUpstreamLightingEvaluationReport_Vol2_CALMAC.pdf.*

[35] NMR Group, Inc. and DNV GL. *Northeast Residential Lighting Hours-of-Use Study.* 2014. 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 5, 2021.) *https://app.box.com/s/o1f3bhbunib2av2wiblu/1/1995940511/17399081887/1.*

[36] DNV KEMA Energy and Sustainability and Pacific Northwest National Laboratory. *Residential Lighting End-Use Consumption Study: Estimation Framework and Baseline Estimates.* 2012. U.S. Department of Energy: Washington, DC (Last accessed February 23, 2022.) *https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf.*

[37] Northwest Energy Efficiency Alliance. *Residential Building Stock Assessment II: Single-Family Homes Report: 2016–2017.* 2019. Northwest Energy Efficiency Alliance. (Last accessed August 16, 2021.) *https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf.*

[38] Navigant Consulting, Inc. *2015 U.S. Lighting Market Characterization.* 2017. U.S. Department of Energy: Washington, DC Report No. DOE/EE–1719. (Last accessed February 23, 2022.) *https://energy.gov/eere/ssl/downloads/2015-us-lighting-market-characterization.*

[39] U.S. Department of Energy–Energy Information Administration. *2012 Commercial Buildings Energy Consumption Survey (CBECS).* 2012. (Last accessed February 1, 2022.) *https://www.eia.gov/consumption/commercial/data/2012/.*

[40] Cadmus Group. *Commercial Building Stock Assessment 4 (2019) Final Report.* 2020. Northwest Energy Efficiency Alliance: Seattle, WA. (Last accessed August 18, 2021.) *https://neea.org/resources/cbsa-4-2019-final-report.*

Williams, et al.[41] 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.

For this NOPR, DOE assumed that the controls penetration of 9 percent reported in the 2015 LMC is representative of Integrated Omnidirectional Short GSLs. DOE estimated different controls penetrations for Integrated Omnidirectional Long and Integrated and Non-integrated Directional GSLs. The 2015 LMC reports a controls penetration of 0 percent for linear fluorescent lamps in the residential sector; therefore, DOE assumed that no residential Integrated Omnidirectional Long lamps are operated on controls. To estimate controls penetrations for Integrated Directional and Non-integrated Directional GSLs, DOE scaled the controls penetration for Integrated Omnidirectional Short GSLs based on the distribution of room types that reflector lamps are typically installed in relative to A-type GSLs, and the controls penetration by room type from a 2010 KEMA report.[42] Based on this analysis, DOE estimated the controls penetrations for Integrated Directional and Non-integrated Directional GSLs as 10 percent.

For this NOPR, DOE maintains its assumption in the March 2016 NOPR that the fraction of CFLs and LED lamps on controls is the same. By maintaining the same controls fraction for both technologies derived from estimates for all GSLs, DOE's estimates of energy savings may be slightly conservative compared to a scenario where fewer CFLs are on dimmers. Additionally, DOE's shipments model projects that only 2.4 percent of shipments in the Integrated Omnidirectional Short product class and 0.3 percent of shipments in the Integrated Directional product class will be CFLs by 2029, indicating that the control fraction for CFLs will not significantly impact the overall results of DOE's analysis.

In the reference scenario, DOE assumed the fraction of residential GSLs on external controls remain fixed throughout the analysis period at 9 percent for Integrated Omnidirectional Short GSLs, 10 percent for Integrated Directional and Non-integrated Directional GSLs, and 0 percent for Integrated Omnidirectional Long GSLs. The national impact analysis does, however, assume an increasing fraction of residential LED GSLs that operate with controls in the form of smart lamps, as discussed in section VI.H.1.a of this document.

DOE assumed that building codes would drive an increase in floor space utilizing controls in the commercial sector in this NOPR, similar to its assumption in the March 2016 NOPR. By the assumed first full year of compliance (2029), DOE estimated 33.2 percent of commercial GSLs in all product classes will operate on controls.

DOE requests any relevant data and comment on the energy use analysis methodology. *See* section IX.E for a list of issues on which DOE seeks comment.

Chapter 6 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 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 (manufacturer selling price, distribution chain markups, sales tax, and installation costs) plus operating costs (expenses for energy use, maintenance, and repair). To compute the operating costs, DOE discounts future operating costs to the time of purchase and sums them over the lifetime of the product.
- 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 at higher efficiency levels by the change in annual operating cost for the year that amended or new standards are assumed to take effect.

For each considered standard level, DOE measures the change in LCC relative to the LCC in the no-new-standards case, which reflects the change in the estimated efficiency distribution of GSLs in the standards case compared to the absence of new or amended energy conservation standards. In contrast, the PBP for a given efficiency level is measured relative to the baseline product.

For each considered efficiency level in each product class, DOE calculated the LCC and PBP for a nationally representative set of potential residential consumers and commercial customers. Separate calculations were conducted for the residential and commercial sectors. DOE developed consumer samples based on the 2015 RECS and the 2012 CBECS for the residential and commercial sectors, respectively. For each consumer in the sample, DOE determined the energy consumption of the lamp 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 a GSL standard case (*i.e.,* case where a standard would be in place at a particular TSL), DOE measured the annualized LCC savings resulting from the estimated efficacy distribution under the considered standard relative to the estimated efficacy distribution in the no-new-standards case. The 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 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 consumer user samples. The model calculated the LCC and PBP for a sample of 10,000 consumers per simulation run. The analytical results include a distribution of 10,000 data points showing the range

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

[42] KEMA, Inc. *Final Evaluation Report: Upstream Lighting Program: Volume 2.* 2010. California Public Utilities Commission, Energy Division: Sacramento, CA. Report No. CPU0015.02. (Last accessed August 5, 2021.) *https://www.calmac.org/publications/FinalUpstreamLightingEvaluationReport_Vol2_CALMAC.pdf.*

of LCC savings. In performing an iteration of the Monte Carlo simulation for a given consumer, product efficiency is chosen based on its probability. By accounting for consumers who purchase more-efficient products in the no-new-standards case, DOE avoids overstating the potential benefits from increasing product efficiency.

DOE calculated the LCC and PBP for all consumers of GSLs as if each were to purchase a new product in the expected first full year of required compliance with amended standards. As discussed in section VI of this document, since compliance with the statutory backstop requirement for GSLs commenced on July 25, 2022, DOE would set a 6-year compliance date of July 25, 2028 for consistency with requirements in 42 U.S.C. 6295(m)(4)(B) and 42 U.S.C. 6295(i)(6)(B)(iii). Therefore, because the compliance date would be in the second half of 2028, for purposes of its analysis, DOE used 2029 as the first full year of compliance with any amended standards for GSLs.

Table VI.17 summarizes the approach and data DOE used to derive inputs to the LCC and PBP calculations. The subsections that follow provide further discussion. Details of the spreadsheet model, and of all the inputs to the LCC and PBP analyses, are contained in chapter 7 of the NOPR TSD and its appendices.

TABLE VI.17—SUMMARY OF INPUTS AND METHODS FOR THE LCC AND PBP ANALYSIS *

Inputs	Source/method
Product Cost	Weighted-average end-user price determined in the product price determination. To project the price of the LED lamps in the first full year of compliance, DOE used a price-learning analysis.
Sales Tax	Derived 2029 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 $1.73 per installed GSL for the commercial sector.
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.
Annual 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	Based on 2021 average and marginal electricity price data from the Edison Electric Institute. Electricity prices vary by season and U.S. region.
Energy Price Trends	Based on AEO 2022 price forecasts.
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.
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.
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 8 of the NOPR TSD for details.
First Full Year of Compliance	2029.

* References for the data sources mentioned in this table are provided in the sections following the table or in chapter 7 of the NOPR TSD.

1. Product Cost

To calculate consumer product costs, DOE typically multiplies the manufacturer production costs (MPCs) developed in the engineering analysis by the markups along with sales taxes. For GSLs, the engineering analysis determined end-user prices directly; therefore, for the LCC analysis, the only adjustment was to add sales taxes, which were assigned to each household or building in the LCC sample based on its location. In the March 2016 NOPR, due to the high variability in LED lamp price by light output, DOE developed and analyzed lamp options across three additional lumen ranges (310–749 lm, 1050–1489 lm, and 1490–1999 lm) for the Integrated Low-Lumen product class. However, for this NOPR analysis DOE has not analyzed any of the representative product classes on a lumen range basis because DOE has found that the price variability for LED lamps has lessened to such a degree that conducting the analysis by lumen range is unnecessary.

DOE also used a price-learning analysis to account for changes in LED lamp prices that are expected to occur between the time for which DOE has data for lamp prices (2020) and the assumed first full year of compliance of the rulemaking (2029). For details on the price-learning analysis, see section VI.G of this document.

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the product. For this NOPR, DOE assumed an installation cost of $1.73 per installed commercial GSL—based on an estimated lamp installation time of 5 minutes from RSMeans [43] and hourly wage data from the U.S. Bureau of Labor Statistics [44]—but zero installation cost for residential GSLs.

DOE requests comment on the installation cost assumptions used in its analyses. *See* section IX.E for a list of issues on which DOE seeks comment.

3. Annual Energy Consumption

For each sampled household or commercial building, DOE determined the energy consumption for a GSL at different efficiency levels using the approach described previously in section VI.E of this document.

4. Energy Prices

Because marginal electricity price more accurately captures the

[43] RSMeans. *Facilities Maintenance & Repair Cost Data 2013.* 2012. RSMeans: Kingston, MA.

[44] U.S. Department of Labor–Bureau of Labor Statistics. *Occupational Employment and Wages, May 2021: 49–9071 Maintenance and Repair Workers, General.* May 2021. (Last accessed April 13, 2022.) *https://www.bls.gov/oes/2021/may/oes499071.htm.*

incremental savings associated with a change in energy use from higher efficiency, it provides a better representation of incremental change in consumer costs than average electricity prices. To use marginal electricity prices, DOE generally applies average electricity prices for the energy use of the product purchased in the no-new-standards case, and marginal electricity prices for the incremental change in energy use associated with the other efficiency levels considered.

In this NOPR, DOE only used marginal electricity prices due to the calculated annual electricity cost for some regions and efficiency levels being negative when using average electricity prices for the energy use of the product purchased in the no-new-standards case. Negative costs can occur in instances where the marginal electricity cost for the region and the energy savings relative to the baseline for the given efficiency level are large enough that the incremental cost savings exceed the baseline cost.

DOE derived electricity prices in 2021 using data from EEI Typical Bills and Average Rates reports.[45] Based upon comprehensive, industry-wide surveys, this semi-annual report presents typical monthly electric bills and average kilowatt-hour costs to the customer as charged by investor-owned utilities. For the residential sector, DOE calculated electricity prices using the methodology described in Coughlin and Beraki (2018).[46] For the commercial sector, DOE calculated electricity prices using the methodology described in Coughlin and Beraki (2019).[47]

DOE's methodology allows electricity prices to vary by sector, region and season. In the analysis, variability in electricity prices is chosen to be consistent with the way the consumer economic and energy use characteristics are defined in the LCC analysis. DOE assigned seasonal marginal prices to each household in the LCC sample based on its location. DOE also assigned seasonal marginal prices to each commercial building in the LCC sample based on its location and annual energy consumption.

For a detailed discussion of the development of electricity prices, see chapter 7 of the NOPR TSD.

To estimate electricity prices in future years, DOE multiplied the 2021 regional energy prices by a projection of annual change in national-average residential or commercial energy price from *AEO2022,* which has an end year of 2050.[48] For each consumer sampled, DOE applied the projection for the census division in which the consumer was located. To estimate price trends after 2050, DOE assumed that the regional prices would remain at the 2050 value.

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 Economic Growth and AEO Low Economic Growth scenarios in the analysis. The high- and low-growth cases show the projected effects of alternative economic growth assumptions on energy prices.

5. Product Lifetime

In this NOPR, DOE considered the GSL lifetime to be the service lifetime (*i.e.,* the age at which the lamp is retired from service). For the representative lamps in this analysis, including GSLs not considered in the March 2016 NOPR, DOE used the reference (Renovation-Driven) lifetime scenario methodology from the March 2016 NOPR. This methodology uses Weibull survival models to calculate the probability of survival as a function of lamp age. In the analysis, DOE considered the lamp's rated lifetime (taken from the engineering analysis), sector- and product class-specific HOU distributions, typical renovation timelines, and effects of on-time cycle length, which DOE assumed only applied to residential CFL GSLs. DOE requests comment on the GSL service lifetime model used in its analyses. In particular, DOE seeks information about the rate of premature failures for LED lamps analyzed in this NOPR and whether this rate differs from that of comparable CFLs or general service fluorescent lamps. DOE also seeks feedback or data that would inform the modeling of Integrated Omnidirectional Long lamp lifetimes, which have a longer rated lifetime than LED lamps in the other analyzed product classes. *See* section IX.E for a list of issues on which DOE seeks comment.

For a detailed discussion of the development of lamp lifetimes, see Appendix 7C of the NOPR TSD.

6. 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 first full year of compliance. 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 LED 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.

7. Disposal Cost

Disposal cost is the cost a consumer pays to dispose of their retired GSLs. DOE assumed that 35 percent of CFLs are recycled (this fraction remains constant over the analysis period), and that the disposal cost is $0.70 per lamp for commercial consumers. Disposal costs were not applied to residential consumers. Because LED lamps do not contain mercury, DOE assumes 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* section IX.E for a list of issues on which DOE seeks comment.

8. Discount Rates

In the calculation of LCC, DOE applies discount rates appropriate to residential and commercial consumers to estimate the present value of future operating cost savings. The subsections below provide information on the derivation of the discount rates by sector. *See* chapter 7 of the NOPR TSD for further details on the development of discount rates.

a. Residential

DOE estimated a distribution of residential discount rates for GSLs based on the opportunity cost of consumer funds. DOE applies weighted average discount rates calculated from consumer debt and asset data, rather than marginal or implicit discount rates.[49] The LCC analysis estimates net

[45] Edison Electric Institute. *Typical Bills and Average Rates Report.* 2021. Winter 2021, Summer 2021: Washington, DC.

[46] Coughlin, K. and B. Beraki. 2018. Residential Electricity Prices: A Review of Data Sources and Estimation Methods. Lawrence Berkeley National Lab. Berkeley, CA. Report No. LBNL–2001169. *https://ees.lbl.gov/publications/residential-electricity-prices-review.*

[47] Coughlin, K. and B. Beraki. 2019. Non-residential Electricity Prices: A Review of Data Sources and Estimation Methods. Lawrence Berkeley National Lab. Berkeley, CA. Report No. LBNL–2001203. *https://ees.lbl.gov/publications/non-residential-electricity-prices.*

[48] U.S. Energy Information Administration. *Annual Energy Outlook 2022.* 2022. Washington, DC (Last accessed April 13, 2022.) *https://www.eia.gov/outlooks/aeo/index.php.*

[49] The implicit discount rate is inferred from a consumer purchase decision between two otherwise identical goods with different first cost and operating cost. It is the interest rate that equates the increment of first cost to the difference in net present value of lifetime operating cost,

Continued

present value over the lifetime of the product, so the appropriate discount rate will reflect the general opportunity cost of household funds, taking this time scale into account. Given the long-time horizon modeled in the LCC analysis, the application of a marginal interest rate associated with an initial source of funds is inaccurate. Regardless of the method of purchase, consumers are expected to continue to rebalance their debt and asset holdings over the LCC analysis period, based on the restrictions consumers face in their debt payment requirements and the relative size of the interest rates available on debts and assets. DOE estimates the aggregate impact of this rebalancing using the historical distribution of debts and assets.

To establish residential discount rates for the LCC analysis, DOE identified all relevant household debt or asset classes in order to approximate a consumer's opportunity cost of funds related to appliance 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 (SCF).[50] 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 4.3 percent.

b. Commercial

For commercial consumers, DOE used the cost of capital 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 the cost of capital is the weighted-average cost to the firm of equity and debt financing. This corporate finance approach is referred to as the weighted-average cost of capital. DOE used currently available economic data in developing commercial discount rates, with Damadoran Online being the primary data source.[51] The average discount rate across the commercial building types is 6.6 percent.

9. Efficacy Distribution in the No-New-Standards Case

To accurately estimate the share of consumers that would be affected by a potential energy conservation standard at a particular TSL, 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 standard cases (*i.e.,* the cases where a standard would be set at each TSL) in the assumed first full year of compliance.

To estimate the efficacy distribution in the first full year of compliance, DOE used a consumer-choice model based on consumer sensitivity to lamp price, lifetime, energy savings, and mercury content, as measured in a market study, as well as on consumer preferences for lighting technology as revealed in historical shipments data. DOE also included consumer sensitivity to dimmability in the market-share model for non-linear lamps to capture the better dimming performance of LED lamps relative to CFLs. Dimmability was excluded as a parameter in the market-share model for linear lamps, because DOE assumed that this feature was equivalently available among lamp options in the consumer-choice model. Consumer-choice parameters were derived from consumer surveys of the residential sector. DOE was unable to obtain appropriate data to directly calibrate parameters for consumers in the commercial sector. Due to a lack of data to support an alternative set of parameters, DOE assumed the same parameters in the commercial sector. For further information on the derivation of the market efficiency distributions, see section VI.G of this document and chapter 8 of the NOPR TSD.

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 VI.18 through Table VI.22 of this document. A description of each of the TSLs is located in section VII.A of this document.

TABLE VI.18—INTEGRATED OMNIDIRECTIONAL SHORT GSL MARKET EFFICACY DISTRIBUTION BY TRIAL STANDARD LEVEL IN 2029

Trial standard level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 * (%)	EL 4 * (%)	EL 5 (%)	EL 6 (%)	EL 7 (%)	Total ** (%)
Residential									
No-New-Standards	0.7	0.7	0.8	26.6	26.1	14.0	13.9	17.1	100.0
TSL 1	0.0	0.0	0.8	27.0	26.4	14.2	14.1	17.4	100.0
TSL 2	0.0	0.0	0.0	27.2	26.6	14.3	14.3	17.5	100.0
TSL 3	0.0	0.0	0.0	0.0	0.0	31.1	30.9	38.0	100.0
TSL 4	0.0	0.0	0.0	0.0	0.0	0.0	44.9	55.1	100.0
TSL 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
TSL 6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Commercial									
No-New-Standards	0.7	0.7	0.8	27.4	26.8	13.6	13.5	16.6	100.0
TSL 1	0.0	0.0	0.8	27.8	27.2	13.8	13.7	16.8	100.0
TSL 2	0.0	0.0	0.0	28.0	27.4	13.9	13.8	17.0	100.0
TSL 3	0.0	0.0	0.0	0.0	0.0	31.1	30.9	38.0	100.0
TSL 4	0.0	0.0	0.0	0.0	0.0	0.0	44.9	55.1	100.0
TSL 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
TSL 6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0

* This EL contains two representative lamp options.

incorporating the influence of several factors: transaction costs; risk premiums and response to uncertainty; time preferences; interest rates at which a consumer is able to borrow or lend. The implicit discount rate is not appropriate for the LCC analysis because it reflects a range of factors that influence consumer purchase decisions, rather than the opportunity cost of the funds that are used in purchases.

[50] U.S. Board of Governors of the Federal Reserve System. *Survey of Consumer Finances.* 1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, and 2019. (Last accessed February 1, 2022.) *https://www.federalreserve.gov/econresdata/scf/scfindex.htm.*

[51] Damodaran, A. *Data Page: Historical Returns on Stocks, Bonds and Bills-United States.* 2021. (Last accessed April 26, 2022.) *https://pages.stern.nyu.edu/~adamodar/.*

** The total may not sum to 100% due to rounding.

TABLE VI.19—INTEGRATED DIRECTIONAL GSL MARKET EFFICACY DISTRIBUTION BY TRIAL STANDARD LEVEL IN 2029

Trial standard level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	EL 5 (%)	Total * (%)
Residential							
No-New-Standards	0.34	12.3	14.7	17.4	21.1	34.2	100.0
TSL 1	0.0	12.3	14.7	17.5	21.1	34.3	100.0
TSL 2	0.0	0.0	0.0	24.0	29.0	47.0	100.0
TSL 3–6	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Commercial							
No-New-Standards	0.3	12.3	14.7	17.4	21.1	34.2	100.0
TSL 1	0.0	12.3	14.7	17.5	21.1	34.3	100.0
TSL 2	0.0	0.0	0.0	24.0	29.0	47.0	100.0
TSL 3–6	0.0	0.0	0.0	0.0	0.0	100.0	100.0

* The total may not sum to 100% due to rounding.

TABLE VI.20—NON-INTEGRATED DIRECTIONAL GSL MARKET EFFICACY DISTRIBUTION BY TRIAL STANDARD LEVEL IN 2029

Trial standard level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	Total * (%)
Residential					
No-New-Standards	25.8	24.6	22.9	26.8	100.0
TSL 1–4	0.0	33.1	30.8	36.1	100.0
TSL 5–6	0.0	0.0	0.0	100.0	100.0
Commercial					
No-New-Standards	25.8	24.6	22.9	26.8	100.0
TSL 1–4	0.0	33.1	30.8	36.1	100.0
TSL 5–6	0.0	0.0	0.0	100.0	100.0

* The total may not sum to 100% due to rounding.

TABLE VI.21—NON-INTEGRATED OMNIDIRECTIONAL GSL MARKET EFFICACY DISTRIBUTION BY TRIAL STANDARD LEVEL IN 2029

Trial standard level	EL 0 (%)	EL 1 * (%)	EL 2 (%)	EL 3 (%)	Total ** (%)
Commercial					
No-New-Standards	2.4	2.2	40.8	54.6	100.0
TSL 1	0.0	2.3	41.8	56.0	100.0
TSL 2–6	0.0	0.0	0.0	100.0	100.0

* This EL contains two representative lamp options.
** The total may not sum to 100% due to rounding.

TABLE VI.22—INTEGRATED OMNIDIRECTIONAL LONG GSL MARKET EFFICACY DISTRIBUTION BY TRIAL STANDARD LEVEL IN 2029

Trial standard level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	EL 5 (%)	EL 6 (%)	Total* (%)
Residential								
No-New-Standards	14.1	14.0	14.0	15.0	14.1	14.6	14.1	100.0
TSL 1	0.0	16.3	16.3	17.5	16.5	17.0	16.4	100.0
TSL 2	0.0	0.0	0.0	25.9	24.45	25.3	24.3	100.0
TSL 3–5	0.0	0.0	0.0	0.0	0.0	51.01	49.0	100.0
TSL 6	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Commercial								
No-New-Standards	14.1	14.0	14.0	15.0	14.1	14.6	14.1	100.0
TSL 1	0.0	16.3	16.3	17.5	16.5	17.0	16.4	100.0
TSL 2	0.0	0.0	0.0	25.9	24.45	25.3	24.3	100.0
TSL 3–5	0.0	0.0	0.0	0.0	0.0	51.0	49.0	100.0
TSL 6	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0

* The total may not sum to 100% due to rounding.

See chapter 7 of the NOPR TSD for further information on the derivation of the efficacy distributions.

10. LCC Savings Calculation

In the reference scenario, DOE calculated the LCC savings at each TSL based on the change in average 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 products that are more efficient than the standard level and is intended to more accurately reflect the impact of a potential standard on consumers.

DOE used the consumer-choice model in the shipments analysis to determine the fraction of consumers that purchase each lamp option under a standard, but the model is unable to track the purchasing decision for individual consumers in the LCC sample. However, DOE must track any difference in purchasing decision for each consumer in the sample in order to determine the fraction of consumers who experience a net cost. Therefore, 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 no-new-standards case would continue to do so in standards cases, and similarly, those consumers who purchased the least efficacious products 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.

11. Payback Period Analysis

The payback period is the amount of time it takes the consumer to recover the additional installed cost of more-efficient products, compared to baseline products, 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 efficiency level are the change in total installed cost of the product and the change in the first-year annual operating expenditures relative to the baseline. The PBP calculation uses the same inputs as the LCC analysis, except that discount rates are not needed.

As noted previously, EPCA 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 efficiency level, 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 projection for the first full year in which compliance with the amended standards would be required.

DOE requests any relevant data and comment on the LCC and PBP analysis methodology. *See* section IX.E for a list of issues on which DOE seeks comment.

G. Shipments Analysis

DOE uses projections of annual product shipments to calculate the national impacts of potential amended or new energy conservation standards on energy use, NPV, and future manufacturer cash flows.[52] 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. Consistent with the May 2022 Backstop Final Rule, DOE developed a shipments model that implements the 45 lm/W minimum efficiency requirement for GSLs in 2022 in the no-new-standards case and all standards cases. Accurate modeling of GSL shipments also requires modeling, in the years prior to 2022, the demand and market shares of those lamps that are eliminated by the implementation of the 45 lm/W minimum efficiency requirement, as well as general service fluorescent lamps (GSFLs), because replacements of these lamps are a source of demand for in-scope products.

[52] 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.

Separate shipments projections are calculated for the residential sector and for the commercial sector. 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 that projects future prices based on historic price trends; and (3) a market-share module that assigns shipments to the available lamp options. DOE requests any relevant data and comment on the shipment analysis methodology. *See* section IX.E for a list of issues on which DOE seeks comment.

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, and total floor space changes over the analysis period according to the EIA's *AEO2022* projections of U.S. residential and commercial floor space.[53] For linear lamps, DOE assumed that there is no new demand from floorspace growth due to the increasing prevalence of integral LED luminaires in new commercial construction.

DOE requests data or feedback that might inform the assumption that linear lamps (regardless of technology type) are increasingly absent from new construction. *See* section IX.E for a list of issues on which DOE seeks comment.

A lamp turnover calculation estimates demand for new lamps in each year based on the growth of floor space in each year, the expected demand for replacement lamps, and sector-specific assumptions about the distribution of per-lamp lumen output desired by consumers. The demand for replacements is computed based on the historical shipments of lamps and the probability of lamp failure as a function of age. DOE used rated lamp lifetimes (in hours) and expected usage patterns in order to derive these probability distributions (*see* section VI.F.5 for further details on the derivation of lamp lifetime distributions).

The lamp demand module also accounts for the reduction in GSL demand due to the adoption of integral LED luminaires into lighting

[53] U.S. Department of Energy–Energy Information Administration. *Annual Energy Outlook 2022 with projections to 2050.* 2022. Washington, DC Report No. *AEO2022.* (Last accessed June 23, 2022.) *https://www.eia.gov/outlooks/aeo/pdf/AEO2022_Narrative.pdf.*

applications traditionally served by GSLs, both prior to and during the analysis period. For non-linear lamps in each year, an increasing portion of demand capped at 15 percent is assumed to be met by integral LED luminaires modeled as a Bass diffusion curve [54] as in the March 2016 NOPR. For linear lamps, DOE assumes that 8.2 percent of stock is replaced in each year with integrated LED fixtures in order to account for retrofits and renovations, and that demand comes from replacement of failures in the remaining stock. This annual rate of stock replacement is based on a projection of commercial lighting stock composition through 2050 produced for *AEO2022*.[55]

DOE requests comment on the assumption that 15 percent of demand will be met by integral LED luminaires.

DOE requests input on the described method of accounting for demand lost to integral LED fixtures. In particular, DOE seeks information about the rate at which linear lamp stock is converted to integrated LED fixtures via retrofit or renovation. *See* section IX.E for a list of issues on which DOE seeks comment. Further details on the assumptions used to model these market transitions are presented in chapter 8 of the NOPR TSD.

For this NOPR, DOE assumed the implementation of a 45 lm/W minimum efficiency requirement for GSLs in 2022, consistent with the May 2022 Backstop Final Rule. DOE notes that CFL and LEDs make up 77 percent of A-line lamp sales in 2020 based on data collected from NEMA A-line lamp indices, indicating that the market has moved rapidly towards increasing production capacity for CFL and LED technologies.[56]

For the Integrated Omnidirectional Short product class, DOE developed separate shipments projections for A-line lamps and for non-A-line lamps (candelabra, intermediate and medium-screw base lamps including, B, BA, C, CA, F, G and T-shape lamps) in order to capture the different market drivers between the two types of lamps. Based on an analysis of online product offerings, DOE assumed that the prices of lamp options at each EL would be approximately the same for A-line and non-A-line Integrated Omnidirectional Short lamps, but scaled the power consumption of non-A-line lamps to be representative of a 450 lumen lamp. Although modelled separately, results for A-line and non-A-line lamps are aggregated into the Integrated Omnidirectional Short product class throughout this NOPR analysis.

b. Price-Learning Module

The price-learning module estimates lamp prices in each year of the analysis period using a standard price-learning model,[57] which relates the price of a given technology to its cumulative production, as represented by total cumulative shipments. Cumulative shipments are determined for each GSL lighting technology under consideration in this analysis (CFL and LED) 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 lighting technology are calculated from the updated cumulative shipments according to the learning (or experience) curve for each technology. The current year's shipments, in turn, affect the subsequent year's prices. Because LED lamps are a relatively young technology, their cumulative shipments increase relatively rapidly and hence they undergo a substantial price decline during the shipments analysis period. For simplicity, shipments of Integrated Omnidirectional Long lamps were not included in the cumulative shipments total used to determine the price learning rate for LED GSLs, as shipments of those lamps would not contribute significantly to the total cumulative LED shipments or the resulting LED GSL learning rate, but Integrated Omnidirectional Long GSLs were assumed to experience the same rate of price decline as all LED GSLs. DOE assumed that CFLs and GSFLs undergo no price learning in the analysis period due to the long history of these lamps in the market.

c. Market-Share Module

The market-share module apportions the lamp shipments in each year among the different lamp options developed in the engineering analysis. DOE used a consumer-choice model based on consumer sensitivity to lamp price, lifetime, energy savings, and mercury content, as measured in a market study, as well as on consumer preferences for lighting technology as revealed in historical shipments data. DOE also included consumer sensitivity to dimmability in the market-share model for non-linear lamps to capture the better dimming performance of LED lamps relative to CFLs. Dimmability was excluded as a parameter in the market-share model for linear lamps, because DOE assumed that this feature was equivalently available among lamp options in the consumer-choice model. GSFL substitute lamp options were included in the consumer-choice model for Integrated Omnidirectional Long lamps, as such GSFLs can serve as substitutes for linear LED lamps. Specifically, the 4-foot T8 lamp options described in the 2022 GSFL NOPD analysis (*see* 87 FR, 32338–32342) were included as lamp options to more accurately estimate the impact of any potential standard on costs and energy use in the broader linear lamp market.

The market-share module assumes that, when replacing a lamp, consumers will choose among all of the available lamp options. Substitution matrices were developed to specify the product choices available to consumers. 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, and relevant alternative lamps, 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,[58] the parameters of which are based on data on the market penetration of LED lamps published by NEMA,[59] as discussed previously. In this way, the module assigns market shares to available lamp options, based on observations of consumer preferences.

DOE also used a Bass adoption model to estimate the diffusion of LED lamp technologies into the non-integrated product class and requests feedback on its assumption that non-integrated LED lamp options became available starting in 2015. *See* section IX.E for a list of issues on which DOE seeks comment.

DOE requests relevant historical data on GSL shipments, disaggregated by product class and lamp technology, as they become available in order to improve the accuracy of the shipments analysis. *See* section IX.E for a list of issues on which DOE seeks comment.

[54] Bass, F.M. A New Product Growth Model for Consumer Durables. *Management Science.* 1969. 15(5): pp. 215–227.

[55] U.S. Department of Energy–Energy Information Administration. *Annual Energy Outlook 2022 with Projections to 2050.* Washington, DC Report No. AEO2022. (Last accessed June 23, 2022.) *https://www.eia.gov/outlooks/aeo/.*

[56] National Electrical Manufacturers Association. *Lamp Indices.* (Last accessed August 2nd, 2021.) *https://www.nema.org/analytics/lamp-indices.*

[57] 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 August 5. 2021) *https://eta.lbl.gov/publications/accounting-technological-change.*

[58] Bass, F.M. A New Product Growth Model for Consumer Durables. *Management Science.* 1969. 15(5): pp. 215–227.

H. National Impact Analysis

The NIA assesses the NES and the NPV from a national perspective of total consumer costs and savings that would be expected to result from new or amended standards at specific efficiency levels.[59] (''Consumer'' in this context refers to consumers of the product being regulated.) DOE calculates the NES and NPV for the potential standard levels considered based on projections of annual product shipments, along with the annual energy consumption and total installed cost data from the energy use and LCC analyses. 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 2029 through 2058.

DOE evaluates the impacts of new or 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 product class in the absence of new or amended energy conservation standards. For this projection, DOE considers historical trends in efficiency and various forces that are likely to affect the mix of efficiencies over time. 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 energy efficiency levels (*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 and, in the case of Integrated Omnidirectional Long lamps, out-of-scope alternatives such as GSFLs.

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

Table VI.23 summarizes the inputs and methods DOE used for the NIA analysis for the NOPR. Discussion of these inputs and methods are described in Table VI.23. See chapter 9 of the NOPR TSD for further details.

TABLE VI.23—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.
First Full Year of Compliance	2029.
No-New-Standards Case and Standards-case Efficacy Distributions.	Both No-New-Standards Case and Standards-case efficiency distributions are estimated by the market-share module of the shipments analysis.
Annual Energy Consumption 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.
Annual Operating Cost per Unit	Calculated for each lamp option using the energy use per unit, and electricity prices and trends.
Energy Price Trends	*AEO2022* projections (to 2050) and held fixed to 2050 value thereafter.
Energy Site-to-Primary and FFC Conversion	A time-series conversion factor based on *AEO2022*.
Discount Rate	3 percent and 7 percent.
Present Year	2022.

1. National Energy Savings

The national energy savings analysis involves a comparison of national energy consumption of the considered products between each potential standards case (TSL) and the case with no new or amended energy conservation standards. DOE calculated the national energy consumption by multiplying the number of units (stock) of each product (by vintage or age) by the unit energy consumption (also by vintage). For the unit energy consumption, DOE used average hours of use that were product class and sector specific (*see* section VI.E.1 of this document). DOE calculated annual NES based on the difference in national energy consumption for the no-new standards case and for each higher efficiency standard case. DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy (*i.e.,* the energy consumed by power plants to generate site electricity) using annual conversion factors derived from *AEO2022.* Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

Use of higher-efficiency products is occasionally associated with a direct rebound effect, which refers to an increase in utilization of the product due to the increase in efficiency. In the case of lighting, the rebound effect could be manifested in increased HOU or in increased lighting density (lamps per square foot). DOE assumed no rebound effect in both the residential and commercial sectors for consumers switching from CFLs to LED lamps or from less efficacious LED lamps to more efficacious LED lamps. This is due to the relatively small incremental increase in efficacy between CFLs and LED GSLs or less efficacious LED lamps and more efficacious LED lamps, as well as an examination of DOE's 2001, 2010, and 2015 U.S. LMC studies, which indicates that there has been a reduction in total lamp operating hours in the residential sector concomitant with increases in lighting efficiency. Consistent with the residential sector, DOE does not expect there to be any rebound effect associated with the commercial sector. Therefore, DOE assumed no rebound effect in all NOPR scenarios for both the residential and commercial sectors.

In 2011, 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 (Aug. 18, 2011). After evaluating the approaches discussed in the August 18,

[59] The NIA accounts for impacts in the 50 states and U.S. territories.

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 (Aug. 17, 2012). NEMS is a public domain, multi-sector, partial equilibrium model of the U.S. energy sector[60] that EIA uses to prepare its *Annual Energy Outlook.* The FFC factors incorporate losses in production and delivery in the case of natural gas (including fugitive emissions) and additional energy used to produce and deliver the various fuels used by power plants. The approach used for deriving FFC measures of energy use and emissions is described in appendix 9B 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 for this NOPR analysis. To account for the additional standby energy consumption from smart lamps in the NIA, DOE assumed that smart lamps would make up an increasing fraction of Integrated Omnidirectional Short, Integrated Directional, Non-integrated Directional, and Non-integrated Omnidirectional lamps in the residential sector following a Bass adoption curve. DOE assumes for this NOPR that smart lamp penetration is limited to the residential sector.

DOE requests comment on the assumption that smart lamps will reach 50 percent market penetration by 2058. *See* section IX.E for a list of issues on which DOE seeks comment.

DOE assumed a standby power of 0.2 W per smart lamp in alignment with standby requirements in California Code of Regulations—Title 20, as it is assumed that manufacturers would sell the same smart lamp models in California as in the rest of the U.S.[61] DOE further assumed that the majority of smart lamps would be standalone and not require the need of a hub.

b. Unit Energy Consumption Adjustment To Account for GSL Lumen Distribution for the Integrated Omnidirectional Short Product Class

The engineering analysis provides representative units within the lumen range of 750–1049 lumens for the Integrated Omnidirectional Short product class. For the NIA, DOE adjusted the energy use of the representative units for the Integrated Omnidirectional Short product class to account for the full distribution of GSL lumen outputs (*i.e.,* 310–2600 lumens).

Using the lumen range distribution for Integrated Omnidirectional Short A-line lamps from the March 2016 NOPR analysis derived from data provided by NRDC, DOE calculated unit energy consumption (UEC) scaling factors to apply to the energy use of the Integrated Omnidirectional Short representative lamp options by taking the ratio of the stock-weighted wattage equivalence of the full GSL lumen distribution to the wattage equivalent of the representative lamp bin (750–1049 lumens). DOE applied a UEC scaling factor of 1.15 for the residential sector and 1.21 for the commercial sector for Integrated Omnidirectional Short A-line lamps.

DOE requests comment on the methodology and assumptions used to determine the market share of the lumen range distributions. *See* section IX.E for a list of issues on which DOE seeks comment.

c. Unit Energy Consumption Adjustment To Account for Type A Integrated Omnidirectional Long Lamps

The representative units in the engineering analysis for the Integrated Omnidirectional Long product class represent Type B lamp options. To account for Type A lamps that were not explicitly modeled, DOE scaled the energy consumption values of Type B Integrated Omnidirectional Long lamp options based on the relative energy consumption of equivalent Type A lamps. DOE assumed a 60/40 market share of Type B and Type A linear LED lamps, respectively, based on product offerings in the DesignLights Consortium database, which was held constant throughout the analysis period.

DOE requests information on market share by lamp type and the composition of stock by type for Type A and Type B linear LED lamps in order to help refine the applied scaling. *See* section IX.E for a list of issues on which DOE seeks comment.

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 operating costs (energy costs and repair and maintenance 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 projection period.

As discussed in section VI.G.1.b of this document, DOE developed LED lamp prices using a price-learning module incorporated in the shipments analysis. By 2058, which is the end date of the forecast period, the average LED GSL price is projected to drop 34.8 percent relative to 2021 in the no-new-standards case. DOE's projection of product prices as described in chapter 8 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 *AEO2022,* which has an end year of 2050. For years after 2050, DOE maintained the 2050 electricity price. As part of the NIA, DOE also analyzed scenarios that used inputs from variants of the *AEO2022* Reference case that have lower and higher economic growth. Those cases have lower and higher energy price trends compared to the Reference case. NIA results based on these cases are presented in appendix 9C 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.[62] 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

[60] For more information on NEMS, refer to *The National Energy Modeling System: An Overview 2009,* DOE/EIA–0581(2009), October 2009. Available at *https://www.eia.gov/analysis/pdfpages/0581(2009)index.php* (last accessed 4/21/2022).

[61] California Energy Commission. California Code of Regulations: Title 20—Public Utilities and Energy. May 2018.

[62] United States Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. Section E. Available at *https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf* (last accessed March 25, 2022).

future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended energy conservation standards on consumers, DOE evaluates the impact on identifiable subgroups of consumers that may be disproportionately affected by a new or amended national standard. The purpose of a subgroup analysis is to determine the extent of any such disproportional impacts. 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 two subgroups—low-income households and small businesses—using the analytical framework and inputs described in section VI.F of this document.

Chapter 10 in the NOPR TSD describes the consumer subgroup analysis.

J. Manufacturer Impact Analysis

1. Overview

DOE performed an MIA to estimate the financial impacts of new and amended energy conservation standards on manufacturers of GSLs and to estimate the potential impacts of such standards on employment and manufacturing capacity. The MIA has both quantitative and qualitative aspects and includes analyses of projected industry cash flows, the INPV, as well as investments in research and development (R&D) and manufacturing capital. Additionally, the MIA seeks to determine how new and amended energy conservation standards might affect domestic manufacturing employment, capacity, and competition, as well as how standards contribute to overall regulatory burden. Finally, the MIA serves to identify any disproportionate impacts on manufacturer subgroups, including small business manufacturers.

The quantitative part of the MIA primarily relies on the GRIM, an industry cash flow model with inputs specific to this rulemaking. The key GRIM inputs include data on the industry cost structure, unit production costs, product shipments, manufacturer markups, and investments in R&D and manufacturing capital required to produce compliant products. The key GRIM output is the INPV, which is the sum of industry annual cash flows over the analysis period, discounted using the industry-weighted average cost of capital. The model uses standard accounting principles to estimate the impacts of more-stringent energy conservation standards on a given industry by comparing changes in INPV between a no-new-standards case and the various standards cases (*i.e.,* TSLs). To capture the uncertainty relating to manufacturer pricing strategies following new and amended standards, the GRIM estimates a range of possible impacts under different manufacturer markup scenarios.

The qualitative part of the MIA addresses manufacturer characteristics and market trends. Specifically, the MIA considers such factors as a potential standard's impact on domestic production and non-production employment, manufacturing capacity, competition within the industry, the cumulative impact of other DOE and non-DOE regulations, and impacts on manufacturer subgroups. The complete MIA is outlined in chapter 11 of the NOPR TSD.

2. Government Regulatory Impact Model and Key Inputs

DOE uses the GRIM to quantify the changes in cash flow due to new and amended standards that could result in a higher or lower industry value. The GRIM uses an annual discounted cash-flow analysis that incorporates MPCs, manufacturer markups, shipments, and industry financial information as inputs. The GRIM models changes in costs, distribution of shipments, investments, and manufacturer margins that could result from new and amended energy conservation standards. The GRIM uses the inputs to arrive at a series of annual cash flows, beginning in 2022 (the reference year of the analysis) and continuing to 2058. DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For manufacturers of GSLs, DOE used a real discount rate of 6.1 percent, which was derived from industry financials and then modified according to feedback received during manufacturer interviews.

The GRIM calculates cash flows using standard accounting principles and compares changes in INPV between the no-new-standards case and each TSL. The difference in INPV between the no-new-standards case and a standards case represents the financial impact of the new and amended energy conservation standards on GSL manufacturers. As discussed previously, DOE developed critical GRIM inputs using several sources, including publicly available data, results of the engineering analysis, and information gathered from industry stakeholders during manufacturer interviews and previous rulemaking public comments. The GRIM results are presented in section VII.B.2. Additional details about the GRIM, the discount rate, and other financial parameters can be found in chapter 11 of the NOPR TSD.

a. Manufacturer Production Costs

Manufacturing more efficacious GSLs can result in changes in MPCs as a result of varying components and technology types necessary to meet standards for each TSL. Changes in MPCs for these more efficacious components can impact the revenue, gross margin, and 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 used the SEC 10-Ks of publicly traded GSL manufacturers to estimate the manufacturer markup of 1.55 for all GSLs in this rulemaking. DOE used the SEC 10-Ks of the major publicly traded lighting retailers to estimate the distribution chain markup of 1.52 for all GSLs.

For a complete description of end-user prices, see the cost analysis in section VI.D of this document.

DOE requests comment on the use of 1.52 as the average distribution chain markup for all GSLs and the use of 1.55 as the average manufacturer markup for all GSLs. See section IX.E for a list of issues on which DOE seeks comment.

b. Shipments Projections

The GRIM estimates manufacturer revenues based on total GSL shipment projections and the distribution of those shipments by product class and EL. Changes in sales volumes and efficacy mix over time can significantly affect manufacturer finances. For this analysis, 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 used in the GRIM, see the shipments analysis discussion in section VI.G of this document.

c. Product and Capital Conversion Costs

New and amended energy conservation standards could cause manufacturers to incur conversion costs to bring their production facilities and product designs into compliance. DOE evaluated the level of conversion-related expenditures that would be needed to comply with each considered EL in each product class. For the MIA, DOE classified these conversion costs into two major groups: (1) product conversion costs; and (2) capital conversion costs. Product conversion costs are investments in research, development, testing, marketing, and other non-capitalized costs necessary to make product designs comply with new and amended energy conservation standards. Capital conversion costs are investments in property, plant, and equipment necessary to adapt or change existing production facilities such that new compliant product designs can be fabricated and assembled.

Using feedback from manufacturer interviews, DOE conducted a bottom-up analysis to calculate the 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 average dollar amounts or average amount of labor estimated to design a new product or remodel an existing model. DOE then estimated the number of GSL models that would need to be re-modeled or introduced into the market for each product class at each EL in the standard year using DOE's database of existing GSL models and the distribution of shipments from the shipments analysis (see section VI.G).

DOE assumed GSL manufacturers would not re-model non-compliant CFL models into compliant CFL models, even if it is possible for the remodeled CFLs to meet the analyzed energy conservation standards. Additionally, DOE assumed that GSL manufacturers would not need to introduce any new LED lamp models due to CFL models not being able to meet the analyzed energy conservation standards.[63] However, DOE assumed that all non-compliant LED lamp models would be remodeled to meet the analyzed energy conservation standards.

Based on feedback in manufacturer interviews, DOE assumed that most LED lamp models would be remodeled between the estimated publication of this rulemaking's final rule and the estimated date which energy conservation standards are required, even in the absence of DOE energy conservation standards for GSLs. Additionally, DOE estimated that remodeling a non-compliant LED lamp model, that would already be scheduled to be remodeled, into a compliant one would require an additional month of engineering time per LED lamp model.[64]

DOE assumed that capital conversion costs would only be necessary if GSL manufacturers would need to increase the production volume of LED lamps in the standards case compared to the no-new-standards case and if existing LED lamp production capacity did not already exist to meet this additional market demand for LED lamps. Based on the shipments analysis, the volume of LED lamp sales in the years leading up to 2029, exceeds the volume of LED lamp sales in 2029 (the estimated first full year of compliance) for every product class at all TSLs. Therefore, DOE assumed no capital conversion costs as GSL manufacturers would not need to make any additional investments in product equipment to maintain, or reduce, their LED lamp production volumes from the previous year.

In general, DOE assumes all conversion-related investments occur between the expected year of publication of the final rule and the year by which manufacturers must comply with the new and amended standards. The conversion cost figures used in the GRIM can be found in section VII.B.2 of this document. For additional information on the estimated capital and product conversion costs, see chapter 11 of the NOPR TSD.

DOE requests comment on the methodology used to calculate product and capital conversion costs for GSLs in this NOPR. Specifically, DOE requests comment on whether GSL manufacturers would incur any capital conversion costs, given the decline in LED lamp sales leading up to the compliance year for all TSLs. If capital conversion costs would be incurred, DOE requests these costs be quantified, if possible. Additionally, DOE requests comment on the estimated product conversion costs; the assumption that most LED lamp models would be remodeled between the estimated publication of this rulemaking's final rule and the estimated date which energy conservation standards are required, even in the no-new-standards case; and the estimated additional engineering time to remodel LED lamp models to comply with the analyzed TSLs. See section IX.E for a list of issues on which DOE seeks comment.

d. Markup Scenarios

As previous discussed in section VI.J.2.a, 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); R&D; interest) as well as profit. Total industry revenue for GSL manufacturers equals the MSPs at each product class and EL multiplied by the number of shipments at that product class and EL. Modifying these manufacturer markups in the standards cases yields different sets of impacts on manufacturers.

For the MIA, DOE modeled two standards-case manufacturer markup scenarios to represent uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of new and amended energy conservation standards: (1) a preservation of gross margin scenario; and (2) a preservation of operating profit scenario. These scenarios lead to different manufacturer margins that, when applied to the MPCs, result in varying revenue and cash flow impacts on GSL manufacturers.

Under the preservation of gross margin scenario, DOE assumes 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

[63] Based on the Shipment Analysis, LED lamp sales exceed 95 percent of the total GSL sales for every analyzed product class by 2029 (the estimated compliance year of this analysis). DOE assumed there are replacement LED lamps for all CFL models.

[64] Based on feedback from manufacturers, DOE estimates that most LED lamp models are remodeled approximately every 2 years and it takes manufacturers approximately 6 months of engineering time to remodel one LED lamp model. DOE is therefore estimating that it would take manufacturers approximately 7 months (one additional month) to remodel a non-compliant LED lamp model into a compliant LED lamp model, due to the extra efficacy and any other requirement induced by DOE's standards.

gross margin, as a percentage, in the standards cases as in the no-new-standards case, despite higher MPCs. In this manufacturer markup scenario, GSL manufacturers fully pass on any additional MPC increase due to standards to their consumers. As previously discussed in section VI.J.2.a, DOE used a manufacturer markup of 1.55 for all GSLs in the no-new standards case. DOE used this same manufacturer markup for all TSLs in the preservation of gross margin scenario. This manufacturer markup scenario represents the upper-bound of manufacturer INPV and is the manufacturer markup scenario used to calculate the economic impacts on consumers.

Under the preservation of operating profit scenario, DOE modeled a situation in which manufacturers are not able to increase per-unit operating profit in proportion to increases in MPCs in the standards cases. Under this scenario, as the cost of production increases, manufacturers reduce the manufacturer margins to maintain a cost competitive offering in the market. Therefore, gross margin (as a percentage) shrinks in the standards cases. This manufacturer markup scenario represents the lower-bound to industry profitability under new and amended energy conservation standards.

A comparison of industry financial impacts under the two manufacturer markup scenarios is presented in section VII.B.2.a of this document.

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 other gases due to ''upstream'' activities in the fuel production chain. These upstream activities comprise extraction, processing, and transporting fuels to the site of combustion.

The analysis of electric power sector emissions of CO_2, NO_X, SO_2, and Hg uses emissions factors intended to represent the marginal impacts of the change in electricity consumption associated with amended or new standards. The methodology is based on results published for the *AEO,* including a set of side cases that implement a variety of efficiency-related policies. The methodology is described in appendix 12A in the NOPR TSD. The analysis presented in this rulemaking uses projections from *AEO2022.* Power sector emissions of CH_4 and N_2O from fuel combustion are estimated using Emission Factors for Greenhouse Gas Inventories published by the Environmental Protection Agency (EPA).[65]

FFC upstream emissions, which include emissions from fuel combustion during extraction, processing, and transportation of fuels, and ''fugitive'' emissions (direct leakage to the atmosphere) of CH_4 and CO_2, are estimated based on the methodology described in chapter 14 of the NOPR TSD.

The emissions intensity factors are expressed in terms of physical units per megawatt-hours (MWh) or million British thermal units (MMBtu) of site energy savings. For power sector emissions, specific emissions intensity factors are calculated by sector and end use. Total emissions reductions are estimated using the energy savings calculated in the national impact analysis.

1. Air Quality Regulations Incorporated in DOE's Analysis

DOE's no-new-standards case for the electric power sector reflects the *AEO,* which incorporates the projected impacts of existing air quality regulations on emissions. *AEO2022* generally represents current legislation and environmental regulations, including recent government actions, that were in place at the time of preparation of *AEO2022,* including the emissions control programs discussed in the following paragraphs.[66]

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 numerous States in the eastern half of the United States are also limited under the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (Aug. 8, 2011). CSAPR requires these States to reduce certain emissions, including annual SO_2 emissions; it went into effect in 2015 and has been subsequently updated.[67] *AEO2022* incorporates implementation of CSAPR, including the Revised CSAPR Update issued in 2021. Compliance with CSAPR is flexible among EGUs and is enforced through the use of tradable emissions allowances. Under existing EPA regulations, for states subject to SO_2 emissions limits under CSAPR, 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 another regulated EGU.

Beginning in 2016, SO_2 emissions began to fall as a result of implementation of the Mercury and Air Toxics Standards (MATS) for power plants. 77 FR 9304 (Feb. 16, 2012). In the MATS final 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 are being reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. In order to continue operating, coal power plants must have either flue gas desulfurization or dry sorbent injection systems installed. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Because of the emissions reductions under the MATS, 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 another regulated EGU. Therefore, energy conservation standards that decrease electricity generation would generally reduce SO_2 emissions. DOE estimated SO_2 emissions reduction using emissions factors based on *AEO2022.*

CSAPR also established limits on NO_X emissions for numerous States in the

[65] Available at *www.epa.gov/sites/production/files/2021-04/documents/emission-factors_apr2021.pdf* (last accessed August 4, 2022).

[66] For further information, see the Assumptions to *AEO2022* report that sets forth the major assumptions used to generate the projections in the Annual Energy Outlook. Available at *https://www.eia.gov/outlooks/aeo/assumptions/* (last accessed June 23, 2022).

[67] CSAPR requires states to address annual emissions of SO_2 and NO_X, precursors to the formation of fine particulate matter ($PM_{2.5}$) pollution, in order to address the interstate transport of pollution by attaining and maintaining compliance with the 1997 and 2006 $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS). CSAPR also requires certain states to address the ozone season (May–September) emissions of NO_X, a precursor to the formation of ozone pollution, in order to address the interstate transport of ozone pollution with respect to the 1997 ozone NAAQS. 76 FR 48208 (Aug. 8, 2011). EPA subsequently issued a supplemental rule that included an additional five states in the CSAPR ozone season program; 76 FR 80760 (Dec. 27, 2011) (Supplemental Rule).

eastern half of the United States. Energy conservation standards would have little effect on NO_X emissions in those States covered by CSAPR emissions limits if excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions from other EGUs. In such case, NO_X emissions would remain near the limit even if electricity generation goes down. A different case could possibly result, depending on the configuration of the power sector in the different regions and the need for allowances, such that NO_X emissions might not remain at the limit in the case of lower electricity demand. In this case, energy conservation standards might reduce NO_X emissions in covered States. Despite this possibility, DOE has chosen to be conservative in its analysis and has maintained the assumption that standards will not reduce NO_X emissions in States covered by CSAPR. Energy conservation standards would be expected to reduce NO_X emissions in the States not covered by CSAPR.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would be expected to slightly reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO2022,* which incorporates the MATS.

L. Monetizing Emissions Impacts

As part of the development of this proposed rule, for the purpose of complying with the requirements of Executive Order 12866, DOE considered the estimated monetary climate and health benefits from the reduced emissions of CO_2, CH_4, N_2O, NO_X, and SO_2 that are expected to result from each of the TSLs considered. In order 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 projection period for each TSL. This section summarizes the basis for the values used for monetizing the emissions benefits and presents the values considered in this NOPR.

1. Monetization of Greenhouse Gas Emissions

On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. As reflected in this proposed rule, DOE has reverted to its approach prior to the injunction and presents monetized greenhouse gas abatement benefits where appropriate and permissible under law. DOE requests comment on how to address the climate benefits and other effects of the proposal. *See* section IX.E for a list of issues on which DOE seeks comment.

DOE estimates the monetized benefits of the reductions in emissions of CO_2, CH_4, and N_2O by using a measure of the social cost (SC) of each pollutant (*e.g.,* SC–CO_2). These estimates represent the monetary value of the net harm to society associated with a marginal increase in emissions of these pollutants in a given year, or the benefit of avoiding that increase. These estimates are intended to include (but are not limited to) climate-change-related changes in net agricultural productivity, human health, property damages from increased flood risk, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services.

DOE exercises its own judgment in presenting monetized climate benefits as recommended by applicable Executive Orders, and DOE would reach the same conclusion presented in this rulemaking in the absence of the social cost of greenhouse gases, including the February 2021 Interim Estimates presented by the Interagency Working Group on the Social Cost of Greenhouse Gases. DOE estimated the global social benefits of CO_2, CH_4, and N_2O reductions (*i.e.,* SC–GHGs) using the estimates presented in the Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990, published in February 2021 by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).[68] The SC–GHGs is the monetary value of the net harm to society associated with a marginal increase in emissions in a given year, or the benefit of avoiding that increase. In principle, SC–GHGs includes the value of all climate change impacts, including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased flood risk and natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The SC–GHGs therefore, reflects the societal value of reducing emissions of the gas in question by one metric ton. The SC–GHGs is the theoretically appropriate value to use in conducting benefit-cost analyses of policies that affect CO_2, N_2O and CH_4 emissions. As a member of the IWG involved in the development of the February 2021 SC–GHG TSD, the DOE agrees that the interim SC–GHG estimates represent the most appropriate estimate of the SC–GHG until revised estimates have been developed reflecting the latest, peer-reviewed science.

The SC–GHGs estimates presented here were developed over many years, using transparent process, peer-reviewed methodologies, the best science available at the time of that process, and with input from the public. Specifically, in 2009, an IWG that included the DOE and other executive branch agencies and offices was established to ensure that agencies were using the best available science and to promote consistency in the social cost of carbon (SC–CO_2) values used across agencies. The IWG published SC–CO_2 estimates in 2010 that were developed from an ensemble of three widely cited integrated assessment models (IAMs) that estimate global climate damages using highly aggregated representations of climate processes and the global economy combined into a single modeling framework. The three IAMs were run using a common set of input assumptions in each model for future population, economic, and CO_2 emissions growth, as well as equilibrium climate sensitivity—a measure of the globally averaged temperature response to increased atmospheric CO_2 concentrations. These estimates were updated in 2013 based on new versions of each IAM. In August 2016 the IWG published estimates of the social cost of methane (SC–CH_4) and nitrous oxide (SC–N_2O) using

[68] *See* Interagency Working Group on Social Cost of Greenhouse Gases, *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Interim Estimates Under Executive Order 13990,* Washington, DC, February 2021. Available at: *www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf* (last accessed March 17, 2021).

methodologies that are consistent with the methodology underlying the SC–CO_2 estimates. The modeling approach that extends the IWG SC–CO_2 methodology to non-CO_2 GHGs has undergone multiple stages of peer review. The SC–CH_4 and SC–N_2O estimates were developed by Marten et al. and underwent a standard double-blind peer review process prior to journal publication.[69]

In 2015, as part of the response to public comments received to a 2013 solicitation for comments on the SC–CO_2 estimates, the IWG announced a National Academies of Sciences, Engineering, and Medicine review of the SC–CO_2 estimates to offer advice on how to approach future updates to ensure that the estimates continue to reflect the best available science and methodologies. In January 2017, the National Academies released their final report, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, and recommended specific criteria for future updates to the SC–CO_2 estimates, a modeling framework to satisfy the specified criteria, and both near-term updates and longer-term research needs pertaining to various components of the estimation process.[70] Shortly thereafter, in March 2017, President Trump issued Executive Order 13783, which disbanded the IWG, withdrew the previous TSDs, and directed agencies to ensure SC–CO_2 estimates used in regulatory analyses are consistent with the guidance contained in OMB's Circular A–4, ''including with respect to the consideration of domestic versus international impacts and the consideration of appropriate discount rates'' (E.O. 13783, Section 5(c)). Benefit-cost analyses following E.O. 13783 used SC–GHG estimates that attempted to focus on the U.S.-specific share of climate change damages as estimated by the models and were calculated using two discount rates recommended by Circular A–4, 3 percent and 7 percent. All other methodological decisions and model versions used in SC–GHG calculations remained the same as those used by the IWG in 2010 and 2013, respectively.

On January 20, 2021, President Biden issued Executive Order 13990, which re-established the IWG and directed it to ensure that the U.S. Government's estimates of the social cost of carbon and other greenhouse gases reflect the best available science and the recommendations of the National Academies (2017). The IWG was tasked with first reviewing the SC–GHG estimates currently used in Federal analyses and publishing interim estimates within 30 days of the E.O. that reflect the full impact of GHG emissions, including by taking global damages into account. The interim SC–GHG estimates published in February 2021 are used here to estimate the climate benefits for this proposed rulemaking. The E.O. instructs the IWG to undertake a fuller update of the SC–GHG estimates by January 2022 that takes into consideration the advice of the National Academies (2017) and other recent scientific literature. The February 2021 SC–GHG TSD provides a complete discussion of the IWG's initial review conducted under E.O. 13990. In particular, the IWG found that the SC–GHG estimates used under E.O. 13783 fail to reflect the full impact of GHG emissions in multiple ways.

First, the IWG found that the SC–GHG estimates used under E.O. 13783 fail to fully capture many climate impacts that affect the welfare of U.S. citizens and residents, and those impacts are better reflected by global measures of the SC–GHG. Examples of omitted effects from the E.O. 13783 estimates include direct effects on U.S. citizens, assets, and investments located abroad, supply chains, U.S. military assets and interests abroad, and tourism, and spillover pathways such as economic and political destabilization and global migration that can lead to adverse impacts on U.S. national security, public health, and humanitarian concerns. In addition, assessing the benefits of U.S. GHG mitigation activities requires consideration of how those actions may affect mitigation activities by other countries, as those international mitigation actions will provide a benefit to U.S. citizens and residents by mitigating climate impacts that affect U.S. citizens and residents. A wide range of scientific and economic experts have emphasized the issue of reciprocity as support for considering global damages of GHG emissions. If the United States does not consider impacts on other countries, it is difficult to convince other countries to consider the impacts of their emissions on the United States. The only way to achieve an efficient allocation of resources for emissions reduction on a global basis—and so benefit the U.S. and its citizens—is for all countries to base their policies on global estimates of damages. As a member of the IWG involved in the development of the February 2021 SC–GHG TSD, DOE agrees with this assessment and, therefore, in this proposed rule DOE centers attention on a global measure of SC–GHG. This approach is the same as that taken in DOE regulatory analyses from 2012 through 2016. A robust estimate of climate damages to U.S. citizens and residents does not currently exist in the literature. As explained in the February 2021 TSD, existing estimates are both incomplete and an underestimate of total damages that accrue to the citizens and residents of the U.S. because they do not fully capture the regional interactions and spillovers discussed above, nor do they include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature. As noted in the February 2021 SC–GHG TSD, the IWG will continue to review developments in the literature, including more robust methodologies for estimating U.S.-specific SC–GHG values, and explore ways to better inform the public of the full range of carbon impacts. As a member of the IWG, DOE will continue to follow developments in the literature pertaining to this issue.

Second, the IWG found that the use of the social rate of return on capital (7 percent under current OMB Circular A–4 guidance) to discount the future benefits of reducing GHG emissions inappropriately underestimates the impacts of climate change for the purposes of estimating the SC–GHG. Consistent with the findings of the National Academies (2017) and the economic literature, the IWG continued to conclude that the consumption rate of interest is the theoretically appropriate discount rate in an intergenerational context, and recommended that discount rate uncertainty and relevant aspects of intergenerational ethical considerations be accounted for in selecting future discount rates.[71 72 73 74]

[69] Marten, A.L., E.A. Kopits, C.W. Griffiths, S.C. Newbold, and A. Wolverton. Incremental CH4 and N_2O mitigation benefits consistent with the U.S. Government's SC–CO_2 estimates. *Climate Policy.* 2015. 15(2): pp. 272–298.

[70] National Academies of Sciences, Engineering, and Medicine. *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide.* 2017. The National Academies Press: Washington, DC. (Last accessed September 28, 2021.) *https://www.nap.edu/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of.*

[71] Interagency Working Group on Social Cost of Carbon. *Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866.* 2010. United States Government. (Last accessed May 18, 2022.) *www.epa.gov/sites/default/files/2016–12/documents/scc_tsd_2010.pdf.*

[72] Interagency Working Group on Social Cost of Carbon. *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* 2013. (Last accessed May 18, 2022.) *www.federalregister.gov/documents/2013/11/26/2013–28242/technical-support-document-technical-update-of-the-social-cost-of-carbon-for-regulatory-impact.*

Furthermore, the damage estimates developed for use in the SC–GHG are estimated in consumption-equivalent terms, and so an application of OMB Circular A–4's guidance for regulatory analysis would then use the consumption discount rate to calculate the SC–GHG. DOE agrees with this assessment and will continue to follow developments in the literature pertaining to this issue. DOE also notes that while OMB Circular A–4, as published in 2003, recommends using 3% and 7% discount rates as ''default'' values, Circular A–4 also reminds agencies that ''different regulations may call for different emphases in the analysis, depending on the nature and complexity of the regulatory issues and the sensitivity of the benefit and cost estimates to the key assumptions.'' On discounting, Circular A–4 recognizes that ''special ethical considerations arise when comparing benefits and costs across generations,'' and Circular A–4 acknowledges that analyses may appropriately ''discount future costs and consumption benefits. . . at a lower rate than for intragenerational analysis.'' In the 2015 Response to Comments on the Social Cost of Carbon for Regulatory Impact Analysis, OMB, DOE, and the other IWG members recognized that ''Circular A–4 is a living document'' and ''the use of 7 percent is not considered appropriate for intergenerational discounting. There is wide support for this view in the academic literature, and it is recognized in Circular A–4 itself.'' Thus, DOE concludes that a 7% discount rate is not appropriate to apply to value the social cost of greenhouse gases in the analysis presented in this analysis. In this analysis, to calculate the present and annualized values of climate benefits, DOE uses the same discount rate as the rate used to discount the value of damages from future GHG emissions, for internal consistency. That approach to discounting follows the same approach that the February 2021 TSD recommends ''to ensure internal consistency—*i.e.,* future damages from climate change using the SC–GHG at 2.5 percent should be discounted to the base year of the analysis using the same 2.5 percent rate.'' DOE has also consulted the National Academies' 2017 recommendations on how SC–GHG estimates can ''be combined in RIAs with other cost and benefits estimates that may use different discount rates.'' The National Academies reviewed ''several options,'' including ''presenting all discount rate combinations of other costs and benefits with [SC–GHG] estimates.''

As a member of the IWG involved in the development of the February 2021 SC–GHG TSD, DOE agrees with this assessment and will continue to follow developments in the literature pertaining to this issue. While the IWG works to assess how best to incorporate the latest, peer reviewed science to develop an updated set of SC–GHG estimates, it set the interim estimates to be the most recent estimates developed by the IWG prior to the group being disbanded in 2017. The estimates rely on the same models and harmonized inputs and are calculated using a range of discount rates. As explained in the February 2021 SC–GHG TSD, the IWG has recommended that agencies use the same set of four values drawn from the SC–GHG distributions based on three discount rates and subject to public comment. For each discount rate, the IWG combined the distributions across models and socioeconomic emissions scenarios (applying equal weight to each) and then selected a set of four values recommended for use in benefit-cost analyses: an average value resulting from the model runs for each of three discount rates (2.5 percent, 3 percent, and 5 percent), plus a fourth value, selected as the 95th percentile of estimates based on a 3 percent discount rate. The fourth value was included to provide information on potentially higher-than-expected economic impacts from climate change. As explained in the February 2021 SC–GHG TSD, and DOE agrees, this update reflects the immediate need to have operational SC–GHG values for use in regulatory benefit-cost analyses and other applications that were developed using a transparent process, peer-reviewed methodologies, and the science available at the time of that process. Those estimates were subject to public comment in the context of dozens of proposed rulemakings as well as in a dedicated public comment period in 2013.

There are a number of limitations and uncertainties associated with the SC–GHG estimates. First, the current scientific and economic understanding of discounting approaches suggests discount rates appropriate for intergenerational analysis in the context of climate change are likely to be less than 3 percent, near 2 percent or lower.[75] Second, the IAMs used to produce these interim estimates do not include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature and the science underlying their ''damage functions''—*i.e.,* the core parts of the IAMs that map global mean temperature changes and other physical impacts of climate change into economic (both market and nonmarket) damages—lags behind the most recent research. For example, limitations include the incomplete treatment of catastrophic and non-catastrophic impacts in the integrated assessment models, their incomplete treatment of adaptation and technological change, the incomplete way in which inter-regional and intersectoral linkages are modeled, uncertainty in the extrapolation of damages to high temperatures, and inadequate representation of the relationship between the discount rate and uncertainty in economic growth over long time horizons. Likewise, the socioeconomic and emissions scenarios used as inputs to the models do not reflect new information from the last decade of scenario generation or the full range of projections. The modeling limitations do not all work in the same direction in terms of their influence on the SC–CO_2 estimates. However, as discussed in the February 2021 TSD, the IWG has recommended that, taken together, the limitations suggest that the interim SC–GHG estimates used in this final rule likely underestimate the damages from GHG emissions. DOE concurs with this assessment.

DOE's derivations of the SC–CO_2, SC–N_2O, and SC–CH_4 values used for this NOPR are discussed in the following sections, and the results of DOE's analyses estimating the benefits of the reductions in emissions of these pollutants are presented in section VII.B.6.

[73] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Technical Update on the Social Cost of Carbon for Regulatory Impact Analysis-Under Executive Order 12866. August 2016. (Last accessed January 18, 2022.) *https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf.*

[74] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide. August 2016. (Last accessed January 18, 2022.) *https://www.epa.gov/sites/default/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf.*

[75] Interagency Working Group on Social Cost of Greenhouse Gases (IWG). 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. February. United States Government. Available at: <*https://www.whitehouse.gov/briefing-room/blog/2021/02/26/a-return-to-science-evidence-based-estimates-of-the-benefits-of-reducing-climate-pollution/.*

a. Social Cost of Carbon

The SC–CO_2 values used for this NOPR were generated using the values presented in the 2021 update from the IWG's February 2021 TSD. Table VI.24 shows the updated sets of SC–CO_2 estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in Appendix 13A of the NOPR TSD. For purposes of capturing the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate include all four sets of SC–CO_2 values, as recommended by the IWG.[76]

TABLE VI.24—ANNUAL SC–CO_2 VALUES FROM 2021 INTERAGENCY UPDATE, 2020–2050

[2020$ per metric ton CO_2]

Year	Discount rate 5% Average	Discount rate 3% Average	Discount rate 2.5% Average	Discount rate 3% 95th percentile
2020	14	51	76	152
2025	17	56	83	169
2030	19	62	89	187
2035	22	67	96	206
2040	25	73	103	225
2045	28	79	110	242
2050	32	85	116	260

For 2051 to 2070, DOE used SC–CO_2 estimates published by EPA, adjusted to 2021$.[77] These estimates are based on methods, assumptions, and parameters identical to the 2020–2050 estimates published by the IWG. DOE expects additional climate benefits to accrue for any longer-life GSLs after 2070, but a lack of available SC–CO2 estimates for emissions years beyond 2070 prevents DOE from monetizing these potential benefits in this analysis. If further analysis of monetized climate benefits beyond 2070 becomes available prior to the publication of the final rule, DOE will include that analysis in the final rule.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SC–CO_2 value for that year in each of the four cases. DOE adjusted the values to 2021$ using the implicit price deflator for gross domestic product (GDP) from the Bureau of Economic Analysis. 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 SC–CO_2 values in each case.

b. Social Cost of Methane and Nitrous Oxide

The SC–CH_4 and SC–N_2O values used for this NOPR were generated using the values presented in the February 2021 TSD. Table VI.25 shows the updated sets of SC–CH_4 and SC–N_2O estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in Appendix 13A of the NOPR TSD. To capture the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate to include all four sets of SC–CH_4 and SC–N_2O values, as recommended by the IWG. DOE derived values after 2050 using the approach described above for the SC–CO_2.

TABLE VI.25—ANNUAL SC–CH_4 AND SC–N_2O VALUES FROM 2021 INTERAGENCY UPDATE, 2020–2050

[2020$ per metric ton]

Year	SC–CH_4				SC–N_2O			
	Discount rate and statistic				Discount rate and statistic			
	5% Average	3% Average	2.5% Average	3% 95th percentile	5% Average	3% Average	2.5% Average	3% 95th percentile
2020	670	1,500	2,000	3,900	5,800	18,000	27,000	48,000
2025	800	1,700	2,200	4,500	6,800	21,000	30,000	54,000
2030	940	2,000	2,500	5,200	7,800	23,000	33,000	60,000
2035	1,100	2,200	2,800	6,000	9,000	25,000	36,000	67,000
2040	1,300	2,500	3,100	6,700	10,000	28,000	39,000	74,000
2045	1,500	2,800	3,500	7,500	12,000	30,000	42,000	81,000
2050	1,700	3,100	3,800	8,200	13,000	33,000	45,000	88,000

[76] For example, the February 2021 TSD discusses how the understanding of discounting approaches suggests that discount rates appropriate for intergenerational analysis in the context of climate change may be lower than 3 percent.

[77] See EPA, *Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis*, Washington, DC, December 2021. Available at: *www.epa.gov/system/files/documents/2021-12/420r21028.pdf* (last accessed January 13, 2022).

DOE multiplied the CH_4 and N_2O emissions reduction estimated for each year by the SC–CH_4 and SC–N_2O estimates for that year in each of the cases. DOE adjusted the values to 2021$ using the implicit price deflator for gross domestic product (GDP) from the Bureau of Economic Analysis. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the cases using the specific discount rate that had been used to obtain the SC–CH_4 and SC–N_2O estimates in each case.

2. Monetization of Other Air Pollutants

For the NOPR, DOE estimated the monetized value of NO_X and SO_2 emissions reductions from electricity generation using the latest benefit per ton estimates for that sector from the EPA's Benefits Mapping and Analysis Program.[78] DOE used EPA's values for $PM_{2.5}$-related benefits associated with NO_X and SO_2 and for ozone-related benefits associated with NO_X for 2025, 2030, 2035, and 2040, calculated with discount rates of 3 percent and 7 percent. DOE used linear interpolation to define values for the years not given in the 2025 to 2040 period; for years beyond 2040 the values are held constant. DOE derived values specific to the sector for GSLs using a method described in appendix 13B of the NOPR TSD.

DOE multiplied the site emissions reduction (in 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. Additional details on the monetization of NO_X and SO_2 emissions reductions are included in chapter 13 of the NOPR TSD.

M. Utility Impact Analysis

The utility impact analysis estimates the changes in installed electrical capacity and generation that would result for each considered TSL. The analysis is based on published output from the NEMS associated with *AEO2022*. 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. For the current analysis, impacts are quantified by comparing the levels of electricity sector generation, installed capacity, fuel consumption and emissions in the *AEO2022* Reference case and various side cases. Details of the methodology are provided in the appendices to chapters 12 and 14 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 potential new or amended energy conservation standards.

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 consumers on energy, (2) reduced spending on new energy supply by the utility industry, (3) increased consumer spending on the products to which the new standards apply and other goods and services, 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). 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.[79] 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, the BLS data suggest that 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 called Impact of Sector Energy Technologies version 4 (ImSET).[80] 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 that 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 over-estimate actual job impacts over the long run for this proposed rule. Therefore, DOE used ImSET only to generate results for near-term timeframes (2029), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 15 of the NOPR TSD.

VII. 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

[78] *Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 21 Sectors.. www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-21-sectors.*

[79] See U.S. Department of Commerce—Bureau of Economic Analysis. *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II).* 1997. U.S. Government Printing Office: Washington, DC. Available at *https://apps.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf* (last accessed March 25, 2022).

[80] Livingston, O.V., S.R. Bender, M.J. Scott, and R.W. Schultz. *ImSET 4.0: Impact of Sector Energy Technologies Model Description and User Guide.* 2015. Pacific Northwest National Laboratory: Richland, WA. PNNL–24563.

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 document.

A. Trial Standard Levels

In general, DOE typically evaluates potential amended standards for products and equipment by grouping individual efficiency levels for each class into TSLs. Use of TSLs allows DOE to identify and consider manufacturer cost interactions between the product classes, to the extent that there are such interactions, and market cross elasticity from consumer purchasing decisions that may change when different standard levels are set.

In the analysis conducted for this NOPR, DOE analyzed the benefits and burdens of six TSLs for GSLs. DOE developed TSLs that combine efficiency levels for each analyzed product class. These TSLs were developed by combining specific efficiency levels for each of the GSL product classes analyzed by DOE. TSL 1 represents a modest increase in efficiency, with CFL technology retained as an option for product classes that include fluorescent lamps, including the Integrated Omnidirectional Short and Non-integrated Omnidirectional product classes. TSL 2 represents a moderate standard level that can only be met by LED options for all product classes. TSL 3 increases the stringency for the Integrated Omnidirectional Short, Integrated Omnidirectional Long and Integrated Directional product classes, and represents a significant increase in NES compared to TSLs 1 and 2. TSL 4 increases the proposed standard level for the Integrated Omnidirectional Short product class, as well as the expected NES. TSL 5 represents the maximum NPV. TSL 6 represents max tech. DOE presents the results for the TSLs in this document, while the results for all efficiency levels that DOE analyzed are in the NOPR TSD.

Table VII.1 presents the TSLs and the corresponding efficiency levels that DOE has identified for potential amended energy conservation standards for GSLs.

TABLE VII.1—TRIAL STANDARD LEVELS FOR GSLS BY EFFICACY LEVEL

TSL	Representative product class				
	Integrated omnidirectional short	Integrated omnidirectional long	Integrated directional	Non-integrated omnidirectional	Non-integrated directional
1	EL 2	EL 1	EL 1	EL 1	EL 1
2	EL 3	EL 3	EL 3	EL 3	EL 1
3	EL 5	EL 5	EL 5	EL 3	EL 1
4	EL 6	EL 5	EL 5	EL 3	EL 1
5	EL 7	EL 5	EL 5	EL 3	EL 3
6	EL 7	EL 6	EL 5	EL 3	EL 3

DOE constructed the TSLs for this NOPR to include ELs representative of ELs with similar characteristics (*e.g.,* using similar technologies and/or efficiencies) or representing significant increases in efficiency and energy savings. The use of representative ELs provided for greater distinction between the TSLs. While representative ELs were included in the TSLs, DOE considered all efficiency levels as part of its analysis.[81]

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 that potential standards at each TSL would have on the LCC and PBP. DOE also examined the impacts of potential standards on selected consumer subgroups. These analyses are discussed in the following sections.

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. 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 7 of the NOPR TSD provides detailed information on the LCC and PBP analyses.

Table VII.2 through Table VII.11 show the LCC and PBP results for the TSLs considered for each product class. In the first of each pair of tables, the simple payback is measured relative to the baseline product. In the second table, impacts are measured based on the changes in the efficacy distribution under a standard relative to the efficacy distribution in the no-new-standards case in the first full year of compliance (see section VI.F.9 of this document). Because some consumers purchase products with higher efficiency than the minimum allowed under a standard or in the no-new standards case, the average savings can differ from than the difference between the average LCC of the baseline product and the average LCC at each TSL. The savings refer only to consumers who are affected by a standard at a given TSL. Consumers for whom the LCC increases at a given TSL experience a net cost.

[81] Efficiency levels that were analyzed for this NOPR are discussed in section VI.C.5 of this document. Results by efficiency level are presented in TSD chapters 7, 9, and 11.

TABLE VII.2—AVERAGE LCC AND PBP RESULTS FOR INTEGRATED OMNIDIRECTIONAL SHORT GSLS

Lamp option	EL	Average costs 2021$					Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost*	Residual value	LCC		
Residential								
0	0	3.24	3.90	6.84	0.00	10.07		7.1
1	1	3.38	3.64	6.38	0.00	9.76	0.5	7.1
2	2	3.52	3.38	5.93	0.00	9.44	0.5	7.1
3	3	2.85	2.60	4.56	1.25	6.15	0.0	11.9
4	3	3.88	2.60	4.56	2.00	6.44	0.5	13.5
5	4	3.49	2.34	4.10	1.54	6.06	0.2	11.9
6	4	4.74	2.34	4.10	2.44	6.40	1.0	13.5
7	5	4.13	2.08	3.65	1.82	5.96	0.5	11.9
8	6	4.76	1.82	3.19	2.10	5.86	0.7	11.9
9	7	5.08	1.69	2.96	2.24	5.81	0.8	11.9
Commercial								
0	0	4.97	6.30	12.88	0.00	18.05		2.8
1	1	5.11	5.88	12.02	0.00	17.34	0.3	2.8
2	2	5.25	5.46	11.16	0.00	16.62	0.3	2.8
3	3	4.58	4.20	8.59	0.85	12.32	0.0	4.1
4	3	5.61	4.20	8.59	2.07	12.13	0.3	6.7
5	4	5.22	3.78	7.73	1.04	11.91	0.1	4.1
6	4	6.48	3.78	7.73	2.53	11.68	0.6	6.7
7	5	5.86	3.36	6.87	1.23	11.50	0.3	4.1
8	6	6.49	2.94	6.01	1.42	11.09	0.5	4.1
9	7	6.82	2.73	5.58	1.52	10.88	0.5	4.1

Note: The results for each lamp option represent the average value if all purchasers use products at that lamp option. The PBP is measured relative to the baseline (EL 0) product; therefore, the PBP is not defined for EL 0.
* Calculated over the LCC analysis period, which is the lifetime of the EL 0 lamp.

TABLE VII.3—AVERAGE LCC SAVINGS RESULTS FOR INTEGRATED OMNIDIRECTIONAL SHORT GSLS

TSL	EL	Average LCC savings* (2021$)	Percent of consumers that experience net cost
Residential Sector			
1	2	1.89	0.9
2	3	2.35	1.3
3	5	0.51	19.9
4	6	0.56	21.1
5–6	7	0.59	22.0
Commercial Sector			
1	2	2.32	0.2
2	3	2.91	0.3
3	5	0.82	5.6
4	6	1.01	5.1
5–6	7	1.11	4.8

* The savings represent the average LCC for affected consumers.

TABLE VII.4—AVERAGE LCC AND PBP RESULTS FOR INTEGRATED OMNIDIRECTIONAL LONG GSLS

Lamp option	EL	Average costs 2021$					Simple payback years	Average lifetime years
		Installed cost	First year's operating cost	Lifetime operating cost*	Residual value	LCC		
Residential								
0	0	8.11	2.39	22.07	0.00	30.18		17.4
1	1	9.05	2.23	20.60	0.00	29.65	5.9	17.4
2	2	10.31	2.00	18.39	0.00	28.70	5.5	17.4
3	3	10.21	1.92	17.65	0.00	27.87	4.4	17.4
4	4	11.10	1.84	16.92	0.00	28.02	5.4	17.4
5	5	11.70	1.68	15.45	0.00	27.14	5.0	17.4
6	6	13.11	1.47	13.54	0.00	26.64	5.4	17.4
Commercial								
0	0	9.84	4.51	34.58	0.00	44.42		13.8

TABLE VII.4—AVERAGE LCC AND PBP RESULTS FOR INTEGRATED OMNIDIRECTIONAL LONG GSLS—Continued

Lamp option	EL	Average costs 2021$					Simple payback years	Average lifetime years
		Installed cost	First year's operating cost	Lifetime operating cost *	Residual value	LCC		
1	1	10.78	4.21	32.28	0.00	43.06	3.1	13.8
2	2	12.04	3.75	28.82	0.00	40.86	2.9	13.8
3	3	11.95	3.60	27.67	0.00	39.61	2.3	13.8
4	4	12.83	3.45	26.51	0.00	39.34	2.8	13.8
5	5	13.43	3.15	24.21	0.00	37.64	2.7	13.8
6	6	14.84	2.76	21.21	0.00	36.05	2.9	13.8

Note: The results for each lamp option represent the average value if all purchasers use products at that lamp option. The PBP is measured relative to the baseline (EL 0) product; therefore, the PBP is not defined for EL 0.
* Calculated over the LCC analysis period, which is the lifetime of the EL 0 lamp.

TABLE VII.5—AVERAGE LCC SAVINGS RESULTS FOR INTEGRATED OMNIDIRECTIONAL LONG GSLS

TSL	EL	Average LCC savings * (2021$)	Percent of consumers that experience net cost
Residential Sector			
1	1	0.59	21.1
2	3	1.02	39.0
3–5	5	1.57	41.7
6	6	1.82	43.4
Commercial Sector			
1	1	1.42	2.8
2	3	2.37	3.8
3–5	5	3.80	1.9
6	6	4.74	2.3

* The savings represent the average LCC for affected consumers.

TABLE VII.6—AVERAGE LCC AND PBP RESULTS FOR INTEGRATED DIRECTIONAL GSLS

Lamp option	EL	Average costs (2021$)					Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost *	Residual value	LCC		
Residential								
0	0	17.13	6.52	11.70	0.00	28.83		7.3
1	1	11.25	4.82	8.65	5.67	14.23	0.0	13.5
2	2	10.42	4.53	8.14	5.25	13.31	0.0	13.5
3	3	9.61	4.25	7.63	4.84	12.40	0.0	13.5
4	4	8.69	3.97	7.12	4.38	11.43	0.0	13.5
5	5	7.11	3.54	6.36	3.58	9.88	0.0	13.5
Commercial								
0	0	18.87	9.76	19.96	0.00	39.03		2.8
1	1	12.99	7.22	14.75	5.97	21.77	0.0	6.8
2	2	12.15	6.79	13.88	5.53	20.51	0.0	6.8
3	3	11.35	6.37	13.02	5.10	19.26	0.0	6.8
4	4	10.43	5.94	12.15	4.61	17.96	0.0	6.8
5	5	8.84	5.31	10.85	3.77	15.92	0.0	6.8

Note: The results for each lamp option represent the average value if all purchasers use products at that lamp option. The PBP is measured relative to the baseline (EL 0) product; therefore, the PBP is not defined for EL 0.
* Calculated over the LCC analysis period, which is the lifetime of the EL 0 lamp.

TABLE VII.7—AVERAGE LCC SAVINGS RESULTS FOR INTEGRATED DIRECTIONAL GSLS

TSL	EL	Average LCC savings * (2021$)	Percent of consumers that experience net cost
Residential Sector			
1	1	8.87	0.0
2	3	1.61	0.0
3–6	5	3.01	0.0

TABLE VII.7—AVERAGE LCC SAVINGS RESULTS FOR INTEGRATED DIRECTIONAL GSLS—Continued

TSL	EL	Average LCC savings* (2021$)	Percent of consumers that experience net cost
Commercial Sector			
1	1	9.44	0.0
2	3	2.01	0.0
3–6	5	3.86	0.0

*The savings represent the average LCC for affected consumers.

TABLE VII.8—AVERAGE LCC AND PBP RESULTS FOR NON-INTEGRATED OMNIDIRECTIONAL GSLS

Lamp option	EL	Average costs (2021$)					Simple payback** (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost*	Residual value	LCC		
Commercial								
0	0	7.11	10.74	22.56	0.00	29.87		3.0
1	1	9.88	10.74	22.56	0.00	32.64	Never	3.0
2	1	20.71	8.68	18.22	6.50	32.62	6.6	4.7
3	2	20.93	4.96	10.41	13.05	18.29	2.4	11.9
4	3	21.79	3.72	7.81	13.64	15.96	2.1	11.9

Note: The results for each lamp option represent the average value if all purchasers use products at that lamp option. The PBP is measured relative to the baseline (EL 0) product; therefore, the PBP is not defined for EL 0.
*Calculated over the LCC analysis period, which is the lifetime of the EL 0 lamp.
**A reported PBP of "Never" indicates that the increased purchase cost will never be recouped by operating cost savings.

TABLE VII.9—AVERAGE LCC SAVINGS RESULTS FOR NON-INTEGRATED OMNIDIRECTIONAL GSLS

TSL	EL	Average LCC savings* (2021$)	Percent of consumers that experience net cost
Residential Sector			
1	1	4.93	9.4%
2–6	3	6.62	0.2%

*The savings represent the average LCC for affected consumers.

TABLE VII.10—AVERAGE LCC AND PBP RESULTS FOR NON-INTEGRATED DIRECTIONAL GSLS

Lamp option	EL	Average costs (2021$)					Simply payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost*	Residual value	LCC		
Residential								
0	0	8.47	2.24	12.66	0.00	21.13		13.4
1	1	9.34	1.96	11.08	0.00	20.41	3.1	13.4
2	2	10.10	1.82	10.29	0.00	20.38	3.9	13.4
3	3	10.82	1.68	9.49	0.00	20.32	4.2	13.4
Commercial								
0	0	10.20	3.38	15.07	0.00	25.27		6.8
1	1	11.07	2.96	13.19	0.00	24.26	2.1	6.8
2	2	11.83	2.75	12.25	0.00	24.08	2.6	6.8
3	3	12.56	2.53	11.30	0.00	23.86	2.8	6.8

Note: The results for each lamp option represent the average value if all purchasers use products at that lamp option. The PBP is measured relative to the baseline (EL 0) product; therefore, the PBP is not defined for EL 0.
*Calculated over the LCC analysis period, which is the lifetime of the EL 0 lamp.

TABLE VII.11—AVERAGE LCC SAVINGS RESULTS FOR NON-INTEGRATED DIRECTIONAL GSLS

TSL	EL	Average LCC savings* (2021$)	Percent of consumers that experience net cost
Residential Sector			
1–4	1	0.34	22.2
5–6	3	0.28	34.6
Commercial Sector			
1–4	1	0.59	9.0
5–6	3	0.69	16.5

* 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 VII.12 and Table VII.13 compare the average LCC savings and PBP at each efficiency level for the consumer subgroups with similar metrics for the entire consumer sample for GSLs. In most cases, the average LCC savings and PBP for low-income households and small businesses do not substantially differ from the average for all consumers. Chapter 10 of the NOPR TSD presents the complete LCC and PBP results for the subgroups.

TABLE VII.12—COMPARISON OF LCC SAVINGS FOR CONSUMER SUBGROUPS AND ALL CONSUMERS

TSL	Average LCC savings* (2021$)			
	Residential		Commercial	
	Low-income households	All households	Small businesses	All businesses
Integrated Omnidirectional Short				
1	1.94	1.89	2.22	2.32
2	2.57	2.35	2.78	2.91
3	0.53	0.51	0.77	0.82
4	0.59	0.56	0.94	1.01
5–6	0.62	0.59	1.03	1.11
Integrated Omnidirectional Long				
1	N/A**	0.59	1.15	1.42
2		1.02	1.94	2.37
3–5		1.57	3.08	3.80
6		1.82	3.81	4.74
Integrated Directional				
1	9.61	8.87	9.22	9.44
2	1.66	1.61	1.98	2.01
3–6	3.03	3.01	3.82	3.86
Non-integrated Omnidirectional				
1	N/A		4.54	4.93
2–6			6.20	6.62
Non-integrated Directional				
1–4	0.33	0.34	0.48	0.59
5–6	0.27	0.28	0.52	0.69

* The savings represent the average LCC for affected consumers.

** Approximately 95% of Integrated Omnidirectional Long GSLs are shipped to the commercial sector. Moreover, for those low-income consumers who are renters (a subset of the residential consumer subgroup), DOE anticipates that the landlord, rather than the tenant, would typically purchase the lamps because Integrated Omnidirectional Long GSLs are not typical screw-in bulbs. For these reasons, DOE provides results for this PC only for the commercial sector.

TABLE VII.13—COMPARISON OF PBP FOR CONSUMER SUBGROUPS AND ALL CONSUMERS

Lamp option	Simple payback period* (years)			
	Residential		Commercial	
	Low-income households	All households	Small businesses	All businesses
Integrated Omnidirectional Short				
1	0.5	0.5	0.3	0.3
2	0.5	0.5	0.3	0.3
3	0.0	0.0	0.0	0.0
4	0.5	0.5	0.3	0.3
5	0.2	0.2	0.1	0.1
6	0.9	1.0	0.6	0.6
7	0.5	0.5	0.3	0.3
8	0.7	0.7	0.5	0.5
9	0.8	0.8	0.5	0.5
Integrated Omnidirectional Long				
1	N/A **	5.9	3.2	3.1
2		5.5	3.0	2.9
3		4.4	2.4	2.3
4		5.4	2.9	2.8
5		5.0	2.7	2.7
6		5.4	2.9	2.9
Integrated Directional				
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
Non-integrated Omnidirectional				
1	N/A		Never	Never
2			6.7	6.6
3			2.4	2.4
4			2.1	2.1
Non-integrated Directional				
1	3.1	3.1	2.1	2.1
2	3.9	3.9	2.6	2.6
3	4.3	4.2	2.8	2.8

* A reported PBP of "Never" indicates that the increased purchase cost will never be recouped by operating cost savings.

** Approximately 95% of Integrated Omnidirectional Long GSLs are shipped to the commercial sector. Moreover, for those low-income consumers who are renters (a subset of the residential consumer subgroup), DOE anticipates that the landlord, rather than the tenant, would typically purchase the lamps because Integrated Omnidirectional Long GSLs are not typical screw-in bulbs. For these reasons, DOE provides results for this PC only for the commercial sector.

c. Rebuttable Presumption Payback

As discussed in section VI.F.11, 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 TSLs, 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 VII.B.1.a of this document were calculated using distributions that reflect the range of energy use in the field.

Table VII.14 presents the rebuttable-presumption payback periods for the considered TSLs for GSLs. 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 VII.14—REBUTTABLE-PRESUMPTION PAYBACK PERIODS

Lamp option	Rebuttable PBP * (years)				
	Integrated omnidirectional short	Integrated omnidirectional long	Integrated directional	Non-integrated omnidirectional	Non-integrated directional
Residential					
1	0.5	5.9	0.0		3.0
2	0.5	5.5	0.0		3.8
3	0.0	4.4	0.0		4.1
4	0.5	5.4	0.0		
5	0.2	5.0	0.0		
6	0.9	5.4			
7	0.5				
8	0.7				
9	0.8				
Commercial					
1	0.3	2.8	0.0	Never	1.8
2	0.3	2.6	0.0	5.9	2.3
3	0.0	2.1	0.0	2.1	2.5
4	0.3	2.6	0.0	1.9	
5	0.1	2.4	0.0		
6	0.5	2.6			
7	0.3				
8	0.4				
9	0.5				

* A reported PBP of "Never" indicates that the increased purchase cost will never be recouped by operating cost savings.

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 section describes the expected impacts on manufacturers at each considered TSL. Chapter 11 of the NOPR TSD explains the analysis in further detail.

a. Industry Cash Flow Analysis Results

In this section, DOE provides GRIM results from the analysis, which examines changes in the industry that would result from new and amended standards. The following tables summarize the estimated financial impacts (represented by changes in INPV) of new and amended energy conservation standards on manufacturers of GSLs, as well as the conversion costs that DOE estimates manufacturers of GSLs would incur at each TSL.

To evaluate the range of cash flow impacts on the GSL industry, DOE modeled two manufacturer markup scenarios that correspond to the range of possible market responses to new and amended standards. Each manufacturer markup scenario results in a unique set of cash flows and corresponding INPVs 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 (2022) through the end of the analysis period (2058). The results also discuss the difference in cash flows between the no-new-standards case and the standards cases in the year before the estimated compliance date for new and amended energy conservation standards. This figure 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 preservation of gross margin scenario. This scenario assumes that in the standards cases, GSL manufacturers would be able to pass along all the 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 the higher production costs in the standards cases. In general, the larger the product price increases, the less likely manufacturers are to achieve the cash flow from operations calculated in this scenario because it is less likely that manufacturers would be able to fully markup these larger production cost increases.

To assess the lower (more severe) end of the range of potential impacts on the GSL manufacturers, DOE modeled a preservation of operating profit scenario. This scenario represents the lower end of the range of impacts on manufacturers because no additional operating profit is earned on the higher production costs, eroding profit margins as a percentage of total revenue.

TABLE VII.15—MANUFACTURER IMPACT ANALYSIS FOR GENERAL SERVICE LAMPS—PRESERVATION OF GROSS MARGIN SCENARIO

	Units	No-new-standards case	Trial standard level					
			1	2	3	4	5	6
INPV	*2021$ millions*	2,014	1,968	1,874	1,868	1,873	1,868	1,867

TABLE VII.15—MANUFACTURER IMPACT ANALYSIS FOR GENERAL SERVICE LAMPS—PRESERVATION OF GROSS MARGIN SCENARIO—Continued

	Units	No-new-standards case	Trial standard level					
			1	2	3	4	5	6
Change in INPV	*2021$ millions*		(46)	(139)	(144)	(139)	(144)	(145)
	%		(2.3)	(6.9)	(7.1)	(6.9)	(7.2)	(7.2)
Total Conversion Costs	*2021$ millions*		82	220	337	373	403	407

* Numbers in parentheses indicate negative numbers.

TABLE VII.16—MANUFACTURER IMPACT ANALYSIS FOR GENERAL SERVICE LAMPS—PRESERVATION OF OPERATING PROFIT SCENARIO

	Units	No-new-standards case	Trial standard level					
			1	2	3	4	5	6
INPV	*2021$ millions*	2,014	1,964	1,880	1,838	1,821	1,745	1,741
Change in INPV	*2021$ millions*		(50)	(134)	(174)	(190)	(266)	(271)
	%		(2.5)	(6.6)	(8.6)	(9.5)	(13.2)	(13.5)
Total Conversion Costs	*2021$ millions*		82	220	337	373	403	407

* Numbers in parentheses indicate negative numbers.

TSL 1 sets the efficacy level at EL 2 for the Integrated Omnidirectional Short product class and EL 1 for all other product classes (Integrated Omnidirectional Long, Integrated Directional, Non-Integrated Omnidirectional, Non-Integrated Directional). At TSL 1, DOE estimates impacts on INPV would range from −$50 million to −$46 million, or a change in INPV of −2.5 percent to −2.3 percent. At TSL 1, industry free cash flow (operating cash flow minus capital expenditures) is estimated to decrease to $74 million, or a drop of 28 percent, compared to the no-new-standards case value of $103 million in 2028, the year leading up to the estimated compliance date of new and amended energy conservation standards.

Percentage impacts on INPV are slightly negative at TSL 1. DOE estimates that approximately 99 percent of the Integrated Omnidirectional Short and Integrated Directional product class shipments; 86 percent of the Integrated Omnidirectional Long product class shipments; 98 percent of the Non-Integrated Omnidirectional Short product class shipments; and 74 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 1 in 2029, the estimated first full year of compliance of new and amended standards.

DOE does not expect manufacturers to incur any capital conversion costs at TSL 1. At TSL 1, additional LED lamp production capacity is not expected to be needed to meet the expected volume of LED lamp shipments, as GSL manufacturers are expected to produce more LED lamps for every product class in years leading up to 2029 than in 2029, the estimated first full year of compliance of new and amended standards. DOE estimates approximately $82 million in product conversion costs as some LED lamps may need to be remodeled to meet ELs required at TSL 1. DOE does not estimate any conversion costs for CFL models as GSL manufacturers are not expected to remodel non-compliant CFLs, even though that may be possible for some CFLs at TSL 1.

At TSL 1, under the preservation of gross margin scenario, the shipment weighted-average MPC increases slightly by approximately 0.8 percent relative to the no-new-standards case MPC. This slight price increase is outweighed by the $82 million in conversion costs estimated at TSL 1, resulting in slightly negative INPV impacts at TSL 1 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, manufacturers earn the same nominal operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments. The slight increase in the shipment weighted-average MPC results in a slightly lower average manufacturer markup (slightly smaller than the 1.55 manufacturer markup used in the no-new-standards case). This slightly lower average manufacturer markup and the $82 million in conversion costs result in slightly negative INPV impacts at TSL 1 under the preservation of operating profit scenario.

TSL 2 sets the efficacy level at EL 1 for the Non-Integrated Directional product class and EL 3 for all other product classes (Integrated Omnidirectional Short, Integrated Omnidirectional Long, Integrated Directional, Non-Integrated Omnidirectional). At TSL 2, DOE estimates impacts on INPV would range from −$134 million to −$139 million, or a change in INPV of −6.6 percent to −6.9 percent. At TSL 2, industry free cash flow is estimated to decrease to $25 million, or a drop of 76 percent, compared to the no-new-standards case value of $103 million in 2028, the year leading up to the estimated compliance date of new and amended energy conservation standards.

Percentage impacts on INPV are moderately negative at TSL 2. DOE estimates that approximately 98 percent of the Integrated Omnidirectional Short product class shipments; 58 percent of the Integrated Omnidirectional Long product class shipments; 73 percent of the Integrated Directional product class shipments; 55 percent of the Non-Integrated Omnidirectional Short product class shipments; and 74 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 2 in 2029, the estimated first full year of compliance of new and amended standards.

DOE does not expect manufacturers to incur any capital conversion costs at TSL 2. At TSL 2, additional LED lamp production capacity is not expected to be needed to meet the expected volume of LED lamp shipments, as GSL manufacturers are expected to produce more LED lamps for every product class in years leading up to 2029 than in 2029, the estimated first full year of compliance of new and amended standards. DOE estimates approximately $220 million in product conversion costs as some LED lamps may need to be re-modeled to meet ELs required at TSL 2. DOE does not estimate any conversion costs for CFL models as GSL manufacturers are expected to discontinue all CFLs for any standard level beyond TSL 1.

At TSL 2, under the preservation of gross margin scenario, the shipment weighted-average MPC increases slightly by approximately 0.1 percent relative to the no-new-standards case MPC. This slight price increase is outweighed by the $220 million in conversion costs estimated at TSL 2, resulting in moderately negative INPV impacts at TSL 2 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, the slight increase in the shipment weighted-average MPC results in a slightly lower average manufacturer markup (slightly smaller than the 1.55 manufacturer markup used in the no-new-standards case). This slightly lower average manufacturer markup and the $220 million in conversion costs result in moderately negative INPV impacts at TSL 2 under the preservation of operating profit scenario.

TSL 3 sets the efficacy level at EL 1 for the Non-Integrated Directional product class; at EL 3 for the Non-Integrated Omnidirectional Short product class, which is ''max-tech'' for the Non-Integrated Omnidirectional Short product class; and at EL 5 for all other product classes (Integrated Omnidirectional Short, Integrated Omnidirectional Long, Integrated Directional), EL 5 is ''max-tech'' for the Integrated Directional product class. At TSL 3, DOE estimates impacts on INPV would range from −$174 million to −$144 million, or a change in INPV of approximately −8.6 percent to −7.1 percent. At TSL 3, industry free cash flow is estimated to decrease to −$26 million, or a drop of 126 percent, compared to the no-new-standards case value of $103 million in 2028, the year leading up to the estimated compliance date of new and amended energy conservation standards.

Percentage impacts on INPV are moderately negative at TSL 3. DOE estimates that approximately 45 percent of the Integrated Omnidirectional Short product class shipments; 29 percent of the Integrated Omnidirectional Long product class shipments; 34 percent of the Integrated Directional product class shipments; 55 percent of the Non-Integrated Omnidirectional Short product class shipments; and 74 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 3 in 2029, the estimated first full year of compliance of new and amended standards.

DOE does not expect manufacturers to incur any capital conversion costs at TSL 3. At TSL 3, additional LED lamp production capacity is not expected to be needed to meet the expected volume of LED lamp shipments, as GSL manufactures are expected to produce more LED lamps for every product class in the years leading up to 2029 than in 2029, the estimated first full year of compliance of new and amended standards. DOE estimates approximately $337 million in product conversion costs as many LED lamps may need to be re-modeled to meet ELs required at TSL 3.

At TSL 3, under the preservation of gross margin scenario, the shipment weighted-average MPC increases moderately by approximately 6.4 percent relative to the no-new-standards case MPC. This moderate price increase is outweighed by the $337 million in conversion costs estimated at TSL 3, resulting in moderately negative INPV impacts at TSL 3 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, the moderate increase in the shipment weighted-average MPC results in a slightly lower average manufacturer markup (slightly smaller than the 1.55 manufacturer markup used in the no-new-standards case). This slightly lower average manufacturer markup and the $337 million in conversion costs result in moderately negative INPV impacts at TSL 3 under the preservation of operating profit scenario.

TSL 4 sets the efficacy level at EL 1 for the Non-Integrated Directional product class; at EL 3 for the Non-Integrated Omnidirectional Short product class, which is ''max-tech'' for the Non-Integrated Omnidirectional Short product class; at EL 5 for the Integrated Omnidirectional Long and Integrated Directional product classes, which is ''max-tech'' for the Integrated Directional product class; and at EL 6 for the Integrated Omnidirectional Short product class. At TSL 4, DOE estimates impacts on INPV would range from −$190 million to −$139 million, or a change in INPV of −9.5 percent to −6.9 percent. At TSL 4, industry free cash flow is estimated to decrease to −$42 million, or a drop of 141 percent, compared to the no-new-standards case value of $103 million in 2028, the year leading up to the estimated compliance date of new and amended energy conservation standards.

Percentage impacts on INPV are moderately negative at TSL 4. DOE estimates that approximately 31 percent of the Integrated Omnidirectional Short product class shipments; 29 percent of the Integrated Omnidirectional Long product class shipments; 34 percent of the Integrated Directional product class shipments; 55 percent of the Non-Integrated Omnidirectional Short product class shipments; and 74 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 4 in 2029, the estimated first full year of compliance of new and amended standards.

DOE does not expect manufacturers to incur any capital conversion costs at TSL 4. At TSL 4, additional LED lamp production capacity is not expected to be needed to meet the expected volume of LED lamp shipments, as GSL manufacturers are expected to produce more LED lamps for every product class in the years leading up to 2029 than in 2029, the estimated first full year of compliance of new and amended standards. DOE estimates approximately $373 million in product conversion costs as many LED lamps may need to be re-modeled to meet ELs required at TSL 4. DOE does not estimate any conversion costs for CFL models as GSL manufacturers are expected to discontinue all CFLs for any standard level beyond TSL 1.

At TSL 4, under the preservation of gross margin scenario, the shipment weighted-average MPC increases moderately by approximately 10.2 percent relative to the no-new-standards case MPC. This moderate price increase is outweighed by the $373 million in conversion costs estimated at TSL 4, resulting in moderately negative INPV impacts at TSL 4 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, the moderate increase in the shipment weighted-average MPC results in a slightly lower average manufacturer markup of 1.54 (compared to the 1.55 manufacturer markup used in the no-new-standards case). This slightly lower average manufacturer markup and the $373 million in conversion costs result in moderately negative INPV impacts at TSL 4 under the preservation of operating profit scenario.

TSL 5 sets the efficacy level at EL 3 for the Non-Integrated Omnidirectional Short and Non-Integrated Directional product classes, which is ''max-tech'' for those product classes; at EL 5 for the

Integrated Omnidirectional Long and Integrated Directional product classes, which is ''max-tech'' for the Integrated Directional product class; and at EL 7 for the Integrated Omnidirectional Short product class, which is ''max-tech'' for this product class. At TSL 5, DOE estimates impacts on INPV would range from −$266 million to −$144 million, or a change in INPV of −13.2 percent to −7.2 percent. At TSL 5, industry free cash flow is estimated to decrease to −$56 million, or a drop of 154 percent, compared to the no-new-standards case value of $103 million in 2028, the year leading up to the estimated compliance date of new and amended energy conservation standards.

Percentage impacts on INPV are moderately negative at TSL 5. DOE estimates that approximately 17 percent of the Integrated Omnidirectional Short product class shipments; 29 percent of the Integrated Omnidirectional Long product class shipments; 34 percent of the Integrated Directional product class shipments; 55 percent of the Non-Integrated Omnidirectional Short product class shipments; and 27 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 5 in 2029, the estimated first full year of compliance of new and amended standards.

DOE does not expect manufacturers to incur any capital conversion costs at TSL 5. At TSL 5, additional LED lamp production capacity is not expected to be needed to meet the expected volume of LED lamp shipments, as GSL manufacturers are expected to produce more LED lamps for every product class in the years leading up to 2029 than in 2029, the estimated first full year of compliance of new and amended standards. DOE estimates approximately $403 million in product conversion costs as many LED lamps may need to be re-modeled to meet ELs required at TSL 5. DOE does not estimate any conversion costs for CFL models as GSL manufacturers are expected to discontinue all CFLs for any standard level beyond TSL 1.

At TSL 5, under the preservation of gross margin scenario, the shipment weighted-average MPC increases moderately by approximately 12.5 percent relative to the no-new-standards case MPC. This moderate price increase is outweighed by the $403 million in conversion costs estimated at TSL 5, resulting in moderately negative INPV impacts at TSL 5 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, the moderate increase in the shipment weighted-average MPC results in a slightly lower average manufacturer markup of 1.53 (compared to the 1.55 manufacturer markup used in the no-new-standards case). This slightly lower average manufacturer markup and the $403 million in conversion costs result in moderately negative INPV impacts at TSL 5 under the preservation of operating profit scenario.

TSL 6 sets the efficacy level at EL 3 for the Non-Integrated Omnidirectional Short and Non-Integrated Directional product classes, which is ''max-tech'' for those product classes; at EL 5 for the Integrated Directional product class, which is ''max-tech''; at EL 6 for the Integrated Omnidirectional Long product classes, which is ''max-tech''; and at EL 7 for the Integrated Omnidirectional Short product class, which is ''max-tech''. At TSL 6, DOE estimates impacts on INPV would range from −$271 million to −$145 million, or a change in INPV of −13.5 percent to −7.2 percent. At TSL 6, industry free cash flow is estimated to decrease to −$58 million, or a drop of 156 percent, compared to the no-new-standards case value of $103 million in 2028, the year leading up to the estimated compliance date of new and amended energy conservation standards.

Percentage impacts on INPV are moderately negative at TSL 6. DOE estimates that approximately 17 percent of the Integrated Omnidirectional Short product class shipments; approximately 14 percent of the Integrated Omnidirectional Long product class shipments; 34 percent of the Integrated Directional product class shipments; 55 percent of the Non-Integrated Omnidirectional Short product class shipments; and 27 percent of the Non-Integrated Directional product class shipments will meet the ELs required at TSL 6 in 2029, the estimated first full year of compliance of new and amended standards.

DOE does not expect manufacturers to incur any capital conversion costs at TSL 6. At TSL 6, additional LED lamp production capacity is not expected to be needed to meet the expected volume of LED lamp shipments, as GSL manufacturers are expected to produce more LED lamps for every product class in the years leading up to 2029 than in 2029, the estimated first full year of compliance of new and amended standards. DOE estimates approximately $407 million in product conversion costs as most LED lamps may need to be re-modeled to meet ELs required at TSL 6. DOE does not estimate any conversion costs for CFL models as GSL manufacturers are expected to discontinue all CFLs for any standard level beyond TSL 1.

At TSL 6, under the preservation of gross margin scenario, the shipment weighted-average MPC increases moderately by approximately 12.7 percent relative to the no-new-standards case MPC. This moderate price increase is outweighed by the $407 million in conversion costs estimated at TSL 6, resulting in moderately negative INPV impacts at TSL 6 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, the moderate increase in the shipment weighted-average MPC results in a slightly lower average manufacturer markup of 1.53 (compared to the 1.55 manufacturer markup used in the no-new-standards case). This slightly lower average manufacturer markup and the $407 million in conversion costs result in moderately negative INPV impacts at TSL 6 under the preservation of operating profit scenario.

b. Direct Impacts on Employment

Based on previous manufacturer interviews and public comments from GSL rulemaking documents previously published, DOE determined that there are no GSL manufacturers that manufacture CFLs in the United States, as all CFLs sold in the United States are manufactured abroad. Some of these CFL manufacturing facilities are owned by the GSL manufacturer and others outsource their CFL production to original equipment manufacturers located primarily in Asia. However, several GSL manufacturers that sell CFLs in the United States have domestic employees responsible for the R&D, marketing, sales, and distribution of CFLs.

In the March 2016 NOPR, DOE estimated that there would be approximately 100 domestic employees dedicated to the non-production aspects of CFLs in 2020, the estimated compliance year of the March 2016 NOPR analysis.[82] Due to the ongoing decline in CFL shipments since the March 2016 NOPR, the shipments analysis for this NOPR projects that CFL shipments will decline by more than two-thirds between 2020, the estimated compliance year of the March 2016 NOPR, and 2029, the estimated first full year of compliance in this NOPR analysis. Therefore, in this NOPR analysis, DOE estimated that in the no-new-standards case there could be approximately 30 domestic employees dedicated to the non-production aspects of CFLs in 2029, the estimated first full

[82] 81 FR 14528, 14609.

year of compliance for this NOPR analysis.[83] For this NOPR analysis, DOE estimates GSL manufacturers selling CFLs in the U. S. could reduce or eliminate up to 30 domestic non-production employees if CFLs are not able to meet the adopted new and amended standards.[84]

While most LED lamp manufacturing is done abroad, there is a limited number of LED lamps and LED lamp components covered by this rulemaking that are manufactured domestically. DOE assumed that all GSL manufacturers selling LED lamps in the U.S. would not reduce or eliminate any domestic production or non-production employees involved in manufacturing or selling LED lamps due to any of the analyzed TSLs in this NOPR. DOE did not estimate the potential increase in domestic production employment due to energy conservation standards, as existing domestic LED lamp manufacturing represents a small portion of LED lamp manufacturing overall and would not necessarily increase as LED lamp sales increase.

DOE seeks comment on the assumption that there are no GSL manufacturers manufacturing CFLs in the United States. Additionally, DOE requests comment on the assumption that up to 30 domestic non-production employees are involved in the R&D, marketing, sales, and distribution of CFLs in the United States, which may be eliminated if energy conservation standards are set at TSL 2 or higher. Lastly, DOE seeks comment on the assumption that GSL manufacturers would not reduce or eliminate any domestic production or non-production employees involved in manufacturing or selling LED lamps due to any of the analyzed TSLs in this NOPR. *See* section IX.E for a list of issues on which DOE seeks comment.

c. Impacts on Manufacturing Capacity

Based on the NOPR shipments analysis, the quantity of LED lamps sold for all product classes reaches approximately 751 million in 2022 and then declines to approximately 397 million by 2029, the estimated first full year of compliance for this NOPR analysis, in the no-new-standards case. This represents a decrease of approximately 47 percent from 2022 to 2029. Based on the NOPR shipments analysis, while all TSLs project an increase in number of LED lamps sold in 2029 (in the standards cases) compared to the no-new standards case, the number of LED lamps sold in 2029 (for all TSLs), is smaller than the number of LED lamps sold in the years leading up to 2029. Therefore, DOE assumed that GSL manufacturers would be able to maintain their 2028 LED lamp production capacity in 2029 and manufactures would be able to meet the LED lamp production capacity for all TSLs in 2029.

DOE does not anticipate that manufacturing the same, or slightly fewer, quantity of LED lamps that are more efficacious would impact the production capacity for LED manufacturers.

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 manufacturers, and manufacturers exhibiting a cost structure substantially different from the industry average could be affected disproportionately. DOE used the results of the industry characterization to group manufacturers exhibiting similar characteristics. Consequently, DOE identified small business manufacturers as a subgroup for a separate impact analysis.

For the small business subgroup analysis, DOE applied the small business size standards published by the Small Business Administration (SBA) to determine whether a company is considered a small business. The size standards are codified at 13 CFR part 121. To be categorized as a small business under North American Industry Classification System (NAICS) code 335139, ''electric lamp bulb and other lighting equipment manufacturing'' a GSL manufacturer and its affiliates may employ a maximum of 1,250 employees. The 1,250-employee threshold includes all employees in a business's parent company and any other subsidiaries. DOE identified more than 300 GSL manufacturers that qualify as small businesses.

The small business subgroup analysis is discussed in more detail in section VIII.B and in chapter 11 of the NOPR TSD.

e. Cumulative Regulatory Burden

One aspect of assessing manufacturer burden involves looking at the cumulative impact of multiple DOE standards and the product-specific regulatory actions of other Federal agencies that affect the manufacturers of a covered product or equipment. While any one regulation may not impose a significant burden on manufacturers, the combined effects of several existing or impending regulations may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. In the cumulative regulatory burden (CRB) analysis, DOE considers burdens associated with meeting other Federal, product-specific regulations that occur within the CRB timeframe. The CRB timeframe is the seven-year period that covers the three years before the compliance year, the compliance year, and the three years after the compliance year of the proposed standard.

DOE acknowledges that most GSL manufacturers also make other lighting products that are subject to energy conservation standards set by DOE. Thus, DOE assesses regulations that could affect GSL manufacturers that will take effect three years prior to and three years after the estimated compliance date of any new GSL standards. For this analysis, DOE was not able to identify any potential energy conservation standard for other products or equipment manufactured by GSL manufacturers that is scheduled to require compliance between 2025 and 2031. However, DOE has ongoing rulemakings for other products that GSL manufacturers produce that could result in amended energy conservation standards. These rulemakings include ceiling fans[85] and ceiling fan light kits.[86] If DOE proposes or finalizes any energy conservation standards for these products prior to finalizing energy conservation standards for GSLs, DOE will include the energy conservation standards for these other products as part of the cumulative regulatory burden for the GSL final rule.

DOE requests information regarding the impact of cumulative regulatory burden on manufacturers of GSLs associated with multiple DOE standards or product-specific regulatory actions of other Federal agencies, specifically if these standards occur within three years prior to and after 2028. *See* section IX.E for a list of issues on which DOE seeks comment.

[83] DOE assumed the number of domestic non-production employees scales with the number of CFL shipments. Therefore, a two-third reduction in CFL shipments between 2020 and 2029, would cause a two-third reduction in domestic non-production employees.

[84] DOE assumed most, if not all, CFLs would not be able to meet standards if energy conservation standards are set at TSL 2 or higher. The majority of CFLs projected to be sold in 2029 (the estimated compliance year) are in the Integrated Omnidirectional-Short product class.

[85] *www.regulations.gov/docket/EERE-2021-BT-STD-0011.*

[86] *www.regulations.gov/docket/EERE-2019-BT-STD-0040.*

3. National Impact Analysis

This section presents DOE's estimates of the national energy savings and the NPV of consumer benefits that would result from each of the TSLs considered as potential amended standards.

a. Significance of Energy Savings

To estimate the energy savings attributable to potential amended standards for GSLs, DOE compared their energy consumption 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 first full year of anticipated compliance with amended standards (2029–2058). Table VII.17 presents DOE's projections of the national energy savings for each TSL considered for GSLs. The savings were calculated using the approach described in section VI.H of this document.

TABLE VII.17—CUMULATIVE NATIONAL ENERGY SAVINGS FOR GSLS; 30 YEARS OF SHIPMENTS (2029–2058)

	Product class	Trial standard level					
		1	2	3	4	5	6
		quads					
Primary Energy Savings	Integrated Omnidirectional Short	0.095	0.136	2.336	2.859	3.114	3.114
	Integrated Omnidirectional Long	0.050	0.113	0.185	0.185	0.185	0.205
	Integrated Directional	0.004	0.235	0.490	0.490	0.490	0.490
	Non-integrated Omnidirectional	0.000	0.003	0.003	0.003	0.003	0.003
	Non-integrated Directional	0.009	0.009	0.009	0.009	0.020	0.020
	Total	0.159	0.496	3.024	3.546	3.812	3.832
FFC Energy Savings	Integrated Omnidirectional Short	0.099	0.141	2.427	2.970	3.236	3.236
	Integrated Omnidirectional Long	0.052	0.117	0.192	0.192	0.192	0.213
	Integrated Directional	0.005	0.244	0.510	0.510	0.510	0.510
	Non-integrated Omnidirectional	0.000	0.003	0.003	0.003	0.003	0.003
	Non-integrated Directional	0.010	0.010	0.010	0.010	0.021	0.021
	Total	0.165	0.515	3.141	3.684	3.961	3.981

OMB Circular A–4 [87] 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 9 years, rather than 30 years, of product shipments. The choice of a 9-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.[88] 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 9-year analytical period are presented in Table VII.18. The impacts are counted over the lifetime of GSLs purchased in 2029–2037.

TABLE VII.18—CUMULATIVE NATIONAL ENERGY SAVINGS FOR GSLS; 9 YEARS OF SHIPMENTS (2029–2037)

	Product class	Trial standard level					
		1	2	3	4	5	6
		quads					
Primary Energy Savings	Integrated Omnidirectional Short	0.029	0.041	0.343	0.724	0.891	0.981
	Integrated Omnidirectional Long	0.025	0.055	0.086	0.086	0.086	0.087
	Integrated Directional	0.001	0.061	0.134	0.134	0.134	0.134
	Non-integrated Omnidirectional	0.000	0.003	0.003	0.003	0.003	0.003
	Non-integrated Directional	0.003	0.003	0.003	0.003	0.003	0.008
	Total	0.059	0.163	0.569	0.950	1.117	1.213
FFC Energy Savings	Integrated Omnidirectional Short	0.030	0.043	0.356	0.752	0.926	1.020
	Integrated Omnidirectional Long	0.026	0.058	0.090	0.090	0.090	0.090
	Integrated Directional	0.001	0.063	0.139	0.139	0.139	0.139
	Non-integrated Omnidirectional	0.000	0.003	0.003	0.003	0.003	0.003
	Non-integrated Directional	0.004	0.004	0.004	0.004	0.004	0.008

[87] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. *https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf* (last accessed March 25, 2022).

[88] 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 products, the compliance period is 5 years rather than 3 years.

TABLE VII.18—CUMULATIVE NATIONAL ENERGY SAVINGS FOR GSLS; 9 YEARS OF SHIPMENTS (2029–2037)—Continued

	Product class	Trial standard level 1	2	3	4	5	6
		quads					
	Total	0.061	0.170	0.592	0.988	1.162	1.260

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,[89] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table VII.19 shows the consumer NPV results with impacts counted over the lifetime of products purchased in 2029–2058.

TABLE VII.19—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR GSLS; 30 YEARS OF SHIPMENTS (2029–2058)

Discount rate	Product class	Trial standard level 1	2	3	4	5	6
		Billion $2021					
3 percent	Integrated Omnidirectional Short	0.731	1.062	11.622	13.969	15.141	15.141
	Integrated Omnidirectional Long	0.179	0.369	0.523	0.523	0.523	0.415
	Integrated Directional	0.065	2.213	4.737	4.737	4.737	4.737
	Non-integrated Omnidirectional	0.001	0.017	0.017	0.017	0.017	0.017
	Non-integrated Directional	0.034	0.034	0.035	0.035	0.063	0.063
	Total	1.010	3.694	16.937	19.283	20.483	20.373
7 percent	Integrated Omnidirectional Short	0.296	0.431	4.031	4.810	5.208	5.208
	Integrated Omnidirectional Long	0.074	0.143	0.179	0.179	0.179	0.081
	Integrated Directional	0.029	0.908	1.976	1.976	1.976	1.976
	Non-integrated Omnidirectional	0.001	0.009	0.009	0.009	0.009	0.009
	Non-integrated Directional	0.011	0.011	0.012	0.012	0.018	0.018
	Total	0.411	1.503	6.207	6.986	7.391	7.294

The NPV results based on the aforementioned 9-year analytical period are presented in Table VII.20. The impacts are counted over the lifetime of products purchased in 2029–2037. 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 VII.20 CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR GSLS; 9 YEARS OF SHIPMENTS (2029–2037)

Discount rate	Product class	Trial standard level 1	2	3	4	5	6
		Billion $2021					
3 percent	Integrated Omnidirectional Short	0.270	0.391	2.218	4.772	5.708	6.216
	Integrated Omnidirectional Long	0.104	0.205	0.266	0.266	0.266	0.157
	Integrated Directional	0.023	0.769	1.731	1.731	1.731	1.731
	Non-integrated Omnidirectional	0.001	0.017	0.017	0.017	0.017	0.017
	Non-integrated Directional	0.015	0.015	0.015	0.015	0.015	0.028
	Total	0.414	1.397	4.246	6.801	7.738	8.149
7 percent	Integrated Omnidirectional Short	0.143	0.207	1.017	2.196	2.596	2.814
	Integrated Omnidirectional Long	0.050	0.092	0.102	0.102	0.102	0.015
	Integrated Directional	0.014	0.424	0.960	0.960	0.960	0.960
	Non-integrated Omnidirectional	0.001	0.009	0.009	0.009	0.009	0.009
	Non-integrated Directional	0.006	0.006	0.006	0.006	0.006	0.010
	Total	0.214	0.739	2.095	3.273	3.674	3.809

[89] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. *https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf* (last accessed March 25, 2022).

The previous results reflect the use of a default trend to estimate the change in price for GSLs over the analysis period (*see* section VI.G, VI.H of this document). As part of the NIA, DOE also analyzed a high and low benefits scenarios that use inputs from variants of the *AEO 2022* Reference case. For the high benefits scenario, DOE uses the *AEO 2022* High Economic Growth scenario, which has a higher energy price trend relative to the Reference case, as well as a lower price learning rate. The lower learning rate in this scenario slows down the adoption of more efficacious lamp options in the no-new-standards case, increasing the available energy savings attributable to a standard. For the low benefits scenario, DOE uses the *AEO 2022* Low Economic Growth scenario, which has a lower energy price trend relative to the Reference case, as well as a higher price learning rate. The higher learning rate in this scenario accelerates the adoption of more efficacious lamp options in the no-new-standards case (relative to the reference scenario) decreasing the available energy savings attributable to a standard. NIA results based on these cases are presented in appendix 9C of the NOPR TSD.

c. Indirect Impacts on Employment

It is estimated that amended energy conservation standards for GSLs would reduce energy expenditures 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 VI.M 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. 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 (2029–2032), where these uncertainties are reduced.

The results suggest that the proposed standards would be 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 15 of the NOPR TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

As discussed in section IV.C.1.b of this document, DOE has tentatively concluded that the standards proposed in this NOPR would not lessen 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.

5. Impact of Any Lessening of Competition

DOE considered any lessening of competition that would be likely to result from new or amended standards. 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 this 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. DOE invites comment from the public regarding the competitive impacts that are likely to result from this proposed rule. In addition, stakeholders may also provide comments separately to DOJ regarding these potential impacts. *See* the **ADDRESSES** section for information to send comments to DOJ.

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. Chapter 14 in the NOPR TSD presents the estimated impacts on electricity generating capacity, relative to the no-new-standards case, for the TSLs that DOE considered in this rulemaking.

Energy conservation resulting from potential energy conservation standards for GSLs is expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table VII.21 provides DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this rulemaking. The emissions were calculated using the multipliers discussed in section VI.K. DOE reports annual emissions reductions for each TSL in chapter 12 of the NOPR TSD.

TABLE VII.21—CUMULATIVE EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2029–2058

	Trial standard level					
	1	2	3	4	5	6
Power Sector Emissions						
CO_2 (*million metric tons*)	5.07	15.72	95.56	112.20	120.70	121.21
SO_2 (*thousand tons*)	2.41	7.54	46.19	54.31	58.44	58.63
NO_X (*thousand tons*)	2.55	7.83	47.36	55.66	59.91	60.11
Hg (*tons*)	0.02	0.05	0.31	0.36	0.39	0.40
CH_4 (*thousand tons*)	0.39	1.22	7.43	8.73	9.40	9.43
N_2O (*thousand tons*)	0.066	0.17	1.04	1.22	1.31	1.32
Upstream Emissions						
CO_2 (*million metric tons*)	0.39	1.22	7.44	8.72	9.389	9.43
SO_2 (*thousand tons*)	0.03	0.08	0.50	0.59	0.64	0.65
NO_X (*thousand tons*)	5.96	18.55	112.89	132.30	142.22	142.94
Hg (*tons*)	0.00	0.00	0.00	0.00	0.00	0.00
CH_4 (*thousand tons*)	37.19	115.79	705.02	826.81	888.80	893.33

TABLE VII.21—CUMULATIVE EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2029–2058—Continued

	Trial standard level					
	1	2	3	4	5	6
N_2O (*thousand tons*)	0.00	0.01	0.04	0.04	0.05	0.05
Total FFC Emissions						
CO_2 (*million metric tons*)	5.46	16.95	103.011	120.92	130.08	130.63
SO_2 (*thousand tons*)	2.44	7.62	46.70	54.90	59.08	59.27
NO_X (*thousand tons*)	8.50	26.36	160.17	187.96	202.13	203.05
Hg (*tons*)	0.02	0.05	0.31	0.36	0.39	0.39
CH_4 (*thousand tons*)	37.58	117.01	712.45	835.54	898.21	902.76
N_2O (*thousand tons*)	0.06	0.18	1.08	1.26	1.36	1.36

As part of the analysis for this rulemaking, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 that DOE estimated for each of the considered TSLs for GSLs. Section VI.L of this document discusses the SC–CO_2 values that DOE used. Table VII.22 presents the value of CO_2 emissions reduction at each TSL for each of the SC–CO_2 cases. The time-series of annual values is presented for the proposed TSL in chapter 13 of the NOPR TSD.

TABLE VII.22—PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2029–2058

TSL	SC–CO_2 Case discount rate and statistics			
	5% Average	3% Average	2.5% Average	3% 95th percentile
	Billion 2021$			
1	0.05	0.21	0.33	0.65
2	0.14	0.64	1.01	1.94
3	0.84	3.76	5.94	11.40
4	0.99	4.42	7.00	13.42
5	1.07	4.77	7.54	14.47
6	1.07	4.79	7.57	14.52

As discussed in section VI.L.2, DOE estimated monetary benefits likely to result from the reduced emissions of methane and N_2O that DOE estimated for each of the considered TSLs for GSLs. Table VII.23 presents the value of the CH_4 emissions reduction at each TSL, and Table VII.24 presents the value of the N_2O emissions reduction at each TSL. The time-series of annual values is presented for the proposed TSL in chapter 13 of the NOPR TSD.

TABLE VII.23—PRESENT VALUE OF METHANE EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2029–2058

TSL	SC–CH_4 Case discount rate and statistics			
	5% Average	3% Average	2.5% Average	3% 95th percentile
	Billion 2021$			
1	0.02	0.05	0.07	0.12
2	0.05	0.14	0.20	0.38
3	0.27	0.84	1.19	2.23
4	0.32	0.99	1.40	2.62
5	0.34	1.07	1.51	2.83
6	0.34	1.07	1.51	2.84

TABLE VII.24—PRESENT VALUE OF NITROUS OXIDE EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2029–2058

TSL	SC–N_2O Case discount rate and statistics			
	5% Average	3% Average	2.5% Average	3% 95th percentile
	Billion 2021$			
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.01
3	0.00	0.01	0.02	0.04

TABLE VII.24—PRESENT VALUE OF NITROUS OXIDE EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2029–2058—Continued

TSL	SC–N_2O Case discount rate and statistics			
	5% Average	3% Average	2.5% Average	3% 95th percentile
	Billion 2021$			
4	0.00	0.02	0.03	0.04
5	0.00	0.02	0.03	0.05
6	0.00	0.02	0.03	0.05

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 GHG emissions in this rulemaking is subject to change. That said, because of omitted damages, DOE agrees with the IWG that these estimates most likely underestimate the climate benefits of greenhouse gas reductions. DOE, together with other Federal agencies, will continue to review 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. DOE notes that the proposed standards would be economically justified even without inclusion of monetized benefits of reduced GHG emissions.

DOE also estimated the monetary value of the health benefits associated with NO_X and SO_2 emissions reductions anticipated to result from the considered TSLs for GSLs. The dollar-per-ton values that DOE used are discussed in section VI.L.2 of this document. Table VII.25 presents the present value for NO_X emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates, and Table VII.26 presents similar results for SO_2 emissions reductions. The results in these tables reflect application of EPA's low dollar-per-ton values, which DOE used to be conservative. The time-series of annual values is presented for the proposed TSL in chapter 13 of the NOPR TSD.

TABLE VII.25—PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2029–2058

TSL	3% Discount rate	7% Discount rate
	Million 2021$	
1	128.52	328.95
2	361.78	977.41
3	1,999.29	5,694.00
4	2,364.15	6,705.13
5	2,558.94	7,231.34
6	2,556.26	7,254.16

TABLE VII.26—PRESENT VALUE OF SO_2 EMISSIONS REDUCTION FOR GSLS SHIPPED IN 2029–2058

TSL	3% Discount rate	7% Discount rate
	Million 2021$	
1	50.32	127.15
2	142.19	380.10
3	793.83	2,235.21
4	940.53	2,636.87
5	1,018.93	2,846.03
6	1,016.18	2,850.98

DOE has not considered the monetary benefits of the reduction of Hg for this NOPR. Not all the public health and environmental benefits from the reduction of greenhouse gases, NOx, and SO_2 are captured in the values above, and additional unquantified benefits from the reductions of those pollutants as well as from the reduction of Hg, direct PM, and other co-pollutants may be significant.

DOE emphasizes that the emissions analysis, including the SC–GHG analysis, presented in this NOPR and TSD was performed in support of the cost-benefit analyses required by Executive Order 12866, and is provided to inform the public of the impacts of emissions reductions resulting from this each TSL considered.

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 Economic Impacts

Table VII.27 presents the NPV values that result from adding the monetized estimates of the potential economic, climate, and health benefits resulting from reduced GHG, SO_2, and NO_X emissions to the NPV of consumer benefits calculated for each TSL considered in this rulemaking. The consumer benefits are domestic U.S. monetary savings that occur as a result of purchasing the covered GSLs, and are measured for the lifetime of products shipped in 2029–2058. The climate benefits associated with reduced GHG emissions resulting from the adopted standards are global benefits, and are also calculated based on the lifetime of GSLs shipped in 2029–2058. The climate benefits associated with four SC–GHG estimates are shown. DOE does not have a single central SC–GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates.

TABLE VII.27—CONSUMER NPV COMBINED WITH MONETIZED CLIMATE AND HEALTH BENEFITS FROM EMISSIONS REDUCTIONS

[Billions 2021$]

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
3% discount rate for NPV of Consumer and Health Benefits (billion 2021$)						
5% d.r., Average SC–GHG case	1.53	5.24	25.98	29.94	31.97	31.90
3% d.r., Average SC–GHG case	1.73	5.84	29.48	34.06	36.42	36.36
2.5% d.r., Average SC–GHG case	1.87	6.26	32.02	37.05	39.64	39.59
3% d.r., 95th percentile SC–GHG case	2.24	7.38	38.53	44.72	47.91	47.89
7% discount rate for NPV of Consumer and Health Benefits (billion 2021$)						
5% d.r., Average SC–GHG case	0.65	2.20	10.11	11.60	12.38	12.28
3% d.r., Average SC–GHG case	0.85	2.79	13.62	15.72	16.83	16.74
2.5% d.r., Average SC–GHG case	0.99	3.22	16.16	18.71	20.05	19.98
3% d.r., 95th percentile SC–GHG case	1.37	4.33	22.67	26.38	28.32	28.28

C. Conclusion

When considering new or amended energy conservation standards, the 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 and resulted in the maximum improvement in energy efficiency. Where the max-tech level was not economically justified or did not result in the maximum improvement in energy efficiency, DOE then considered the next most efficient level and undertook the same evaluation until it reached the efficiency level that represented the maximum improvement in energy efficiency that is technologically feasible and economically justified and saves a significant amount of energy. DOE refers to this process as the ''walk-down'' analysis.

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 tradeoffs, 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 standard 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 8 of the NOPR TSD. However, DOE's current analysis does not explicitly control for heterogeneity in consumer preferences, preferences across subcategories of products or specific features, or consumer price sensitivity variation according to household income.[90]

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.[91] 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.

1. Benefits and Burdens of TSLs Considered for GSLs Standards

Table VII.28 and Table VII.29 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 first full year of compliance with amended standards 2029–2058. The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. DOE exercises its own judgment in presenting monetized climate benefits as recommended in applicable Executive Orders and DOE would reach the same conclusion presented in this rulemaking in the absence of the social cost of greenhouse gases, including the February 2021 Interim Estimates presented by the Interagency Working Group on the Social Cost of Greenhouse Gases. The efficiency levels contained in each TSL are described in section VII.A of this document.

TABLE VII.28—SUMMARY OF ANALYTICAL RESULTS FOR GSL TSLS: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Cumulative FFC National Energy Savings						
Quads	0.17	0.52	3.14	3.68	3.96	3.98
Cumulative FFC Emissions Reduction						
CO_2 (*million metric tons*)	5.5	16.9	103.0	120.9	130.1	130.6
CH_4 (*thousand tons*)	37.6	117.0	712.4	835.5	898.2	902.8
N_2O (*thousand tons*)	0.1	0.2	1.1	1.3	1.4	1.4
SO_2 (*thousand tons*)	2.4	7.6	46.7	54.9	59.1	59.3
NO_X (*thousand tons*)	8.5	26.4	160.2	188.0	202.1	203.0
Hg (*tons*)	0.0	0.0	0.3	0.4	0.4	0.4
Present Value of Benefits and Costs (*3% discount rate, billion 2021$*)						
Consumer Operating Cost Savings	1.0	3.2	19.5	23.1	24.9	25.0
Climate Benefits *	0.3	0.8	4.6	5.4	5.9	5.9
Health Benefits **	0.5	1.4	7.9	9.3	10.1	10.1
Total Benefits †	1.8	5.4	32.1	37.9	40.9	41.0
Consumer Incremental Product Costs ‡	0.0	−0.5	2.6	3.8	4.4	4.6
Consumer Net Benefits	1.0	3.7	16.9	19.3	20.5	20.4
Total Net Benefits	1.7	5.8	29.5	34.1	36.4	36.4
Present Value of Benefits and Costs (*7% discount rate, billion 2021$*)						
Consumer Operating Cost Savings	0.4	1.3	7.5	8.9	9.7	9.7
Climate Benefits *	0.3	0.8	4.6	5.4	5.9	5.9
Health Benefits **	0.2	0.5	2.8	3.3	3.6	3.6
Total Benefits†	0.9	2.6	14.9	17.7	19.1	19.1
Consumer Incremental Product Costs ‡	0.0	−0.2	1.3	2.0	2.3	2.4
Consumer Net Benefits	0.4	1.5	6.2	7.0	7.4	7.3
Total Net Benefits	0.9	2.8	13.6	15.7	16.8	16.7

Note: This table presents the costs and benefits associated with GSLs shipped in 2029−2058. These results include benefits to consumers which accrue after 2058 from the products shipped in 2029–2058.

[90] P.C. Reiss and M.W. White. Household Electricity Demand, Revisited. *Review of Economic Studies*. 2005. 72(3): pp. 853–883. doi: *10.1111/0034–6527.00354*.

[91] Sanstad, A.H. *Notes on the Economics of Household Energy Consumption and Technology Choice*. 2010. Lawrence Berkeley National Laboratory. *www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf* (last accessed March 25, 2022).

* Climate benefits are calculated using four different estimates of the SC–CO_2, SC–CH_4 and SC–N_2O. Together, these represent the global SC–GHG. For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions As reflected in this proposed rule, DOE has reverted to its approach prior to the injunction and presents monetized greenhouse gas abatement benefits where appropriate and permissible under law.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for NO_X and SO_2) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. See section VI.L of this document for more details.

† Total benefits include consumer, climate, and health benefits. Total benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, but the Department does not have a single central SC–GHG point estimate. DOE emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates. See Table VII.27 for net benefits using all four SC–GHG estimates.

‡ Costs include incremental equipment costs as well as installation costs. Negative increment cost increases reflect a lower total first cost under a particular standard for GSLs shipped in 2029–2058. Several factors contribute to this, including that certain lamp option at higher ELs are less expensive than certain lamp options at lower ELs that would be eliminated under a particular standard level, the relative decrease in price of LED lamp options compared to less efficient CFL options due to price learning, and the longer lifetime of LED lamp options resulting in fewer purchases over the analysis period.

TABLE VII.29—SUMMARY OF ANALYTICAL RESULTS FOR GSL TSLS: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Manufacturer Impacts						
Industry NPV (*million 2021$*) (No-new-standards case INPV = 2,014)	1,964–1,968	1,880–1,874	1,838–1,868	1,821–1,873	1,745–1,868	1,741–1,867
Industry NPV *(% change*)	(2.5)–(2.3)	(6.6)–(6.9)	(8.6)–(7.1)	(9.5)–(6.9)	(13.2)–(7.2)	(13.5)–(7.2)
Consumer Average LCC Savings (***2021$***)						
Integrated Omnidirectional Short	1.95	2.42	0.55	0.62	0.66	0.66
Integrated Omnidirectional Long	1.35	2.27	3.63	3.63	3.63	4.53
Integrated Directional	8.92	1.65	3.09	3.09	3.09	3.09
Non-integrated Omnidirectional	4.93	6.62	6.62	6.62	6.62	6.62
Non-integrated Directional	0.48	0.48	0.48	0.48	0.52	0.52
Shipment-Weighted Average *	2.77	2.30	1.18	1.24	1.26	1.32
Consumer Simple PBP (***years***)						
Integrated Omnidirectional Short	0.5	0.2	0.5	0.7	0.8	0.8
Integrated Omnidirectional Long	3.4	2.5	2.8	2.8	2.8	3.0
Integrated Directional	0.0	0.0	0.0	0.0	0.0	0.0
Non-integrated Omnidirectional	**>6.6	2.1	2.1	2.1	2.1	2.1
Non-integrated Directional	2.5	2.5	2.5	2.5	3.4	3.4
Shipment-Weighted Average *	0.8	0.4	0.7	0.8	0.9	0.9
Percent of Consumers that Experience a Net Cost						
Integrated Omnidirectional Short	0.8%	1.2%	18.0%	19.0%	19.8%	19.8%
Integrated Omnidirectional Long	4.2%	6.6%	4.9%	4.9%	4.9%	5.1%
Integrated Directional	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Non-integrated Omnidirectional	9.4%	0.2%	0.2%	0.2%	0.2%	0.2%
Non-integrated Directional	14.6%	14.6%	14.6%	14.6%	24.2%	24.2%
Shipment-Weighted Average *	1.2%	1.7%	14.4%	15.1%	15.8%	15.9%

Parentheses indicate negative (−) values.

* Weighted by shares of each product class in total projected shipments in 2029.

** Two lamp options exist at the minimum EL for TSL 1. One lamp option has a simple payback period of 6.6 years, and the other lamp has an infinite simple payback period. The aggregated simple payback period is therefore reported as greater than 6.6 years. Note that the shipment-weighted average (two rows below) assumes a defined value of 6.6 years for Non-integrated Omnidirectional lamps at TSL 1.

DOE first considered TSL 6, which represents the max-tech efficiency levels for all product classes. At this level, DOE expects that all product classes would require the most efficacious LED technology current available on the market. DOE estimates that approximately 17 percent of annual shipments across all GSL product classes currently meet the max-tech efficiencies required. TSL 6 would save an estimated 3.98 quads of energy, an amount DOE considers significant. Under TSL 6, the NPV of consumer benefit would be $7.3 billion using a discount rate of 7 percent, and $20.4 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 6 are 130.6 Mt of CO_2, 59.3 thousand tons of SO_2, 203.0 thousand tons of NO_X, 0.4 tons of Hg, 902.8 thousand tons of CH_4, and 1.4 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC–GHG at a 3-percent discount rate) at TSL 6 is $5.9 billion. The estimated monetary value of the health benefits from reduced SO_2 and

NO_X emissions at TSL 6 is $3.6 billion using a 7-percent discount rate and $10.1 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 6 is $16.7 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 6 is $36.4 billion. The estimated total NPV is provided for additional information, however DOE primarily relies upon the NPV of consumer benefits when determining whether a proposed standard level is economically justified.

At TSL 6 in the residential sector, the largest product classes are Integrated Omnidirectional Short GSLs, including traditional pear-shaped, candle-shaped, and globe-shaped GSLs, and Integrated Directional GSLs, including reflector lamps commonly used in recessed cans, which together account for 99 percent of annual shipments. The average LCC impact is a savings of $0.59 and $3.01 and a simple payback period of 0.8 years, and 0.0 years, respectively, for those product classes. The fraction of purchases associated with a net LCC cost is 22.0 percent and 0.0 percent, respectively. In the commercial sector, the largest product classes are Integrated Omnidirectional Short GSLs and Integrated Omnidirectional Long GSLs, including tubular LED GSLs often referred to as TLEDs, which together account for 91 percent of annual shipments. The average LCC impact is a savings of $1.11 and $4.74 and a simple payback period of 0.5 years and 2.9 years, respectively, for those product classes. The fraction of purchases associated with a net LCC cost is 4.8 and 2.3 percent, respectively. Overall, 15.9 percent of GSL purchases are associated with a net cost and the average LCC savings are positive for all product classes.

At TSL 6, an estimated 21.0 percent of purchases of Integrated Omnidirectional Short GSLs and 0.0 percent of purchases of Integrated Directional GSLs by low-income households are associated with a net cost. While 21.0 percent of purchases of Integrated Omnidirectional Short GSLs by low-income households would be associated with a net cost, DOE notes that a third of those purchases have a net cost of no more than $0.25 and over 75 percent of those purchases have a net cost of no more than $1.00. Moreover, DOE notes that the typical low-income household has multiple Integrated Omnidirectional Short GSLs. Based on the average total number of lamps in a low-income household (23, based on RECS 2015) and the average fraction of lamps in the residential sector that are Integrated Omnidirectional Short GSLs (84 percent, based on DOE's shipments analysis), DOE estimates that low-income households would have approximately 19 Integrated Omnidirectional Short GSLs, on average. An analysis accounting for multiple lamp purchases would show significantly fewer low-income consumers experience a net cost at the household level than on a per-purchase basis. For example, assuming low-income households purchase two lamps per year over a period of seven years (corresponding to the average service life of the baseline Integrated Omnidirectional Short lamp), DOE estimates that only 6.0 percent of low-income households would experience a net cost and 94.0 percent would experience a net benefit.

At TSL 6, the projected change in INPV ranges from a decrease of $271 million to a decrease of $145 million, which corresponds to decreases of 13.5 percent and 7.2 percent, respectively. DOE estimates that approximately 83 percent of Integrated Omnidirectional Short shipments; approximately 86 percent of the Integrated Omnidirectional Long shipments; approximately 66 percent of the Integrated Directional shipments; approximately 45 percent of the Non-Integrated Omnidirectional-Short shipments; approximately 73 percent Non-Integrated Directional shipments are estimated to not meet the ELs analyzed at TSL 6 by 2029, the estimated first full year of compliance.

DOE estimates that industry must invest approximately $407 million to redesign these non-compliant models into compliant models in order to meet the ELs analyzed at TSL 6. DOE assumed that most, if not all, LED lamp models would be remodeled between the estimated publication of this rulemaking's final rule and the estimated date which energy conservation standards are required, even in the absence of DOE energy conservation standards for GSLs. Therefore, GSL energy conservation standards set at TSL 6 would require GSL manufacturers to remodel their GSL models to a higher efficacy level during their regularly scheduled remodel cycle, due to energy conservation standards. GSL manufacturers would incur additional engineering resources to redesign their LED lamps to meet this higher efficacy requirement. DOE did not estimate that GSL manufacturers would incur any capital conversion costs as the volume of LED lamps manufactured in 2029 would be fewer than the volume of LED lamps manufactured in the previous year, 2028, even at TSL 6. Additionally, DOE did not estimate that manufacturing more efficacious LED lamps would require additional or different capital equipment or tooling.

After considering the analysis and weighing the benefits and burdens, the Secretary has tentatively concluded that a standard set at TSL 6 for GSLs would result in the maximum improvement in energy efficiency that is technologically feasible and economically justified. At this TSL, the average LCC savings for all product classes is positive. An estimated 15.9 percent of all GSL purchases are associated with a net cost. While 21.0 percent of purchases of Integrated Omnidirectional Short GSLs by low-income households would be associated with a net cost, a third of those purchases have a net cost of no more than $0.25 and over 75 percent of those purchases have a net cost of no more than $1.00. And significantly fewer low-income consumers experience a net cost at the household level after accounting for multiple lamp purchases. The FFC national energy savings of 3.98 quads are significant and the NPV of consumer benefits is positive using both a 3-percent and 7-percent discount rate. Notably, the benefits to consumers vastly outweigh the decrease in manufacturers' INPV. At TSL 6, the NPV of consumer benefits, even measured at the more conservative discount rate of 7 percent is over 26 times higher than the maximum estimated manufacturers' loss in INPV. The standard levels at TSL 6 are economically justified even without weighing the estimated monetary value of emissions reductions. When those emissions reductions are included—representing $5.9 billion in climate benefits (associated with the average SC–GHG at a 3-percent discount rate), and $10.1 billion (using a 3-percent discount rate) or $3.6 billion (using a 7-percent discount rate) in health benefits—the rationale becomes stronger still.

As stated, DOE conducts the walk-down analysis to determine the TSL that represents the maximum improvement in energy efficiency that is technologically feasible and economically justified as required under EPCA. 86 FR 70892, 70908. Although DOE has not conducted a comparative economic analysis to select the proposed energy conservation standards, DOE notes that the proposed standard level represents the maximum improvement in energy efficiency for all product classes and is only $0.1 billion less that the maximum consumer NPV, represented by TSL 5, at both 3 and 7 percent discount rates. Compared to TSL 4, Integrated Omnidirectional Short purchases at TSL 6 are approximately 1 percent more likely to be associated with a net cost, but NES is an additional 0.3 quads and NPV is an additional $1.1 billion at 3 percent discount rate and $0.3 billion at 7 percent discount rate. Compared to TSL 1 or 2, while 18 percent of Integrated Omnidirectional Short purchases at TSL 6 are associated with a net cost, compared to 1 percent at TSL 1 or 2, NES is more than 3 quads larger at TSL 6 and NPV is greater by more than $16 billion at 3 percent discount rate and more than $5 billion at 7 percent discount rate. These additional savings and benefits at TSL 6 are significant. DOE considers the impacts to be, as a whole, economically justified at TSL 6.

DOE acknowledges that TSL 6 is estimated to result in 0.02 quads of additional FFC national energy savings compared to TSL 5. The national consumer NPV is larger at TSL 5, compared to TSL 6, by $0.1 billion using either a 7-percent discount rate or a 3-percent discount rate. However, as noted previously, EPCA requires DOE to adopt the standard that would represent the maximum improvement in energy efficiency that is technically feasible and economically justified. DOE seeks comment on the merits of adopting TSL 5 as an alternative for the final rule. DOE could consider TSL 5, among others, in the final rule based on comments received. Additionally, given the relatively modest differences, DOE requests comment on the relative estimates of energy savings and net benefits for TSLs 6 and 5 and whether there are additional sensitivities to consider beyond the equipment switching for TLEDs.

Although DOE considered proposed amended standard levels for GSLs by grouping the efficiency levels for each product class into TSLs, DOE evaluates all analyzed efficiency levels in its analysis. DOE notes that among all possible combinations of ELs, the proposed standard level represents the max NES and differs from max NPV by only $0.1 billion.

Therefore, based on the previous considerations, DOE proposes to adopt the energy conservation standards for GSLs at TSL 6. The proposed amended energy conservation standards for GSLs, which are expressed as lamp efficacy or lumens per watt (lm/W), are shown in Table VII.30.

TABLE VII.30—PROPOSED AMENDED ENERGY CONSERVATION STANDARDS FOR GSLS

Representative product class	Efficacy (lm/W)
Integrated Omnidirectional Short (Not Capable of Operating in Standby Mode)	$123/(1.2+e^{-0.005*(Lumens-200))}) + 25.9$
Integrated Omnidirectional Long (Not Capable of Operating in Standby Mode)	$123/(1.2+e^{(-0.005*(Lumens-200))}) + 74.1$
Integrated Directional (Not Capable of Operating in Standby Mode)	$73/(0.5+e^{(-0.0021*(Lumens+1000))}) - 47.2$
Non-integrated Omnidirectional Short	$122/(0.55+e^{(-0.003*(Lumens+250))}) - 83.4$
Non-integrated Directional	$67/(0.45+e^{(-0.00176*(Lumens+1310))}) - 53.1$
Integrated Omnidirectional Short (Capable of Operating in Standby Mode)	$123/(1.2+e^{(-0.005*(Lumens-200))}) + 17.1$
Integrated Directional (Capable of Operating in Standby Mode)	$73/(0.5+e^{(-0.0021*(Lumens+1000))}) - 50.9$
Non-integrated Omnidirectional Long	$123/(1.2+e^{(-0.005*(Lumens-200))}) + 93.0$

2. 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 (1) the annualized national economic value (expressed in 2021$) 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 climate and health benefits from emission reductions.

Table VII.31 shows the annualized values for GSLs under TSL 6, expressed in 2021$. The results under the primary estimate are as follows.

Using a 7-percent discount rate for consumer benefits and costs and NO_X and SO_2 reduction benefits, and a 3-percent discount rate case for GHG social costs, the estimated cost of the proposed standards for GSLs is $289.4 million per year in increased equipment costs, while the estimated annual benefits are $1,171.5 million from reduced equipment operating costs, $358.1 million from GHG reductions, and $432.0 million from reduced NO_X and SO_2 emissions. In this case, the net benefit amounts to $1,672.2 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the proposed standards for GSLs is $280.3 million per year in increased equipment costs, while the estimated annual benefits are $1,521.4 million in reduced operating costs, $358.1 million from GHG reductions, and $615.6 million from reduced NO_X and SO_2 emissions. In this case, the net benefit amounts to $2,214.8 million per year.

TABLE VII.31—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GSLS (TSL 6)

	Million 2021$/year		
	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
3% discount rate			
Consumer Operating Cost Savings	1,521.4	1,469.8	1,586.0
Climate Benefits *	358.1	357.7	358.5
Health Benefits **	615.6	615.0	616.3
Total Benefits †	2495.1	2,442.5	2,560.8

TABLE VII.31—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GSLS (TSL 6)—Continued

	Million 2021$/year		
	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
Consumer Incremental Product Costs ‡	280.3	291.0	270.0
Net Benefits	2,214.8	2,151.6	2,290.7
7% discount rate			
Consumer Operating Cost Savings	1,171.5	1,135.9	1,215.2
Climate Benefits * (3% discount rate)	358.1	357.7	358.5
Health Benefits **	432.0	431.7	432.4
Total Benefits †	1,961.6	1,925.3	2,006.1
Consumer Incremental Product Costs ‡	289.4	299.4	279.8
Net Benefits	1,672.2	1,625.9	1,726.3

Note: This table presents the costs and benefits associated with GSLs shipped in 2029–2058. These results include benefits to consumers which accrue after 2058 from the products shipped in 2029–2058.

* Climate benefits are calculated using four different estimates of the global SC–GHG (see section VI.L of this erulemaking). For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate, and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates. On March 16, 2022, the Fifth Circuit Court of Appeals (No. 22–30087) granted the federal government's emergency motion for stay pending appeal of the February 11, 2022, preliminary injunction issued in *Louisiana* v. *Biden,* No. 21–cv–1074–JDC–KK (W.D. La.). As a result of the Fifth Circuit's order, the preliminary injunction is no longer in effect, pending resolution of the federal government's appeal of that injunction or a further court order. Among other things, the preliminary injunction enjoined the defendants in that case from ''adopting, employing, treating as binding, or relying upon'' the interim estimates of the social cost of greenhouse gases—which were issued by the Interagency Working Group on the Social Cost of Greenhouse Gases on February 26, 2021—to monetize the benefits of reducing greenhouse gas emissions. As reflected in this proposed rule, DOE has reverted to its approach prior to the injunction and presents monetized greenhouse gas abatement benefits where appropriate and permissible under law.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for NO_X and SO_2) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. *See* section VI.L of this document for more details.

† Total benefits include consumer, climate, and health benefits. Total benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, but the Department does not have a single central SC–GHG point estimate. DOE emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates.

‡ Costs include incremental equipment costs as well as installation costs.

D. Reporting, Certification, and Sampling Plan

Manufacturers, including importers, must use product-specific certification templates to certify compliance to DOE. For GSLs, the certification template reflects the general certification requirements specified at 10 CFR 429.12 and the product-specific requirements specified at 10 CFR 429.57. As discussed in the previous paragraphs, DOE is not proposing to amend the product-specific certification requirements for these products.

VIII. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Executive Order (E.O.) 12866, ''Regulatory Planning and Review,'' as supplemented and reaffirmed by E.O. 13563, ''Improving Regulation and Regulatory Review, 76 FR 3821 (Jan. 21, 2011), requires agencies, to the extent permitted by law, 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 E.O. 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, the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget (OMB) 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, this proposed regulatory action is consistent with these principles.

Section 6(a) of E.O. 12866 also requires agencies to submit ''significant regulatory actions'' to OIRA for review. OIRA has determined that this proposed regulatory action constitutes an ''economically significant regulatory action'' under section 3(f) of E.O. 12866. Accordingly, pursuant to section 6(a)(3)(C) of E.O. 12866, DOE has provided to OIRA an assessment, including the underlying analysis, of benefits and costs anticipated from the proposed 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 are summarized in this preamble and further detail can be found in the technical support document for this rulemaking.

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 E.O. 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (Aug. 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 website (*www.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 *www.sba.gov/document/support-table-size-standards.* Manufacturing of GSLs is classified under NAICS 335139, ''electric lamp bulb and other lighting equipment manufacturing.'' The SBA sets a threshold of 1,250 employees or less for an entity to be considered as a small business for this category.

DOE created a database of GSLs covered by this rulemaking using publicly available information. DOE's research involved information from DOE's compliance certification database,[92] EPA's ENERGY STAR Certified Light Bulbs Database,[93] manufacturers' websites, and retailer websites. DOE found over 800 companies that sell or manufacture GSLs covered in this rulemaking. Using information from D&B Hoovers, DOE screened out companies that have more than 1,250 employees or are completely foreign owned and operated. Based on the results of this analysis, DOE estimates there are approximately 347 small businesses that sell or manufacture GSLs covered by this rulemaking. Based on DOE's database, 326 of these potential small businesses exclusively sell or manufacture LED lamps and do not sell lamps using other technologies (*i.e.,* CFLs), while 21 potential small businesses sell or manufacture some CFLs covered by this rulemaking.

2. Description and Estimate of Compliance Requirements Including Differences in Cost, if Any, for Different Groups of Small Entities

For the 326 small businesses that exclusively sell or manufacture LED lamps, these small businesses will be required to remodel many of the LED lamps they sell or manufacture if the proposed standards are adopted. However, GSL manufacturers stated during manufacturer interviews conducted prior to the March 2016 NOPR that their normal redesign cycle for an LED lamp model is between 18 months to 24 months.[94] DOE assumed that most, if not all, LED lamp models would be remodeled between the estimated publication of this rulemaking's final rule and the estimated date which energy conservation standards are required, even in the absence of DOE energy conservation standards for GSLs. However, small businesses exclusively selling or manufacturing LED lamps would be required to spend additional engineering time to remodel all LED lamp models that would not meet the proposed energy conservation standards, since these LED lamp models would be required to be more efficacious than originally planned, in the no-new-standards case.

The methodology DOE used to estimate product conversion costs for this NOPR analysis is described in section VI.J.2.c of this document. At the proposed standards, TSL 6, DOE estimates that all manufacturers would incur approximately $407 million in product conversion costs. These estimated product conversion costs, at TSL 6, represent approximately 6.6 percent of annual revenue over the estimated five-year compliance period.[95] While small manufacturers are likely to have lower per-model sales volumes than larger manufacturers, GSL manufacturer revenue from LED lamps is estimated to be approximately $1,503 million in 2029, the estimated first full year of compliance, at TSL 6 compared to $1,340 million in the no-new-standards case. This represents an increase of approximately 12 percent in annual revenue generated from the sales of LED lamps, since LED lamps will be the only technology capable of meeting the proposed standard.[96] DOE estimates that small GSL manufacturers exclusively selling LED lamps would incur no more than 4.5 percent of their annual revenue over the estimated five-year compliance period to redesign non-compliant LED lamps into compliant LED lamps meeting the proposed standards (*i.e.,* TSL 6).

For the 21 small businesses that sell some CFLs covered by this rulemaking, the impact of these proposed standards for each small business depends on the number of CFLs a small business sells or manufacturers, and if they also sell LED lamps to replace these non-compliant CFLs. The 21 potential small businesses that DOE identified range in the number of covered CFLs they sell or manufacture from just one CFL model to 533 CFL models.

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[92] *www.regulations.doe.gov/certification-data.*

[93] ENERGY STAR Qualified Lamps Product List, *https://www.energystar.gov/productfinder/product/certified-light-bulbs/results* (last accessed May 2, 2022).

[94] Redesign cycle refers to the time a specific LED lamp is on the market before it is redesigned and a newer model is introduced to the market to replace the existing model.

[95] The total estimated revenue between 2024, the estimated announcement year, and 2028, the year prior to the compliance year is approximately, $9,078 million. $407 ÷ $9,078 = 4.5%.

[96] In the no-new-standards case, the revenue in 2029 includes revenue from the sale of CFLs in addition to the revenue from LED lamps.

TABLE VIII.1—NUMBER OF SMALL BUSINESSES BY NUMBER OF COVERED CFL MODELS SOLD

	Number of covered CFL models sold by a small business				
	1–5 CFL models	6–20 CFL models	21–60 CFL models	61–533 CFL models	Total
Number of Small Businesses	8	4	4	5	21
Revenue from Small Business (Upper)	$68 million	$68 million	$31 million	$216 million.	
Revenue from Small Business (Lower)	$0.4 million	$28 million	$1.8 million	$7.1 million.	

Based on data from D&B Hoovers, DOE collected estimates of the range of annual revenue for small businesses based on the number of covered CFL models each small business sells or manufactures.

For the eight small businesses that sell or manufacture five or fewer covered CFLs, DOE does not anticipate these proposed standards would significantly impact these small businesses. All of the small businesses sell other products not covered by this rulemaking and would either continue to sell LED lamps covered by this rulemaking or exit the GSL market and would not recover any of the revenue previously earned from the sale of their five or fewer CFL models.

For the four small businesses that sell or manufacture between six and 20 CFL models, DOE also does not anticipate these proposed standards would significantly impact these small businesses. All these small businesses have annual revenue over $28 million. The loss of sales from up to 20 CFL models is not likely to be a significant impact to a company with annual sales of $28 million.

Some small businesses that sell or manufacture between 21 and 60 CFL models, could be potentially impacted by the proposed standards. Specifically, one small business has an annual revenue of $1.8 million and sells approximately 41 CFL models (compared to 264 LED lamp models) covered by this rulemaking and another small business has an annual revenue of $3.2 million and sells approximately 59 CFL models (compared to 557 LED lamp models) covered by this rulemaking. These two small businesses could be significantly impacted by the potential loss of CFL sales if these manufacturers are not able to replace these lost CFL sales with LED lamp sales.

For the five small businesses that manufacture between 61 and 533 CFL models, four of them have annual revenue of more than $50 million. All of these four manufacturers also offer more than 1,000 LED lamps that are covered by this rulemaking. The loss of sales from these CLFs models, between 61 and 533 CFL models, is not likely to be a significant impact to a company with annual sales of more than $50 million, especially since all of these small manufacturers have more than 1,000 LED lamp models in addition to their CFL models. The last small business sells approximately 336 CFL models (compared to 925 LED lamp models) covered by this rulemaking and has an annual revenue of approximately $7.1 million. This small business could be significantly impacted by the potential loss of CFL sales if this manufacturer is not able to replace their lost CFL sales with LED lamp sales.

Lastly, these CFL model counts represent the current market offerings of the identified small businesses. The shipment analysis projects a significant decline in CFL shipments from the reference year of the analysis (in 2022 CFL shipments are estimated to be approximately 33 million) compared to the CFL shipments in the estimated first full year of compliance (in 2029 CFL shipments are estimated to be approximately 6.6 million). Many of these small businesses will continue to replace CFL models with LED lamp models between now and the estimated compliance date even in the absence of energy conservation standards.

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. As discussed in this NOPR, the May 2022 Backstop Rule and May 2022 Definition Rule were recently issued under the first cycle of GSL rulemaking under 42 U.S.C. 6295(i)(6)(A). Effective July 2022, these rules expanded the definition of GSL and codified a statutorily prescribed backstop sales prohibition for the sale of any GSL that does not meet a minimum efficacy standard of 45 lm/W. Pursuant to statutory direction in 42 U.S.C. 6295(i)(6)(B), DOE is initiating this second cycle of rulemaking for GSLs to determine whether standards for GSLs should be further amended. While the statute directs DOE to begin this second cycle no later than January 1, 2020, DOE is delayed in initiating this rulemaking for the reasons previously discussed in this NOPR. DOE is proposing an effective date for this NOPR consistent with statutory requirements in 42 U.S.C. 6295(i)(6)(B)(iii) that the Secretary publish a final rule with an effective date that is not earlier than 3 years after the date on which the final rule under this second cycle of rulemaking is published. 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, represented by TSL 6. In reviewing alternatives to the proposed rule, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1, TSL 2, TSL 3, TSL 4, and TSL 5 would reduce the impacts on small business manufacturers, it would come at the expense of a reduction in energy savings and consumer NPV. TSL 1 achieves 95.9 percent lower energy savings and a 95.0 percent lower consumer NPV compared to the energy savings and consumer NPV at TSL 6. TSL 2 achieves 87.1 percent lower energy savings and a 81.9 percent lower consumer NPV compared to the energy savings and consumer NPV at TSL 6. TSL 3 achieves 21.1 percent lower energy savings and a 16.9 percent lower consumer NPV compared to the energy savings and consumer NPV at TSL 6. TSL 4 achieves 7.5 percent lower energy savings and 5.5 percent lower consumer NPV compared to the energy savings and consumer NPV at TSL 6. TSL 5 achieves 0.5 percent lower energy savings compared to the energy savings at TSL 6.

Based on the presented discussion, establishing standards at TSL 6 balances the benefits of the energy savings at TSL 6 with the potential burdens placed on GSL manufacturers, including small business manufacturers. Moreover, establishing standards at TSL 6 represents the maximum improvement in energy efficiency that is technologically feasible and economically justified as required under EPCA. Accordingly, DOE declines to propose one of the other TSLs considered in the analysis, or the other policy alternatives examined as part of the regulatory impact analysis included in chapter 16 of the NOPR TSD.

Additional compliance flexibilities may be available through other means. 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 part 1003 for additional details.

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, including GSLs. (*See* generally 10 CFR part 429). 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. Public reporting burden for the certification is estimated to average 35 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

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

DOE is analyzing this proposed regulation in accordance with the National Environmental Policy Act of 1969 (NEPA) and DOE's NEPA implementing regulations (10 CFR part 1021). DOE's regulations include a categorical exclusion for rulemakings that establish energy conservation standards for consumer products or industrial equipment. 10 CFR part 1021, subpart D, appendix B5.1. DOE anticipates that this rulemaking qualifies for categorical exclusion B5.1 because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, none of the exceptions identified in categorical exclusion B5.1(b) apply, no extraordinary circumstances exist that require further environmental analysis, and it otherwise meets the requirements for application of a categorical exclusion. *See* 10 CFR 1021.410. DOE will complete its NEPA review before issuing the final rule.

E. Review Under Executive Order 13132

E.O. 13132, ''Federalism,'' 64 FR 43255 (Aug. 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 E.O. 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 E.O. 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 E.O. 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, section 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 *https://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 research and development 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 higher-efficiency GSLs, starting at the compliance date for the applicable standard.

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(i)(6)(A)–(B)), this proposed rule would establish 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, as required by 42 U.S.C. 6295(o)(2)(A) and 6295(o)(3)(B). A full discussion of the alternatives considered by DOE is presented in chapter 16 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 proposed 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 E.O. 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (Mar. 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). Pursuant to OMB Memorandum M–19–15, Improving Implementation of the Information Quality Act (April 24, 2019), DOE published updated guidelines which are available at *www.energy.gov/sites/prod/files/2019/12/f70/DOE%20Final%20Updated%20IQA%20Guidelines%20Dec%202019.pdf.* 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

E.O. 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 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. Information Quality

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.'' 70 FR 2664, 2667.

In response to OMB's Bulletin, DOE conducted formal peer reviews of the energy conservation standards development process and the analyses that are typically used and has prepared a report describing that peer review.[97]

[97] The 2007 ''Energy Conservation Standards Rulemaking Peer Review Report'' is available at the following website: *http://energy.gov/eere/buildings/*

Continued

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. Because available data, models, and technological understanding have changed since 2007, DOE has engaged with the National Academy of Sciences to review DOE's analytical methodologies to ascertain whether modifications are needed to improve the Department's analyses. DOE is in the process of evaluating the resulting report.[98]

M. Description of Materials Incorporated by Reference

UL 1598C is an industry accepted test standard that provides requirements for LED downlight retrofit kits. To clarify the scope of the standard proposed in this NOPR, DOE is updating the definition for ''LED Downlight Retrofit Kit'' to reference UL 1598C in the definition. UL 1598C is reasonably available on UL's website at *https://www.shopulstandards.com/Default.aspx.*

The following standards have already been approved for incorporation by reference in their respective locations in the regulatory text: ANSI C78.79–2014 (R2020); ANSI C81.61–2006.

IX. Public Participation

A. Participation in the Webinar

The time and date of the webinar meeting are listed in the **DATES** section at the beginning of this document. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's website: *https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4.* 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 an interest in the topics addressed in this rulemaking, or who is representative of a group or class of persons that has an interest in these issues, may request an opportunity to make an oral presentation at the webinar. Such persons may submit to *ApplianceStandardsQuestions@ee.doe.gov.* Persons who wish to speak should include with their request a computer file in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format that briefly describes the nature of their interest in this rulemaking and the topics they wish to discuss. Such persons should also provide a daytime telephone number where they can be reached.

Persons requesting to speak should briefly describe the nature of their interest in this rulemaking and provide a telephone number for contact. DOE requests persons selected to make an oral presentation to submit an advance copy of their statements at least two weeks before the webinar. At its discretion, DOE may permit persons who cannot supply an advance copy of their statement to participate, if those persons have made advance alternative arrangements with the Building Technologies Office. As necessary, requests to give an oral presentation should ask for such alternative arrangements.

C. Conduct of the Webinar

DOE will designate a DOE official to preside at the webinar 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 webinar/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 webinar/public meeting and until the end of the comment period, interested parties may submit further comments on the proceedings and any aspect of the rulemaking.

The webinar will be conducted in an informal, conference style. DOE will present summaries of comments received before the webinar/public meeting, allow time for prepared general statements by participants, and encourage all interested parties to share their views on issues affecting this proposed rule. Each participant will be allowed to make a general statement (within time limits determined by DOE), before the discussion of specific topics. DOE will permit, 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. 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 webinar/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 webinar/public meeting.

A transcript of the webinar meeting will be included in the docket, which can be viewed as described in the *Docket* section at the beginning of this proposed rule. 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 document.

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

downloads/energy-conservation-standards-rulemaking-peer-review-report-0. (last accessed 3/24/2022)

[98] The report is available at *www.nationalacademies.org/our-work/review-of-methods-for-setting-building-and-equipment-performance-standards.*

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 (CBI)). Comments submitted through *www.regulations.gov* cannot be claimed as CBI. Comments received through the website will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

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. Comments and documents submitted via email 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. 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 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. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

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 comments on the proposed updates to the definitions of "General service incandescent lamp," "General service lamp," "LED downlight retrofit kit", "Reflector lamp," "Showcase lamp," and Specialty MR lamp." *See* section IV.B of this document.

(2) DOE requests comments on the proposed definition for "Circadian-friendly integrated LED lamp." DOE also requests comments on the consumer utility and efficacy potential of lamps marketed to improve the sleep-wake cycle. See section IV.B of this document.

(3) DOE requests comments on the non-efficacy metrics proposed for GSLs. See section V of this document.

(4) DOE requests comments on whether or not phased-in effective dates are necessary for this rulemaking. *See* section VI of this document.

(5) DOE requests comments and data on the impact of diameter on efficacy for linear LED lamps. *See* section of this document.

(6) DOE requests comments on all attributes the same, how the efficacy of pin base LED lamp replacements and linear LED lamps compare. *See* section VI.A.1 of this document.

(7) DOE requests comments on the proposed product classes. *See* section VI.A.1 of this document.

(8) DOE requests comments on the proposed technology options. *See* section VI.A.2 of this document.

(9) DOE requests comments on the design options it has identified. *See* section VI.B of this document.

(10) DOE requests comments on the representative product classes (*i.e.,* product classes directly analyzed) identified for this analysis. *See* section VI.C.2 of this document.

(11) DOE requests comments on the baseline lamps selected for each representative product class (*i.e.,* Integrated Omnidirectional Short Non-standby Mode, Integrated Directional Non-standby Mode, Integrated Omnidirectional Long, Non-integrated Omnidirectional Short, and Non-integrated Directional). *See* section VI.C.3 of this document.

(12) DOE requests comments on the more efficacious substitutes selected for each representative product class (*i.e.,* Integrated Omnidirectional Short Non-standby Mode, Integrated Directional Non-standby Mode, Integrated Omnidirectional Long, Non-integrated Omnidirectional Short, and Non-integrated Directional). *See* section VI.C.4 of this document.

(13) DOE requests comments on whether any characteristics (*e.g.,* diameter [T5, T8]) may prevent or allow a linear LED lamp to achieve high efficacies. *See* section VI.C.4 of this document.

(14) DOE requests comments on the ELs analyzed for each representative product class (*i.e.,* Integrated Omnidirectional Short Non-standby Mode, Integrated Directional Non-standby Mode, Integrated Omnidirectional Long, Non-integrated Omnidirectional Short, and Non-integrated Directional). *See* section VI.C.5 of this document.

(15) DOE requests comment on its approach to scaling non-representative product classes in this NOPR. *See* section IX.E for a list of issues on which DOE seeks comment.

(16) DOE requests comments on its tentative determination that lamps such as Type B or Type A/B linear LED lamps do not have standby mode functionality. *See* section VI.C.6.a of this document.

(17) DOE requests comments on its methodology for determining end-user prices and the resulting prices. *See* section VI.D of this document.

(18) DOE requests comment on the data and methodology used to estimate operating hours for GSLs in the residential sector. *See* section VI.E.1 of this document.

(19) DOE requests comment on the data and methodology used to estimate operating hours for GSLs in the commercial sector. *See* section VI.E.1 of this document.

(20) DOE requests any relevant data and comment on the energy use analysis methodology. *See* section VI.E.3 of this document.

(21) DOE requests comment on the installation cost assumptions used in its analyses. *See* section VI.F.2 of this document.

(22) DOE requests comment on the GSL service lifetime model used in its analyses. In particular, DOE seeks information about the rate of premature failures for LED lamps analyzed in this NOPR and whether or not this rate differs from that of comparable CFLs or general service fluorescent lamps. DOE also seeks feedback or data that would inform the modeling of Integrated Omnidirectional Long lamp lifetimes, which have a longer rated lifetime than LED lamps in the other analyzed product classes. *See* section VI.F.5 of this document.

(23) DOE requests comment and relevant data on the disposal cost assumptions used

in its analyses. *See* section VI.F.7 of this document.

(24) DOE requests any relevant data and comment on the LCC and PBP analysis methodology. *See* section VI.F.11 of this document.

(25) DOE requests comment on the assumption that 15 percent of demand will be met by integral LED luminaires. *See* section VI.G.1.a of this document.

(26) DOE requests any relevant data and comment on the shipment analysis methodology. *See* section VI.G.1 of this document.

(27) DOE requests data or feedback that might inform the assumption that linear lamps (regardless of technology type) are increasingly absent from new construction. *See* section VI.G.1.a of this document.

(28) DOE requests input on the described method of accounting for demand lost to integral LED fixtures. In particular, DOE seeks information about the rate at which linear lamp stock is converted to integrated LED fixtures via retrofit or renovation. *See* section VI.G.1.a of this document.

(29) DOE also used a Bass adoption model to estimate the diffusion of LED lamp technologies into the non-integrated product class and requests feedback on its assumption that non-integrated LED lamp options became available starting in 2015. *See* section VI.G.1.c of this document.

(30) DOE requests relevant historical data on GSL shipments, disaggregated by product class and lamp technology, as they become available in order to improve the accuracy of the shipments analysis. *See* section VI.G.1.c of this document.

(31) DOE requests comment on the assumption that smart lamps will reach 50 percent market penetration by 2058. *See* section VI.H.1.a of this document.

(32) DOE requests comment on the methodology and assumptions used to determine the market share of the lumen range distributions. *See* section VI.H.1.b of this document.

(33) DOE requests information on market share by lamp type and the composition of stock by type for Type A and Type B linear LED lamps in order to help refine the applied scaling. *See* section VI.H.1.c of this document.

(34) DOE requests comment on the use of 1.52 as the average distribution chain markup for all GSLs and the use of 1.55 as the average manufacturer markup for all GSLs. *See* section VI.J.2.a of this document.

(35) DOE requests comment on the methodology used to calculate product and capital conversion costs for GSLs in this NOPR. Specifically, DOE requests comment on whether GSL manufacturers would incur any capital conversion costs, given the decline in LED lamps sales in the first full year of compliance for all TSLs. If capital conversion costs would be incurred, DOE requests these costs be quantified, if possible. Additionally, DOE requests comment on the estimated product conversion costs; the assumption that most LED lamp models would be remodeled between the estimated publication of this rulemaking's final rule and the estimated date which energy conservation standards are required, even in the no-new-standards case; and the estimated additional engineering time to remodel LED lamp models to comply with the analyzed TSLs. *See* section VI.J.2.c of this document.

(36) DOE requests comment on how to address the climate benefits and other effects of the proposal. *See* section VI.L of this document.

(37) DOE seeks comment on the assumption that there are no GSL manufacturers manufacturing CFLs in the United States. Additionally, DOE requests comment on the assumption that up to 30 domestic non-production employees are involved in the R&D, marketing, sales, and distribution of CFLs in the United States, which may be eliminated if energy conservation standards are set at TSL 2 or higher. Lastly, DOE seeks comment on the assumption that GSL manufacturers would not reduce or eliminate any domestic production or non-production employees involved in manufacturing or selling LED lamps due to any of the analyzed TSLs in this NOPR. *See* section VII.B.2.b of this document.

(38) DOE requests information regarding the impact of cumulative regulatory burden on manufacturers of GSLs associated with multiple DOE standards or product-specific regulatory actions of other Federal agencies, specifically if these standards occur within three years prior to and after 2028. *See* section VII.B.2.e of this document.

(39) 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 VII.C of this document.

(40) DOE seeks comment on the merits of adopting TSL 5 as an alternative. *See* section VII.C.1 of this document.

(41) DOE requests comment on the relative estimates of energy savings and net benefits for TSLs 6 and 5 and whether there are additional sensitivities to consider. *See* section VII.C.1 of this document.

(42) Additionally, DOE welcomes comments on other issues relevant to the conduct of this rulemaking that may not specifically be identified in this document. *See* section IX.E of this document.

X. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this notice of proposed rulemaking and announcement of public meeting.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Signing Authority

This document of the Department of Energy was signed on December 16, 2022, by Francisco Alejandro Moreno, Acting Assistant Secretary for Energy Efficiency and Renewable Energy, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the **Federal Register**.

Signed in Washington, DC, on December 20, 2022.

Treena V. Garrett

Federal Register Liaison Officer, U.S. Department of Energy.

For the reasons set forth in the preamble, DOE proposes to amend 430 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

■ 1. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291–6309; 28 U.S.C. 2461 note.

■ 2. Section 430.2 is amended by:

■ a. Adding, in alphabetical order, the definition for ''Circadian-friendly integrated LED lamp''; and

■ b. Revising the definitions for ''General service incandescent lamp'', ''General service lamp'', ''LED downlight retrofit kit'', ''Reflector lamp'', ''Showcase Lamp'', and ''Specialty MR Lamp''.

The addition and revisions read as follows:

§ 430.2 Definitions.

* * * * *

Circadian-friendly integrated LED lamp means an integrated LED lamp that—

(1) Is designed and marketed for use in the human sleep-wake (circadian) cycle;

(2) Is designed and marketed as an equivalent replacement for a 40 W or 60 W incandescent lamp;

(3) Has at least one setting that decreases or removes standard spectrum radiation emission in the 440 nm to 490 nm range; and

(4) Is sold in packages of two lamps or less.

* * * * *

General service incandescent lamp means a standard incandescent or halogen type lamp that is intended for general service applications; has a medium screw base; has a lumen range of not less than 310 lumens and not more than 2,600 lumens or, in the case of a modified spectrum lamp, not less than 232 lumens and not more than 1,950 lumens; and is capable of being operated at a voltage range at least partially within 110 and 130 volts; however, this definition does not apply to the following incandescent lamps—

(1) An appliance lamp;
(2) A black light lamp;
(3) A bug lamp;
(4) A colored lamp;
(5) A G shape lamp with a diameter of 5 inches or more as defined in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3);
(6) An infrared lamp;
(7) A left-hand thread lamp;
(8) A marine lamp;
(9) A marine signal service lamp;
(10) A mine service lamp;
(11) A plant light lamp;
(12) An R20 short lamp;
(13) A sign service lamp;
(14) A silver bowl lamp;
(15) A showcase lamp; and
(16) A traffic signal lamp.

* * * * *

General service lamp means a lamp that has an ANSI base; is able to operate at a voltage of 12 volts or 24 volts, at or between 100 to 130 volts, at or between 220 to 240 volts, or of 277 volts for integrated lamps (as defined in this section), or is able to operate at any voltage for non-integrated lamps (as defined in this section); has an initial lumen output of greater than or equal to 310 lumens (or 232 lumens for modified spectrum general service incandescent lamps) and less than or equal to 3,300 lumens; 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. General service lamps do not include:

(1) Appliance lamps;
(2) Black light lamps;
(3) Bug lamps;
(4) Colored lamps;
(5) G shape lamps with a diameter of 5 inches or more as defined in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3);
(6) General service fluorescent lamps;
(7) High intensity discharge lamps;
(8) Infrared lamps;
(9) J, JC, JCD, JCS, JCV, JCX, JD, JS, and JT shape lamps that do not have Edison screw bases;
(10) Lamps that have a wedge base or prefocus base;
(11) Left-hand thread lamps;
(12) Marine lamps;
(13) Marine signal service lamps;
(14) Mine service lamps;
(15) MR shape lamps that have a first number symbol equal to 16 (diameter equal to 2 inches) as defined in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3), operate at 12 volts, and have a lumen output greater than or equal to 800;
(16) Other fluorescent lamps;
(17) Plant light lamps;
(18) R20 short lamps;
(19) Reflector lamps (as defined in this section) that have a first number symbol less than 16 (diameter less than 2 inches) as defined in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3) and that do not have E26/E24, E26d, E26/50x39, E26/53x39, E29/28, E29/53x39, E39, E39d, EP39, or EX39 bases;
(20) S shape or G shape lamps that have a first number symbol less than or equal to 12.5 (diameter less than or equal to 1.5625 inches) as defined in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3);
(21) Sign service lamps;
(22) Silver bowl lamps;
(23) Showcase lamps;
(24) Specialty MR lamps;
(25) T-shape lamps that have a first number symbol less than or equal to 8 (diameter less than or equal to 1 inch) as defined in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3), nominal overall length less than 12 inches, and that are not compact fluorescent lamps (as defined in this section);
(26) Traffic signal lamps.

* * * * *

LED downlight retrofit kit means a product designed and marketed 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.

* * * * *

Reflector lamp means a lamp that has an R, PAR, BPAR, BR, ER, MR, or similar bulb shape as defined in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3) and is used to provide directional light.

* * * * *

Showcase lamp means a lamp that has a T-shape as specified in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3), is designed and marketed as a showcase lamp, and has a maximum rated wattage of 75 watts.

* * * * *

Specialty MR lamp means a lamp that has an MR shape as defined in ANSI C78.79–2014 (R2020) (incorporated by reference; see § 430.3), a diameter of less than or equal to 2.25 inches, a lifetime of less than or equal to 300 hours, and that is designed and marketed for a specialty application.

* * * * *

■ 4. Section 430.3 is amended by adding paragraph (w)(4) to read as follows:

§ 430.3 Materials incorporated by reference.

* * * * *

(w) * * *

(4) UL 1598C, Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits, approved January 12, 2017, IBR approved for § 430.2.

■ 5. Section 430.32 is amended by:

■ a. Removing and reserving paragraph (u); and

■ b. Revising paragraphs (x) and (dd)

The revisions read as follows:

§ 430.32 Energy and water conservation standards and their compliance dates.

* * * * *

(x) *Intermediate base incandescent lamps and candelabra base incandescent lamps.* (1) Each candelabra base incandescent lamp shall not exceed 60 rated watts.

(2) Each intermediate base incandescent lamp shall not exceed 40 rated watts.

* * * * *

(dd) *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 (dd)(1)(ii) of this section, shall have a color rendering index greater than or equal to 80 and shall have a rated wattage no greater than, and a lifetime no less than the values shown in the table as follows:

GENERAL SERVICE INCANDESCENT LAMPS

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

* Use lifetime determined in accordance with § 429.66 to determine compliance with this standard.

(ii) Modified spectrum general service incandescent lamps manufactured after the dates specified in the table below shall have a color rendering index greater than or equal to 75 and shall have a rated wattage no greater than, and a lifetime no less than the values shown in the table as follows:

MODIFIED SPECTRUM GENERAL SERVICE INCANDESCENT LAMPS

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

* Use lifetime determined in accordance with § 429.66 to determine compliance with this standard.

(iii) 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	Labeled wattage (watts)	Requirements
Configuration *		Minimum initial lamp efficacy (lumens per watt) must be at least:
(A) Bare Lamp	(*1*) Labeled Wattage <15	45.0
	(*2*) Labeled Wattage ≥15	60.0
(B) Covered Lamp (no reflector)	(*1*) Labeled Wattage <15	40.0
	(*2*) 15 ≤ Labeled Wattage <19	48.0
	(*3*) 19 ≤ Labeled Wattage <25	50.0
	(*4*) 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.

(iv) Each general service lamp manufactured on or after July 25, 2028 must have:

(A) 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

(B) A lamp efficacy greater than or equal to the values shown in the table as follows:

Lamp type	Length	Standby mode operation	Efficacy (lm/W)
(*1*) Integrated Omnidirectional	Short (<45 inches)	No Standby Mode	$123/(1.2+e^{-0.005*(\text{Lumens}-200))}) + 25.9$
(*2*) Integrated Omnidirectional	Long (≥45 inches)	No Standby Mode	$123/(1.2+e^{(-0.005*(\text{Lumens}-200))}) + 74.1$
(*3*) Integrated Directional	All Lengths	No Standby Mode	$73/(0.5+e^{(-0.0021*(\text{Lumens}+1000))}) - 47.2$
(*4*) Non-integrated Omnidirectional	Short (<45 inches)	No Standby Mode	$122/(0.55+e^{(-0.003*(\text{Lumens}+250))}) - 83.4$
(*5*) Non-integrated Directional	All Lengths	No Standby Mode	$67/(0.45+e^{(-0.00176*(\text{Lumens}+1310))}) - 53.1$
(*6*) Integrated Omnidirectional	Short (<45 inches)	Standby Mode	$123/(1.2+e^{(-0.005*(\text{Lumens}-200))}) + 17.1$
(*7*) Integrated Directional	All Lengths	Standby Mode	$73/(0.5+e^{(-0.0021*(\text{Lumens}+1000))}) - 50.9$
(*8*) Non-integrated Omnidirectional	Long (≥45 inches)	No Standby Mode	$123/(1.2+e^{(-0.005*(\text{Lumens}-200))}) + 93.0$

(2) Medium base CFLs (as defined in § 430.2) manufactured on or after the dates specified in the table shall meet or exceed the following standards as follows:

Metrics	Requirements for MBCFLs manufactured on or after January 1, 2006	Requirements for MBCFLs manufactured on or after July 25, 2028
(i) Lumen Maintenance at 1,000 Hours	≥90.0%	
(ii) Lumen Maintenance at 40 Percent of Lifetime.*	≥80.0%	
(iii) 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.*
(iv) Lifetime*	≥6,000 hours	≥10,000 hours
(v) Start time	No requirement	The time needed for a MBCFL to remain continuously illuminated must be within: {1} one second of application of electrical power for lamp with standby mode power; {2} 750 milliseconds of application of electrical power for lamp without standby mode power.

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

(3) Lamps with a medium screw base or any other screw base not defined in ANSI C81.61–2006 (incorporated by reference, see § 430.3); intended for a general service or general illumination application (whether incandescent or not); capable of being operated at a voltage at least partially within the range of 110 to 130 volts; and manufactured or imported after the dates specified in the table must meet or exceed the following standards:

Lamp type	Color Rendering Index (CRI) requirement	Compliance date
Non-modified spectrum	80	July 25, 2028.
Modified spectrum	70	July 25, 2028.

(4) The standards described in paragraph (dd)(3) of this section do not apply to lamps exempted from the definition of general service lamps.

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