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: Final rule.

SUMMARY: The Energy Policy and Conservation Act, as amended (''EPCA''), prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including general service lamps (''GSLs''). EPCA also requires the U.S. Department of Energy (''DOE'') to periodically determine whether more stringent standards would be technologically feasible and economically justified and would result in significant energy savings. In this final rule, DOE is adopting amended energy conservation standards for GSLs. DOE has determined that the amended energy conservation standards for these products would result in significant conservation of energy and are technologically feasible and economically justified.

DATES: The effective date of this rule is July 3, 2024. Compliance with the amended standards established for GSLs in this final rule is required on and after July 25, 2028.

The incorporation by reference of certain material listed in this rule is approved by the Director of the Federal Register on July 3, 2024. The incorporation by reference of certain other material listed in this rule was approved by the Director of the Federal Register as of September 30, 2022.

ADDRESSES: The docket for this rulemaking, which includes **Federal Register** notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov.* All documents in the docket are listed in the *www.regulations.gov* index. However, 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.

For further information on how to review the docket, contact the Appliance and Equipment Standards Program staff at (202) 287–1445 or by email: *ApplianceStandardsQuestions@ee.doe.gov.*

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SUPPLEMENTARY INFORMATION: DOE maintains a previously approved incorporation by reference for: ANSI C78.79–2014 (R2020) and incorporates by reference the following industry standard into 10 CFR part 430:

UL 1598C, *Standard for Safety for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits,* First edition, dated January 16, 2014 (including revisions through November 17, 2016) (''UL 1598C–2016'').

A copy of UL 1598C may be obtained from the Underwriters Laboratories, Inc. (UL), 2600 NW Lake Rd., Camas, WA 98607–8542 (*www.UL.com*).

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

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I. Synopsis of the Final Rule

The Energy Policy and Conservation Act, Public Law 94–163, as amended ("EPCA"),[1] authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317) Title III, part B of 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 rulemaking.

This is the second rulemaking cycle for GSLs. As a result of the first rulemaking cycle initiated per 42 U.S.C. 6295(i)(6)(A), on May 9, 2022, DOE codified a prohibition on the sale of any GSLs that do not meet a minimum efficacy standard of 45 lumens per watt. (87 FR 27439) 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). DOE is issuing this final rule pursuant to multiple provisions in EPCA. First, EPCA requires that DOE 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. Consistent with the first review, 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))

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 a product. (42 U.S.C. 6295(p)(1))

In accordance with these and other statutory provisions discussed in this document, DOE analyzed the benefits and burdens of six trial standard levels ("TSLs") for GSLs. The TSLs and their associated benefits and burdens are discussed in detail in sections V.A through V.C of this document. As discussed in section V.C of this document, DOE has determined that TSL 6 represents the maximum improvement in energy efficiency that is technologically feasible and economically justified. The adopted standards, 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 standards apply to all products listed in table I.1 and manufactured in, or imported into, the United States starting on July 25, 2028.

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[1] 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.

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

Table I.1 Energy Conservation Standards for GSLs (Compliance Starting July 25, 2028)

Product Class	Adopted Energy Conservation Standards - Efficacy Equation (lm/W)	Example Efficacy for Common Lumen Lamp
Integrated Omnidirectional Short GSLs, No Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + 25.9$	124.6 lm/W (810 lumens)
Integrated Omnidirectional Short GSLs, With Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + 17.1$	115.7 lm/W (810 lumens)
Integrated Directional GSLs, No Standby Power	$\text{Efficacy} = \frac{73}{0.5 + e^{-0.0021(\text{Lumens}+1000)}} - 47.2$	96.0 lm/W (1200 lumens)
Integrated Directional GSLs, With Standby Power	$\text{Efficacy} = \frac{73}{0.5 + e^{-0.0021(\text{Lumens}+1000)}} - 50.9$	92.3 lm/W (1200 lumens)
Integrated Omnidirectional Long GSLs, No Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + 71.7$	174.1 lm/W (1625 lumens)
Non-integrated Omnidirectional Long GSLs, No Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + 93.0$	195.4 lm/W (1625 lumens)
Non-integrated Omnidirectional Short GSLs, No Standby Power	$\text{Efficacy} = \frac{122}{0.55 + e^{-0.003(\text{Lumens}+250)}} - 83.4$	133.3 lm/W (1200 lumens)
Non-integrated Directional GSLs, No Standby Power	$\text{Efficacy} = \frac{67}{0.45 + e^{-0.00176(\text{Lumens}+1310)}} - 53.1$	83.3 lm/W (500 lumens)

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A. Benefits and Costs to Consumers

Table I.2 summarizes DOE's evaluation of the economic impacts of the adopted standards on consumers of GSLs, as measured by the average life-cycle cost (''LCC'') savings and the simple payback period (''PBP'').[3] The average LCC savings are positive for all product classes, and the PBP is less than the average lifetime of GSLs, which varies by product class and efficiency level (*see* section IV.F.5 of this document).

[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 compliance year in the absence of new or amended standards (*see* section IV.F.9 of this document). The simple PBP, which is designed to compare specific efficiency levels, is measured relative to the baseline product (*see* section IV.D of this document).

Table I.2 Impacts of Adopted Energy Conservation Standards on Consumers of GSLs

Product Class	Average LCC Savings *2022$*	Simple Payback Period *years*
Integrated Omnidirectional Short	0.60	0.9
Integrated Omnidirectional Long	4.00	3.4
Integrated Directional	3.23	0.0
Non-Integrated Omnidirectional	6.67	2.4
Non-Integrated Directional	0.37	3.8

DOE's analysis of the impacts of the adopted standards on consumers is described in section V.B.1 of this document.

B. 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 (2024–2058). 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 $2,108 million in 2022$. Under the adopted standards, DOE estimates the change in INPV to range from −15.3 percent to −7.3 percent, which is approximately −$322 million to −$155 million. In order to bring products into compliance with new and amended standards, it is estimated that industry will incur total conversion costs of $430 million.

DOE's analysis of the impacts of the adopted standards on manufacturers is described in sections IV.J and V.B.2 of this document.

C. National Benefits and Costs [4]

DOE's analyses indicate that the adopted energy conservation standards for GSLs would save a significant amount of energy. Relative to the case without 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 17 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 standards for GSLs ranges from $8.5 billion (at a 7-percent discount rate) to $22.2 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 during the period 2029–2058.

In addition, the adopted standards for GSLs are projected to yield significant environmental benefits. DOE estimates that the standards will result in cumulative emission reductions (over the same period as for energy savings) of 70.3 million metric tons (''Mt'')[6] of carbon dioxide (''CO_2''), 22.1 thousand tons of sulfur dioxide (''SO_2''), 133.3 thousand tons of nitrogen oxides (''NO_X''), 608.1 thousand tons of methane (''CH_4''), 0.70 thousand tons of nitrous oxide (''N_2O''), and 0.15 tons of mercury (''Hg'').[7] The estimated cumulative reduction in CO_2 emissions through 2030 amounts to 0.61 Mt, which is equivalent to the emissions resulting from the annual electricity use of more than one hundred thousand homes.

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 (in terms of benefit per ton of GHG avoided) developed by an Interagency Working Group on the Social Cost of Greenhouse Gases (''IWG'').[8] The derivation of these values is discussed in section IV.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 $3.8 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 sets of SC–GHG estimates.

DOE estimated the monetary health benefits of SO_2 and NO_X emissions reductions, using benefit per ton estimates from the Environmental Protection Agency (''EPA''),[9] as discussed in section IV.L of this document. DOE estimated the present value of the health benefits would be $2.9 billion using a 7-percent discount rate, and $7.5 billion using a 3-percent discount rate.[10] DOE is currently only

[4] All monetary values in this document are expressed in 2022 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 0 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 2023* (''*AEO2023*''). *AEO2023* reflects, to the extent possible, laws and regulations adopted through mid-November 2022, including the Inflation Reduction Act. *See* section IV.K of this document for further discussion of *AEO2023* assumptions that affect air pollutant emissions.

[8] To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the *Technical Support Documents: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG. (''February 2021 SC–GHG TSD''). Available at *www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.*

[9] U.S. Environmental Protection Agency. Estimating the Benefit per Ton of Reducing Directly-Emitted $PM_{2.5}$, $PM_{2.5}$ Precursors and Ozone Precursors from 21 Sectors. Available at *www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-21-sectors.*

[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.

monetizing health benefits from changes in ambient fine particulate matter (''$PM_{2.5}$'') concentrations from two precursors (SO_2 and NO_X), and from changes in ambient ozone from one precursor (for NO_X), but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions.

Table 1.3 summarizes the monetized benefits and costs expected to result from the amended 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.

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Table I.3 Summary of Monetized Benefits and Costs of Adopted Energy Conservation Standards for GSLs (2029-2058)

	Billion $2022
3% discount rate	
Consumer Operating Cost Savings	27.2
Climate Benefits*	3.8
Health Benefits**	7.5
Total Benefits†	38.5
Consumer Incremental Product Costs‡	5.1
Net Benefits	33.5
Change in Producer Cashflow (INPV)‡‡	(0.3) – (0.2)
7% discount rate	
Consumer Operating Cost Savings	11.3
Climate Benefits* (3% discount rate)	3.8
Health Benefits**	2.9
Total Benefits†	18.0
Consumer Incremental Product Costs‡	2.9
Net Benefits	15.1
Change in Producer Cashflow (INPV)‡‡	(0.3) – (0.2)

Note: This table presents the costs and benefits associated with GSLs shipped during the period 2029−2058. These results include consumer, climate, and health benefits that accrue after 2058 from the products shipped during the period 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 a 3-percent discount rate) (*see* section IV.L of this final rule). 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; however, DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim 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 IWG.

** 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 IV.L of this document for more details.

† Total and net benefits include those consumer, climate, and health benefits that can be quantified and monetized. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with a 3-percent discount rate.

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

‡‡ Operating cost savings are calculated based on the life-cycle cost analysis and national impact analysis

as discussed in detail below. *See* sections IV.F and IV.H of this document. DOE's national impact analysis includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the product and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (*i.e.*, manufacturer impact analysis, or "MIA"). *See* section IV.J of this document. In the detailed MIA, DOE models manufacturers' pricing decisions based on assumptions regarding investments, conversion costs, cashflow, and margins. The MIA produces a range of impacts, which is the rule's expected impact on the INPV. The change in INPV is the present value of all changes in industry cashflow, including changes in production costs, capital expenditures, and manufacturer profit margins. Change in INPV is calculated using the industry weighted average cost of capital value of 6.1 percent that is estimated in the MIA (*see* chapter 11 of the final rule technical support document ("TSD") for a complete description of the industry weighted average cost of capital). For GSLs, the change in INPV ranges from -$322 million to -$155 million. DOE accounts for that range of likely impacts in analyzing whether a trial standard level is economically justified. *See* section V.C of this document. DOE is presenting the range of impacts to the INPV under two markup scenarios: the Preservation of Gross Margin scenario, which is the manufacturer markup scenario used in the calculation of Consumer Operating Cost Savings in this table; and the Preservation of Operating Profit scenario, where DOE assumed manufacturers would not be able to increase per-unit operating profit in proportion to increases in manufacturer production costs. DOE includes the range of estimated change in INPV in the above table, drawing on the MIA explained further in section IV.J of this document to provide additional context for assessing the estimated impacts of this final rule to society, including potential changes in production and consumption, which is consistent with OMB's Circular A-4 and E.O. 12866. If DOE were to include the change in INPV into the net benefit calculation for this final rule, the net benefits would range from $33.2 billion to $33.3 billion at a 3-percent discount rate and would range from $14.8 billion to $14.9 billion at a 7-percent discount rate. Parentheses () indicate negative values.

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The benefits and costs of the amended 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 reductions, all annualized.[11]

The national operating cost 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 during the period 2029–2058. The benefits associated with reduced emissions achieved as a result of the adopted standards are also calculated based on the lifetime of GSLs shipped during the period 2029–2058. Total benefits for both the 3-percent and 7-percent cases are presented using the average GHG social costs with a 3-percent discount rate. Estimates of SC–GHG values are presented for all four discount rates in section V.B.8 of this document.

Table I.4 presents the total estimated monetized benefits and costs associated with the amended standard, expressed in terms of annualized values. The results under the primary estimate are as follows.

Using a 7-percent discount rate for consumer benefits and costs and health benefits from reduced NO_X and SO_2 emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated cost of the standards adopted in this rule is $301.4 million per year in increased equipment costs, while the estimated annual benefits are $1,193.6 million in reduced equipment operating costs, $217.7 million in climate benefits, and $303.2 million in health benefits. In this case, the net benefit would amount to $1,413.1 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the standards is $292.2 million per year in increased equipment costs, while the estimated annual benefits are $1,564.6 million in reduced operating costs, $217.7 million in climate benefits, and $430.8 million in health benefits. In this case, the net benefit would amount to $1,920.9 million per year.

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[11] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2024, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (*e.g.,* 2020 or 2030), and then discounted the present value from each year to 2024. 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 Adopted Standards for GSLs (2029-2058)

	Million 2022$/year		
	Primary Estimate	**Low Net Benefits Estimate**	**High Net Benefits Estimate**
3% discount rate			
Consumer Operating Cost Savings	1,564.6	1,473.8	1,639.9
Climate Benefits*	217.7	213.0	220.6
Health Benefits**	430.8	421.6	436.3
Total Benefits†	2,213.1	2,108.4	2,296.8
Consumer Incremental Product Costs‡	292.2	279.0	304.4
Net Benefits	1,920.9	1,829.5	1,992.4
Change in Producer Cashflow (INPV)‡‡	(22.5) – (10.8)	(22.5) – (10.8)	(22.5) – (10.8)
7% discount rate			
Consumer Operating Cost Savings	1,193.6	1,129.5	1,248.5
Climate Benefits* (3% discount rate)	217.7	213.0	220.6
Health Benefits**	303.2	297.4	306.7
Total Benefits†	1,714.5	1,639.9	1,775.8
Consumer Incremental Product Costs‡	301.4	288.9	312.8
Net Benefits	1,413.1	1351.0	1,463.0
Change in Producer Cashflow (INPV)‡‡	(22.5) – (10.8)	(22.5) – (10.8)	(22.5) – (10.8)

Note: This table presents the costs and benefits associated with GSLs shipped during the period 2029−2058. These results include consumer, climate, and health benefits that accrue after 2058 from the products shipped during the period 2029−2058. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the *AEO2023* 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. The methods used to derive projected price trends are explained in section IV.G 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 IV.L of this document). For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown; however, DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim 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 IWG.

** 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 IV.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.

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

‡‡ Operating cost savings are calculated based on the life cycle costs analysis and national impact analysis as discussed in detail below. *See* sections IV.F and IV.H of this document. DOE's national impact analysis includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the product and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (*i.e.*, manufacturer impact analysis, or "MIA"). *See* section IV.J of this document. In the detailed MIA, DOE models manufacturers' pricing decisions based on assumptions regarding investments, conversion costs, cashflow, and margins. The MIA produces a range of impacts, which is the rule's expected impact on the INPV. The change in INPV is the present value of all changes in industry cash flow, including changes in production costs, capital expenditures, and manufacturer profit margins. The annualized change in INPV is calculated using the industry weighted average cost of capital value of 6.1 percent that is estimated in the MIA (*see* chapter 11 of the final rule TSD for a complete description of the industry weighted average cost of capital). For GSLs, the annualized change in INPV ranges from -$22.5 million to -$10.8 million. DOE accounts for that range of likely impacts in analyzing whether a trial standard level is economically justified. *See* section V.C of this document. DOE is presenting the range of impacts to the INPV under two markup scenarios: the Preservation of Gross Margin scenario, which is the manufacturer markup scenario used in the calculation of Consumer Operating Cost Savings in this table; and the Preservation of Operating Profit scenario, where DOE assumed manufacturers would not be able to increase per-unit operating profit in proportion to increases in manufacturer production costs. DOE includes the range of estimated annualized change in INPV in the above table, drawing on the MIA explained further in section IV.J of this document to provide additional context for assessing the estimated impacts of this final rule to society, including potential changes in production and consumption, which is consistent with OMB's Circular A-4 and E.O. 12866. If DOE were to include the change in INPV into the annualized net benefit calculation for this final rule, the net benefits would range from $1,898.4 million to $1,910.1 million at 3-percent discount rate and would range from $1,390.6 million to $1,402.3 million at 7-percent discount rate. Parentheses () indicate negative values.

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DOE's analysis of the national impacts of the adopted standards is described in sections IV.H, IV.K, and IV.L of this document.

D. Conclusion

DOE concludes that the standards adopted in this final rule represent the maximum improvement in energy efficiency that is technologically feasible and economically justified and would result in the significant conservation of energy. Specifically, with regard to technological feasibility, products achieving these standard levels are already commercially available for all product classes covered by this final rule. As for economic justification, DOE's analysis shows that the benefits of the standards exceed, to a great extent, the burdens of the 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 standards for GSLs is $301.4 million per year in increased GSL costs, while the estimated annual benefits are $1,193.6 million in reduced GSL operating costs, $217.7 million in climate benefits, and $303.2 million in health benefits. The net benefit amounts to $1,413.1 million per year. While DOE presents monetized climate benefits, DOE would reach the same conclusion presented in this rulemaking in the absence of the benefits of the social cost of greenhouse gases.

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 energy savings of 4.0 quad full-fuel-cycle (''FFC''), the equivalent of the primary annual energy use of 261 million homes. In addition, they are projected to reduce CO_2 emissions by 70.3 Mt. Based on these findings, DOE has determined the energy savings from the standard levels adopted in this final rule are ''significant'' within the meaning of 42 U.S.C. 6295(o)(3)(B). A more detailed discussion of the basis for these conclusions is contained in the remainder of this document and the accompanying TSD.

II. Introduction

The following section briefly discusses the statutory authority underlying this final 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 future rulemakings to determine whether to amend these

[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).

standards. *Id.* EPCA further provides that, not later than 6 years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a notice of proposed rulemaking (''NOPR'') including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1))

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)) That 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 required 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)). DOE did not complete a rulemaking in accordance with the statutory criteria, and so accordingly codified this backstop requirement in a rule issued on May 9, 2022 (''May 2022 Backstop Final Rule''). 87 FR 27439.

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 final rule 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 in limited instances 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 42 U.S.C. 6295(r)) Manufacturers of covered products must use the prescribed DOE test procedure as the basis for certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of those products. (42 U.S.C. 6293(c) and 6295(s)) Similarly, DOE must use these test procedures to determine whether the products comply with standards adopted pursuant to EPCA. (42 U.S.C. 6295(s)) The DOE test procedures for 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)) Furthermore, DOE may not adopt any standard that would not result in the significant conservation of energy. (42 U.S.C. 6295(o)(3)) Moreover, DOE may not prescribe a standard (1) for certain products, including GSLs, if no test procedure has been established for the product, or (2) if DOE determines by rule that the standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)–(B)) In deciding whether a proposed standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i)) DOE must make this determination after receiving comments on the proposed standard, and by considering, to the greatest extent practicable, the following seven statutory factors:

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

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

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

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

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

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

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

(42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

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

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

Additionally, 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 products 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 such a 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 and standards for GSLs address standby mode, as do the amended standards adopted in this final rule.

B. Background

1. Current Standards

This is the second cycle of energy conservation standards rulemakings for GSLs. As noted in section II.B.2 of this document, DOE has codified the statutory backstop requirement prohibiting sales of GSLs that do not meet a 45 lm/W requirement. Because incandescent and halogen GSLs are not 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 the adopted 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	40.0
	15 ≥ lamp power < 19	48.0
	19 ≥ lamp power < 25	50.0
	Lamp power ≥ 25	55.0
Lumen Maintenance at 1,000 Hours	≥ 90%	
Lumen Maintenance at 40% of Rated Lifetime	≥ 80%	
Rapid Cycle Stress Test	Each lamp must be cycled once for every 2 hours of lifetime.** At least 5 lamps must meet or exceed the minimum number of cycles.	
Lamp Lifetime**	≥ 6,000 hours	

*Use labeled wattage to determine the appropriate efficacy requirements in this table; do not use measured wattage for this purpose.

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

MBCFLs fall within the Integrated Omnidirectional Short product class (*see* section IV.B.2 of this document for further details on product classes). Because DOE determined that a lamp cover (*i.e.,* bare or covered) is not a feature that justifies separate standards in this analysis, the baseline efficacy requirements are determined by lamp wattage. Therefore, for products with wattages less than 15 W that 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 that 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	Minimum Efficacy
	W	*lm/W*
Integrated GSLs	< 15	45.0
	≥ 15	60.0

2. History of Standards Rulemaking for GSLs

Pursuant to its statutory authority to complete the first cycle of rulemaking for GSLs, DOE published a NOPR on March 17, 2016 (''March 2016 NOPR''), that addressed the first question that Congress directed it to consider—whether to amend energy conservation standards for GSLs. 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, on October 18, 2016, DOE published a Notice of Proposed Definition and Data Availability (''October 2016 NOPDDA''), which proposed to amend the definitions of GSIL, GSL, and related terms. 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, *i.e.,* whether to maintain or discontinue ''exemptions'' for certain incandescent lamps. 82 FR 7276, 7277; 82 FR 7322, 7324 (*see* 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 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 Manufacturers 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-

[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).

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 (''NODA'') and request for information 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 reconsider 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* 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 reassessed the legal interpretations underlying certain decisions made in the January 2017 Definition Final Rules. *Id.*

On February 11, 2019, DOE published a NOPR that proposed 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* 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. 84 FR 46661, 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. 84 FR 46661, 46662. DOE initiated that separate rulemaking by publishing a notice of proposed definition (''NOPD'') on September 5, 2019 (''September 2019 NOPD''), regarding whether standards for GSILs should be amended. 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. 84 FR 46830, 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. 84 FR 71626, 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. On May 9, 2022, DOE published a final rule that revised the determination at issue in these consolidated cases and adopted new regulations in accordance with that revision. 87 FR 27439. In August 2022, the petitioners moved the court to dismiss the petitions for review, which the court granted.

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). These petitions were also dismissed in August 2022.

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. Section 1 of E.O. 13990 lists a number of policies related to the protection of public health and the environment, including reducing greenhouse gas emissions and bolstering the Nation's resilience to climate change. 86 FR 7037, 7041. Section 2 of E.O. 13990 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, DOE published a request for information (''RFI'') on May 25, 2021, initiating a reevaluation of its prior determination that the Secretary was not required to implement the statutory backstop requirement for GSLs (''May 2021 Backstop RFI''). 86 FR 28001. 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 (''December 2021 Backstop

[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 Resources Defense Council, Sierra Club, Consumer Federation of America, Massachusetts Union of Public Housing Tenants, Environment America, and U.S. Public Interest Research Group.

NOPR''). 86 FR 70755. On May 9, 2022, DOE published a final rule codifying the 45 lm/W backstop requirement (''May 2022 Backstop Final Rule''). 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). When DOE published the May 2022 Backstop Final Rule, it also released an enforcement policy statement for GSLs.[16] In response to lead-in time concerns raised by members of the industry and comments supporting immediate enforcement, DOE outlined a progressive enforcement model where it would exercise its discretion when taking enforcement action.

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 (''August 2021 Definition NOPR''). 86 FR 46611. 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 (''May 2022 Definition Final Rule''). 87 FR 27461.

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). EPCA directs DOE to initiate this second cycle of rulemaking procedure no later than January 1, 2020. 42 U.S.C. 6295(i)(6)(B) 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.

On January 11, 2023, DOE published a NOPR (''January 2023 NOPR''), pursuant to this second cycle of rulemaking as well as 42 U.S.C. 6295(m). 88 FR 1638 (Jan. 11, 2023).

DOE received 17 comments in response to the January 2023 NOPR from the interested parties listed in table II.3. DOE also received 158 comments from private citizens.

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[16] Enforcement Policy Statement—General Service Lamps, April 26, 2022, available at: *www.energy.gov/sites/default/files/2022–04/GSL_EnforcementPolicy_4_25_22.pdf.*

Table II.3 List of Commenters with Written Submissions in Response to the January 2023 NOPR

Commenter(s)	Abbreviation	Comment No. in the Docket	Commenter Type
Appliance Standards Awareness Project ("ASAP"), American Council for an Energy-Efficient Economy ("ACEEE"), Northeast Energy Efficiency Partnerships ("NEEP"), Alliance to Save Energy ("ASE"), Natural Resources Defense Council ("NRDC"), Northwest Energy Efficiency Alliance ("NEEA")	ASAP *et al.*	174	Efficiency Organizations
Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company	CA IOUs	167	Utilities
California Energy Commission	CEC	176	State Official/Agency
Collaborative Labeling and Appliance Standards Program	CLASP	177	Energy Efficiency Organization
Earthjustice	Earthjustice	179	Energy Efficiency Organization
Edison Electric Institute	EEI	181	Energy Efficiency Organization
Institute for Policy Integrity at New York University School of Law	IPI	175	Energy Efficiency Organization
Lutron	Lutron	182	Manufacturer
National Electrical Manufacturers Association	NEMA	183	Trade Association
New York State Energy Research and Development Authority	NYSERDA	166	State Official/Agency
Soft Lights Foundation	Soft Lights	18, 19, 48, 50, 54, 114	Activist Organization
Friends of Merrymeeting Bay	Friends of Merrymeeting Bay	100	Energy Efficiency Organization

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A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[17] To the extent that interested parties have provided written comments that are substantively consistent with any oral comments provided during the February 1, 2023, public meeting, DOE cites the written comments throughout this final rule. Any oral comments provided during the webinar that are not substantively addressed by written comments are summarized and cited separately throughout this final rule.

III. General Discussion

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

A. General Comments

This section summarizes and discusses general comments received from interested parties. As specified in section I, the adopted standards in this final rule are expressed as lumens per watt (''lm/W'') of a lamp or lamp efficacy. In this document the terms efficacy and efficiency both refer to lm/W of the lamp.

NEMA supported DOE's statements in the January 2023 NOPR regarding EPCA's preemption provisions to state regulation. NEMA stated that in the final rule, DOE clearly specified the preemptive effect on all covered products that meet the Federal definition of a GSL in accordance with E.O. 13132 as well as the timing of the effect in accordance with E.O. 12988. NEMA stated that this clarification will prevent confusion that may otherwise arise due to a patchwork of differing State regulations that had previously been implemented prior to May 9, 2022, when DOE published the May 2022 Backstop Final Rule. (NEMA, No. 183 at p. 21)

Regarding comments received on Federal preemption, in the January 2023 NOPR (88 FR 1638, 1644) and in this final rule (*see* section II.A of this

[17] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop energy conservation standards for GSLs. (Docket No. EERE–2022–BT–STD–0022, which is maintained at *www.regulations.gov*.) The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

document), DOE specifies that 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)). For the first cycle of the GSL rulemaking, EPCA provided California and Nevada with certain preemption allowances (*see* 42 U.S.C. 6295(i)(6)(A)(vi)). However, these allowances do not apply to this second cycle of GSL rulemaking (*see* 42 U.S.C. 6295(i)(6)(B)).

CLASP recommended that DOE, in partnership with the U.S. Environmental Protection Agency (''EPA'') and the Consumer Product Safety Commission (''CPSC''), implement a national policy banning fluorescent lighting on the basis of toxicity due to the mercury content contained in all fluorescent lamps, which is already adopted in California and Vermont and is under consideration in several other States. CLASP commented that such a national regulation would help to accelerate market shift to LED lamps and promote even more cost-effective energy savings in the United States. CLASP recommended that DOE prioritize an advanced schedule for the phase-out of fluorescent lighting at increased rates of efficacy, as it would yield several benefits across various DOE objectives. CLASP stated that replacing fluorescent bulbs with retrofittable LED bulbs (*i.e.,* plug-and-play, drop-in replacements that require no rewiring) will eliminate mercury and cut lighting-related power consumption in half and will reduce CO_2 and Hg emissions from power stations. CLASP also noted that LED bulbs last 2–3 times longer than fluorescent bulbs, reducing the volume of municipal waste generated. CLASP further stated that LCC studies had shown LED bulbs to have the lowest associated energy utilization and lowest environmental impact compared to other lighting technologies. (CLASP, No. 177 at pp. 4–5)

CLASP also recommended that DOE work with EPA to update ENERGY STAR requirements for lamp efficacy levels to at least double the current level of 80 lm/W in an effort to further support this GSL regulation by creating a market 'pull' for higher efficacy lamps. CLASP stated that an update to ENERGY STAR is necessary to discontinue the inclusion of CFLs in the program, as seven fluorescent lamps are currently recognized by ENERGY STAR while Africa, Europe, and India are phasing out fluorescent lighting. (CLASP, No. 177 at p. 5) NEMA noted EPA's intention to sunset all ENERGY STAR lighting programs except for a new program for recessed lighting, recognizing its significant energy savings. NEMA supported the more focused continuation of this ENERGY STAR program to maintain minimum levels of quality and performance. (NEMA, No. 183 at p. 19)

The scope of this rule is to evaluate energy conservation standards for GSLs (*see* section II.A of this document) which does not include general service fluorescent lamps or other fluorescent lamps (*see* definition of GSLs at 10 CFR 430.2). DOE considers out-of-scope lamps such as fluorescent lamps in the shipment and NIA analyses (*see* respectively, sections IV.G and IV.H of this document). Additionally, the scope of this rule does not include updating requirements set by EPA's ENERGY STAR program. Note that on March 13, 2023, EPA announced it will be sunsetting ENERGY STAR specifications for lamps and luminaires effective December 31, 2024, with the exception of recessed downlights, which would be covered by a new specification.[18]

As noted in section II.A of this document and in the January 2023 NOPR per 42 U.S.C. 6295(i)(6)(B)(iv)(I)–(II), the Secretary shall consider phased-in effective dates after considering certain manufacturer and retailer impacts. In the January 2023 NOPR, DOE requested comments on whether phased-in effective dates were necessary for the proposed GSL standards. 88 FR 1638, 1656. Westinghouse stated its preference for a single effective date for the standard, as phased-in effective dates would make things more complicated. (Westinghouse, Public Meeting Transcript, No. 27 at p. 13). NEMA stated its support for the implementation of one effective date versus phased-in effective dates. (NEMA, No. 183 at p. 5) DOE did not receive any requests for a phased-in effective date approach. Regarding the standards being adopted in this final rule, DOE does not find any particular reason(s) that phased-in effective dates would be of value for manufacturers or retailers and thus has determined the adopted standards will become effective on one date. Specifically, DOE reviewed the market and did not find impacts on manufacturers and retailers would differ by product class.

Several comments from private citizens stated that free-market forces should direct the lighting market instead of government regulation and that there should be less government interference with consumer choices. Additionally, EEI commented that if the proposed standard is not revised, many consumers will realize direct economic losses, and that by setting the standard at near maximum TSLs, DOE will make it very difficult for electric companies to justify investments in future lighting efficiency rebate programs. EEI stated that according to a recent EEI report, electric companies spent nearly $7 billion on efficiency programs in 2021, saving 237 billion kWh of electricity—enough to power 33 million U.S. homes for one year. Citing a meta-analysis by the Lawerence Berkeley National Laboratory, from 2010 through 2018, EEI stated that residential lighting programs were responsible for 48 percent of all residential program savings (*i.e.,* 14.8 percent of all market sectors). EEI added that the levelized cost to save a kWh of electricity through residential lighting programs is extremely cost-effective at just over 1 cent per kWh. (EEI, No. 181 at pp. 2–3)

When evaluating energy conservation standards for products, DOE determines whether a standard is economically justified based on several factors, including consumer impacts and lessening of the utility or the performance likely to result from the imposition of the standard, as it did in this rulemaking. 42 U.S.C. 6295(o)(2)(B)(i). Therefore, DOE's analysis accounts for the impacts on consumers. Additionally, E.O. 12866 directs DOE to assess 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 (*see* chapter 16 of the final rule TSD).

In response to the January 2023 NOPR, DOE received several comments in support of the proposed rule including the proposed TSL. 88 FR 1638, 1706–1708. CLASP stated that it agreed with DOE's finding that setting new energy conservation standards for GSLs would benefit the United States by delivering significant, cost-effective energy savings that are both technologically feasible and economically justified. (CLASP, No. 177 at p. 1) Earthjustice commented that the January 2023 NOPR demonstrates that even with DOE's recent implementation of the EPCA statutory backstop

[18] ENERGY STAR Lighting Sunset—March 13, 2023. Available at: *www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Lighting%20Sunset%20Memo.pdf.*

standard, GSLs continue to hold significant potential for additional cost-effective energy savings and air pollutant emissions reductions. (Earthjustice, No. 179 at p. 1) The CA IOUs stated that after DOE ends its enforcement discretion of the 45 lm/W backstop standard, all GSLs on the market will be light-emitting diode (''LED'') lamps or compact fluorescent lamps (''CFLs''), with LED GSLs offering many efficacies. The CA IOUs encouraged DOE to finalize this rule before June 2024 to ensure the legal durability of this and future GSL standards. (CA IOUs, No. 167 at p. 2) The CEC also stated its general support for DOE's efforts to improve the minimum efficacy for GSLs, which they stated will move the market to high-efficacy LED lighting. The CEC commented that California has been able to provide a test market as the world's fourth-largest economy for high-quality and high-efficacy LEDs since January 1, 2018. The CEC commented that the success of California's standards demonstrates the technological feasibility and economic justification of pursuing minimum efficacy standards for GSLs. (CEC, No. 176 at pp. 1–2)

NYSERDA stated its support for TSL 6 as proposed in the NOPR, as this TSL represents all product categories at their maximum technologically feasible (''max-tech'') standard efficiencies. (NYSERDA, No. 166 at pp. 1–2) NEMA stated that with the exception of the new product classes it had suggested, for all other product classes DOE should adopt TSL 5, because TSL 5 represents the maximum NPV and maintains design flexibility for lamps of varying lengths to produce sufficient light while meeting various application requirements. Specifically, NEMA stated that TSL 6 would require max-tech performance for linear LED lamps designed to replace fluorescent tubes. NEMA stated that linear LED lamps provide lower lumens, which may hinder manufacturers from producing lamps able to provide the appropriate amount of light to meet the max-tech performance standard of efficiency or efficacy level (''EL'') 7 (*see* section IV.D.1.d of this document for full comment and response). Finally, NEMA stated that because TSL 5 and TSL 6 save energy, have similar payback periods, and represent the maximum NPV, NEMA members believe DOE should adopt TSL 5 to best balance consumer cost and benefit. (NEMA, No. 183 at p. 20) ASAP *et al.* commented that DOE should not adopt TSL 5 as an alternative to TSL 6, as DOE should adopt the standard that represents the maximum improvement in energy efficiency that is technically feasible and economically justified, which is TSL 6. ASAP *et al.* commented that adopting a lower level would not fulfill DOE's statutory obligations and would needlessly result in additional energy waste and greenhouse gas and other emissions. (ASAP *et al.,* No. 174 at p. 5)

In this final rule DOE is adopting TSL 6 as proposed in the January 2023 NOPR. 88 FR 1638, 1708. DOE discusses the benefits and burdens of each TSL considered and DOE's conclusion in section V.C of this document. As discussed in that section, TSL 6 represents the maximum energy savings that are technically feasible and economically justified, as required by EPCA. Regarding requiring the max-tech level for linear LED lamps at TSL 6, all max-tech efficiency levels in this analysis are based on existing products available on the market.

B. Scope of Coverage

This rulemaking covers all consumer products that meet the definition of ''general service lamp'' as codified at 10 CFR 430.2. While all GSLs are subject to the 45 lm/W sales prohibition at 10 CFR 430.32(dd), not all GSLs are subject to the amended standards adopted in this final rule, though DOE may consider amended standards for them in a future rulemaking (*see* section IV.A.3 of this document).

C. 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's current energy conservation standards for GSLs are expressed in terms of lumens per watt (''lm/W''). GSILs and certain IRLs, CFLs, and LED lamps are GSLs. 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 integrated 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.

D. 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. *See* sections 6(b)(3)(i) and 7(b)(1) of appendix A to 10 CFR part 430, subpart C (''Process Rule'').

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. *See* section 7(b)(2)–(5) of the Process Rule. Section IV.C 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 final rule technical support document (''TSD'').

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt a new or 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 IV.D.1.c of this final rule and in chapter 5 of the final rule TSD.

E. 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 amended standards (2029–2058).[19] The savings are measured over the entire lifetime of GSLs purchased in the 30-year analysis period, *i.e.,* including savings until the longest-lifetime GSL purchased in 2058 is retired from service in 2091. 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 models to estimate national energy savings (''NES'') from potential amended standards for GSLs. The NIA model (described in section IV.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. For natural gas, the primary energy savings are considered to be equal to the site energy savings. 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.[20] DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered products or equipment. For more information on FFC energy savings, *see* section IV.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.[21] 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, taking into account the significance of cumulative FFC national energy savings, the cumulative FFC emissions reductions, and the need to confront the global climate crisis, among other factors.

As stated, the standard levels adopted in this final rule are projected to result in national energy savings of 4.0 quad, the equivalent of the primary annual energy use of 261 million homes. Based on the amount of FFC savings, the corresponding reduction in emissions, and the need to confront the global climate crisis, DOE has determined the energy savings from the standard levels adopted in this final rule are ''significant'' within the meaning of 42 U.S.C. 6295(o)(3)(B).

F. 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 rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of potential new or amended standards on manufacturers, DOE conducts an MIA, as discussed in section IV.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 payback period (''PBP'') associated with new or amended standards. These measures are discussed further in the following section. For consumers in the aggregate, DOE also calculates the national 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 (Life-Cycle Cost (''LCC'') and Payback Period Analysis (''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 cost (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

[19] DOE also presents a sensitivity analysis that considers impacts for products shipped in a 9-year period.

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

[21] The numeric threshold for determining the significance of energy savings established in a final rule published on February 14, 2020 (85 FR 8626, 8670), was subsequently eliminated in a final rule published on Dec. 13, 2021 (86 FR 70892).

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 IV.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 IV.H of this document, DOE uses the NIA spreadsheet models 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 adopted 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 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 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)) To assist the Department of Justice (''DOJ'') in making such a determination, DOE transmitted copies of its proposed rule and the NOPR TSD to the Attorney General for review, with a request that the DOJ provide its determination on this issue. In its assessment letter responding to DOE, DOJ concluded that it does not have evidence that the new proposed energy conservation standards for GSLs are substantially likely to adversely impact competition. DOE is publishing the Attorney General's assessment at the end of this final rule.

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 adopted 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 IV.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 adopted 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 IV.K of this document; the estimated emissions impacts are reported in section V.B.6 of this document. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.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 effect potential amended 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 IV.F of this final rule.

IV. Methodology and Discussion of Related Comments

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

DOE used several analytical tools to estimate the impact of the standards considered in this document. The first tool is a spreadsheet that calculates the LCC savings and PBP of potential amended or new energy conservation standards. The national impact analysis uses a second spreadsheet set that provides shipments projections and calculates national energy savings and net present value 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: *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*'') for the emissions and utility impact analyses.

A. Scope of Coverage

This rulemaking covers all consumer products that meet the definition of ''general service lamps'' as codified at 10 CFR 430.2. While all GSLs are subject to the 45 lm/W sales prohibition at 10 CFR 430.32(dd), DOE is not adopting amended energy conservation standards in this final rule for all GSLs, though DOE may consider amended standards for them in a future rulemaking. In this rulemaking, DOE is analyzing and adopting amended standards for CFLs and general service LED lamps that have a lumen output within the range of 310–3,300 lumens; have 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. In this rulemaking as specified in § 430.32(dd)(1)(iv)(C), DOE is not analyzing and adopting amended standards for general service organic LED lamps and any GSL that (1) is a non-integrated lamp that is capable of operating in standby mode and is sold in packages of two lamps or less; (2) is designed and marketed as a lamp that has at least one setting that allows the user to change the lamp's CCT and has no setting in which the lamp meets the definition of a colored lamp (as defined in 10 CFR 430.2); and is sold in packages of two lamps or less; (3) is designed and marketed as a lamp that has at least one setting in which the lamp meets the definition of a colored lamp (as defined in 10 CFR 430.2) and at least one other setting in which it does not meet the definition of colored lamp (as defined in 10 CFR 430.2) and is sold in packages of two lamps or less; or (4) is designed and marketed as a lamp that has one or more component(s) offering a completely different functionality (*e.g.,* a speaker, a camera, an air purifier, etc.) where each component is integrated into the lamp but does not affect the light output of the lamp (*e.g.,* does not turn the light on/off, dim the light, change the color of the light, etc.), is capable of operating in standby mode, and is sold in packages of two lamps or less. *See* section IV.A.3 of this document for further details. 42 U.S.C. 6295(i)(6)(B)(ii) of EPCA provides that this rulemaking's 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.

General service lamp means a lamp that has an American National Standards Institute (''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 at 277 volts for integrated lamps, or is able to operate at any voltage for non-integrated lamps; 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 C79.1–2002; (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, 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 that have a first number symbol less than 16 (diameter less than 2 inches) as defined in ANSI C79.1–2002 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; (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, nominal overall length less than 12 inches, and that are not compact fluorescent lamps; and (26) Traffic signal lamps. 10 CFR 430.2.

The definitions for compact fluorescent lamps, general service light-emitting diode lamps, and general service organic light emitting diode lamps, and other terms used in the GSL definition are also specified in 10 CFR 430.2.

Additionally, 42 U.S.C. 6295(i)(6)(B)(i)(II) directs DOE to consider whether the exemptions for certain incandescent lamps should be maintained or discontinued. In the January 2023 NOPR, DOE reviewed the regulatory definitions of GSL, GSIL, and supporting definitions adopted in the May 2022 Definition Final Rule and determined that no amendments are needed with regards to the maintenance or discontinuation of exemptions for certain incandescent lamps. 88 FR 1638, 1651. DOE received no comments regarding this assessment. DOE maintains this assessment in this final rule.

1. Supporting Definitions

In the January 2023 NOPR, DOE proposed minor updates to clarify certain supplemental definitions adopted in the May 2022 Definition Final Rule. In the January 2023 NOPR, DOE proposed to amend the existing definition of LED downlight retrofit kit to specify that it must be a retrofit kit classified or certified to Underwriters Laboratories (''UL'') 1598C–2014.[22] 88 FR 1638, 1652.

NEMA requested that DOE reference UL 1598C generally, without reference to a specific publication year. NEMA noted that American National Standards publications (*e.g.,* ANSI/UL 1598C) are dynamic with revisions continuously evaluated, refined, voted upon, published, and implemented by subject matter experts seeking to improve the utility of these publications in the market. NEMA stated that by specifying a publication year, DOE would be unnecessarily forgoing the benefit of revisions to this important consumer safety standard and working against the standards' adoption in the broader market. (NEMA, No. 183 at p. 3).

The GSL definition states that a GSL is not an LED downlight retrofit kit. 10 CFR 430.2. Therefore, the definition of LED downlight retrofit kit informs what is or is not a GSL. DOE reviewed UL 1598C–2014 before proposing that a LED downlight retrofit kit be classified or certified to the standard. 88 FR 1638, 1652. DOE would need to review updates in any new version of the standard to assess any impacts on the LED downlight retrofit kit definition and subsequently on the GSL definition. If DOE does not specify the version of the UL 1598C standard, it may result in

[22] UL, UL1598C Standard for Safety Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits. Approved November 17, 2016.

changes to these definitions that have not been reviewed by DOE and/or put forth for public comment. Therefore, in this final rule, DOE is adopting the definition for LED downlight retrofit kit with reference to UL 1598C–2014 as proposed in the January 2023 NOPR. Further, note that the edition of UL 1598C DOE reviewed and proposed for incorporation in the January 2023 NOPR was the first edition dated January 16, 2014, including revisions through November 17, 2016. To ensure the appropriate version is being referenced and to align with the referencing of industry standards in other definitions, DOE is specifying the year when referencing UL 1598C in the LED downlight retrofit kit definition as UL 1598C–2016 in this final rule.

In the January 2023 NOPR, DOE also proposed to update the industry standards referenced in the definitions of ''Reflector lamp'' and ''Showcase lamp.'' Specifically, DOE proposed to remove the reference to ANSI C78.20–2003 [23] 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 another industry standard, ANSI C79.1–2002,[24] with ANSI C78.79–2014 (R2020).[25] Accordingly, DOE proposed to update the following supporting definitions that currently reference ANSI C79.1–2002 to reference ANSI C78.79–2014 (R2020): (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. 88 FR 1638, 1652. DOE received no comments on this proposal. Therefore, in this final rule, DOE adopts the updates to industry standards referenced in these supporting definitions as proposed in the January 2023 NOPR.

DOE received a comment regarding the term ''general service.'' Seasonal Specialties commented that there does not seem to be a definition for ''general service'', and it is unclear what ''general service'' includes and excludes. (Seasonal Specialties, Public Meeting Transcript, No. 27 at pp. 18–19)

As noted previously in section IV.A of this document, the definition of GSL in 10 CFR 430.2 specifies a GSL must have an ANSI base, operate in certain voltage ranges, and have lumens in certain lumens ranges. It also identifies lamp types that are GSLs as well as 26 lamp types that are exempt from the GSL definition. Hence, DOE finds that the GSL definition in 10 CFR 430.2 clearly specifies what is or is not a GSL and no other definitions are necessary.

Additionally, DOE received comments on the definition of standby power. NEMA recommended that DOE revise the definition of ''Standby mode,'' because the current definition focuses only on the energy consumption of a lamp's standby mode condition and not the reason that it operates on standby (*i.e.,* a lamp's functional capabilities). NEMA stated that the definition of ''Standby mode'' in the January 2023 NOPR TSD could become problematic and restrictive as the category more fully develops. NEMA recommended that DOE instead replace the term ''Standby mode'' with ''Lamp capable of operating in standby mode'' and to denote it as an ''an energy-using product.'' (NEMA, No. 183 at p. 9) Lutron commented that it supports NEMA's revisions to the January 2023 NOPR definition of ''standby mode.'' (Lutron, No. 182 at p. 8)

The definition of ''standby mode'' is a statutory definition specified in 42 U.S.C. 6295(gg)(1)(iii). In appendix A of the January 2023 NOPR TSD, DOE repeated this definition as it appears in 42 U.S.C. 6295(gg)(1)(iii) and is codified in 10 CFR 430.2. This definition specifies that standby mode means the condition in which an energy-using product is connected to a main power source; and offers certain user-oriented or protective functions. (*see* 42 U.S.C. 6295(gg)(1)(iii), 10 CFR 430.2)

NEMA's suggested changes would add language that states, ''Lamps capable of operating in standby mode.'' However, this definition applies to all covered products, not only lamps. Further, in the January 2023 NOPR, DOE proposed a table to codify the proposed GSL standards in the CFR. This table included the column ''Standby Mode Operation'' indicating the lamps that are capable of standby mode operation and those that are not and the standards to which they would be subject. 88 FR 1638, 1718. Therefore, proposed GSL standards and those adopted in this rulemaking would clearly indicate the difference between lamps capable of operating in standby mode and those that are not. NEMA also suggested adding language that specifies the product in standby mode as ''an energy-using product.'' This language is already present in the existing definition. Finally, NEMA's concern that the definition does not focus on the lamp's functional capabilities that require it to operate in standby mode is addressed in paragraph 2 of the definition, which describes the additional user-oriented or protective functions the product offers. Hence, because it is a statutory definition and changing it would not have a substantive impact on clarity or accuracy, DOE is not amending the definition of ''Standby mode'' in this final rule.

2. Definition of Circadian-Friendly Integrated Light-Emitting Diode (''LED'') Lamp

In the January 2023 NOPR, DOE proposed a definition for ''circadian-friendly integrated LED lamp'' and proposed that lamps meeting that definition be excluded from the GSL definition. DOE 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 and also observed that their efficacies ranged from 47.8 lm/W to 85.7 lm/W. Specifically, DOE proposed to define ''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. 88 FR 1638, 1652. In addition, based on the potential utility they offer and DOE's tentative findings that such lamps did not have high efficacy values, DOE proposed to exclude them from meeting the definition of GSLs.

DOE received several comments regarding the proposed definition and exemption of the circadian-friendly integrated LED lamp, including

[23] 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 Oct. 30, 2003.

[24] 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 Sept. 16, 2002.

[25] 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 Jan. 17, 2020.

comments questioning DOE's authority to exempt them from the GSL definition.

Earthjustice and ASAP *et al.* stated that DOE lacks the legal authority to exempt these lamps and doing so would violate the anti-backsliding provision. (Earthjustice, No. 179 at pp. 1–3; ASAP *et al.,* No. 174 at pp. 1–2) Earthjustice commented that the proposed GSL exemption for circadian-friendly LED lamps would mean that these lamps would no longer be subject to the 45 lm/W backstop standard level or any standard, an action EPCA's anti-backsliding provision explicitly forbids. Regarding authority, Earthjustice commented that the January 2023 NOPR cited no EPCA provision for excluding circadian-friendly integrated LED lamps from the GSL definition, indicating that such authority does not exist. Earthjustice commented that EPCA grants DOE explicit authority to enlarge the scope of GSLs to encompass any lamps ''used to satisfy lighting applications traditionally served by general service incandescent lamps'' but offers limited authority to grant exemptions. Further, Earthjustice stated that the requirement per EPCA that DOE complete a rulemaking to consider whether ''the exemptions for certain incandescent lamps should be maintained or discontinued'' (*see* 42 U.S.C. 6295(i)(6)(A)(i)(II)) is not applicable in this case. Earthjustice stated that EPCA authorizes DOE to exclude: (1) from the term ''medium base compact fluorescent lamp'' any lamp that is ''designed for special applications'' and ''unlikely to be used in general purpose applications'' (*see* 42 U.S.C. 6291(30)(S)(ii)(II)); and (2) from the terms ''fluorescent lamp'' and ''incandescent lamp'' any lamp to which DOE makes ''a determination that standards for such lamp would not result in significant energy savings because such lamp is designed for special applications or has special characteristics not available in reasonably substitutable lamp types'' (*see* 42 U.S.C. 6291(30)(E)). Earthjustice stated that neither of these two provisions authorizes DOE to exclude products from the definition of GSLs because GSLs need not meet the definitions of MBCFL, fluorescent lamp, or incandescent lamp to be covered as GSLs. Earthjustice concluded by stating that because the proposed action for circadian-friendly LED lamps does not fit into one of the categories of exemptions DOE is statutorily authorized to create, the proposed action is unlawful, and that where a statute confers authority on an agency to create specific exemptions, broader authority to create other types of exemptions cannot be inferred. (Earthjustice, No. 179 at pp. 1–3)

NEMA stated that the proposed circadian-friendly integrated LED lamp exemption could lead to standards being set at the State level, resulting in a patchwork of product regulations. NEMA recommended that DOE finalize a rule that creates no exemptions and sets minimum ELs for all GSLs, regardless of product claims. NEMA recommended that DOE work with stakeholders to develop better, more useful definitions, and to set minimum ELs for energy conservation standards that will allow the market to develop and mature. (NEMA, No. 183 at p. 4).

Based on the comment received, DOE does not have sufficient information to establish a separate product class for circadian-friendly integrated LED lamps. (See 42 U.S.C. 6295(q)) Therefore, DOE is not exempting circadian-friendly integrated LED lamps from the GSL definition in this final rule. As a result, these lamps will be subject to the standards for GSLs.

With regards to the specific definition of circadian-friendly lamps, CLASP, NYSERDA, and the CEC commented that DOE's proposed definition of circadian-friendly integrated LED lamps is too broad and recommended that DOE include more specific requirements. (CEC, No. 176 at p. 3; NYSERDA, No. 166 at pp. 2–3; CLASP, No. 177 at pp. 3–4) Specifically, NYSERDA stated that the proposed definition called only for a ''decrease'' in blue light without providing more strict specific guidance (*i.e.,* ''decreasing by 90 percent'') or requiring removal of blue light. NYSERDA commented that the definition could be met by minimal design modifications targeting blue wavelengths, with the result that inefficient LED lamps in popular form factors could continue to be available without producing positive health outcomes. (NYSERDA, No. 166 at pp. 2–3) CLASP also recommended that DOE not include language like ''one setting that decreases or removes standard spectrum radiation'' and rather specify that such lamps should only—and always—operate in this modified mode. CLASP offered the example of DOE subjecting ''modified-spectrum'' GSLs which had a neodymium coating on the glass to an adjusted efficacy level because of the modified-spectrum feature. (CLASP, No. 177 at pp. 3–4) NYSERDA also stated that the other criteria in DOE's proposed definition (*i.e.,* marketing, replacement wattage, and packaging) could also be easily adjusted to meet the definition through minimal manufacturer changes. (NYSERDA, No. 166 at pp. 2–3) EEI stated that it was unclear how efficiency connected to DOE's proposed criteria that circadian-friendly integrated LED lamps be sold in packages of two lamps or less. Regarding the criteria that the lamp be designed and marketed as an equivalent replacement for a 40 W or 60 W incandescent lamp, EEI stated that there could be replacements for other wattage equivalents such as 100 W incandescent or 72 W halogen. (EEI, Public Meeting Transcript, No. 27 at pp. 19–20)

DOE believes at this time that circadian friendly integrated LED lamps do not possess unique attributes compared to other GSLs. There is no consensus on specific lamp attributes that meaningfully impact the human circadian cycle. The human circadian system's response curves are not yet fully understood and the proper dosing of light to achieve circadian effects has not been standardized. Therefore, DOE finds that an accurate definition of a circadian-friendly integrated LED lamp is not possible and the claim that these lamps provide unique utility is not accurate at this time. Accordingly, DOE is declining to adopt a definition of circadian-friendly integrated LED lamp at this time, which is consistent with comments on the proposed rule. As noted above, DOE is not exempting circadian-friendly integrated LED lamps from the GSL definition in this final rule and as a result, these lamps will be subject to the standards for GSLs.

3. Scope of Standards

In the January 2023 NOPR, DOE stated that it was not assessing standards for general service organic light-emitting diode (''OLED'') lamps, a type of GSL, in this rulemaking. 88 FR 1638, 1653. Due to the lack of commercially available GSLs that use OLED technology, in the January 2023 NOPR DOE determined that it is unclear whether the efficacy of these products can be increased. DOE tentatively determined that standards for these lamps would not be technologically feasible and did not evaluate them in the January 2023 NOPR. DOE did not receive any comments on this proposal. In this final rule, DOE continues to not evaluate standards for general service OLED lamps for the reasons stated previously.

DOE received comments that it should create separate product classes and thereby standards for each of the following lamp types: (1) lamps that change the lamp's correlated color temperature (''CCT''); (2) lamps that change the lamp to be a colored lamp; (3) lamps that are capable of operating in standby mode and have at least one additional feature that does not control light output; and (4) lamps that are non-integrated and capable of operating in standby mode. In this rulemaking, DOE did not analyze amended standards for these lamp categories because DOE lacks sufficient information about the performance of these lamps given the rapidly evolving market. DOE has carefully reviewed the lamp categories and determined that because the markets for these lamps are rapidly developing, DOE is unable to make a clear and accurate determination regarding the consumer utility, how various technology options would affect the efficiency, and the maximum technologically feasible efficiency of these lamps, which prevents DOE from determining whether a specific standard for these lamps would be economically justified at this time. Accordingly, DOE did not consider standards for these lamps in this rulemaking. DOE may evaluate amended standards for these lamps in a future rulemaking. DOE notes that these lamps are still subject to the 45 lm/W sales prohibition at 10 CFR 430.32(dd). For a full discussion of these comments and DOE's responses, *see* section IV.B.2 of this document.

In the January 2023 NOPR, DOE proposed to exempt circadian-friendly integrated LED lamp (see section IV.A.2 of this document) from amended standards because these lamps offered a utility to consumers in the form of aiding in the human sleep-wake (*i.e.,* circadian) cycle and also these lamps did not have high efficacies. 88 FR 1638, 1652. DOE received several comments citing concerns regarding potential loopholes resulting from such an exemption from standards. ASAP *et al.,* CLASP, NYSERDA, and the CEC commented that DOE's proposal to exclude circadian-friendly integrated LED lamps from GSL regulation would risk creating a loophole and allow inefficient lamps on the market. (CEC, No. 176 at p. 3; NYSERDA, No. 166 at pp. 2–3; CLASP, No. 177 at pp. 3–4; ASAP *et al.,* No. 174 at pp. 1–2) NEMA stated that the circadian-friendly integrated lamp definition and exemption could provide manufacturers an opportunity to evade regulations. (NEMA, No. 183 at p. 4) DOE also received comments on the utility of circadian-friendly integrated LED lamps. NYSERDA commented that these lamps provide general illumination and found no clear evidence of a utility that justified exempting the lamps. (NYSERDA, No. 166 at p. 2) NEMA stated that the human circadian system's response curves are not yet fully understood and the proper dosing of light to achieve circadian effects has not been standardized. NEMA noted that IES RP–46 Recommended Practice: Supporting the Physiological and Behavioral Effects of Lighting in Interior Daytime Environments is still in development. NEMA commented some spectrally tunable lamps are marketed with ''circadian features'' entrainment but there are reasons to dismiss such claims because the ability to affect circadian entrainment is not a product attribute but a matter of proper lighting product application (*i.e.,* attention to timing, intensity, spectrum and duration of the applied light). Further NEMA commented that the two circadian-friendly integrated LED lamps cited in the January 2023 NOPR could be applied in such a way as to not produce the claimed circadian effects and offer a limited representation of the circadian entrainment potential as they only decrease or remove blue light to promote better sleep while other products can be programmed to provide more or less blue light by time of day. (NEMA, No. 183 at pp. 3–4)

DOE also received comments addressing DOE's observed lower efficacy of the circadian-friendly integrated LED lamps and suggestions to establish appropriate standards for these lamps instead of exempting them from standards. ASAP *et al.* commented that DOE's proposal to exempt circadian-friendly integrated LED lamps because it had observed an efficacy range of 47.8 lm/W to 85.7 lm/W suggested DOE assumed that the lower efficacy is representative of this technology. ASAP *et al.* stated that this may not be the case, as many common integrated omnidirectional short lamps on the market today have efficacies of 80–90 lm/W, which is similar to those of some of the circadian-friendly lamps identified by DOE. (ASAP *et al.,* No. 174 at pp. 1–2) CLASP and ASAP *et al.* commented that circadian-friendly lamps are based on the same design principles as other LED lamps (*e.g.,* improved drivers and LED chips) and therefore can be made more efficient in the same way. CLASP and ASAP *et al.* commented that, rather than exempting the lamps, DOE should determine the technologically justified efficacy adjustment for these lamps. (ASAP *et al.,* No. 174 at pp. 1–2; CLASP, No. 177 at pp. 3–4)

Similarly, NYSERDA, the CEC, and the CA IOUs recommended that DOE consider establishing a separate product class targeting circadian-friendly products at a level slightly lower than currently proposed for most product classes of GSLs. (NYSERDA, No. 166 at pp. 2–3; CA IOUs, No. 167 at p. 3; CEC, No. 176 at p. 3–4) NYSERDA commented that such a product class should include a clear definition and serve a specific health utility. (NYSERDA, No. 166 at pp. 2–3) The CEC also stated that the definition should include specific and objective features, such as color shifting, that can provide a basis for determining the additional power required to efficiently provide one or more specific circadian benefits. (CEC, No. 176 at p. 3–4) NYSERDA and the CEC stated that the product class approach based on a well-defined lamp type would achieve DOE's intent to preserve the circadian-friendly integrated LED lamps while limiting a loophole that would result in inefficient LED lamps on the market. (NYSERDA, No. 166 at pp. 2–3; CEC, No. 176 at p. 3–4) The CA IOUs commented that circadian-friendly integrated LED lamps are in early stages of development and there is no industry-wide definition of ''circadian-friendly'' lighting. The CA IOUs recommended that circadian-friendly integrated LED lamps be defined as proposed in the January 2023 NOPR but be subjected to a reasonable minimum luminous efficacy requirement. Additionally, the CA IOUs recommended that DOE require manufacturers to report shipments of circadian-friendly integrated LED lamps and issue public reports on shipment growth. The CA IOUs added that DOE could then make informed adjustments to the definition and standards as necessary for circadian-friendly integrated LED lamps in a future GSL rulemaking. (CA IOUs, No. 167 at p. 3)

Based on the comments received, there is no clear consensus on specific lamp attributes that meaningfully impact the human circadian cycle. The human circadian system's response curves are not yet fully understood and the proper dosing of light to achieve circadian effects has not been standardized. Further, as pointed out by the commenters, there are circadian-friendly integrated LED lamps with comparable efficacies to other GSLs. As a result, DOE does not have sufficient information to establish a separate product class for circadian-friendly integrated LED lamps. (See 42 U.S.C. 6295(q)) And as Earthjustice noted, DOE agrees that the proposed GSL exemption for circadian-friendly LED lamps would mean that these lamps would no longer be subject to the 45 lm/W backstop standard level or any standard, an action EPCA's anti-backsliding provision explicitly forbids. Consistent with these and the above comments, DOE is including circadian-friendly integrated LED lamps within the scope of amended standards. DOE notes, however, that it could decide not to amend existing standards for circadian-friendly integrated LED lamps in a future rulemaking if so warranted by a product class designation.

Relatedly, while all GSLs are subject to the 45 lm/W sales prohibition at 10 CFR 430.32(dd), not all GSLs are subject to the amended standards adopted in this final rule, though DOE may consider amended standards for them in a future rulemaking. In this rulemaking, DOE is analyzing and adopting amended standards for CFLs and general service LED lamps that have a lumen output within the range of 310–3,300 lumens; have 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. In this rulemaking as specified in § 430.32(dd)(1)(iv)(C), DOE is not analyzing and adopting amended standards for general service organic LED lamps and any GSL that:

(1) Is a non-integrated lamp that is capable of operating in standby mode and is sold in packages of two lamps or less;

(2) Is designed and marketed as a lamp that has at least one setting that allows the user to change the lamp's CCT and has no setting in which the lamp meets the definition of a colored lamp (as defined in 10 CFR 430.2); and is sold in packages of two lamps or less;

(3) Is designed and marketed as a lamp that has at least one setting in which the lamp meets the definition of a colored lamp (as defined in 10 CFR 430.2) and at least one other setting in which it does not meet the definition of colored lamp (as defined in 10 CFR 430.2) and is sold in packages of two lamps or less; or

(4) Is designed and marketed as a lamp that has one or more component(s) offering a completely different functionality (*e.g.,* a speaker, a camera, an air purifier, etc.) where each component is integrated into the lamp but does not affect the light output of the lamp (*e.g.,* does not turn the light on/off, dim the light, change the color of the light, etc.), is capable of operating in standby mode, and is sold in packages of two lamps or less. Lamps that would not meet these criteria and therefore would not be exempt from standards would be lamps that have integrated motion sensors that affect light output, lamps with internal battery backup used for light output, and lamps designed and marketed as dusk to dawn lamps.

Please note that DOE is not exempting circadian-friendly integrated LED lamps from the GSL definition or the scope of standards in this final rule. As a result, these lamps will be subject to the standards for GSLs.

4. Scope of Metrics

As stated in section II.A, this rulemaking is being conducted pursuant to 42 U.S.C. 6295(i)(6)(B) and (m). 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 all GSLs. In the January 2023 NOPR, DOE explained that 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 considered in the analysis for this rulemaking. In the January 2023 NOPR, DOE discussed its decision to use minimum lumens per watt as the metric for measuring lamp efficiency for GSLs rather than maximum wattage of a lamp. 88 FR 1638, 1653. DOE did not receive comments on this decision. In this final rule, DOE continues to use minimum lumens per watt as the metric for measuring lamp efficiency for GSLs.

In the January 2023 NOPR, DOE also discussed proposed updates to existing metrics and the proposed addition of new metrics for GSLs. These included updating the existing lumen maintenance at 1,000 hours and at 40 percent of lifetime, rapid cycle stress test, lifetime requirements, and adding a power factor and start time requirement for MBCFLs. DOE also proposed adding a power factor requirement for integrated LED lamps. Finally, DOE proposed codifying color rendering index (''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 [27]; 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 as specified in section 321(a) of EISA. 88 FR 1638, 1653. The following sections discuss the comments received on these proposals.

a. Lifetime

NYSERDA commented that it supports DOE's proposed increase to a 10,000-hour lifetime for MBCFLs and recommended DOE consider adding a 10,000-hour-minimum requirement for LED lamps to ensure consumer needs are met. (NYSERDA, No. 166 at p. 3)

DOE only has authority to amend the lifetime requirement for MBCFLs, not LED lamps. 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 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)) Based on this authority, in the January 2023 NOPR, DOE proposed to update the existing lifetime requirement for MBCFLs. The only metric that DOE proposed for LED lamps was a minimum power factor for integrated LED lamps. DOE finds that it has the authority to set this metric because power factor impacts energy use. A low power factor product is inefficient and

[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 section 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, section 321(a)(3)(A)(ii), *with* 42 U.S.C. 6295(i)(1). It appears, however, that Congress's intention in section 322(b) of EISA 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).

[27] American National Standards, ''for electrical lamp bases—Specifications for Bases (Caps) for Electric Lamps,'' approved August 25, 2006.

requires an increase in an electric utility's generation and transmission capacity. (*See* further details on the power factor requirement for integrated LED lamps in section IV.A.4.c of this document.)

b. Color Rendering Index (''CRI'')

NYSERDA stated its support for the inclusion of a minimum of 80 CRI for non-modified-spectrum GSLs, noting that an 80 CRI or above has been demonstrated to ensure sufficient visual acuity for general illumination situations. (NYSERDA, No. 166 at p. 3) EEI stated that while a CRI of 80 was adequate, a higher CRI is always better and a CRI of 90 would be preferable, if possible. (EEI, Public Meeting Transcript, No. 27 at pp. 24–26) NEMA stated its support for DOE's proposal to codify a minimum CRI of 80 but requested the requirement apply to all GSLs within the scope of the rulemaking rather than only to those with medium screw bases or any other screw base not defined in ANSI C81.61–2006, as specified in the January 2023 NOPR. NEMA stated that the proposed CRI requirement excludes many lamps in the scope of this regulation that are already normalized at a minimum CRI of 80 due to consumer preference and therefore their inclusion in the requirement would pose no regulatory burden for manufacturers. Further, NEMA stated its concern that as an offset to the new efficacy and performance requirements, the removal of a consistent regulated threshold will incentivize market introduction of lower CRI products. Additionally, NEMA stated that to its knowledge, there are no modified-spectrum incandescent lamps in the U.S. market today and recommended that all mentions of ''modified spectrum'' be excluded from the final rule. In the event that regulatory requirements for this product category must be maintained, NEMA recommended that all requirements for modified spectrum lamps be made identical to those of the non-modified spectrum lamps. (NEMA, No. 183 at p. 5)

These CRI requirements are from section 321(a) of EISA, which amended 42 U.S.C. 6295(i)(1). But because of an apparent conflict with section 322(b) of EISA, which purported to strike paragraph (1) of 42 U.S.C. 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. It has been DOE's position that Congress's intention in section 322(b) of EISA was to replace the existing paragraph (1), not the newly amended paragraph (1). There is no reason to believe that Congress intended to amend 42 U.S.C. 6295(i) to include requirements for CRI only to delete those the requirements in the same Act. *See* 88 FR 1638, 1653. In the January 2023 NOPR, DOE proposed to codify the CRI requirements in section 321(a) of EISA and mistakenly included a 2028 compliance date for CRI requirements. 88 FR 1638, 1654, 1719. However, section 321(a)(3)(A)(ii) of EISA and 42 U.S.C. 6295(i)(1) specify that these CRI requirements apply to lamps manufactured or imported after December 31, 2011. Because DOE lacks the legal authority to change the compliance date of CRI requirements established in EISA, DOE is declining to codify the CRI requirements in this rulemaking and will, instead, conduct a separate rulemaking to codify these requirements.

c. Power Factor

In the January 2023 NOPR, DOE proposed a minimum power factor requirement of 0.5 for MBCFLs and 0.7 for integrated LED lamps. 88 FR 1638, 1654. The CEC stated its support for DOE's proposal to include a minimum power factor for MBCFLs and integrated LED lamps. The CEC stated that as the number of LED lamps increases, harmonic waves sent over the power grid can cause issues, requiring expensive equipment to correct such issues and if uncorrected, harmonic waves will reduce the quality of power delivered to all electrical loads, including lamps, and the grid will experience avoidable losses. (CEC, No. 176 at pp. 4–5) NYSERDA stated its support for a power factor requirement of 0.7 for integrated LED lamps as established by ENERGY STAR. (NYSERDA, No. 166 at p. 3)

Hawaii State Energy Office (''HSEO'') stated that it supported a minimum power factor of 0.9 with certain exemptions for specialty lamps. HSEO further stated that regarding lamps of less than 5 W, given the efficacy of CFLs and LED lamps, 0.7 would be an appropriate minimum power factor. (HSEO, Public Meeting Transcript, No. 27 at p. 36) EEI also stated that both CFLs and LED lamps should have power factors over 0.9 as low power factors are not good for the grid and there are commercial customers that face financial penalties if their power factors go below 0.9. (EEI, Public Meeting Transcript, No. 27 at pp. 24–26)

NEMA recommended that DOE specify minimum power factors by wattage rather than setting a minimum power factor for all integrated LED lamps. NEMA stated that DOE should adopt the power factor requirements set forth in ANSI C82.77–10 without modification. Specifically, in its comment NEMA provides a table from ANSI C82.77–10 with the following power factor requirements: no minimum power factor for lamps less than or equal to 5 W, a minimum power factor of 0.57 for lamps 5 W to 25 W inclusive, and a minimum power factor of 0.86 for lamps greater than 25W. (*Note:* The table also specifies requirements for the minimum displacement factor, but it is not clear from NEMA's statements whether it is recommending DOE should require this additional requirement.) NEMA also noted that ENERGY STAR requirements are similarly less strict for low power lamps—*i.e.,* no minimum power factor for lamps less than or equal to 5 W, a minimum power factor of 0.6 for lamps greater than 5W to less than or equal to 10 W, and a minimum power factor of 0.7 for lamps greater than 10W. (NEMA, No. 183 at pp. 4–5, 40–41)

NEMA provided several reasons for using the wattage-tiered approach to power factor requirements specified in ANSI C82.77–10. NEMA stated that these requirements align with the International Electrotechnical Commission (''IEC'') standard and Global Lighting Association recommendations. NEMA stated that any reduction of imaginary current (which causes electrical losses in the equipment of the power company) from the proposed increase in power factor will be minimal compared to that due to the proposed increases in efficacy. NEMA stated that a single higher power factor requirement for products of all wattages will increase the amount of electronics in lamps and thereby the size of the lamps, especially posing a problem for small, low power lamps, and increasing the manufacturing burden to achieve the regulated efficacies. NEMA also stated that additional electronics required to achieve the higher power factor causes a small, unavoidable decrease in efficacy. Further, NEMA stated that there is a correlation between low power lamps and low power factor. (NEMA, No. 183 at pp. 4–5)

Regarding data available for determining an appropriate power factor requirement, Signify and Westinghouse stated that databases from sources such as ENERGY STAR contain a limited number of products that are not always representative of the entire market and DOE should be cautious of using them to develop requirements that apply to all lamps on the market. (Signify, Public Meeting Transcript, No. 27 at p. 29;

Westinghouse, Public Meeting Transcript, No. 27 at pp. 30–31)

In the January 2023 NOPR and in this final rule, DOE considered ENERGY STAR Lamps Specification V2.1 requirements,[28] industry standards, and characteristics of lamps in the current market when selecting power factor requirements for MBCFL and integrated LED lamps. 88 FR 1638, 1654. The assessment of lamps in the current market was based on the lamps database developed for the NOPR analysis and this final rule analysis (*see* section IV.D of this document). This lamps database is a comprehensive accounting of lamps on the market as it includes data from manufacturer catalogs, DOE's compliance certification database, retailer websites, and the ENERGY STAR Certified Light Bulbs database. Hence, DOE considered power factor requirements based on data that is representative of all lamps on the market.

Passive and active technologies that can correct power factors in lamps are commercially available and the circuitry used in power factor correction is made to be very efficient, while consuming small amounts of power. DOE reviewed the current U.S. market via its lamps database used in this analysis (*see* section IV.D of this document) and found that about 98 percent of integrated LED lamps have power factors of 0.7 or greater. DOE also found numerous low-wattage LED lamps from 2 to 5 W, on the market, that are within the covered lumen range of GSLs, have a power factor of 0.7 or greater, and meet the max tech levels for integrated LED lamps. Hence, DOE finds that a power factor requirement of 0.7 for integrated LED lamps is achievable for lamps across all wattages and does not prevent these lamps from meeting or exceeding the max-tech levels across the full lumen range. Therefore, in this final rule, DOE is adopting the power factor requirements as proposed in the January 2023 NOPR for MBCFLs and integrated LED lamps.

d. Summary of Metrics

Table IV.1 summarizes the non-efficacy metrics being adopted in this rulemaking (efficacy metrics are discussed in the engineering analysis; *see* section IV.D of this document). For MBCFLs, performance requirements were specified for five metrics: (1) minimum initial efficacy; (2) lumen maintenance at 1,000 hours; (3) lumen maintenance at 40 percent of lifetime; (4) rapid cycle stress; and (5) lamp life. (42 U.S.C. 6295(bb)(1)) In addition to revising the existing requirements for MBCFLs, DOE has the authority to establish requirements for additional metrics including CRI, power factor, operating frequency, and maximum allowable start time based on the requirements prescribed by the August 9, 2001 ENERGY STAR® Program Requirements for CFLs Version 2.0, or establish other requirements after considering energy savings, cost effectiveness, and consumer satisfaction. (42 U.S.C. 6295(bb)(2)–(3)) DOE is also establishing a minimum power factor for integrated LED lamps. DOE finds that it has the authority to set this metric because power factor impacts energy use. (42 U.S.C. 6295(bb)(3)(B)) A low power factor product is inefficient and requires an increase in an electric utility's generation and transmission capacity. DOE has determined that these new metrics for MBCFLs and integrated LED lamps will provide consumers with increased energy savings and/or consumer satisfaction for those products capable of achieving the adopted standard levels. DOE has existing test procedures for the metrics being proposed. (*See* sections III.C and IV.A.5 of this document for more information on test procedures for GSLs.) Further, DOE has concluded that the new metrics being adopted in this rule will not result in substantial testing burden, as many manufacturers already test their products according to these metrics.

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

Table IV.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

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

5. Test Procedure

As noted in section III.C of this document, GSILs and certain IRLs, CFLs, and LED lamps are GSLs. 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 integrated 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.

DOE received comments on some of DOE's test procedures applicable to GSLs. NEMA stated that section 3.1.4 in appendix BB and section 3.5 in appendix DD specifies testing be done at the ''maximum input power'' and for a color-tunable (multi-primary) lamp this will typically occur when all LED packages within are driven at 100-percent output. NEMA stated that when all primary color sources (*e.g.,* R, G, B, and W) are at full output, the chromaticity coordinates of the whole lamp may not be on or even close to the blackbody locus, about which white light chromaticities are standardized. Further, NEMA stated that depending on the exact parameters of the LED packages within, the chromaticity coordinates for this operating condition may not be in the range for which the color-rendering index, as defined in International Commission on Illumination 13.3, is a valid metric. NEMA stated that at the maximum input power condition, the lamp may not be operating as a GSL, but as a colored lamp. NEMA further commented that section 5.1 of the ENERGY STAR lamps V2.1 specification states that testing is to be done at the most consumptive white light setting covered by the specification. NEMA stated that this approach guarantees a tested lamp will operate in the GSL region with a chromaticity defined by ANSI C78.377 and accepted as ''white'' light. NEMA stated that DOE should amend its test procedures to require testing for color-tunable lamps at the highest input power nominal white chromaticity as defined in ANSI C78.377. (NEMA, No. 183 at pp. 21–22)

NEMA further stated that lamps with four or more primary colors exhibit a wider gamut area and will be able to produce a consumer-selected chromaticity with many different settings of those primaries. NEMA commented that, for example, a lamp may have one mode to maximize light output and another to maximize color rendering, and that the input power is likely to differ among modes. NEMA recommended that where the same chromaticity can be achieved with multiple primary settings, DOE should allow the manufacturer to determine the test conditions and provide instruction for how to repeat the condition for the highest input power white light chromaticity as per ANSI C78.377. (NEMA, No. 183 at pp. 21–22)

DOE is exempting from standards adopted in this final rule lamps that allow consumers to change the lamp from a non-colored lamp to a colored lamp (as defined in 10 CFR 430.2), which is referred to in NEMA's comment as a color tunable lamp. DOE appreciates NEMA's comments on how the test procedure might be amended to better address these products and encourages NEMA to submit them during an active rulemaking to amend the test procedure for integrated LED lamps and other GSLs. DOE is not amending any test procedure in this final rule.

NEMA stated that section 3.4 of appendix DD states to operate non-integrated LED lamps at the manufacturer declared input voltage and current, which only provides a partial description of the testing conditions and does not represent a repeatable test condition for Type A or Type C linear LED lamps (''TLEDs''). NEMA stated it is repeating the point made in the 2016 GSL test procedure rulemaking that frequency and waveform are important parameters that vary among LED lamps. NEMA stated that DOE should amend the test procedure to allow testing with a manufacturer-designated commercial ballast in alignment with ANSI C78.53, and DOE should accept ANSI C78.53 testing for compliance with this rule. NEMA stated that manufacturers would specify performance ratings, indicate a ballast factor associated with those ratings, and identify the compatible ballast type and model. (NEMA, No. 183 at p. 21)

In the January 2023 NOPR, DOE did not propose amendments to the GSL test procedures. DOE cannot amend a test procedure without allowing opportunity for comment on proposed changes. DOE notes that it received similar comments regarding testing non-integrated LED lamps in response to the test procedure rulemaking for GSLs that culminated in a final rule published on October 20, 2016 (''October 2016 TP Final Rule''). 81 FR 72493. In that final rule, DOE concluded that requiring manufacturers to specify input voltage and current and operate the lamp at full light output resulted in a repeatable test procedure that allows for performance to be more fairly compared. 81 FR 72493, 72496. DOE will consider the comments including new information regarding testing of non-integrated LED lamps provided in this rulemaking in a future test procedure rulemaking.

B. 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 final rule TSD for further discussion of the market and technology assessment.

1. Concerns Regarding LED Lamp Technology

DOE received 158 comments from private citizens.[29] The comments, along with those from Soft Lights and Friends of Merrymeeting Bay, focused on various concerns regarding LED lamp technology including health impacts, lamp attributes, application, consumer costs, and manufacturer impacts. In this rulemaking, LED lamp technology is considered as a means for improving the energy efficiency of GSLs (*see* section IV.C of this document) and will be needed to achieve the standards being adopted in this final rule (*see* section V.C of this document). DOE has reviewed the concerns expressed in comments from private citizens and continues to consider LED lamp technology as a means for improving energy efficiency of GSLs in this rulemaking. The sections below provide a general summary of the comments received from private citizens and DOE responses.

a. Health Impacts

DOE received comments from private citizens that LED lamps can lead to adverse health effects (*e.g.,* headaches, eye strain, sleep issues, seizures). Commenters stated that this was due to the blue light that LED lamps emit and their overall brightness, which are issues that do not occur with incandescent or halogen lamps. In the May 2022 Backstop Final Rule and May 2022 Definition Final Rule DOE also received comments on potential adverse health effects of LED lamps. In the May 2022 Backstop Rule, DOE responded to these comments, stating that DOE researched studies and other publications to ascertain any known impacts of LED lamps on human health and has not found any evidence concluding that LED lighting used for general lighting applications directly results in adverse health effects. 87 FR 27439, 27457. In the May 2022 Definition Final Rule, DOE also stated it had considered the comments. DOE further stated it had considered the potential for health benefits of emissions reductions from reducing energy use by the covered products. In that rule, DOE maintained that the final rule's definitional changes appropriately promote EPCA's goals for increasing the energy efficiency of covered products through the establishment and amendment of energy conservation standards and promoting conservation measures when feasible. 42 U.S.C. 6291 *et seq.,* as amended. 87 FR 27461, 27468. (*See* May 2022 Backstop Final Rule and May 2022 Definition Final Rule for full comments and responses.) Additionally, Soft Lights filed a petition requesting DOE withdraw the May 2022 Backstop Final Rule and May 2022 Definition Final Rule. Soft Lights' petition asserted that LED lamps do not provide uniform illumination, do not emit light that disperses following the inverse square law, and are not regulated with regards to comfort, health or safety by the U.S. Food and Drug Administration (''FDA''). DOE denied the petition stating that granting Soft Light's request would be inconsistent with statutory law. Further, DOE declined to comment on Soft Light's assertion that the FDA has failed to publish comfort, health, or safety regulations for LEDs, stating these arguments are not for consideration by DOE. DOE also stated it is not aware of any prohibition on the use of LED lighting that would have impacted its rulemakings. 88 FR 16869, 16870. DOE notes that the FDA has authority to regulate certain aspects of LED products as radiation-emitting devices and has issued performance standards for certain types of light-emitting products.[30] Currently, there are no FDA performance standard for LED products in part 1040. DOE is not currently aware or any prohibition on the use of LED lighting that would impact this rulemaking.

In this final rule, DOE maintains its responses in previous rulemakings and petition denials regarding potential adverse health impacts of LED lamps.

DOE also received comments that LED lamps have adverse health effects on animal and plant life. Commenters stated that LED lamps contain toxic waste, plastic waste, and substances that pollute the land and water. DOE has not found any information or data indicating LED lamps contain toxic waste. In reviewing general guidelines for disposing of LED lamps, DOE found that either there is no guidance, or the guidance is to recycle them as electronic products. Hence DOE finds that LED lamps are similar in terms of the waste

[29] Comments submitted in response to the January 2023 NOPR, including comments from private citizens can be found in the docket of DOE's rulemaking to develop energy conservation standards for GSLs at *www.regulations.gov/docket/EERE–2022–BT–STD–0022/comments.*

[30] *See,* the Federal Food, Drug and Cosmetic Act section 531 *et seq.;* 21 U.S.C. 360KK; and 21 CFR part 1040.

produced by any other electronic products. Given LED lamp lifetime, most LED lamps will last longer and therefore not need to be replaced as frequently as other lamp technologies, leading to less waste. Further, DOE's research found no sources indicating that LED lamps covered under the GSL definition have adverse impacts on animal or plant life.

Based on the previous assessments, DOE continues to consider LED lamp technology as a means for improving energy efficiency of GSLs in this rulemaking (*see* section IV.C of this document).

b. Lamp Attributes

DOE received comments that LED lamps are failing prematurely (*e.g.,* burning out or changing color) before their marketed lifetime (*e.g.,* failure at 6 months, at 10 percent of marketed lifetime). Commenters attributed this to overheating of components. DOE reviewed the latest industry articles, journals, and research reports on this topic. DOE's research indicates that premature LED lamp failure can be attributable to factors including poorly designed lamps, power surges, or incompatible fixtures, among others. However, DOE has not found data or reports indicating that premature LED lamp failure is a significant problem with lamps offered on the market.

Flicker in LED lamps was also cited as an issue by commenters. Commenters stated that this could be due to installing LED lamps on existing dimmers. DOE reviewed the latest industry articles, journals, and research reports on this topic. While flicker was an issue in the early stages of LED lamp technology development, DOE's research has indicated no evidence that it remains a prevalent issue with lamps currently on the market. Flicker in LED lamps can occur due to use with an incompatible dimmer switch. Not all incandescent/halogen dimmers (*i.e.,* phase-cut control dimmers) are incompatible with LED technology. NEMA's Solid State Lighting (''SSL'') 7A, which provides basic requirements for phase-cut dimming of LED light sources, includes a list of forward phase-cut dimmers and scenarios in which they can be compatible with LED technology (*e.g.,* up to 125 W LED load). Further, in response to the May 2022 Definition Final Rule, NEMA had estimated 520 million out of 665 million decorative lamps on mostly switch-controlled sockets have already been converted to LED technology. DOE finds that NEMA's comment indicates that almost 80 percent of decorative lamps on switch-controlled sockets have already been converted to LED technology without a significant negative market reaction. 87 FR 27461, 27468. Further, manufacturers such as Signify, Green Creative, and Waveform Lighting are developing LED lamps that are compatible with a wider range of dimmer switches.

DOE also received comments that LED lamps emit unnatural blueish light that is too bright for regular use making them an inadequate replacement for incandescent and halogen lamps which emit light that mimics natural sunlight more closely. However, LED lamps are sold in a variety of color temperatures including the traditional 2700 K warm white CCT typically found in incandescent lamps. DOE's review of the market, including offerings at major retailers, indicates that these LED lamps are widely available on the market.

DOE received comments that LED lamps should be labeled with their peak luminance and this metric should be regulated. Commenters stated that the correct metric for measuring LED visible radiation is luminance (candela per square meter). Commenters further stated that the metric of lumens per watts can eliminate innovation with ultraviolet (''UV'') and infrared (''IR'') wavelengths that are used for color rendering and health benefits. Regarding labeling, the Federal Trade Commission specifies labeling requirements for products including GSLs (*see* 16 CFR 305.5(c)). As noted in section IV.A.4, this rulemaking uses lumens per watt as the metric to measure efficiency of GSLs. Lumens do include the measure of candela as they are the luminous flux emitted within a unit solid angle (one steradian) by a point source having a uniform luminous intensity of one candela.[31] Additionally, lumens are the measure by which lamp manufacturers specify light output on lamp specification sheets.

DOE also received comments that the owner's manuals for garage door openers state that they are designed for incandescent lamps and LED lamps can cause interference with the remote door openers. DOE reviewed the websites of manufacturers of the garage door openers mentioned in these comments. The websites cite universal LED lamps that can be used with garage door openers and would not cause interference. Further, Lighting Supply, a distributor of lamps for garages, states on its website that interference is primarily an issue with LED lamps from unknown manufacturers as most known brands are certified by the Federal Communications Commission, which requires lamps to have shielding within them to mitigate any radio frequency interference.

Additionally, DOE received comments that the use of LEDs in vehicle lights makes these lights bright and strenuous to eyes, creating hazardous driving conditions. In the analysis for the January 2017 Definition Final Rules, DOE determined that certain voltages and/or base types are typical for specialty lighting applications and excluded them from the GSL definition. 82 FR 7267, 7306, 7310. Typical specialty lighting applications include lamps used in vehicles.

Finally, DOE received comments that LED streetlights are too bright and when they degrade, the lights turn purple, flash on and off, and eventually burn out after a couple of years. DOE also received comments that LED lamps contribute to light pollution in the night sky. In response to similar comments received, in the May 2022 Backstop Final Rule DOE noted that the GSL definition excludes lamps with lumens greater than 3,300 and stated that streetlamps and lighting for construction applications are generally 5,000 lumens or greater. 87 FR 27439, 27457. Further, DOE's research of street lighting products shows that most products are sold as complete fixtures rather than as individual lamps and, therefore, would not fall within the GSL definition. As such, the lamps relevant to these comments are generally not covered as GSLs and therefore, not within the scope of the rulemaking.

Based on the above assessments, DOE does not find that there are issues with the lamp attributes of GSL LED lamps and continues to consider LED lamp technology as a means for improving the energy efficiency of GSLs (*see* section IV.C of this document).

c. Application

DOE received comments that LED lamps are too large to replace incandescent lamps in preexisting fixtures. Some commenters provided specifics—*i.e.,* B10 shape, E12 base LED lamps are 4 to 4.8 inches in length and 1.4 to 1.6 inches in width whereas their incandescent counterparts measure 3.8 inches in length and 1.25 inches in width. DOE reviewed several major manufacturer catalog and retailer websites and compared the specifications of the incandescent and LED version of B10 shape, E12 base lamps and found that the difference in width ranges from 0 to 0.05 inches and the difference in length ranges is 0.0 to 0.1 inches. DOE finds that these

[31] Illuminating Engineering Society, ''Lumens.'' Available at *www.ies.org/definitions/lumen/.*

differences in width and length are not as large as cited by the commenters and therefore, would likely not affect the usability of these lamps within existing fixtures. Hence, DOE does not find the size of LED lamps to be prohibitive of being used in existing fixtures.

DOE also received comments that LED lamps are inaccurately marketed to be used in enclosed fixtures and the comments further stated that LED lamp components are more sensitive to overheating so they are prone to premature failure due to the increased heat inside enclosed fixtures. DOE reviewed the latest industry articles, journals, and research reports on this topic. DOE's research found no evidence that lamps specifically rated for use in an enclosed fixture are failing due to use in an enclosed fixture; nor has it found this to be a reported issue within the lighting industry.

DOE received comments that the CRI of LED lamps is worse than incandescent lamps and high-CRI and red-rendering (R9) LED lamps cannot meet the proposed standards and would eliminate innovation of better color rendering LED lamps. DOE's analysis ensures that a range of lamp characteristics such as lumens, CCT, and CRI are available at the highest levels of efficacy. This includes products with high CRIs (*i.e.,* 90 or above). (*See* section IV.D.1.d of this document for more details.)

For the concerns noted above by commentators DOE did a thorough assessment of products and reviewed the latest industry articles, journals, and research reports on these topics. DOE was unable to find data or evidence showing that these concerns are being cited as prevalent and/or significant issues in the lamp market. Based on the assessments above, DOE does not find that there are issues with the use and application of GSL LED lamps and therefore continues to consider LED lamp technology as a means for improving the energy efficiency of GSLs (*see* section IV.C of this document).

d. Consumer Costs and Manufacturer Impacts

DOE received comments that LED lamps are not as cost efficient compared to incandescent and halogen lamps. Commenters stated that incandescent lamps are 100-percent energy efficient and pay for themselves when the outside temperature is below room temperature by reducing the need for heat systems. Commenters also stated that due to the cost of the LED lamps as well as the cost of upgrading to an appropriate dimmer, the final costs end up being more than the projected savings. Commenters stated DOE's estimate that switching to LED lamps could save $3 billion per year equates to around $2 per month per household, which should not be considered significant. DOE also received comments that the best way to conserve energy is to use lights less often regardless of lamp technology. DOE notes that May 2022 Backstop Final Rule codified a 45 lm/W requirement that incandescent and halogen lamps are unable to meet. Therefore, incandescent and halogen lamps were not analyzed as options available to consumers during the analysis period for this final rule. DOE does not anticipate that consumers will need to upgrade their dimmer under a standard compared to the dimmers that would be used with CFLs and LED lamps available in the no-new-standards case. With respect to the significance of savings, DOE notes that most households own a significant number of GSLs (the 2015 U.S. Lighting Market Characterization report estimates an average of over 50 lamps per household [32]). The household-level savings will be significantly higher than the savings associated with a single purchase. For details on consumer cost savings from these standards being adopted in this final rule, *see* sections V.B.1 and V.B.3.b. of this document. DOE agrees that energy savings can be had from a reduction in operating hours but notes this is also the case under a standard, and DOE does not estimate a change in operating hours under a standard. (See section IV.H.1 of this document for discussion.)

2. Product Classes

When evaluating and establishing energy conservation standards, DOE may establish separate standards for a group of covered products (*i.e.,* establish a separate product class) if DOE determines that separate standards are justified based on the type of energy used, or if DOE determines that a product's capacity or other performance-related feature justifies a different standard. (42 U.S.C. 6295(q)) 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. (*Id.*)

In the January 2023 NOPR, DOE proposed product class divisions based on lamp component location (*i.e.,* location of ballast/driver); 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. 88 FR 1638, 1656. In chapter 3 of the final rule TSD, DOE discusses factors it ultimately determined were not performance-related features that justify different standard levels; including lamp technology, lumen package, lamp cover, dimmability, base type, lamp spectrum, CRI, and CCT. *See* chapter 3 of the final rule TSD for further discussion.

DOE received several comments on product class setting factors including lamp cover, lamp length, tunability, and non-illumination features. These comments are discussed in the following sections.

a. Lamp Cover

In the January 2023 NOPR, DOE considered lamp cover as a performance-related feature that justified a different standard level but determined that it was not such a feature (*see* chapter 3 of the January 2023 NOPR TSD). NEMA stated that when visible, frosted lamps reduce glare, although they are slightly less efficient. While max-tech performance may be achievable with clear lamps, they represent only a portion of the GSL market. (NEMA, No. 183 at p. 20)

In the January 2023 NOPR, DOE considered the impact of a lamp cover (*e.g.,* added glass, silicone coating) over the main light source, which can reduce the lumen output of the lamp. The lamp cover adds a white finish to these lamps, and they are sometimes referred to as frosted lamps. By contrast, lamps without a cover are sometimes referred to as bare or clear. In some cases, covered lamps may offer utility to consumers as they more closely resemble traditional lighting technologies and are frequently utilized where a lamp is visible (*e.g.,* without a lamp shade). DOE examined the difference in efficacies of lamps that have a cover versus those that do not. DOE found that while a cover could generally decrease efficacy, it could also increase it, such as when a phosphor coating transforms light emitted from LEDs into visible light. DOE also determined that many LED lamps that have covers have high efficacies. GSLs without a cover (*i.e.,* clear, bare) are mainly in the Integrated Omnidirectional Short product class. This product class also has lamps with covers (*i.e.,* frosted lamps). DOE's analysis shows that both the frosted and

[32] Navigant Consulting, Inc. *2015 U.S. Lighting Market Characterization.* 2017. U.S. Department of Energy: Washington, DC Report No. DOE/EE–1719. (Last accessed August 10, 2023.) *www.energy.gov/eere/ssl/downloads/2015-us-lighting-market-characterization.*

clear lamps in this product class can meet the max-tech EL identified in the January 2023 GSL NOPR and in this analysis. Hence, for the reasons provided in the January 2023 NOPR and above, DOE is not creating a product class for covered versus bare products in this final rule.

b. Lamp Dimensions

In the January 2023 NOPR, DOE stated it observed that pin base LED lamp replacements with 2G11 bases and lengths close to 2 feet are less efficacious than 2-foot linear LED lamps. To further understand this observation on lamp length, DOE requested comments on, assuming all other attributes are the same, how the efficacy of pin base LED lamp replacements compares to that of linear LED lamps. 88 FR 1638, 1657. NEMA commented that DOE should avoid assuming that pin base LED retrofit lamps and linear LED retrofit lamps have similar luminous efficacy because they differ in shape, size, directionality, and operating environments. NEMA stated that pin base retrofit lamps and linear LED retrofit lamps differ in the following ways: (1) pin base LED lamps designed to replace legacy CFLs either do not have the same single straight tube shape or are designed to take advantage of LED package directionality to provide more directional illumination; (2) pin base LED lamps must fit within a much smaller, shorter, and narrower luminaire type and application than linear LED retrofit lamps and are designed to direct light output either horizontally or vertically, depending on the luminaire type and application; and (3) typically, the thermal environment differs greatly between these applications, resulting in different efficiency expectations. NEMA stated that only in limited cases when the lamps have the same shape and directionality of light output is the luminous efficacy of a pin base LED retrofit lamp and linear LED retrofit lamp directly comparable. (NEMA, No. 183 at p. 6)

In the January 2023 NOPR, DOE requested comment on the observed lower pin base LED lamps with 2G11 base and close to 2-feet length (typically used as replacements for pin base CFLs) having a lower efficacy than linear LED lamps 2 feet in length (88 FR 1638, 1657), as DOE expected them to achieve similar levels of efficacy due to similarity in length. DOE appreciates NEMA's comments, which help inform the differences between these two lamp configurations and potential impacts on efficacy. Because they are both less than 45 inches in length, DOE groups them in the same product class (*i.e.,* either the Integrated Omnidirectional Short product class or the Non-integrated Omnidirectional Short product class) (*see* table IV.2 for product class division summary). In the January 2023 NOPR and in this final rule, DOE did not observe that the difference in efficacy between these two lamp configurations is substantial enough to result in a loss of the consumer utility provided by each lamp. DOE's analysis indicates that both pin base LED lamps with a 2G11 base close to 2 feet in length and linear LED lamps that are 2 feet can meet the max-tech ELs considered for the Non-integrated Omnidirectional Short product class (*see* section IV.D.1.d of this document). Therefore, DOE does not find that adjustments to product class setting factors are necessary.

In the January 2023 NOPR, DOE observed 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 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 requested comments and data on the impact of diameter on efficacy for linear LED lamps. 88 FR 1638, 1656–1657.

Westinghouse stated that for linear fluorescent tubes a smaller diameter means higher efficacy, for LED lamps it is the inverse as a smaller diameter means less space for electronics and thermal management. (Westinghouse, Public Meeting Transcript, No. 27 at pp. 42–43) DOE appreciates Westinghouse's comments, which help inform the impact of diameter on linear LED lamps. Linear LED lamps of both T5 and T8 diameters are grouped in the Integrated Omnidirectional Long product class (*see* table IV.2 for product class division summary) and both can meet the max-tech ELs. Hence, adjustments to product class setting factors are not necessary.

c. Non-Integrated Standby Operation

NEMA commented that none of DOE's proposed product classes included LED smart and connected lamps that are also non-integrated. To account for these products, NEMA recommended the following product classes: (1) Non-integrated Omnidirectional short (with standby) capturing the low voltage LED retrofit lamps less than 45 inches in length, (2) Non-integrated Omnidirectional long (with standby) capturing lamps operating on non-building mains 45 inches or more in length, and (3) Non-integrated Directional (with standby) capturing LED lamps designed to replace legacy CFLs. NEMA specified that all of these lamps would require operating on a remote driver or legacy fluorescent or high-intensity discharge (''HID'') ballast. (NEMA, No. 183 at p. 6)

In the January 2023 NOPR, DOE proposed only standby mode operation as a product class setting factor for integrated lamps. At the time of the January 2023 NOPR analysis, DOE did not observe non-integrated GSLs with standby mode power consumption. 88 FR 1638, 1657, 1667. Based on a review of the market for this final rule analysis, DOE identified non-integrated LED lamps that have standby mode power operation capability allowing the lamp to have dimming controls. For example, DOE identified a linear LED lamp that is designed to operate on fluorescent lamp ballast (*i.e.,* Type B), to have additional circuitry contained within the lamp that interprets the signal from the ballast and changes the light output accordingly. Hence, because the standby mode operation of this lamp is not solely external to the lamp (*i.e.,* in the ballast or driver) but also part of the lamp itself, DOE considers it as having standby mode operation capability and therefore standby mode power consumption.

Because the market for these non-integrated LED lamps that have standby mode power operation capability is rapidly developing, DOE is unable to make a clear and accurate determination regarding the consumer utility, how various technology options would affect the efficiency, and maximum technologically feasible efficiency of these lamps, which prevents DOE from determining whether a specific standard for these lamps would be economically justified at this time. Accordingly, DOE did not consider amended standards for these lamps in this rulemaking. DOE may evaluate amended standards for these products in a future rulemaking. DOE notes that these lamps are still subject to the 45 lm/W sales prohibition at 10 CFR 430.32(dd). The criteria that non-integrated GSLs with standby mode power operation capability must meet to be exempt from amended standards adopted in this final rule is specified in section IV.A.3 of this document.

d. Tunability

NEMA and Lutron stated that DOE incorrectly assumed that all lamps capable of operating in standby mode are fundamentally the same as lamps without standby functionality but with the addition of wireless communication components. NEMA and Lutron stated that because of this assumption, DOE did not create product classes for tunable white lamps and color tunable lamps. (NEMA, No. 183 at p. 8; Lutron, No. 182 at p. 2) NEMA stated that including these additional categories will allow for a thorough analysis of lamps capable of operating in standby mode by the next rulemaking in 2028—which may result in the need for separate categories, different efficacy curves, and amended test procedures—and will allow DOE to set efficacy levels without restricting innovation in the coming years. (NEMA, No. 183 at pp. 13–14) Lutron stated that the product classes and scaling approach for standby mode proposed in the January 2023 NOPR would limit innovation and potentially regulate out of the market many lamps capable of dynamic color tuning and dynamic spectral tuning. (Lutron, No. 182 at pp. 2–3)

NEMA and Lutron stated that for these lamps DOE should set separate product classes and adopt ELs proposed in the January 2023 NOPR as follows: (1) Tunable white integrated omnidirectional lamps capable of operating in standby mode subject to EL 6; (2) Tunable white integrated directional lamps capable of operating in standby mode subject to EL 4; (3) Full-color tunable integrated omnidirectional lamps capable of operating in standby mode subject to EL 4; and (4) Full-color tunable integrated directional lamps capable of operating in standby mode subject to EL 4. (NEMA, No. 183 at p. 8; Lutron, No. 182 at p. 3)

NEMA and Lutron defined ''tunable white'' as a feature allowing the end user to adjust the light output to create different colors of white light; in which tuning must be capable of altering the color appearance along the black body curve from two or more LED colors, where each LED color is inside one of those defined by ANSI-defined (ANSI C78.377) white correlated color temperature ranges (*i.e.,* between 2700 K and 6500 K) inside of the seven-step MacAdam ellipse or the ANSI quadrangles. NEMA and Lutron defined ''full color tunable'' as a feature allowing the end user to adjust the light output to create white or colored white; in which tuning must include white light that can alter the color appearance along the black body curve by dynamically tuning color from three of more colors of LEDs where at least one LED extends to colors beyond the ANSI-defined (ANSI C78.377) white correlated color temperature ranges (*i.e.,* between 2700 K and 6500 K) outside of the seven-step MacAdam ellipse or the ANSI quadrangles. (NEMA, No. 183 at p. 14; Lutron, No. 182 at p. 2)

Lutron and NEMA provided comments on the impact on efficacy due to the tunable features of these lamps. Lutron commented that tunable lamps are less efficacious than a single-chromaticity lamp [33] because tunable lamps require: (1) effective LED color mixing on a small light-emitting surface, which leads to higher LED current densities; (2) a control system to vary intensity of each LED color; and (3) optics to mix LED colors into the appropriate beam pattern. Lutron estimated a 10-percent efficacy loss independent from the power consumed in standby mode. (Lutron, No. 182 at p. 6)

Lutron stated it is possible for static white lamps to meet the proposed EL requirement by employing highly efficacious white LEDs in efficient configurations. Lutron stated, in contrast, tunable white lamps employ a second color LED close to the blackbody locus at a different CCT and color tunable lamps employ three or more colors of LEDs where at least one LED is far from the blackbody locus. Lutron stated that these additional color LEDs are less efficacious because the human eye is insensitive to light radiated from LEDs at colors far from green (555 nm), such as red (620 nm) or blue (470 nm). (Lutron, No. 182 at pp. 4–5, 6) NEMA provided the example that having the functionality of selecting ''warm white'' (*i.e.,* a setting corresponding to nominally 2700 K on the blackbody locus) may require both white LEDs and lower efficacy LEDs, such as red and blue, to achieve the precise color point. NEMA stated primary color LEDs are placed farther out in the color space, expanding the gamut area, which represents the number of colors, including shades of white, the lamp can produce. NEMA stated that the result is a loss in efficacy compared to a single chromaticity lamp containing only 2700 K LEDs and that this loss is in addition to the efficacy reduction caused by the lamp's standby power functionality. (NEMA, No. 183 at p. 10)

Lutron also stated that, compared to tunable white lamps, full-color-tunable lamps introduce at least one color far from the blackbody locus to achieve the desired utility, and because the human eye is less sensitive to wavelengths far from green, there is an impact on efficacy beyond the impacts described for white tunable lamps. As an example, Lutron stated that 1400 K or lower, which is a setting that may provide more consumer comfort, can't be achieved without a higher intensity of red LEDs. Lutron commented that greater control of color variation and accuracy, color quality, beam angle, and other aspects can require higher-end LEDs, more sophisticated designs, and innovative constructions that prevent the lamps from achieving high efficacy levels. (Lutron, No. 182 at p. 5–6)

Lutron and NEMA also provided comments on the utility of tunable lamps. Lutron and NEMA stated that tunable white lamps and color tunable lamps are a growing sector of the market. (Lutron, No. 182 at pp. 7–8; NEMA, No. 183 at p. 10) Lutron stated that tunable lamps offer capabilities such as dimming, scene selection, geo-fencing, event scheduling, programmability and demand response to further achieve energy savings. (Lutron, No. 182 at p. 7) Lutron and NEMA stated that sectors such as retail, hospitality, restaurants, bars, entertainment, museums, theme parks, and architectural use lighting with deep dimming, warm dimming, CCT control, and color saturation to create unique consumer experiences. (Lutron, No. 182 at p. 7; NEMA, No. 183 at p. 10)

Lutron cited DOE's web page on ''Understanding LED Color-Tunable Products'' as noting that offices using white light during work hours could shift to evening get-togethers with saturated mood-setting colors without using additional color lamps that are exempted from DOE standards and therefore may not be efficacious. (Lutron, No. 182 at pp. 6–7) Lutron stated that one of the key benefits of all color tunable lamps is the ability to control colors and match chromaticity and also manipulate light and color intensities to affect moods and create effects. Lutron commented that tunable white lamps offer users multiple similar benefits as color tunable lamps, such as simulating daylight or candlelight to set a mood without the use of additional lighting or to match existing light to provide light consistency in a space. Lutron also stated that the ability to change the intensity and color of white light has been incorporated into green building and healthy building standards, particularly the WELL standard, operated by the International WELL Building Institute. (Lutron, No. 182 at p. 7)

NEMA also raised concerns regarding the DOE test procedure and its applicability for color tunable GSLs. Specifically, NEMA stated that DOE's test procedure for GSLs requires testing at maximum input power at which setting a color tunable lamp may not be operating as a GSL, but as a colored lamp. NEMA further noted that a lamp may have one mode to maximize light output and another to maximize color

[33] Commenters use ''static'' white lamps and single chromaticity lamps interchangeably and DOE assumes these terms identify lamps that are non-tunable.

rendering, and that the input power is likely to differ among modes. (NEMA, No. 183 at pp. 21–22) (*See* further discussion of these comments in section IV.A.5 of this document).

Because the market for these tunable lamps is rapidly developing, DOE is unable to make a clear and accurate determination regarding the consumer utility, how various technology options would affect the efficiency, and maximum technologically feasible efficiency of these lamps, which prevents DOE from determining whether a specific standard for these lamps would be economically justified at this time. Accordingly, DOE did not consider amended standards for these lamps in this rulemaking. DOE may evaluate amended standards for these products in a future rulemaking. DOE notes that these lamps are still subject to the 45 lm/W sales prohibition at 10 CFR 430.32(dd). The criteria that tunable white GSLs and color tunable GSLs must meet to be exempt from amended standards adopted in this final rule is specified in section IV.A.3 of this document.

e. Non-Illumination Features

NEMA stated that there are multi-functional lighting products without wireless communication components that include power-consuming non-lighting features when the product is not generating light. NEMA gave examples of outdoor lamps with motion sensors for home security, outdoor dusk-to-dawn lamps with ambient light sensors, and indoor lamps with an internal battery backup to be used as a flashlight for use during a power outage. NEMA stated that the January 2023 NOPR did not accommodate these products and elimination of their security/safety features would be a mistake and impede further innovation and development for future generations of similar products. NEMA stated that for these lamps, DOE's approach of determining ELs for lamps with standby mode power by adding 0.5 W to ELs for similar non-standby mode lamps, assuming all else being equal, was not correct. NEMA stated that for these lamps DOE should set separate product classes and adopt ELs proposed in the January 2023 NOPR as follows: (1) Omnidirectional lamps capable of operating on standby mode, incorporating energy-consuming non-illumination feature(s) subject to EL 4 and (2) Directional lamps capable of operating on standby mode, incorporating energy-consuming non-illumination feature(s) subject to EL 4. (NEMA, No. 183 at pp. 13–14)

NEMA provided comments on the impact on efficacy due to the non-illumination features of these lamps. As an example, NEMA stated that a lamp with a speaker has unavoidably lower efficacy than lamps with no additional features. NEMA stated that a lamp with Bluetooth speaker functionality would be roughly 30 percent lower in efficacy compared to the equivalent light output single-chromaticity lamp without integrated speakers. NEMA stated that these lamps provide desirable features for consumers, who will often purchase and install several of the lamps in a room. (NEMA, No. 183 at pp. 11–12) Additionally, NEMA stated that unless a lamp offers a physical switch or an app-based method for disabling the power from non-illumination features, the only way to measure the lamp's luminous efficacy independent of the non-illumination features is to disassemble the product and identify the appropriate solder traces to cut. (NEMA, No. 183 at p. 12)

NEMA stated that many smart lamps offer additional functionality and added consumer benefit while providing energy-saving features such as dimming, scheduling, high end trim, and demand response via digital programming or manual setting of these features. NEMA stated the International Energy Agency (''IEA'') SSL Annex Task 7, notes a large market potential for internet-connected lighting systems in the residential sector, including illumination and non-illumination functionality such as: on/off control; changing CCT; dimming; motion detection; daylight sensing to trigger automated lighting changes; temperature and humidity sensing to control heating and air conditioning; Wi-Fi signal boosting; smoke detection; security systems including cameras; security-initiated lighting response; integrated audio; baby monitoring; and energy consumption monitoring. NEMA, however, disagreed with the assumption in the IEA report that smart lamp penetration is limited to the residential sector and cited applications in retail and hospitals. NEMA gave the example of the usefulness of circadian entrainment smart lamp features in nursing homes, congregate care, and independent living facilities, etc. (NEMA, No. 183 at pp. 9, 12–13)

The CA IOUs commented that DOE's proposal may inadvertently restrict the development of new types of lighting products that offer additional capabilities that consumers desire, such as light sensors, Wi-Fi or Bluetooth, speakers, cameras, or LAN links. The CA IOUs commented these additional features often require standby energy consumption that is higher than would be allowed in DOE's proposed standards and to not eliminate them recommended DOE consider different luminous efficacy requirements for GSLs with only lighting-related features and for combination GSLs with non-lighting-related features. (CA IOUs, No. 167 at p. 2)

Because the market for lamps with non-illumination features (*i.e.,* features that do not control light output) is rapidly developing, DOE is unable to make a clear and accurate determination regarding the consumer utility, how various technology options would affect the efficiency, and maximum technologically feasible efficiency of these lamps, which prevents DOE from determining whether a specific standard for these lamps would be economically justified. Accordingly, DOE did not consider amended standards for these lamps in this rulemaking. DOE may evaluate amended standards for these products in a future rulemaking. DOE notes that these lamps are still subject to the 45 lm/W sales prohibition at 10 CFR 430.32(dd) The criteria that GSLs with a non-illumination feature and standby mode power operation capability must meet to be exempt from amended standards adopted in this final rule is specified in section IV.A.3 of this document.

f. Product Class Summary

In summary, in this final rule analysis, DOE is considering the same product class setting factors as those considered in the January 2023 NOPR, as shown in table IV.2. To avoid any confusion as to what lamp types are included in these product classes and therefore subject to the amended standards being adopted in this final rule, DOE is adding two clarifications to the GSL standards table being codified in the CFR by this final rule. Firstly, for all Directional product classes, DOE is specifying in the GSL standards table in the CFR that a directional lamp is a lamp that meets the definition of reflector lamp as defined in 10 CFR 430.2. Secondly, for the Non-integrated Omnidirectional Short product class, DOE is specifying in the GSL standards table in the CFR that this product class comprises, but is not limited to, lamps that are pin base CFLs and pin base LED lamps designed and marketed as replacements of pin base CFLs.

Table IV.2 GSL Product Classes

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

3. Technology Options

In the technology assessment, DOE identifies technology options that are feasible means of improving lamp efficacy. This assessment provides the technical background and structure on which DOE bases its screening and engineering analyses. To develop a list of technology options, DOE reviewed manufacturer catalogs, recent trade publications and technical journals, and consulted with technical experts. In the January 2023 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 were differentiated by those that improve the efficacy of CFLs versus those that improve the efficacy of LED lamps. 88 FR 1638, 1657.

With regards to the technology option of improved secondary optics for LED lamp technology, NEMA stated it is important to note that frosted bulbs, while slightly reducing light output, mitigate glare in LED lamp designs and in doing so provide consumer-desired utility. (NEMA, No. 183 at p. 7) DOE reviewed the utility and efficacy of frosted lamps when evaluating lamp cover as a potential product class setting factor (*see* IV.B.2.a of this document for the detailed discussion). Additionally, NEMA requested that DOE adopt the standardized terminology from ANSI/IES LS–1–22 [34] to ensure clarity in rulemaking discussions. NEMA noted that the term ''LED chip,'' as used in the January 2023 NOPR, is a non-standardized term with ample room for interpretation. (NEMA, No. 183 at p. 7). DOE appreciates NEMA's comment. In chapter 3 of the January 2023 NOPR TSD DOE had specified that the LED die, along with its electrode contacts and any optional additional layers, is referred to as the ''LED chip.'' This description of the LED chip aligns with the definition of LED package [35] specified in ANSI/IES LS–1–22. For further clarity and consistency with industry definitions (*i.e.,* ANSI/IES LS–1–22), DOE has replaced references to ''LED chip'' with ''LED package'' in this final rule notice and TSD. Additionally, in review of the nomenclature used in the January 2023 NOPR and TSD to describe the technology option of reduced current density, DOE stated that the LED package is driven at lower currents. 88 FR 1638, 1657–1658 (*see* chapter 3 of January 2023 NOPR TSD). Because ANSI/IES LS–1–22 defines LED array or module [36] as an assembly of LED packages intended to be connected to the LED driver, DOE finds that it is more appropriate to phrase this technology option as the LED array or module being driven at lower currents.

In this final rule as in the January 2023 NOPR, DOE is considering the technology options as shown in table IV.3.

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[34] American National Standards Institute/ Illuminating Engineering Society, ANSI/IES LS–1–22, ''Lighting Science: Nomenclature and Definitions for Illuminating Engineering.'' Approved Nov. 2, 2021.

[35] ANSI/IES LS–1–22 defines ''LED package'' as an assembly of one or more light emitting diode (LED) dies that includes wire bond or other type of electrical connections, possibly with an optical element and thermal, mechanical, and electrical interfaces. Power source and ANSI standardized base are not incorporated into the device. The device cannot be connected directly to the branch circuit. Available at *www.ies.org/definitions/led-package/.*

[36] ANSI/IES LS–1–22 defines ''LED array or module'' as an assembly of light emitting diode (LED) packages (components), or dies on a printed circuit board or substrate, possibly with optical elements and additional thermal, mechanical, and electrical interfaces that are intended to connect to the load side of an LED driver. Power source and ANSI standard base are not incorporated into the device. The device cannot be connected directly to the branch circuit. Available at *www.ies.org/definitions/led-array-or-module/.*

Table IV.3 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.

Lamp Type	Name of Technology Option	Description
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 package(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 package.
	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.
	Alternating Current ("AC") LEDs	LEDs that operate on AC voltage, eliminating the requirement for and efficiency losses from the driver.

Lamp Type	Name of Technology Option	Description
	Reduced Current Density	Driving LED array or module at lower currents while maintaining light output, and thereby reducing the efficiency losses associated with efficacy droop.

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C. Screening Analysis

DOE uses the following four 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 commercially viable, existing prototypes will not be considered further.

(2) *Practicability to manufacture, install, and service.* If it is determined that mass production of a technology in commercial products and reliable installation and servicing of the technology 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.* If a technology is determined to have a significant adverse impact on the utility of the product to subgroups of consumers, or 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) *Safety of technologies.* 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 technology has proprietary protection and represents a unique pathway to achieving a given efficiency level, it 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 sum, 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 the January 2023 NOPR, DOE proposed 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. DOE did not find evidence that multi-photon phosphors, quantum dots, or improved emitter materials are being used in commercially available products or prototypes. DOE also proposed 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. 88 FR 1638, 1658.

NEMA stated that it agrees with DOE's proposal to screen out AC LEDs as well as quantum dots and improved emitter materials for LED lamps. (NEMA, No. 183 at p. 7)

In this final rule as in the January 2023 NOPR, for reasons stated above, DOE continues to screen out the technologies of multi-photon phosphors for CFLs and quantum dots, improved emitter materials, and AC LEDs for LED lamps.

2. Remaining Technologies

In the January 2023 NOPR, DOE considered active thermal management for LED lamp technology as a design option, among others. 88 FR 1638, 1658. NEMA commented that active thermal management is not typically required or beneficial for products included in the GSL definition and therefore should not be factored in when providing a deviation from the GSL requirements without standby power. NEMA stated that products outside the scope of the GSL definition, namely small size devices with a lumen output of greater than 3,300 lumens, can be dependent upon and benefit from active thermal management, but that this should not be taken into consideration for this rulemaking. NEMA added that manufacturers should not be constrained from utilizing their design freedom to add active thermal management to a product covered by the scope of this rule if the final product meets the requirements and includes the full impacts of the thermal management. (NEMA, No. 183 at pp. 7–8) DOE has not found evidence that the design option of active thermal management is limited to lamps with lumen outputs greater than 3,300 lumens. Additionally, DOE identifies all possible technology options and subsequently design options that manufacturers can utilize to increase the efficacy of their lamps. DOE is not specifying the design options manufacturers must or must not use to achieve higher efficacies for their lamps. Therefore, in this final rule, DOE continues to consider active thermal management as a valid design option.

Through a review of each technology, DOE concludes that all of the other identified technologies listed in section IV.B.3 of this document met all five screening criteria to be examined further as design options in DOE's final rule 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 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). For additional details, *see* chapter 4 of the final rule TSD.

D. 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 interpolate to define ''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 rulemaking, DOE applied an efficiency-level approach. For GSLs, ELs are determined as lumens per watt which is also referred to as the lamp's efficacy (*see* section IV.A.4 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 IV.D.2 of this document discusses the cost analysis (*see* chapter 5 of the final rule 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 final rule TSD for further information on technology and design options. For the January 2023 NOPR engineering analysis, DOE developed a lamps database using data from manufacturer catalogs, ENERGY STAR Certified Light Bulbs database,[37] DOE's compliance certification database,[38] and retailer websites. DOE used performance data of lamps from 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.[39] 88 FR 1638, 1659. For this final rule analysis, DOE updated this database in mid-2022 with the most recent data available from these data sources.

The methodology consists of the following steps: (1) selecting representative product classes, (2) selecting baseline lamps, (3) identifying more efficacious substitutes, and (4) developing efficiency levels by directly analyzing representative product classes and then scaling those efficiency levels to non-representative product classes. The details of the engineering analysis are discussed in chapter 5 of the final rule TSD.

a. Representative Product Classes

In the case where a covered product has multiple product classes, DOE identifies and selects certain product classes as ''representative'' and concentrates its analytical effort on those classes. DOE chooses product classes as representative primarily because of their high market volumes and/or unique characteristics. DOE then scales its analytical findings for those representative product classes to other product classes that are not directly analyzed.

In the January 2023 NOPR, DOE proposed to establish eight product classes: (1) 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. Because of the distinctive difference in design, the Directional and Omnidirectional product classes cannot be scaled from each other and were directly analyzed. For the same reasons, Long (45 inches or longer) and Short (shorter than 45 inches) product classes as well as Integrated (all components within lamp) and Non-integrated (ballast/driver external to lamp) were directly analyzed. The exception was that DOE scaled the Non-integrated Omnidirectional Long product class from the Integrated Omnidirectional Long product class. DOE determined that lamps in both these product classes are 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. 88 FR 1638, 1659–1660.

DOE did not receive any comments on the product classes chosen to be representative. In this final rule, DOE continues to directly analyze (*i.e.,* consider as representative) the product

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

[38] DOE's compliance certification database can be found at *www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A** (last accessed June 17, 2020).

[39] The most recent CEC Appliance Efficiency Database can be found at *www.energy.ca.gov/appliances/* (last accessed June 17, 2020).

classes in the January 2023 NOPR and shown in grey shading in table IV.4. *See* details in chapter 5 of this final rule TSD.

Table IV.4 GSL Representative Product Classes

Lumen Package	Directionality	Lamp Length	Standby Mode Operation
Integrated	Omnidirectional	Short (< 45 inches)	Non-Standby
			Standby
		Long (≥ 45 inches)	Non-Standby
	Directional (reflector lamps)	All Lengths	Non-Standby
			Standby
Non-Integrated	Omnidirectional	Short (< 45 inches)	N/A
		Long (≥ 45 inches)	
	Directional (reflector lamps)	All Lengths	

b. Baseline Efficiency

For each product class, DOE generally selects a baseline model as a reference point for each class, and measures changes resulting from potential energy conservation standards against the baseline. The baseline model in each product class represents the characteristics of a product typical of that class (*e.g.,* capacity, physical size). 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.

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. In the January 2023 NOPR, DOE selected baseline lamps that are the most common, least efficacious lamps that meet 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). 88 FR 1638, 1660–1661. Because incandescent and halogen lamps cannot meet the 45 lm/W backstop requirement for GSLs, DOE did not analyze these lamps at the baseline or at higher ELs in the January 2023 NOPR.

NEMA stated that its member companies have noted for years that DOE's analyses do not account for the ongoing importation of non-compliant outlawed lamps that NEMA members will not manufacture. NEMA commented that, by its estimation, there are hundreds of GSL manufacturers globally who do not follow DOE regulations and instead circumvent legal challenges by closing and reopening their businesses under a variety of names. NEMA stated that it would be much closer to agreeing with DOE's baseline lamp selections if the selections reflected the market impact of these illicit offerings. (NEMA, No. 183 at p. 8)

DOE does not find that the baseline lamp characteristics identified in the January 2023 NOPR are invalid. DOE's analyses for rulemakings assume compliance with current applicable standards. DOE's Office of Enforcement leads DOE's efforts to ensure manufacturers deliver products that meet energy conservation standards.[40] DOE also provides information on its website on how to report on any regulation violations (*see www.energy.gov/gc/report-appliance-regulation-violation*). DOE would welcome any information that NEMA may have on potentially non-compliant manufacturers.

In this final rule, DOE continues to analyze the baseline lamps identified in the January 2023 NOPR as shown in table IV.5. *See* chapter 5 of this final rule TSD for further details.

[40] DOE, ''Office of the Assistant General Counsel for Enforcement.'' Available at *www.energy.gov/gc/office-assistant-general-counsel-enforcement.*

Table IV.5 GSL Baseline Lamps

Representative Product Class	Lamp Shape	Base Type	Lamp Type	Nominal Wattage	Initial Lumens	Rated Efficacy	Lifetime	CCT	CRI
				W	*lm*	*lm/W*	*hr*	*K*	
Integrated Omnidirectional Short	Spiral	E26	CFL	15	900	60.0	10,000	2,700	82
Integrated Omnidirectional Long	Linear (T8, 4-foot)	Medium Bipin	LED	15	1,800	120.0	50,000	4,000	80
Integrated Directional	PAR38	E26	CFL	23	1,100	47.8	10,000	2,700	82
Non-Integrated Omnidirectional Short	G24q-3	Double Tube	CFL	26.0	1,700	65.4	10,000	4,100	82
Non-Integrated Directional	GU5.3	MR16	LED	8.0	500	62.5	25,000	2,700	80

c. More Efficacious Substitutes

In the January 2023 NOPR, DOE selected 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 a 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 IV.D.1 of this document). 88 FR 1638, 1662. As noted, non-integrated lamps are operated on an external ballast or driver. Hence for the Non-integrated Omnidirectional Short product class, 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 this 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. 88 FR 1638, 1664.

DOE received comments regarding the Non-integrated Omnidirectional Short product class. Westinghouse stated that the G24q base lamp identified for the Non-integrated Omnidirectional Short product class is likely not omnidirectional and therefore, may not be the best lamp to analyze. Westinghouse stated that LED lamps designed to replace pin base CFLs are not actually omnidirectional but directional lamps designed to be used in specific luminaires based on the direction the consumer desires light to flow, and therefore, possibly not the right lamp type to use. (Westinghouse, Public Meeting Transcript, No. 27 at p. 54)

In DOE's analysis of the LED replacements for pin base CFLs, DOE reviewed marketing information and lamp specification sheets and spoke to manufacturers' product support. Based on this review, it is clear that the more efficacious LED lamps identified for the Non-integrated Omnidirectional Short product class are designed and marketed to be replacements for pin base CFLs. These LED lamps have shapes and base types designed to fit in existing fixtures that employ pin base CFLs. Additionally, as noted in the January 2023 NOPR, DOE learned that because the LED lamp replacements for pin base CFLs identified 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. 88 FR 1638, 1663. Hence, DOE groups pin base CFLs and their replacement pin base LED lamps in the Non-integrated Omnidirectional Short product class. To minimize any confusion, in the table that will codify in the CFR standards adopted in this final rule, DOE is specifying that the Non-integrated Omnidirectional Short product class includes pin base LED lamps designed and marketed to replace pin base CFLs (*see* section IV.B.2.f of this document).

In this final rule, DOE maintains the more efficacious substitutes selected in the January 2023 NOPR as shown in table IV.6 through table IV.10. (In these tables the A-value is a variable in the equation form (a curve) that specifies 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 IV.D.1.d of this document)). DOE also continues to use the methodology used in the January 2023 NOPR to calculate the lamp-and-ballast system input power of the more efficacious substitutes in Non-integrated Omnidirectional Short product class. *See* chapter 5 of this final rule TSD for further details.

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Table IV.6 Representative Lamp Units in the Integrated Omnidirectional Short Product Class

Product Class	EL	Lifetime	Lamp Shape	Base Type	Lamp Type	Nominal Wattage	Initial Lumens	Rated Efficacy	A-Value*	CCT	CRI
		Hr				*W*	*lm*	*lm/W*		*K*	
Integrated Omnidirectional Short	Baseline	10,000	Spiral	E26	CFL	15.0	900	60.0	-40.0	2700	82
	EL 1	10,000	Spiral	E26	CFL	14.0	900	64.3	-35.7	2700	82
	EL 2	10,000	Spiral	E26	CFL	13.0	900	69.2	-30.8	2700	83
	EL 3	15,000	A19	E26	LED	10.0	800	80.0	-18.5	2700	80
		25,000	A19	E26	LED	10.0	800	80.0	-18.5	2700	84
	EL 4	15,000	A19	E26	LED	9.0	800	88.9	-9.6	2700	80
		25,000	A19	E26	LED	9.0	800	88.9	-9.6	2700	80
	EL 5	15000	A19	E26	LED	8.0	800	100.0	1.5	2700	81
	EL 6	15000	A19	E26	LED	7.0	800	114.3	15.8	2700	82
	EL 7	15000	A19	E26	LED	6.5	810	124.6	25.9	2700	80

Table IV.7 Representative Lamp Units in the Integrated Omnidirectional Long Product Class

Product Class	EL	Lifetime	Lamp Shape	Base Type	Lamp Type	Nominal Wattage	Initial Lumens	Rated Efficacy	A-Value	CCT	CRI
		hr				*W*	*lm*	*lm/W*		*K*	
Integrated Omnidirectional Long	Baseline	50,000	T8 Linear	Medium Bipin	LED	15.0	1800	120.0	17.5	4000	80
	EL 1	50,000	T8 Linear	Medium Bipin	LED	14.0	1800	128.6	26.1	4000	82
	EL 2	50,000	T8 Linear	Medium Bipin	LED	12.5	1750	140.0	37.5	4000	83
	EL 3	50,000	T8 Linear	Medium Bipin	LED	12.0	1800	150.0	47.5	4000	82
	EL 4	50,000	T8 Linear	Medium Bipin	LED	11.5	1800	156.5	54.0	4000	82
	EL 5	50,000	T8 Linear	Medium Bipin	LED	10.5	1700	161.9	59.4	4000	82
	EL 6	50,000	T8 Linear	Medium Bipin	LED	9.2	1625	176.6	74.1	4000	83

Table IV.8 Representative Lamp Units in the Integrated Directional Product Class

Product Class	EL	Lifetime	Lamp Shape	Base Type	Lamp Type	Nominal Wattage	Initial Lumens	Rated Efficacy	A-Value	CCT	CRI
		hr				*W*	*lm*	*lm/W*		*K*	
Integrated Directional	Baseline	10,000	PAR38	E26	CFL	23.0	1100	47.8	94.7	2700	82
	EL 1	25,000	PAR38	E26	LED	17.0	1200	70.6	72.6	2700	80
	EL 2	25,000	PAR38	E26	LED	16.0	1200	75.0	68.2	2700	80
	EL 3	25,000	PAR38	E26	LED	15.0	1200	80.0	63.2	2700	83
	EL 4	25,000	PAR38	E26	LED	14.0	1200	85.7	57.5	2700	82
	EL 5	25,000	PAR38	E26	LED	12.5	1200	96.0	47.2	2700	83

Table IV.9 Representative Lamp Units in the Non-integrated Omnidirectional Short Product Class

Product Class	EL	Lifetime	Lamp Shape	Base Type	Lamp Type	Nominal Wattage	Initial Lumens	Rated Efficacy	A-Value	CCT	CRI
		hr				*W*	*lm*	*lm/W*		*K*	
Non-integrated Omnidirectional Short	Baseline	10,000	Double Tube	G24q-3	CFL	26.0	1700	65.4	155.3	4100	82
	EL 1	10,000	Double Tube	G24q-3	CFL	26.0	1800	69.2	151.8	4100	82
		16,000	Double Tube	G24q-3	CFL	21.0	1525	72.6	147.3	4100	82
	EL 2	50,000	PL	G24q	LED	12.0	1100	91.7	123.4	4000	80
	EL 3	50,000	PL	G24q	LED	9.0	1200	133.3	83.4	4000	80

Table IV.10 Representative Lamp Units in the Non-integrated Directional Product Class

Product Class	EL	Lifetime	Lamp Shape	Base Type	Lamp Type	Nominal Wattage	Initial Lumens	Rated Efficacy	A-Value	CCT	CRI
		hr				*W*	*lm*	*lm/W*		*K*	
Non-integrated Directional	Baseline	25,000	MR16	GU5.3	LED	8.0	500	62.5	73.9	2700	80
	EL 1	25,000	MR16	GU5.3	LED	7.0	500	71.4	65.0	2700	82
	EL 2	25,000	MR16	GU5.3	LED	6.5	500	76.9	59.5	2700	83
	EL 3	25,000	MR16	GU5.3	LED	6.0	500	83.3	53.1	2700	84

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d. Higher Efficiency Levels

As part of DOE's analysis, the maximum available efficiency level is the highest efficiency unit currently available on the market. DOE also defines a ''max-tech'' efficiency level to represent the maximum possible efficiency for a given product.

In the January 2023 NOPR, using the more efficacious substitutes identified, DOE developed ELs for each representative product class 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. Additionally, in the January 2023 NOPR, using the lamps database of commercially available GSLs, 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. 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. 88 FR 1638, 1665. DOE did not receive comments on the equation form used to set ELs in the January 2023 NOPR. In this final rule, DOE is continuing to use the same equation form as it is shown in table IV.11.

Table IV.11 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").

DOE received comments on higher efficiency levels considered in the January 2023 NOPR that are detailed in the following sections.

Max-Tech

ASAP *et al.* stated DOE should reevaluate max-tech ELs presented in the January 2023 NOPR because DOE's analysis was based on lamp models available in June 2020 and lamps with higher efficacies appear to be currently available. Specifically, ASAP *et al.* stated that ENERGY STAR listed a 5.9 W, 800 lumen integrated omnidirectional short lamp with an efficacy of 135.6 lm/W while DOE had presented the max-tech lamp at 124.6 lm/W for the same lamp type at the same lumens. ASAP *et al.* and NYSERDA stated that integrated omnidirectional short lamps available in Europe have efficacies as high as 200 lm/W. (ASAP *et al.,* No. 174 at p. 2; NYSERDA, No. 166 at pp. 1–2)

CLASP also expressed concern that the LED lamp data on which DOE based its analysis is from mid-2020 and therefore, does not reflect products on the market today. CLASP stated that as a result, DOE's proposal uses efficacy levels that are too low and prices for LED lamps that are too high. CLASP commented that LED products are continuing to improve by around 5 percent per annum as projected by DOE's own SSL R&D program, and therefore, using older lamps means ELs are about 15 percent too low. (CLASP, No. 177 at p. 1) NYSERDA commented that the proposed max-tech levels are significantly below the technical potential across LED products and, as shown by DOE's Solid State Lighting research efforts, LEDs have the potential to reach 200 lm/W or higher. (NYSERDA, No. 166 at pp. 1–2)

In the January 2023 NOPR, DOE developed a lamps database using data from manufacturer catalogs, ENERGY STAR Certified Light Bulbs database, DOE's compliance certification database, and retailer websites. In addition, DOE reviewed applicable lamps in the CEC's Appliance Efficiency Database. This data was collected in June 2020 (*see* footnoted citations in January 2023 NOPR). 88 FR 1638, 1659. For this final rule analysis, DOE updated the lamps database with data collected mid-2022. Using this updated data, DOE reviewed the max-tech levels and determined that no changes are necessary from what was proposed in the January 2023 NOPR.

Regarding the 5.9 W integrated omnidirectional short lamp at 135.6 lm/W cited by ASAP *et al.,* this lamp has a CRI in the 90s. As stated in section IV.D.1.b of this document, DOE's analysis ensures that the baseline lamp just meet standards and has characteristics similar to the most common lamps purchased by consumers in the respective product classes (*e.g.,* wattage, CCT, CRI, and lumen output). Because the baseline lamp for the Integrated Omnidirectional Short product class has a CRI in the 80s, DOE did not consider lamps with CRIs in the 90s as appropriate substitutes. Hence, DOE did not identify the 5.9 W lamp at 135.6 lm/W as a more efficacious substitute representative of an EL. (*See* table IV.5 and January 2023 NOPR (88 FR 1638, 1661)). Regarding projections of LED efficacy increases by DOE's SSL R&D, as noted in section IV.C of this document, design options used to establish ELs must meet five screen criteria, including practicability to manufacture, install, and service. Hence, DOE bases its analysis on lamps that use design options that are incorporated in commercially available products or working prototypes, and not projected efficacies.

NEMA stated the max-tech level proposed in the January 2023 NOPR for linear LED lamps should not be considered. NEMA stated that linear LED lamps are designed to provide the same illumination levels as fluorescent tubes but with lower lumens by utilizing internal luminaire optics to redirect light where it is needed while fluorescent tubes emit light in all directions. NEMA added that because LED tubes are intended to produce the same delivered lumen output to a target area, considering more efficacious substitute lamps that provide lower lumens may hinder manufacturers from producing lamps able to provide the appropriate amount of light to meet the max-tech performance standard of EL 7. (NEMA, No. 183 at p. 20)

The Integrated Omnidirectional Long product class consists of linear tubular LED lamps 45 inches or longer that are Type B or Type A/B (*i.e.,* have an internal driver and connect to the main line voltage). In the January 2023 NOPR for 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 (*see* table IV.5). 88 FR 1638, 1661. In its engineering analysis, DOE identifies more efficacious substitutes that save energy, have light output within 10 percent of baseline lamp, and have characteristics similar to this baseline lamp. Lumen output is kept constant within the 10 percent tolerance to ensure consumer utility of more efficacious substitutes. Hence for the Integrated Omnidirectional Long product class lumen outputs of more efficacious substitutes at each EL including at the max-tech level were within 10 percent of the baseline lamp lumens (*see* table IV.7). 88 FR 1638, 1663. Further, as noted in section IV.D.1, in the January 2023 NOPR, and in this final rule, DOE used a database of commercially available lamps to identify baseline lamps and more efficacious substitutes. Hence, the max-tech level for this product class is based on commercially available linear LED lamps and therefore is technologically feasible.

Quality Metrics

The CEC acknowledged that DOE stated in the January 2023 NOPR that there is value in ensuring a range of lamp characteristics such as lumens, CRI, and CCT are available at max-tech levels. The CEC stated, however, that when evaluating technological feasibility of max-tech or minimum lumen-per-watt requirements DOE should, in addition to raising minimum efficacy levels, consider other lamp quality characteristics such as color fidelity, noise, flicker, and rated life. (CEC, No. 176 at pp. 2–3) The CEC commented that California has shown that high-efficacy, high-quality LEDs are both economically justified and technologically feasible, and DOE should establish minimum energy conservation standards that encourage innovation and provide consumers with the best options for general illumination. The CEC added that such standards will ensure a robust lamp market that saves consumers money, reduce the unnecessary consumption of energy, and address climate change by avoiding the release of unnecessary GHGs. (CEC, No. 176 at p. 5)

Further, the CEC stated its concern that not considering quality characteristics in the development of efficiency levels would result in a race to the bottom (*e.g.,* a driverless lamp that achieves a slightly higher lm/W by avoiding AC to DC-conversion at the cost of flickering). The CEC stated that inclusion of quality characteristics in DOE's analysis would ensure that lamps with higher quality emitters and drivers are not excluded from or disadvantaged in the U.S. market. Further, the CEC commented that DOE's consideration of quality characteristics would provide the opportunity for California to align its existing and future minimum efficiency levels for GSLs more closely with Federal levels. The CEC stated that it is not recommending the creation of a separate product class for high-quality lighting because a single standard that recognizes quality as an essential element of max-tech would be preferable. The CEC stated that it does, however, see establishing a separate product class based on specific quality criteria as an alternative for balancing quality and energy performance concerns, as well as ensuring a compliance path for high-performing products without lowering energy efficiency standards for baseline products. (CEC, No. 176 at pp. 2–3)

Additionally, the CEC requested that DOE consider the lumen disadvantage of providing good color rendering, in particular of red light. The CEC stated that lumens factor in the eye's perception of brightness according to a particular wavelength resulting in a disincentive to use red light in the lamp's spectrum as 1 unit of green light is worth 10 units of red light at the same power. The CEC stated this creates a conflict between costs, consumer preferences, and the lm/W standard, and is particularly impactful for consumers that prefer light at 2700 K, which has more red light. (CEC, No. 176 at pp. 2–3)

In its comment the CEC names color fidelity, noise, flicker and rated life as parameters to consider when evaluating minimum efficiency levels. In this analysis, DOE takes into account lamp characteristics provided in manufacturer's lamp specification sheets. Parameters specific to noise and flicker are not typically provided as part of lamp specifications and therefore DOE was unable to consider them. DOE's analysis does not focus only on whether a lamp has a higher efficacy. As mentioned in the CEC's comment DOE confirms that a range of lamp characteristics such as lumens, lifetime, CCT, and CRI are available at the highest levels of ELs considered, including lamps that offer good color rendering such as lamps with CRI in the 90s and high lifetimes such as lamps with 50,000 hours.

Further as stated in sections IV.D.1.b and IV.D.1.d of this document, DOE identifies baseline lamps that have characteristics typical of the product class such as CCT, CRI, and lifetime, and selects more efficacious substitutes that have similar characteristics. Hence DOE ensures that characteristics common for lamps on the market are not sacrificed at higher ELs. A lamp able to both achieve a set of characteristics common in the market and a higher efficacy is indicative of a product that meets consumer preferences as well as energy efficiency. Hence, DOE finds that DOE's analysis accounts for quality of lamps.

Anti-Backsliding Provision

In the January 2023 NOPR, 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 than the existing standards (*i.e.,* that backsliding would not occur if the proposed ELs were adopted) and ensured that the proposed ELs did not result in less stringent standards than existing ones in violation of EPCA's anti-backsliding provision. 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 proposed 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 and for all other lumen ranges meet the minimum efficacy requirement based on the equation line of EL 1 or EL 2, as applicable. 88 FR 1638, 1655–1656. DOE did not propose lumen ranges at which the minimum efficacy requirement must be the 45 lm/W standard and not the equation line for any other product classes.

Westinghouse stated the proposed EL 1 and EL 2 for the Non-integrated Omnidirectional Short (no standby mode) product class may also require minimums to prevent falling below the current standard. Specifically, Westinghouse stated at 310 to about 400 lumens, products fall below 45 lm/W. (Westinghouse, Public Meeting Transcript, No. 27 at pp. 64–65)

In this final rule, DOE reviewed potential backsliding resulting from ELs under consideration for all product classes, as all product classes are subject to the 45 lm/W backstop requirement. Based on this analysis, for the Integrated Omnidirectional Short (not capable of operating on standby mode) product class, DOE identified an error in its calculation of the lumen range that would result in an efficacy requirement less than the 45 lm/W. DOE is correcting that error in this final rule. For the Integrated Omnidirectional Short product class (not capable of operating on standby mode) for products with lumens less than 425 (rather than 424 as specified in the January 2023 NOPR), the initial EL 1 equation would result in an efficacy requirement less than the 45 lm/W standard. Similarly, for products with lumens less than 372 (rather than 371 as specified in the January 2023 NOPR), the initial EL 2 equation would result in an efficacy requirement less than the 45 lm/W standard. Hence, at EL 1 and EL 2, products with, respectively, lumens less than 425 and lumens less than 372 must meet a minimum efficacy requirement of 45 lm/W. Regarding other lumen ranges, at EL 1, products with lumens equal to 425 and less than or equal to 3,300 meet the minimum efficacy requirement based on the equation line of EL 1; and at EL 2, products with lumens equal to 372 and less than or equal to 3,300 lumens meet the minimum efficacy requirement based on the equation line of EL 2.

Further, DOE determined that for the Non-Integrated Omnidirectional Short product class for products with lumens less than 637, the initial EL 1 equation would result in an efficacy requirement less than the 45 lm/W standard. Similarly, for products with lumens less than 332, the initial EL 2 equation, would result in an efficacy requirement less than the 45 lm/W standard. Therefore, at EL 1 and EL 2 products with respectively, lumens less than 637 and lumens less than 332 must meet a minimum efficacy requirement of 45 lm/W. Regarding other lumen ranges, at EL 1, products with lumens equal to 637 and less than or equal to 3300 meet the minimum efficacy requirement based on the equation line of EL 1; and at EL 2 products with lumens equal to 332 and less than or equal to 3,300 lumens meet the minimum efficacy requirement based on the equation line of EL 2.

e. Scaling of Non-Representative Product Classes

In this January 2023 NOPR, DOE scaled the Non-integrated Omnidirectional Long product class from the representative Integrated Omnidirectional Long product class because the lamps in these product classes are the same in shape and size, and therefore could be scaled from or to one another. Because the linear shapes are substantively more prevalent than the U-shape lamps, DOE compared efficacies of 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 [41]) or non-integrated (Type A). Based

[41] 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 and Type A/B lamps are integrated lamps as they can be directly connected to the main line voltage.

on this analysis, DOE applied a 10.7 percent efficacy increase 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. 88 FR 1638, 1667. DOE received no comments on the scaling of the Non-integrated Omnidirectional Long product class. In this final rule, DOE continues to use the methodology and results of this approach.

In the January 2023 NOPR, DOE scaled standby product classes from similar non-standby product classes. Based on test data, DOE found that standby power consumption was 0.5 W or less for the vast majority of lamps available. 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 efficiency level 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. 88 FR 1638, 1667.

DOE received comments on its approach of scaling standby mode product classes. ASAP *et al.* stated that DOE should set a separate standard for standby mode rather than the proposed integrated efficacy metric that combines standby mode and active mode power. ASAP *et al.* stated that a seemingly small tradeoff between active and standby mode wattage would result in a large percent increase in annual energy consumed due to the significantly greater number of operating hours in standby mode compared to active mode. ASAP *et al.* commented that, given DOE's estimates that 50 percent of lamps will include standby power by the end of the analysis period, failing to incorporate standby power in a way that captures its contribution to total energy use could have significant implications for national energy consumption associated with GSLs. ASAP *et al.* stated that if DOE decides not to set a separate standby standard, it should use a standby value of 0.2 W in setting the efficacy levels for lamps with standby power. ASAP *et al.* stated that, in the January 2023 NOPR, DOE stated that it used 0.2 W in the calculation of lamp unit energy consumption for all lamps with standby power because California requires state-regulated LED lamps to have standby power less than 0.2 W and it is likely that manufacturers sell the same lamp model across the United States. ASAP *et al.* stated that, when determining the standards for products with standby power, DOE instead used 0.5 W as a conservative estimate of standby power. ASAP *et al.* further stated that, while it acknowledges DOE performed standby mode power testing, there are also nearly 2,400 models of GSLs in California's compliance database meeting the 0.2 W standby power minimum. (ASAP *et al.,* No. 174 at pp. 3–5) The CEC also recommended that DOE set a separate standard limiting standby mode power consumption to 0.2 W in alignment with California's standards, rather than a power that varies with a lamp's lumen output. The CEC provided the example that based on DOE's current proposal for integrated omnidirectional short lamps, the standby power is about 0.5 W for 800 lumen lamps and would be 1.9 W for 3,300 lumen lamps. It noted that over 700 connected lamp models certified to the CEC database meet the 0.2 W standby mode power consumption requirement. (CEC, No. 176 at p. 4)

In the January 2023 NOPR, DOE tentatively determined that an integrated metric for active mode and standby mode was the most appropriate approach for establishing ELs for standby mode product classes. Hence, in the January 2023 NOPR, for GSLs with standby mode functionality, the energy efficiency standards 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. 88 FR 1639, 1667.

Because an integrated metric provides flexibility in lamp design and a balance of active mode and standby mode efficiency in a lamp, DOE continues to use this approach in this final rule for determining the ELs for standby mode product classes. Regarding the use of 0.2 W instead of 0.5 W, as stated in the January 2023 NOPR, DOE found that standby power consumption was 0.5 W or less for the vast majority of lamps available. 88 FR 1638, 1667. (*See* appendix 5A of the final rule TSD for more information on the test results.) The purpose of the energy use analysis is to estimate representative values of actual energy consumption. The significant number of lamps available that consume 0.2 W or less in standby power and the requirement that lamps with standby power sold in California (a significant fraction of the GSL market) consume less than 0.2 W continues to suggest that 0.2 W is a reasonable estimate of representative standby energy consumption (*see* section IV.E of this document for further details on the energy use analysis). In this final rule, DOE is continuing to take a conservative approach because this is still a developing market and using 0.5 W as it did in the January 2023 NOPR to scale the ELs for standby mode product classes from the ELs of similar non-standby mode power classes.

f. Summary of All Efficacy Levels

Table IV.12 displays the efficacy requirements for each level analyzed by product class. The non-standby and standby Integrated Omnidirectional Short and Non-Integrated Omnidirectional 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 IV.D.1.d of this document for further information). The representative product classes are shown in grey, and all others are scaled product classes. (*Note:* In the January 2023 NOPR, for the Integrated Omnidirectional Long product class DOE had decided to lower the A-value of EL 6 (max tech level) from 74.1 to 71.7. 88 FR 1638, 1666. However, in table VI.15, ''Proposed Efficacy Levels of GSLs'' and table VII.30, ''Proposed Amended Energy Conservation Standards for GSLs'' in the January 2023 NOPR, the A-value appeared as 74.1 instead of 71.7. 88 FR 1638, 1668, 1708. This has been corrected in the table below and all relevant tables in this final rule.)

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Table IV.12 GSL Efficacy Levels

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 425) $123/(1.2+e^{-0.005*(Lumens-200))}) - 35.7$ (for lumens 425-3,300)
	EL 2	45 (for lumens less than 372) $123/(1.2+e^{-0.005*(Lumens-200))}) - 30.8$ (for lumens 372-3,300)
	EL 3	$123/(1.2+e^{-0.005*(Lumens-200))}) - 18.5$
	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	$123/(1.2+e^{(-0.005*(Lumens-200))}) + 71.7$
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	45 (for lumens less than 637) $122/(0.55+e^{(-0.003*(Lumens+250))}) - 151.8$ (for lumens 637-3300)

	EL 2	45 (for lumens less than 332) $122/(0.55+e^{(-0.003*(Lumens+250))})-123.4$ (for lumens 332-3300)
	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 Operating in 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	$123/(1.2+e^{(-0.005*(Lumens-200))})+93.0$

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2. 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 a 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.

In the January 2023 NOPR, DOE reviewed and used publicly available retail prices to develop end-user prices for GSLs. 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. 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. DOE ensured there was sufficient data to determine average prices and employed the interquartile range (IQR) calculation, a common statistical rule used to identify outliers in a dataset. When sufficient data were not available at a specific distribution channel to develop a representative unit price at an EL, DOE extrapolated pricing from lamps in the product class as similar as possible to the representative unit and with available pricing data. DOE employed price trends observed from the larger dataset of GSL prices as well as scaling factors. 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. For shipment weightings, 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. 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. 88 FR 1638, 1669.

NEMA stated that it could not comment on end-user pricing and referred DOE to individual manufacturer interviews. (NEMA, No. 183 at p. 1) The CA IOUs stated their interest in whether DOE accounted for the impact of mid and upstream energy efficiency program incentives on its retail prices. The CA IOUs stated that DOE's collected retail prices may reflect, depending on the geographic region and rebate program, significant rebates that are applied further up the distribution channel stream and not reflected in manufacturer costs. (CA IOUs, Public Meeting Transcript, No. 27 at pp. 74–75)

When collecting retail prices, DOE recorded the regular prices rather than any discounted or sale prices specified by the retailer. DOE made no adjustment to retail prices for rebate programs. Rebate programs can vary in terms of geography, rebate amount as well as to the extent they are utilized, among other things. Hence it is difficult for DOE to determine the impact of mid or upstream rebate programs on retail price, if any, that is consistently applicable at a national level. The cost analysis in this rulemaking employs a consistent methodology in developing the final consumer prices that are used in the LCC analysis and development of MPC and MSP. Further, EPA's ENERGY STAR Lighting Program has noted that in recent years utility programs have been declining in anticipation of Federal standards, which would result in a new baseline that would make it difficult for utilities to justify their rebates.[42]

Hence, in this final rule, DOE continues to use the methodology and results of the cost analysis as determined in the January 2023 NOPR. The end-user prices are detailed in chapter 5 of the final rule 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 IV.J.2.a of this document for further details.

E. Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of GSLs at different efficiencies 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 January 2023 NOPR, DOE used data from various regional field-metering studies of GSL operating hours conducted across the United States. (88 FR 1669–1670) 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 final rule TSD). Specifically, DOE determined the average HOU for each of the reportable domains (*i.e.,* state, or group of states) used in the EIA 2009 Residential Energy Consumption Survey (''RECS'').[43] 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

[42] EPA ENERGY STAR Lighting Program, ''ENERGY STAR Lighting Sunset Proposal Memo.'' Available at: *www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Lighting%20Sunset%20Proposal%20Memo.pdf* (last accessed Aug. 22, 2023).

[43] U.S. Department of Energy–Energy Information Administration. 2009 RECS Survey Data. Available at *www.eia.gov/consumption/residential/data/2009/*(last accessed Aug. 1, 2023).

(*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'') [44] and room distribution data by lamp type came from a 2010 KEMA report.[45] *See* chapter 6 of this final rule TSD for more detail. DOE notes that its 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 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'' [46] and the ''Residential Lighting End-Use Consumption Study'' (''RLEUCS'') [47]—DOE assumes that the higher HOU found for CFL GSLs were 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 are 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 January 2023 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 in which the lamp is located; 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,[48] which included GSL room-distribution data for more than 700 single-family homes throughout the Northwest.

In response to the January 2023 NOPR, NEMA agreed with the data and methodology DOE used to estimate residential HOU. (NEMA, No. 183 at p. 15)

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.[49] 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 Commercial Buildings Energy Consumption Survey (''CBECS'') 2012,[50] 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'').[51] 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.

In response to the January 2023 NOPR, NEMA agreed with the data and methodology DOE used to estimate commercial HOU. (NEMA, No. 183 at p. 15)

2. Input Power

The input power used in the energy use analysis is the input power presented in the engineering analysis (section IV.D.1.c of this document) for the representative lamps considered in this 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 Williams, *et al.*[52] 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.

In response to the January 2023 NOPR, NEMA commented that the results of the meta-analysis DOE relied on to estimate 30 percent energy savings are not accurate because LED technology was not in general use at that time. NEMA suggested—based on a DesignLights Consortium report [53]

[44] Ecotope Inc. *Residential Building Stock Assessment: Metering Study.* 2014. Northwest Energy Efficiency Alliance: Seattle, WA. Report No. E14–283. Available at *neea.org/resources/2011-rbsa-metering-study* (last accessed Aug. 10, 2023).

[45] KEMA, Inc. Final Evaluation Report: Upstream Lighting Program: Volume 2. 2010. California Public Utilities Commission, Energy Division: Sacramento, CA. Report No. CPU0015.02. *www.calmac.org/publications/FinalUpstreamLightingEvaluationReport_Vol2_CALMAC.pdf* (last accessed Aug. 10, 2023).

[46] 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. Available at *app.box.com/s/o1f3bhbunib2av2wiblu/1/1995940511/17399081887/1* (last accessed Aug. 10, 2023).

[47] 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. Available at: *www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf* (last accessed Aug. 10, 2023).

[48] Northwest Energy Efficiency Alliance. ''Residential Building Stock Assessment II: Single-Family Homes Report: 2016–2017.'' 2019. Northwest Energy Efficiency Alliance. Available at: *neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf* (last accessed Aug. 10, 2023).

[49] Navigant Consulting, Inc. ''2015 U.S. Lighting Market Characterization.'' 2017. U.S. Department of Energy: Washington, DC. Report No. DOE/EE–1719. Available at: *Energy.gov/eere/ssl/downloads/2015-us-lighting-market-characterization* (last accessed Aug. 10, 2023).

[50] U.S. Department of Energy—Energy Information Administration. ''2012 Commercial Buildings Energy Consumption Survey (CBECS).'' 2012. Available at: *www.eia.gov/consumption/commercial/data/2012/* (last accessed Aug. 10, 2023).

[51] Cadmus Group. *Commercial Building Stock Assessment 4 (2019) Final Report.* 2020. Northwest Energy Efficiency Alliance: Seattle, WA. *neea.org/resources/cbsa-4-2019-final-report* (last accessed Aug. 10, 2023).

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

[53] Wen, Y.-J., E. Kehmeier, T. Kisch, A. Springfield, B. Luntz, and M. Frey. Energy Savings

showing average savings of 49 percent for networked lighting controls—that DOE use a range of 30–49 percent energy savings from controls. (NEMA, No. 183 at p. 15) DOE appreciates NEMA identifying this report; however, because the meta-analysis DOE has relied on incorporates a variety of control strategies, DOE believes the meta-analysis is likely more representative of potential savings than the results of a study looking only at networked lighting controls. DOE has thus continued to use 30 percent energy savings for controls in its reference scenario. However, due to the inherent uncertainty in estimating energy savings from controls, DOE also analyzed a scenario in which controls are assumed to result in a 49 percent reduction in energy use. The results of this analysis can be found in appendix 7B of the final rule TSD.

For this final rule, 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 the 2010 KEMA report. Based on this analysis, DOE estimated the controls penetrations for integrated directional and non-integrated directional GSLs at 10 percent.

In response to the January 2023 NOPR, NEMA recommended that DOE use a controls penetration of 1 percent or 2 percent for integrated omnidirectional long lamps. NEMA also commented that DOE should not rely on the 2015 LMC to estimate controls penetration due to the 2015 LMC being outdated and also showing less controls penetration than the previous 2010 LMC report. NEMA estimated that approximately 20 percent of residential lamps are connected to lighting controls and provided multiple explanations for the increased controls penetration. (NEMA, No. 183 at pp. 15–17) DOE has continued to use the 2015 LMC to estimate controls penetration in this final rule because the 2015 LMC estimates are the best nationally representative estimates that DOE has for integrated omnidirectional long lamps, assuming a 2 percent controls penetration for those lamps (as opposed to 0 percent) would have very minor impacts on the energy use and LCC results. For the other lamp types, DOE agrees that there is more uncertainty with the estimated controls penetration. As a result, DOE has analyzed a scenario in which the controls penetration is assumed to be 20 percent for all product classes other than integrated omnidirectional long. The results of this analysis can be found in appendix 7B of the final rule TSD.

For this final rule, DOE maintains its assumption in the January 2023 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 2.3 percent of residential shipments in the integrated omnidirectional short product class and 0.3 percent of residential 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 IV.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 final rule, similar to its assumption in the January 2023 NOPR (*see* appendix 9C of this final rule TSD). By the assumed first full year of compliance (2029), DOE estimated 36 percent of commercial GSLs in all product classes will operate on controls. In response to the January 2023 NOPR, NEMA commented that an estimated 50 percent of commercial GSLs operate on controls. (NEMA, No. 183 at p. 17) Without data to corroborate a different value, DOE has continued to assume 36 percent of commercial GSLs operate on controls in its reference scenario because DOE believes the data sources it used and the analysis it conducted to estimate commercial controls penetration in the compliance year provide a nationally representative estimate. However, based on NEMA's input, DOE has analyzed a scenario in which 50 percent of commercial GSLs operate on controls. The results of this analysis can be found in appendix 7B of the final rule TSD.

Chapter 6 of the final rule 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 a GSL standard case (*i.e.,* case where a standard would be in place at a particular TSL), DOE measured the 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

from Networked Lighting Control (NLC) Systems with and without LLLC. 2020. Energy Solutions: Oakland, CA. Available at: *www.designlights.org/resources/reports/report-energy-savings-from-networked-lighting-control-nlc-systems-with-and-without-lllc/* (last accessed Aug. 10, 2023).

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.

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 2020 RECS [54] and the 2018 CBECS [55] for the residential and commercial sectors, respectively. For each consumer in the sample, DOE determined the energy consumption for the lamp purchased and the appropriate electricity price. By developing representative 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.

The computer model DOE uses to calculate the LCC relies on a Monte Carlo simulation to incorporate uncertainty and variability into the analysis. The Monte Carlo simulations randomly sample input values from the probability distributions and GSL consumer 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 of LCC savings. In performing an iteration of the Monte Carlo simulation for a given consumer, product efficiency is chosen based on its probability. If the chosen product efficiency is greater than or equal to the efficiency of the standard level under consideration, the LCC calculation reveals that a consumer is not impacted by the standard level. By accounting for consumers who already purchase more-efficient products, DOE avoids overstating the potential benefits from increasing product efficiency. DOE calculated the LCC and PBP for 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 II 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 IV.13 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 final rule TSD and its appendices.

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[54] U.S. Department of Energy—Energy Information Administration. *2020 Residential Energy Consumption Survey (RECS).* 2020. *www.eia.gov/consumption/residential/data/2020/.* Last accessed August 10, 2023.

[55] U.S. Department of Energy—Energy Information Administration. *2018 Commercial Buildings Energy Consumption Survey (CBECS).* 2021. Available at *www.eia.gov/consumption/commercial/data/2018/* (last accessed Aug. 10, 2023).

Table IV.13 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 2022 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 *AEO2023* 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 final rule 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 final rule TSD.

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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 for 2020 directly; therefore, for the LCC analysis, the only adjustment was to adjust the prices to 2022$ using the implicit price deflator for gross domestic product (''GDP'') from the Bureau of Economic Analysis [56] and add sales taxes, which were assigned to each household or building in the LCC sample based on its location.

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 IV.G.1.b of this document.

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the product. DOE assumed an installation cost of $1.73 per installed commercial GSL—based on an estimated lamp installation time of 5 minutes from RSMeans [57] and hourly wage data from the U.S. Bureau of Labor Statistics [58]—but zero installation cost for residential GSLs.

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

[56] *www.bea.gov/data/prices-inflation/gdp-price-deflator* (last accessed March 5, 2024).

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

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

approach described previously in section IV.E of this document.

4. Energy Prices

Because marginal electricity price more accurately captures the 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. 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 final rule, consistent with the January 2023 NOPR, DOE used marginal electricity prices to estimate electricity costs for both the incremental change in energy use and the energy use in the no-new-standards case 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 2022 using data from the EEI Typical Bills and Average Rates reports. 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).[59] For the commercial sector, DOE calculated electricity prices using the methodology described in Coughlin and Beraki (2019).[60]

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 marginal prices to each household in the LCC sample based on its location. DOE also assigned 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 Final Rule TSD.

To estimate energy prices in future years, DOE multiplied the 2022 energy prices by the projection of annual average price changes for each of the nine census divisions from the Reference case in the *Annual Energy Outlook 2023* (*AEO2023),* which has an end year of 2050.[61] 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, and the results can be found in appendix 9D of the final rule TSD.

5. Product Lifetime

In this final rule, 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, DOE used the same lifetime methodology as in the January 2023 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.

For a detailed discussion of the development of lamp lifetimes, see appendix 7C of the final rule 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.

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 final rule 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.[62] The LCC analysis estimates net 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, 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

[59] 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. *ees.lbl.gov/publications/residential-electricity-prices-review.*

[60] 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. *ees.lbl.gov/publications/non-residential-electricity-prices.*

[61] EIA. *Annual Energy Outlook 2023.* Available at: *www.eia.gov/outlooks/aeo/* (last accessed Aug. 10, 2023).

[62] 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, 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.

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 triennial Survey of Consumer Finances [63] (''SCF'') starting in 1995 and ending in 2019. 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 4.2 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.[64] The average discount rate across the commercial building types is 6.8 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 (market shares) of product efficacies under the no-new-standards case (*i.e.,* the case without amended or new energy conservation standards) 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 of GSLs for 2029, 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 efficacy distributions, *see* section IV.G of this document and chapter 8 of the final rule TSD.

The estimated market shares for the no-new-standards case and each standards case for GSLs are determined by the shipments analysis and are shown in table IV.14 through table IV.18. A description of each of the TSLs is located in section V.A of this document.

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[63] U.S. Board of Governors of the Federal Reserve System. Survey of Consumer Finances. 1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, and 2019. *www.federalreserve.gov/econresdata/scf/scfindex.htm* (last accessed Aug. 10, 2023).

[64] Damodaran, A. Data Page: Historical Returns on Stocks, Bonds and Bills-United States. 2023. *pages.stern.nyu.edu/~adamodar/* (last accessed August 10, 2023).

Table IV.14 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	0.8	0.8	26.9	26.1	14.0	13.8	16.9	100.0
TSL 1	0.0	0.0	0.8	27.3	26.5	14.2	14.0	17.1	100.0
TSL 2	0.0	0.0	0.0	27.6	26.7	14.3	14.1	17.3	100.0
TSL 3	0.0	0.0	0.0	0.0	0.0	31.4	30.9	37.7	100.0
TSL 4	0.0	0.0	0.0	0.0	0.0	0.0	45.0	55.0	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	0.8	0.8	27.7	26.8	13.6	13.4	16.4	100.0
TSL 1	0.0	0.0	0.8	28.1	27.1	13.8	13.6	16.6	100.0
TSL 2	0.0	0.0	0.0	28.3	27.4	13.9	13.7	16.7	100.0
TSL 3	0.0	0.0	0.0	0.0	0.0	31.4	30.9	37.7	100.0
TSL 4	0.0	0.0	0.0	0.0	0.0	0.0	45.0	55.0	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.
** The total may not sum to 100 percent due to rounding.

Table IV.15 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	0.3	11.9	14.4	17.3	21.1	35.1	100.0
TSL 1	0.0	11.9	14.4	17.3	21.2	35.2	100.0
TSL 2	0.0	0.0	0.0	23.5	28.8	47.8	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	11.9	14.4	17.3	21.1	35.1	100.0
TSL 1	0.0	11.9	14.4	17.3	21.2	35.2	100.0
TSL 2	0.0	0.0	0.0	23.5	28.8	47.8	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 percent due to rounding.

Table IV.16 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	26.3	24.7	22.7	26.3	100.0
TSL 1 - 4	0.0	33.5	30.8	35.7	100.0
TSL 5 - 6	0.0	0.0	0.0	100.0	100.0
Commercial					
No-New-Standards	26.3	24.7	22.7	26.3	100.0
TSL 1 - 4	0.0	33.5	30.8	35.7	100.0
TSL 5 - 6	0.0	0.0	0.0	100.0	100.0

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

Table IV.17 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	2.9	2.5	40.7	53.9	100.0
TSL 1	0.0	2.6	41.9	55.5	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 percent due to rounding.

Table IV.18 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	14.5	14.2	14.0	15.1	14.1	14.5	13.7	100.0
TSL 1	0.0	16.6	16.4	17.6	16.4	16.9	16.1	100.0
TSL 2	0.0	0.0	0.0	26.3	24.5	25.2	24.0	100.0
TSL 3 - 5	0.0	0.0	0.0	0.0	0.0	51.3	48.7	100.0
TSL 6	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Commercial								
No-New-Standards	14.5	14.2	14.0	15.1	14.1	14.5	13.7	100.0
TSL 1	0.0	16.6	16.4	17.6	16.4	16.9	16.1	100.0
TSL 2	0.0	0.0	0.0	26.3	24.5	25.2	24.0	100.0
TSL 3 - 5	0.0	0.0	0.0	0.0	0.0	51.3	48.7	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 percent due to rounding.

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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 (expressed in years) it takes the consumer to recover the additional installed cost of more-efficient products, compared to baseline products, through energy cost savings. 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. DOE refers to this as a ''simple PBP'' because it does not consider changes over time in operating cost savings. The PBP calculation uses the same inputs as the LCC analysis when deriving first-year operating costs.

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 year in which compliance with the amended standards would be required.

G. Shipments Analysis

DOE uses projections of annual product shipments to calculate the national impacts of potential amended or new energy conservation standards on energy use, NPV, and future manufacturer cash flows.[65] 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.

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.

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 *AEO2023* projections of U.S. residential and commercial floor space.[66] 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.

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 IV.F.5 of this document 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 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

[65] 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.

[66] U.S. Department of Energy—Energy Information Administration. Annual Energy Outlook 2023 with projections to 2050. Washington, DC Report No. AEO2023. U.S. Department of Energy—Energy Information Administration. Annual Energy Outlook 2023 with projections to 2050. Washington, DC. Report No. AEO2023. Available at: *www.eia.gov/outlooks/aeo/* (last accessed Aug. 21, 2023).

curve[67] as in the January 2023 NOPR. For linear lamps, DOE assumes that 8.2 percent of stock is replaced 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 *AEO2023*.[68] Further details on the assumptions used to model these market transitions are presented in chapter 8 of the final rule TSD.

NEMA commented that it does not believe the current conversion rate of linear lamp stock to integrated fixtures is likely to be maintained in the long term. (NEMA, No. 183 at p. 18) In addition, NEMA commented that sustainability goals for new construction are likely to support the linear lamp market of the future. (NEMA, No. 183 at p. 18) DOE acknowledges that there is uncertainty in the rate at which integrated fixtures will replace linear lamps fixtures, as well as uncertainty in the persistence of demand for linear lamps in applications that were not explicitly analyzed. In order to account for the possibility that shipments remain higher than those projected in this Final Rule analysis, DOE modeled a scenario where a smaller percentage of stock is removed each year. This lower attrition rate is based on estimates made in DOE's 2019 Forecast of Solid-State Lighting in General Illumination Applications,[69] and results in a more gradual reduction in the size of the linear lamp market. The national impacts of this shipments scenario are presented in appendix 9D of the final rule TSD.

For this final rule, 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 79 percent of A-line lamp sales in 2021 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.[70]

As in the January 2023 NOPR, 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) 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 final rule 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,[71] 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 2023 GSFL Final Determination analysis (see 88 FR 9118–9136) 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

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

[68] U.S. Department of Energy—Energy Information Administration. Annual Energy Outlook 2023 with Projections to 2050. Washington, DC. Report No. AEO2023. Available at: *www.eia.gov/outlooks/aeo/* (last accessed Aug. 21, 2023).

[69] Navigant Consulting, Inc. Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. 2019. U.S. Department of Energy: Washington, DC. Report No. DOE/EERE 2001. Available at: *www.energy.gov/eere/ssl/downloads/2019-ssl-forecast-report* (last accessed March 15, 2023).

[70] National Electrical Manufacturers Association. Lamp Indices. Available at *www.nema.org/analytics/lamp-indices* (last accessed Aug. 24, 2023).

[71] 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) *eta.lbl.gov/publications/accounting-technological-change.* 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) *eta.lbl.gov/publications/accounting-technological-change.* (last accessed Aug. 5, 2021).

Bass adoption model,[72] the parameters of which are based on data on the market penetration of LED lamps published by NEMA,[73] 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 assumes that non-integrated LED lamp options became available starting in 2015.

In response to the January 2023 NOPR, EEI commented that, as proposed, the efficacy requirement of 120 lm/W for most types of lighting would eliminate 98 percent of the highest-efficiency light bulbs currently available to consumers. (EEI, No. 181 at pp. 2–3) NYSERDA commented that findings from its December 2020 study of sales and shipments of GSLs in New York underscores the feasibility of the NOPR's updated standards as LEDs made up 73 percent of all GSLs sold in New York in 2020 and that rate continues to grow. (NYSERDA, No. 166 at p. 3) The CA IOUs cited CEC's MAEDbS, which lists 15,313 integrated, single-ended LED lamps with lighting outputs between 800 and 1100 lumens, all complying with the light quality criteria in California's Appliance Efficiency Regulations. The CA IOUs noted that 14 percent of these lamps claim an efficacy of 120 lm/W or higher and would likely meet DOE's proposed standard, and the CA IOUs commented they anticipate a larger share of marketable GSLs will exceed the efficacy requirements when the new standard becomes effective. (CA IOUs, No. 167 at p. 2).

For the shipments model, DOE included the impact of historically observed trends in LED efficacy based on the 2019 DOE Solid State Lighting report,[74] which projects that the average efficacy of the non-linear LED GSLs will likely exceed the efficacy of the most efficacious (max-tech) lamp options considered in the engineering analysis in future years. As detailed in section IV.F.9 of this document, DOE projects that in the no-new-standards case by 2029, the fraction of GSLs at or above max-tech is at least 13 precent for all product classes, and considerably higher for some. More information on the efficacy trend data can be found in chapter 8 of the final rule TSD. Additionally, DOE does not anticipate a decrease in manufacturing capacity of products that will be able to meet the proposed standard by the compliance date (*see* section V.B.2 of this document for details).

H. National Impact Analysis

The NIA assesses the national energy savings (''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.[75] (''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 efficiencies greater than the standard and, in the case of integrated omnidirectional long lamps, out-of-scope alternatives such as GSFLs.

DOE takes analytical results from the shipments model and calculates the energy savings and the national consumer costs and savings from each TSL. Analytical results and inputs to the model are presented 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 IV.19 summarizes the inputs and methods DOE used for the NIA analysis for the final rule. Discussion of these inputs and methods follows the table. *See* chapter 9 of the final rule TSD for further details.

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

[73] National Electrical Manufacturers Association. Lamp Indices. Available at: *www.nema.org/analytics/lamp-indices* (last accessed Aug. 24, 2023).

[74] Navigant Consulting, Inc. Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. 2019. U.S. Department of Energy: Washington, DC. Report No. DOE/EERE 2001. Available at *www.energy.gov/eere/ssl/downloads/2019-ssl-forecast-report* (last accessed Feb. 23, 2022).

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

Table IV.19 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
Efficiency Trends	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. Incorporates projection of future product prices based on historical data.
Annual Energy Cost per Unit	Calculated for each lamp option using the energy use per unit, and electricity prices and trends
Energy Price Trends	*AEO2023* projections (to 2050) and held fixed to 2050 value thereafter.
Energy Site-to-Primary and FFC Conversion	A time-series conversion factor based on *AEO2023*
Discount Rate	3 and 7 percent.
Present Year	2024

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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). 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 *AEO2023.* Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

Use of higher-efficiency products is sometimes 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). In the January 2023 NOPR, 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 final rule 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, 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 [76] 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 final rule TSD.

EEI commented that DOE's utilization of a fossil fuel equivalent marginal heat rate for electricity generated from

[76] For more information on NEMS, refer to *The National Energy Modeling System: An Overview 2009,* DOE/EIA–0581 (2009), October 2009. Available at *www.eia.gov/forecasts/aeo/index.cfm* (last accessed April 21, 2022).

renewable sources is inconsistent with prior DOE recommendations for all appliance standards rulemakings. EEI commented that by assigning a fossil heat rate to renewable energy as if that energy has an emissions impact (when in fact no carbon emissions are associated with the electricity generated), DOE's analysis does not accurately capture the emissions profile of clean energy resources deployed by the sector at large scale. EEI commented that DOE should use a more appropriate methodology for this rulemaking to accurately capture the ongoing clean energy transition, such as the ''captured energy'' approach. Otherwise, EEI commented, DOE's use of fossil-fuel marginal heat rates results in at least a 3x overstatement of the amount of primary energy that would be saved if new efficiency standards for consumer light bulbs are promulgated. (EEI, No. 181 at pp. 2–3)

As previously mentioned, DOE converts electricity consumption and savings to primary energy using annual conversion factors derived from the AEO. Traditionally, EIA has used the fossil fuel equivalency approach to report noncombustible renewables' contribution to total primary energy. The fossil fuel equivalency approach applies an annualized weighted-average heat rate for fossil fuel power plants to the electricity generated (in kWh) from noncombustible renewables. EIA recognizes that using captured energy (the net energy available for direct consumption after transformation of a noncombustible renewable energy into electricity) or incident energy (the mechanical, radiation, or thermal energy that is measurable as the ''input'' to the device) are possible approaches for converting renewable electricity to a common measure of primary energy, but it continues to use the fossil fuel equivalency approach in the AEO and other reporting of energy statistics. DOE contends that it is important for it to maintain consistency with EIA in DOE's accounting of primary energy savings from energy efficiency standards. This method for calculating primary energy savings has no effect on the estimation of impacts of standards on emissions, which uses a different approach (*see* chapter 9 of the final rule 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 final rule. 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 final rule that smart lamp penetration is limited to the residential sector.

In response to the January 2023 NOPR, NEMA objected to DOE's assumption that integrated lamps with standby functionality are fundamentally similar to lamps without standby functionality but with the addition of wireless communication components and the associated consumption of power in standby mode. NEMA noted that the variety of features that lamps capable of operating on standby power may offer has greatly expanded in recent years and includes functionality such as dimming, scheduling, high end trim, and demand response. (NEMA, No. 183 at p. 9–10) DOE notes that the representative lamps without standby power consumption that were used as the basis for scaling are also capable of dimming. DOE is not aware of data indicating how scheduling, high end trim and demand response functionality impact the energy consumption of smart GSLs with these features, but assumed that smart GSLs offer similar fractional energy savings (30 percent) from controls as representative GSLs used with dimming controls.

NEMA commented on the growing popularity of smart LED lamps, noting that nearly 10 million households use smart speakers to control lighting, based on data from EIA and RECS. (NEMA, No. 183 at p. 10) However, NEMA commented that it could not predict the market share for smart lamps by the end of the analysis period, noting how much the lighting market has changed in the last 35 years. (NEMA, No. 183 at p. 18) For this final rule, DOE continued to assume that there was an increase in the fraction of LED lamps that are smart lamps over the shipments analysis period. In the absence of information to support an alternative projection, DOE continued to assume that the market penetration of smart lamps in the residential sector reached 50 percent by the end of the analysis period.

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 typically sell the same smart lamp models in California as in the rest of the U.S.[77] DOE further assumed that the majority of smart lamps would be standalone and not require the need of a hub.

More details on the incorporation of smart lamps in DOE's analysis can be found in chapter 9 of the TSD.

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 750–1,049 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.,* 310–2,600 lumens).

Using the lumen range distribution for integrated omnidirectional short A-line lamps developed originally for the March 2016 NOPR and used in the January 2023 NOPR, 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 (750–1,049 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.

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 Design Lights Consortium database, which was held constant throughout the analysis period.

2. Net Present Value Analysis

The inputs for determining the NPV of the total costs and benefits experienced by consumers are (1) total

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

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 IV.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 33 percent relative to 2022 in the no-new-standards case. DOE's projection of product prices as described in chapter 8 of the final rule TSD.

To evaluate the effect of uncertainty regarding the price trend estimates, DOE investigated the impact of different product price projections on the consumer NPV for the considered TSLs for GSLs. In addition to the default price trend, DOE considered two product price sensitivity cases: (1) a high price decline case based on a higher price learning rate and (2) a low price decline case based on a lower price learning rate. The derivation of these price trends and the results of these sensitivity cases are described in appendix 9D of the final rule 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 the appropriate form of energy. To estimate energy prices in future years, DOE multiplied the average regional energy prices by the projection of annual national-average residential energy price changes in the Reference case from *AEO2023,* 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 *AEO2023* 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 9D of the final rule TSD.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this final rule, 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.[78] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the ''social rate of time preference,'' which is the rate at which society discounts future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended 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 final rule, DOE analyzed the impacts of the considered standard levels on two subgroups: (1) low-income households and (2) small businesses. The residential low-income household analysis used a subset of the RECS 2020 sample composed of households that are at or below the poverty line. DOE analyzed only the low-income households that are responsible for paying their electricity bill in this analysis. RECS 2020 indicates that approximately 15% of low-income renters are not responsible for paying their electricity bills. Such consumers may incur a net cost (depending on if they purchase their own GSLs or not). DOE notes that this is only relevant for the integrated omnidirectional short GSL product class, as low-income households that purchase integrated directional GSLs would still experience a net benefit even if they are not responsible for paying their electricity bill and low-income households are assumed not to purchase lamps in other GSL product classes, which are uncommon in the residential sector.

The analysis of commercial small businesses uses the CBECS 2018 sample (as in the full-sample LCC analysis) but applies discount rates specific to small businesses. DOE used the analytical framework and inputs described in section IV.F of this document.

Chapter 10 in the final rule 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, investments in research and development (''R&D'') and manufacturing capital, and domestic manufacturing employment. Additionally, the MIA seeks to determine how new and amended energy conservation standards might affect 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 Government Regulatory Impact Model (''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 outputs are the INPV, which is the sum of industry annual cash flows over the analysis period, discounted using the industry-weighted average cost of capital, and the impact to domestic manufacturing employment. 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 and domestic manufacturing employment 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

[78] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* Available at *www.whitehouse.gov/omb/information-for-agencies/circulars* (last accessed March 22, 2024). DOE used the prior version of Circular A–4 (September 17, 2003) in accordance with the effective date of the November 9, 2023 version.

and market trends. Specifically, the MIA considers such factors as a potential standard's impact on 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 final rule 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 result in a higher or lower industry value. The GRIM uses a standard, annual discounted cash-flow analysis that incorporates manufacturer costs, 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 spreadsheet uses the inputs to arrive at a series of annual cash flows, beginning in 2024 (the base 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.

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

a. Manufacturer Production Costs

Manufacturing more efficient products is typically more expensive than manufacturing baseline products due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPCs of covered products can affect the revenues, gross margins, and cash flow of the industry. 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. In the January 2023 NOPR, 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. DOE asked for comment on the use of these values and NEMA stated that it cannot comment on the average distribution chain markup and referred DOE to individual manufacturer interviews for this information. (NEMA, No. 183 at p. 19) The estimated manufacturer markup and the estimated average distribution chain markup values that were used in the January 2023 SNOPR were based on information provided during manufacturer interviews. Therefore, DOE continues to use the same values in this final rule analysis that were used in the January 2023 NOPR.

For a complete description of end-user prices, see the cost analysis in section IV.D.2 of this document.

b. Shipments Projections

The GRIM estimates manufacturer revenues based on total unit shipment projections and the distribution of those shipments by efficiency level. Changes in sales volumes and efficiency 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. The shipments analysis projects shipments from 2024 (the base year) to 2058 (the end year of the analysis period). *See* chapter 8 of the final rule TSD for additional details.

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 efficiency level 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.

In the January 2023 NOPR, 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 amount of engineering time 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 using DOE's database of existing GSL models and the distribution of shipments from the shipments analysis (*see* section IV.G of this document).

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.[79] 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 by which energy conservation standards are required, even in the absence of DOE energy conservation standards for GSLs.

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

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.[80]

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 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 production equipment to maintain, or reduce, their LED lamp production volumes from the previous year.

DOE asked for comment on the methodology used to calculate product and capital conversion costs for GSLs in January 2023 NOPR. DOE did not receive any comments on this methodology. Therefore, DOE continued to use this methodology for this final rule analyses. DOE updated all engineering labor costs from 2021 dollars that were used in the January 2023 NOPR to 2022 dollars for this final rule analysis.

In general, DOE assumes all conversion-related investments occur between the publication of this 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 V.B.2.a of this document. For additional information on the estimated capital and product conversion costs, *see* chapter 11 of the final rule TSD.

d. Manufacturer Markup Scenarios

MSPs include direct manufacturing production costs (*i.e.,* labor, materials, and overhead estimated in DOE's MPCs) and all non-production costs (*i.e.,* SG&A, R&D, and interest), along with profit. To calculate the MSPs in the GRIM, DOE applied non-production cost markups to the MPCs estimated in the engineering analysis for each product class and efficiency level. Modifying these markups in the standards case yields different sets of impacts on manufacturers. For the MIA, DOE modeled two standards-case markup scenarios to represent uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of amended energy conservation standards: (1) a preservation of gross margin scenario; and (2) a preservation of operating profit scenario. These scenarios lead to different markup values that, when applied to the MPCs, result in varying revenue and cash flow impacts.

Under the preservation of gross margin percentage scenario, DOE applied a single uniform ''gross margin percentage'' across all efficiency levels, which assumes that manufacturers would be able to maintain the same amount of profit as a percentage of revenues at all efficiency levels within a product class. DOE continued to use a manufacturer markup of 1.55 for all GSLs, which corresponds to a gross margin of 35.5 percent, and the same manufacturer markup that was used in the January 2023 NOPR. This manufacturer markup scenario represents the upper bound to industry profitability under new and amended energy conservation standards and is the manufacturer markup scenario that is used in all consumer analyses (*e.g.,* LCC, NIA).

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 manufacturer production costs. Under this scenario, as the MPCs increase, manufacturers reduce their margins (on a percentage basis) to a level that maintains the no-new-standards case operating profit (in absolute dollars). The implicit assumption behind this scenario is that the industry can only maintain its operating profit in absolute dollars after compliance with new and amended standards. Therefore, operating profit in percentage terms is reduced between the no-new-standards case and the analyzed standards cases. DOE adjusted the margins in the GRIM at each TSL to yield approximately the same earnings before interest and taxes in the standards cases in the year after the first full year of compliance of the new and amended standards as in the no-new-standards case. This scenario represents the lower bound to industry profitability under new and amended energy conservation standards.

A comparison of industry financial impacts under the two markup scenarios is presented in section V.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 in 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 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 final rule TSD. The analysis presented in this final rule uses projections from *AEO2023.* 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'').[81]

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 12 of the final rule TSD.

The emissions intensity factors are expressed in terms of physical units per MWh or 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.

[80] Based on feedback from manufacturers, DOE estimates that most LED lamp models are remodeled approximately every 2 to 3 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.

[81] Available at*: www.epa.gov/sites/production/files/2021–04/documents/emission-factors_apr2021.pdf* (last accessed July 12, 2021).

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. *AEO2023* reflects, to the extent possible, laws and regulations adopted through mid-November 2022, including the emissions control programs discussed in the following paragraphs the emissions control programs discussed in the following paragraphs, and the Inflation Reduction Act.[82]

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, and went into effect as of January 1, 2015.[83] The *AEO2023* incorporates implementation of CSAPR, including the update to the CSAPR ozone season program emission budgets and target dates issued in 2016. 81 FR 74504 (Oct. 26, 2016). 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.

However, beginning in 2016, SO_2 emissions began to fall as a result of the Mercury and Air Toxics Standards (''MATS'') for power plants.[84] 77 FR 9304 (Feb. 16, 2012). The final rule establishes power plant emission standards for mercury, acid gases, and non-mercury metallic toxic pollutants. 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 will generally reduce SO_2 emissions. DOE estimated SO_2 emissions reduction using emissions factors based on *AEO2023.*

CSAPR also established limits on NO_X emissions for numerous States in the 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. Depending on the configuration of the power sector in the different regions and the need for allowances, however, NO_X emissions might not remain at the limit in the case of lower electricity demand. That would mean that 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. Standards would be expected to reduce NO_X emissions in the States not covered by CSAPR. DOE used *AEO2023* data to derive NO_X emissions factors for the group of 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 *AEO2023,* which incorporates the MATS.

L. Monetizing Emissions Impacts

As part of the development of this final rule, for the purpose of complying with the requirements of Executive Order 12866, DOE considered the estimated monetary 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 final rule.

To monetize the benefits of reducing GHG emissions, this analysis uses the interim 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 IWG.

1. Monetization of Greenhouse Gas Emissions

DOE estimates the monetized benefits of the reductions in emissions of CO_2, CH_4, and N_2O by using a measure of the 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. That is, the social costs of greenhouse gases, whether measured using the February 2021 interim estimates presented by the Interagency Working Group on the Social Cost of Greenhouse Gases or by another means, did not affect the rule ultimately adopted by DOE.

DOE estimated the global social benefits of CO_2, CH_4, and N_2O reductions using SC–GHG values that were based on the interim values presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim*

[82] For further information, see the Assumptions to *AEO2023* report that sets forth the major assumptions used to generate the projections in the Annual Energy Outlook. Available at: *www.eia.gov/outlooks/aeo/assumptions/* (last accessed August 21, 2023).

[83] 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 with respect to 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), and EPA issued the CSAPR Update for the 2008 ozone NAAQS. 81 FR 74504 (Oct. 26, 2016).

[84] 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.

Estimates under Executive Order 13990, published in February 2021 by the IWG (''February 2021 SC–GHG TSD''). The SC–GHG 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, the SC–GHG 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–GHG therefore, reflects the societal value of reducing emissions of the gas in question by one metric ton. The SC–GHG is the theoretically appropriate value to use in conducting benefit-cost analyses of policies that affect CO_2, N_2O and CH4 emissions. As a member of the IWG involved in the development of the February 2021 SC–GHG TSD, 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. DOE continues to evaluate recent developments in the scientific literature, including the updated SC–GHG estimates published by the EPA in December 2023 within their rulemaking on oil and natural gas sector sources.[85] For this rulemaking, DOE used these updated SC–GHG values to conduct a sensitivity analysis of the value of GHG emissions reductions associated with alternative standards for GSLs (see section IV.L.1.c of this document).

The SC–GHG estimates presented here were developed over many years, using peer-reviewed methodologies, transparent process, the best science available at the time of that process, and with input from the public. Specifically, in 2009, the 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 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.*[86] and underwent a standard double-blind peer review process prior to journal publication. 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.[87] 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 in the National Academies 2017 report. 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 rulemaking. The E.O. instructs the IWG to undertake a fuller update of the SC–GHG estimates that takes into consideration the advice in the National Academies 2017 report 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

[85] U.S. EPA. (2023). Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ''Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review'': EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. Washington, DC: U.S. EPA. *www.epa.gov/controlling-air-pollution-oil-and-natural-gas-operations/epas-final-rule-oil-and-natural-gas.*

[86] Marten, A.L., E.A. Kopits, C.W. Griffiths, S.C. Newbold, and A. Wolverton. Incremental CH_4 and N_2O mitigation benefits consistent with the US Government's SC–CO_2 estimates. *Climate Policy.* 2015. 15(2): pp. 272–298.

[87] 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. Available at *nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of.*

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 final 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 that accrue only to U.S. citizens and residents does not currently exist in the literature. As explained in the February 2021 SC–GHG 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 previously discussed, 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 a U.S.-specific SC–GHG value, 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 (estimated to be 7 percent under OMB's 2003 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 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,[88] and recommended that discount rate uncertainty and relevant aspects of intergenerational ethical considerations be accounted for in selecting future discount rates.

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's 2003 Circular A–4 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.

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 SC–GHG 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 the above 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 revert to the same set of four values drawn from the SC–GHG distributions based on three discount rates as were used in regulatory analyses between 2010 and 2016 and were 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

[88] Interagency Working Group on Social Cost of Carbon. Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. 2010. United States Government. Available at *www.epa.gov/sites/default/files/2016-12/documents/scc_tsd_2010.pdf* (last accessed April 15, 2022); 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. Available at *www.federalregister.gov/documents/2013/11/26/2013-28242/technical-support-document-technical-update-of-the-social-cost-of-carbon-for-regulatory-impact* (last accessed April 15, 2022); 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. Available at *www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf* (last accessed Jan. 18, 2022); 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. Available at: *www.epa.gov/sites/default/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf* (last accessed January 18, 2022).

from climate change. As explained in the February 2021 SC–GHG TSD, and DOE agrees, this update reflects the immediate need to have an operational SC–GHG for use in regulatory benefit-cost analyses and other applications that was 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.

IPI commented that even though the proposed rule's costs would exceed its benefits without considering climate effects, DOE appropriately applies the social cost estimates developed by the Interagency Working Group on the Social Cost of Greenhouse Gases to its analysis of climate benefits. IPI commented that DOE should consider applying sensitivity analysis using EPA's draft climate-damage estimates released in November 2022, as EPA's work faithfully implements the roadmap laid out in 2017 by the National Academies of Sciences and applies recent advances in the science and economics on the costs of climate change. (IPI, No. 175 at pp. 1–3)

DOE typically does not conduct analyses using draft inputs that are still under review. DOE notes that because the EPA's draft estimates are considerably higher than the IWG's interim SC–GHG values applied for this final rule, an analysis that used the draft values would result in significantly greater climate-related benefits. However, such results would not affect DOE's decision in this final rule.

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.[89] 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 SC–GHG 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 GHGs are presented in section V.B.6 of this document.

a. Social Cost of Carbon

The SC–CO_2 values used for this final rule were based on the values developed for the IWG's February 2021 TSD, which are shown in table IV.20 in five-year increments from 2020 to 2050. The set of annual values that DOE used, which was adapted from estimates published by EPA,[90] is presented in appendix 13A of the final rule TSD. These estimates are based on methods, assumptions, and parameters identical to the estimates published by the IWG (which were based on EPA modeling), and include values for 2051 to 2070. DOE expects additional climate benefits to accrue for products still operating after 2070, but a lack of available SC–CO_2 estimates for emissions years beyond 2070 prevents DOE from monetizing these potential benefits in this analysis.

Table IV.20. Annual SC-CO_2 Values from 2021 Interagency Update, 2020–2050 (2020$ per Metric Ton CO_2)

Year	Discount Rate and Statistic			
	5%	3%	2.5%	3%
	Average	Average	Average	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

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

[90] See EPA, Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis, Washington, DC, December 2021. Available at *nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1013ORN.pdf* (last accessed Feb. 21, 2023).

NYSERDA commented that the assumption used by DOE in the NOPR regarding SC–CO_2 based on current Federal guidance is significantly lower than that established by the New York Department of Environmental Conservation, and DOE may be underestimating the climate benefits from this proposed standard. (NYSERDA, No. 166 at p. 3)

The IWG is preparing new SC–GHG values that reflect the current state of science related to climate change and its impacts. Until such values have been finalized, DOE continues to use the interim values in the February 2021 TSD. DOE agrees that the climate benefits from the proposed standard may be underestimated in the NOPR, but such underestimation has no bearing on DOE's decision in the NOPR or in this 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 2022$ 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 final rule were based on the values developed for the February 2021 SC–GHG TSD. Table IV.21 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 13–A of the final rule 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 IV.21. 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%	3%	2.5%	3%	5%	3%	2.5 %	3%
	Average	Average	Average	95th percentile	Average	Average	Average	95th percentile
2020	670	1500	2000	3900	5800	18000	27000	48000
2025	800	1700	2200	4500	6800	21000	30000	54000
2030	940	2000	2500	5200	7800	23000	33000	60000
2035	1100	2200	2800	6000	9000	25000	36000	67000
2040	1300	2500	3100	6700	10000	28000	39000	74000
2045	1500	2800	3500	7500	12000	30000	42000	81000
2050	1700	3100	3800	8200	13000	33000	45000	88000

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 2022$ 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.

c. Sensitivity Analysis Using EPA's New SC–GHG Estimates

In the regulatory impact analysis of EPA's December 2023 Final Rulemaking, ''Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review,'' EPA estimated climate benefits using a new set of Social Cost of Greenhouse Gas (SC–GHG) estimates. These estimates incorporate recent research addressing recommendations of the National Academies (2017), responses to public comments on an earlier sensitivity analysis using draft SC–GHG estimates, and comments from a 2023 external peer review of the accompanying technical report.[91]

The full set of annual values is presented in appendix 13C of the direct final rule TSD. Although DOE continues

[91] For further information about the methodology used to develop these values, public comments, and information pertaining to the peer review, see *https://www.epa.gov/environmental-economics/scghg*.

to review EPA's estimates, for this rulemaking, DOE used these new SC–GHG values to conduct a sensitivity analysis of the value of GHG emissions reductions associated with alternative standards for GSLs. This sensitivity analysis provides an expanded range of potential climate benefits associated with amended standards. The final year of EPA's new estimates is 2080; therefore, DOE did not monetize the climate benefits of GHG emissions reductions occurring after 2080.

The results of the sensitivity analysis are presented in appendix 13C of the final rule TSD. The overall climate benefits are larger when using EPA's higher SC–GHG estimates, compared to the climate benefits using the more conservative IWG SC–GHG estimates. However, DOE's conclusion that the standards are economically justified remains the same regardless of which SC–GHG estimates are used.

2. Monetization of Other Emissions Impacts

For the final rule, DOE estimated the monetized value of NO_X and SO_2 emissions reductions from electricity generation using benefit per ton estimates for that sector from EPA's Benefits Mapping and Analysis Program.[92] 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 and 2030, 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 combined the EPA regional benefit-per-ton estimates with regional information on electricity consumption and emissions from *AEO2023* to define weighted-average national values for NO_X and SO_2 (see appendix 13B of the final rule 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.

M. Utility Impact Analysis

The utility impact analysis estimates the changes in installed electrical capacity and generation projected to result for each considered TSL. The analysis is based on published output from the NEMS associated with *AEO2023.* 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 *AEO2023* Reference case and various side cases. Details of the methodology are provided in the appendices to chapter 14 of the final rule 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 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.[93] 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 final rule using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 4 (''ImSET'').[94] 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 rule. Therefore, DOE used ImSET only to generate results for near-term timeframes (2029), where these uncertainties are reduced. For more

[92] U.S. Environmental Protection Agency. ''Estimating the Benefit per Ton of Reducing Directly-Emitted $PM_{2.5}$, $PM_{2.5}$ Precursors and Ozone Precursors from 21 Sectors.'' Available at *www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors.*

[93] 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 *www.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf* (last accessed July 1, 2021).

[94] 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's Guide.* 2015. Pacific Northwest National Laboratory: Richland, WA. PNNL–24563.

details on the employment impact analysis, see chapter 15 of the final rule TSD.

V. Analytical Results and Conclusions

The following section addresses the results from DOE's analyses with respect to the considered energy conservation standards for GSLs. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for GSLs, and the standards levels that DOE is adopting in this final rule. Additional details regarding DOE's analyses are contained in the final rule TSD supporting this document.

A. Trial Standard Levels

In general, DOE typically evaluates potential new or 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 price elasticity of consumer purchasing decisions that may change when different standard levels are set.

In the analysis conducted for this final rule, 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 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 final rule TSD.

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

Table V.1 Trial Standard Levels for General Service Lamps

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 final rule to include ELs representative of ELs with similar characteristics (*i.e.,* using similar technologies and/or efficiencies, and having roughly comparable equipment availability) 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.[95]

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 amended 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 final rule TSD provides detailed information on the LCC and PBP analyses.

Table V.2 through table V.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, the 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 IV.F.9 of this document). Because some consumers purchase products with higher efficiency than the minimum allowed under a standard in the no-new-standards case, the average savings can differ from 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. Those who already purchase a product with efficiency at or above a given TSL are not affected. Consumers for whom the

[95] Efficiency levels that were analyzed for this final rule are discussed in section 0 of this document. Results by efficiency level are presented in TSD chapter 8.

LCC increases at a given TSL experience a net cost.

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Table V.2 Average LCC and PBP Results for Integrated Omnidirectional Short GSLs

Lamp Option	EL	Average Costs 2022$					Simple Payback years	Average Lifetime years
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost*	Residual Value	LCC		
Residential								
0	0	3.57	3.99	7.11	0.00	10.69	--	6.9
1	1	3.73	3.72	6.64	0.00	10.37	0.6	6.9
2	2	3.89	3.45	6.16	0.00	10.05	0.6	6.9
3	3	3.14	2.66	4.74	1.41	6.47	0.0	11.8
4	3	4.28	2.66	4.74	2.24	6.78	0.5	13.4
5	4	3.86	2.39	4.27	1.73	6.39	0.2	11.8
6	4	5.24	2.39	4.27	2.74	6.76	1.0	13.4
7	5	4.56	2.13	3.79	2.05	6.31	0.5	11.8
8	6	5.26	1.86	3.32	2.36	6.22	0.8	11.8
9	7	5.62	1.73	3.08	2.52	6.18	0.9	11.8
Commercial								
0	0	5.31	6.10	12.23	0.00	17.74	--	2.7
1	1	5.46	5.69	11.42	0.00	17.08	0.4	2.7
2	2	5.62	5.29	10.60	0.00	16.42	0.4	2.7
3	3	4.87	4.07	8.16	0.94	12.09	0.0	4.1
4	3	6.01	4.07	8.16	2.29	11.88	0.3	6.6
5	4	5.59	3.66	7.34	1.16	11.77	0.1	4.1
6	4	6.97	3.66	7.34	2.80	11.51	0.7	6.6
7	5	6.29	3.25	6.52	1.37	11.44	0.3	4.1
8	6	6.99	2.85	5.71	1.58	11.12	0.5	4.1
9	7	7.35	2.64	5.30	1.69	10.96	0.6	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 V.3 Average LCC Savings Relative to the No-New-Standards Case for Integrated Omnidirectional Short GSLs

TSL	EL	Average LCC Savings* 2022$	Percent of Consumers that Experience Net Cost
Residential Sector			
1	2	1.75	0.8%
2	3	2.48	1.2%
3	5	0.49	21.6%
4	6	0.53	23.2%
5 - 6	7	0.55	24.0%
Commercial Sector			
1	2	2.27	0.4%
2	3	2.87	0.6%
3	5	0.71	12.0%
4	6	0.86	11.1%
5 - 6	7	0.94	10.8%

* The savings represent the average LCC for affected consumers.

Table V.4 Average LCC and PBP Results for Integrated Omnidirectional Long GSLs

Lamp Option	EL	Average Costs 2022$					Simple Payback years	Average Lifetime years
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost*	Residual Value	LCC		
Residential								
0	0	8.70	2.37	22.82	0.00	31.52	--	17.5
1	1	9.71	2.21	21.30	0.00	31.01	6.4	17.5
2	2	11.06	1.98	19.02	0.00	30.08	6.0	17.5
3	3	10.96	1.90	18.26	0.00	29.22	4.8	17.5
4	4	11.91	1.82	17.50	0.00	29.40	5.8	17.5
5	5	12.55	1.66	15.97	0.00	28.52	5.4	17.5
6	6	14.07	1.46	14.00	0.00	28.06	5.8	17.5
Commercial								
0	0	10.43	4.27	33.07	0.00	43.50	--	13.7
1	1	11.44	3.99	30.86	0.00	42.31	3.6	13.7
2	2	12.80	3.56	27.56	0.00	40.35	3.3	13.7
3	3	12.69	3.42	26.45	0.00	39.15	2.6	13.7
4	4	13.64	3.27	25.35	0.00	38.99	3.2	13.7
5	5	14.28	2.99	23.15	0.00	37.43	3.0	13.7
6	6	15.80	2.62	20.28	0.00	36.08	3.3	13.7

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 V.5 Average LCC Savings Relative to the No-New-Standards Case for Integrated Omnidirectional Long GSLs

TSL	EL	Average LCC Savings* 2022$	Percent of Consumers that Experience Net Cost
Residential Sector			
1	1	0.61	21.7%
2	3	1.07	39.4%
3 - 5	5	1.61	42.7%
6	6	1.88	44.2%
Commercial Sector			
1	1	1.27	3.8%
2	3	2.11	5.2%
3 - 5	5	3.36	2.6%
6	6	4.16	2.9%

* The savings represent the average LCC for affected consumers.

Table V.6 Average LCC and PBP Results for Integrated Directional GSLs

Lamp Option	EL	Average Costs 2022$					Simple Payback years	Average Lifetime years
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost*	Residual Value	LCC		
Residential								
0	0	18.93	6.38	12.06	0.00	30.98	--	7.2
1	1	12.43	4.72	8.91	6.28	15.06	0.0	13.5
2	2	11.51	4.44	8.39	5.82	14.08	0.0	13.5
3	3	10.62	4.16	7.86	5.37	13.11	0.0	13.5
4	4	9.60	3.89	7.34	4.85	12.09	0.0	13.5
5	5	7.85	3.47	6.55	3.97	10.43	0.0	13.5
Commercial								
0	0	20.66	9.27	18.92	0.00	39.79	--	2.8
1	1	14.16	6.85	13.98	6.63	21.52	0.0	6.7
2	2	13.24	6.45	13.16	6.14	20.27	0.0	6.7
3	3	12.35	6.04	12.34	5.66	19.03	0.0	6.7
4	4	11.33	5.64	11.51	5.12	17.73	0.0	6.7
5	5	9.58	5.04	10.28	4.19	15.68	0.0	6.7

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 V.7 Average LCC Savings Relative to the No-New-Standards Case for Integrated Directional GSLs

TSL	EL	Average LCC Savings* 2022$	Percent of Consumers that Experience Net Cost
Residential Sector			
1	1	9.88	0.0%
2	3	1.66	0.0%
3 - 6	5	3.17	0.0%
Commercial Sector			
1	1	9.75	0.0%
2	3	2.02	0.0%
3 - 6	5	3.89	0.0%

* The savings represent the average LCC for affected consumers.

Table V.8 Average LCC and PBP Results for Non-integrated Omnidirectional GSLs

Lamp Option	EL	Average Costs 2022$					Simple Payback years	Average Lifetime years
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost*	Residual Value	LCC		
Commercial								
0	0	7.67	10.33	21.44	0.00	29.32	--	2.9
1	1	10.73	10.33	21.44	0.00	32.38	Never	2.9
2	1	22.70	8.35	17.32	7.20	33.01	7.6	4.6
3	2	22.94	4.77	9.90	14.50	18.33	2.7	11.8
4	3	23.89	3.58	7.42	15.15	16.15	2.4	11.8

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

Table V.9 Average LCC Savings Relative to the No-New-Standards Case for Non-integrated Omnidirectional GSLs

TSL	EL	Average LCC Savings* 2022$	Percent of Consumers that Experience Net Cost
Residential Sector			
1	1	4.80	10.4%
2 - 6	3	6.67	0.1%

* The savings represent the average LCC for affected consumers.

Table V.10 Average LCC and PBP Results for Non-integrated Directional GSLs

Lamp Option	EL	Average Costs 2022$					Simple Payback years	Average Lifetime years
		Installed Cost	First Year's Operating Cost	Lifetime Operating Cost*	Residual Value	LCC		
Residential								
0	0	9.35	2.24	13.01	0.00	22.36	--	13.5
1	1	10.31	1.96	11.38	0.00	21.70	3.4	13.5
2	2	11.15	1.82	10.57	0.00	21.72	4.3	13.5
3	3	11.95	1.68	9.76	0.00	21.71	4.6	13.5
Commercial								
0	0	11.09	3.25	14.47	0.00	25.56	--	6.7
1	1	12.04	2.85	12.66	0.00	24.71	2.4	6.7
2	2	12.89	2.64	11.76	0.00	24.65	3.0	6.7
3	3	13.69	2.44	10.86	0.00	24.54	3.2	6.7

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 V.11 Average LCC Savings Relative to the No-New-Standards Case for Non-integrated Directional GSLs

TSL	EL	Average LCC Savings* 2022$	Percent of Consumers that Experience Net Cost
Residential Sector			
1 - 4	1	0.36	23.6%
5 - 6	3	0.27	37.0%
Commercial Sector			
1 - 4	1	0.45	13.8%
5 - 6	3	0.45	26.4%

* 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 V.12 and table V.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 at the considered efficiency levels are not substantially different from the average for all consumers. Chapter 10 of the final rule TSD presents the complete LCC and PBP results for the subgroups.

Table V.12 Comparison of LCC Savings for Consumer Subgroups and All Consumers

TSL	Average LCC Savings* 2022$			
	Residential		Commercial	
	Low-Income Households	All Households	Small Businesses	All Businesses
Integrated Omnidirectional Short				
1	1.85	1.75	2.18	2.27
2	2.52	2.48	2.76	2.87
3	0.51	0.49	0.65	0.71
4	0.55	0.53	0.79	0.86
5 - 6	0.57	0.55	0.86	0.94
Integrated Omnidirectional Long				
1	N/A**	0.61	1.02	1.27
2		1.07	1.70	2.11
3 - 5		1.61	2.68	3.36
6		1.88	3.27	4.16
Integrated Directional				
1	6.78	9.88	9.57	9.75
2	1.56	1.66	2.01	2.02
3 - 6	3.02	3.17	3.86	3.89
Non-integrated Omnidirectional				
1	N/A		4.33	4.80
2 - 6			6.21	6.67
Non-integrated Directional				
1 - 4	0.31	0.36	0.35	0.45
5 - 6	0.21	0.27	0.29	0.45

* 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 product class ("PC") only for the commercial sector.

Table V.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	0.6	0.6	0.4	0.4
2	0.6	0.6	0.4	0.4
3	0.0	0.0	0.0	0.0
4	0.5	0.5	0.4	0.3
5	0.2	0.2	0.1	0.1
6	1.0	1.0	0.7	0.7
7	0.5	0.5	0.4	0.3
8	0.8	0.8	0.5	0.5
9	0.9	0.9	0.6	0.6
Integrated Omnidirectional Long				
1	N/A**	6.4	3.6	3.6
2		6.0	3.4	3.3
3		4.8	2.7	2.6
4		5.8	3.3	3.2
5		5.4	3.0	3.0
6		5.8	3.3	3.3
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			7.7	7.6
3			2.8	2.7
4			2.4	2.4
Non-integrated Directional				
1	3.5	3.4	2.4	2.4
2	4.4	4.3	3.0	3.0
3	4.8	4.6	3.2	3.2

* 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 IV.F.11 of this document, 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 procedures for GSLs. In contrast, the PBPs presented in section V.B.1.a of this document were calculated using distributions that reflect the range of energy use in the field.

Table V.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 this rule 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 V.14 Rebuttable-Presumption Payback Periods

	Rebuttable PBP* years				
Lamp Option	**Integrated Omnidirectional Short**	**Integrated Omnidirectional Long**	**Integrated Directional**	**Non-Integrated Omnidirectional**	**Non-Integrated Directional**
Residential					
1	0.6	6.4	0.0		3.3
2	0.6	6.0	0.0		4.2
3	0.0	4.8	0.0		4.5
4	0.5	5.8	0.0		
5	0.2	5.4	0.0		
6	1.0	5.8			
7	0.5				
8	0.8				
9	0.9				
Commercial					
1	0.3	3.2	0.0	Never	2.1
2	0.3	3.0	0.0	6.8	2.6
3	0.0	2.4	0.0	2.5	2.9
4	0.3	2.9	0.0	2.2	
5	0.1	2.7	0.0		
6	0.6	2.9			
7	0.3				
8	0.5				
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 next section describes the expected impacts on manufacturers at each considered TSL. Chapter 11 of the final rule 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 a standard. The following tables summarize the estimated financial impacts (represented by changes in INPV) of potential 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 using different assumptions that correspond to the range of anticipated market responses to new and amended energy conservation standards: (1) the preservation of gross margin scenario and (2) the preservation of operating profit scenario, as previously described in section IV.J.2.d of this document.

Each of the modeled scenarios results in a unique set of cash flows and corresponding industry values at each TSL for GSL manufacturers. In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case (*i.e.,* TSLs) resulting from the sum of discounted cash flows from 2024 through 2058. To provide perspective on the short-run cash flow impact, DOE includes in the discussion of results a comparison of free cash flow between the no-new-standards case and the standards case at each TSL in the year before new and amended standards are required.

DOE presents the range in INPV for GSL manufacturers in table V.15 and table V.16. DOE presents the impacts to industry cash flows and the conversion costs in table V.17.

Table V.15 Industry Net Present Value for General Service Lamps - Preservation of Gross Margin Scenario

	Units	No-New-Standards Case	Trial Standard Level*					
			1	2	3	4	5	6
INPV	*2022$ millions*	2,108	2,053	1,941	1,946	1,955	1,951	1,950
Change in INPV	*2022$ millions*	-	(54)	(166)	(159)	(149)	(154)	(155)
	%	-	(2.6)	(7.9)	(7.5)	(7.1)	(7.3)	(7.3)

* Numbers in parentheses indicate a negative number. Some numbers may not sum exactly due to rounding.

Table V.16 Industry Net Present Value for General Service Lamps - Preservation of Operating Profit Scenario

	Units	No-New-Standards Case	Trial Standard Level*					
			1	2	3	4	5	6
INPV	*2022$ millions*	2,108	2,047	1,947	1,904	1,886	1,789	1,783
Change in INPV	*2022$ millions*	-	(60)	(159)	(200)	(219)	(316)	(322)
	%	-	(2.8)	(7.6)	(9.5)	(10.4)	(15.0)	(15.3)

* Numbers in parentheses indicate a negative number. Some numbers may not sum exactly due to rounding.

Table V.17 Cash Flow Analysis for General Service Lamp Manufacturers

	Units	No-New-Standards Case	Trial Standard Level*					
			1	2	3	4	5	6
Free Cash Flow (2028)	*2022$ millions*	119	88	37	(16)	(33)	(47)	(49)
Change in Free Cash Flow (2028)	*2022$ millions*	-	(31)	(83)	(135)	(152)	(166)	(168)
	%	-	(26)	(69)	(113)	(127)	(140)	(141)
Product Conversion Costs	*2022$ millions*	-	87	233	356	394	426	430

* Numbers in parentheses indicate a negative number. Some numbers may not sum exactly due to rounding.

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At TSL 6, DOE estimates the change in INPV will range from −$322 million to −$155 million, which represents a change in INPV of −15.3 percent to −7.3 percent, respectively. At TSL 6, industry free cash flow decreases to −$49 million, which represents a decrease of approximately 141 percent, compared to the no-new-standards case value of $119 million in 2028, the year before the first full year of compliance.

TSL 6 sets the efficacy level at EL 7 for the Integrated Omnidirectional Short product class, which is max-tech; at EL 6 for the Integrated Omnidirectional Long product class, which is max-tech; at EL 5 for the Integrated Directional product class, which is max-tech; and at EL 3 for the Non-Integrated Omnidirectional Short and Non-Integrated Directional product classes, which is max-tech for those product classes. 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; approximately 35 percent of the Integrated Directional product class shipments; approximately 54 percent of the Non-Integrated Omnidirectional Short product class shipments; and approximately 26 percent of the Non-Integrated Directional product class shipments will meet the ELs required at TSL 6 in 2029, the 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 first full year of compliance of new and amended standards. DOE estimates approximately $430 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, the shipment weighted-average MPC increases moderately by approximately 12.9 percent relative to the no-new-standards case MPC. In the preservation of gross margin scenario, this increase in MPC causes an increase in manufacturer free cash flow. However, the $430 million in conversion costs estimated at TSL 6, ultimately results in a moderately negative change in INPV 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 $430 million in conversion costs result in a moderately negative change in INPV at TSL 6 under the preservation of operating profit scenario.

At TSL 5, DOE estimates the change in INPV will range from −$316 million to −$154 million, which represents a change in INPV of −15.0 percent to −7.3 percent, respectively. At TSL 5, industry free cash flow decreases to −$47 million, which represents a decrease of approximately 140 percent, compared to the no-new-standards case value of $119 million in 2028, the year before the first full year of compliance.

TSL 5 sets the efficacy level at EL 7 for the Integrated Omnidirectional Short product class, which is max-tech; at EL 5 for the Integrated Omnidirectional Long product class; at EL 5 for the Integrated Directional product class, which is max-tech; and at EL 3 for the Non-Integrated Omnidirectional Short and Non-Integrated Directional product classes, which is max-tech for those product classes. DOE estimates that approximately 17 percent of the Integrated Omnidirectional Short product class shipments; approximately 28 percent of the Integrated Omnidirectional Long product class shipments; approximately 35 percent of the Integrated Directional product class shipments; approximately 54 percent of the Non-Integrated Omnidirectional Short product class shipments; and approximately 26 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 5 in 2029, the 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 first full year of compliance of new and amended standards. DOE estimates approximately $426 million in product conversion costs as most 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, the shipment weighted-average MPC increases moderately by approximately 12.8 percent relative to the no-new-standards case MPC. In the preservation of gross margin scenario, this increase in MPC causes an increase in manufacturer free cash flow. However, the $429 million in conversion costs estimated at TSL 5, ultimately results in a moderately negative change in INPV 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 $429 million in conversion costs result in a moderately negative change in INPV at TSL 5 under the preservation of operating profit scenario.

At TSL 4, DOE estimates the change in INPV will range from −$219 million to −$149 million, which represents a change in INPV of −10.4 percent to −7.1 percent, respectively. At TSL 4, industry free cash flow decreases to −$33 million, which represents a decrease of approximately 127 percent, compared to the no-new-standards case value of $119 million in 2028, the year before the first full year of compliance.

TSL 4 sets the efficacy level at EL 6 for the Integrated Omnidirectional Short product class; at EL 5 for the Integrated Omnidirectional Long product class; at EL 5 for the Integrated Directional product class, which is max-tech; at EL 3 for the Non-Integrated Omnidirectional Short product class, which is max-tech; and at EL 1 for the Non-Integrated Directional product class. DOE estimates that approximately 31 percent of the Integrated Omnidirectional Short product class shipments; approximately 28 percent of the Integrated Omnidirectional Long product class shipments; approximately 35 percent of the Integrated Directional product class shipments; approximately 54 percent of the Non-Integrated Omnidirectional Short product class shipments; and approximately 74 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 4 in 2029, the 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 first full year of compliance of new and amended standards. DOE estimates approximately $394 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, the shipment weighted-average MPC increases moderately by approximately 10.4 percent relative to the no-new-standards case MPC. In the preservation of gross margin scenario, this increase in MPC causes an increase in manufacturer free cash flow. However, the $394 million in conversion costs estimated at TSL 4, ultimately results in a moderately negative change in INPV 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 $394 million in conversion costs result in a moderately negative change in INPV at TSL 4 under the preservation of operating profit scenario.

At TSL 3, DOE estimates the change in INPV will range from −$200 million to −$159 million, which represents a change in INPV of −9.5 percent to −7.5 percent, respectively. At TSL 3, industry free cash flow decreases to −$16 million, which represents a decrease of approximately 113 percent, compared to the no-new-standards case value of $119 million in 2028, the year before the first full year of compliance.

TSL 3 sets the efficacy level at EL 5 for the Integrated Omnidirectional Short product class; at EL 5 for the Integrated Omnidirectional Long product class; at EL 5 for the Integrated Directional product class, which is max-tech; at EL 3 for the Non-Integrated Omnidirectional Short product class, which is max-tech; and at EL 1 for the Non-Integrated Directional product class. DOE estimates that approximately 45 percent of the Integrated Omnidirectional Short product class shipments; approximately 28 percent of the Integrated Omnidirectional Long product class shipments; approximately 35 percent of the Integrated Directional product class shipments; approximately 54 percent of the Non-Integrated Omnidirectional Short product class shipments; and approximately 74 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 3 in 2029, the 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 manufacturers are expected to produce more LED lamps for every product class in the years leading up to 2029 than in 2029, the first full year of compliance of new and amended standards. DOE estimates approximately $356 million in product conversion costs as many LED lamps may need to be re-modeled to meet ELs required at TSL 3. 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 3, the shipment weighted-average MPC increases by approximately 6.7 percent relative to the no-new-standards case MPC. In the preservation of gross margin scenario, this increase in MPC causes an increase in manufacturer free cash flow. However, the $356 million in conversion costs estimated at TSL 3, ultimately results in a moderately negative change in INPV at TSL 3 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, the increase in the shipment weighted-average MPC results in a slightly lower average manufacturer markup. This slightly lower average manufacturer markup and the $356 million in conversion costs result in a moderately negative change in INPV at TSL 3 under the preservation of operating profit scenario.

At TSL 2, DOE estimates the change in INPV will range from −$166 million to −$159 million, which represents a change in INPV of −7.9 percent to −7.6 percent, respectively. At TSL 2, industry free cash flow decreases to $37 million, which represents a decrease of approximately 69 percent, compared to the no-new-standards case value of $119 million in 2028, the year before the first full year of compliance.

TSL 2 sets the efficacy level at EL 3 for the Integrated Omnidirectional Short product class; at EL 3 for the Integrated Omnidirectional Long product class; at EL 3 for the Integrated Directional product class; at EL 3 for the Non-Integrated Omnidirectional Short product class, which is max-tech; and at EL 1 for the Non-Integrated Directional product class. DOE estimates that approximately 98 percent of the Integrated Omnidirectional Short product class shipments; approximately 57 percent of the Integrated Omnidirectional Long product class shipments; approximately 73 percent of the Integrated Directional product class shipments; approximately 54 percent of the Non-Integrated Omnidirectional Short product class shipments; and approximately 74 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 2 in 2029, the 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 the years leading up to 2029 than in 2029, the first full year of compliance of new and amended standards. DOE estimates approximately $233 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, the shipment weighted-average MPC slightly increases by approximately 0.2 percent relative to the no-new-standards case MPC. In the preservation of gross margin scenario, this slight increase in MPC causes a marginal increase in manufacturer free cash flow. However, the $233 million in conversion costs estimated at TSL 2, ultimately results in a moderately negative change in INPV 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. This slightly lower average manufacturer markup and the $233 million in conversion costs result in a moderately negative change in INPV at TSL 2 under the preservation of operating profit scenario.

At TSL 1, DOE estimates the change in INPV will range from −$60 million to −$54 million, which represents a change in INPV of −2.8 percent to −2.6 percent, respectively. At TSL 1, industry free cash flow decreases to $88 million, which represents a decrease of approximately 26 percent, compared to the no-new-standards case value of $119 million in 2028, the year before the first full year of compliance.

TSL 1 sets the efficacy level at EL 2 for the Integrated Omnidirectional Short product class; at EL 1 for the Integrated Omnidirectional Long product class; at EL 1 for the Integrated Directional product class; at EL 1 for the Non-Integrated Omnidirectional Short product class; and at EL 1 for the Non-Integrated Directional product class. DOE estimates that approximately 99 percent of the Integrated Omnidirectional Short product class shipments; approximately 86 percent of the Integrated Omnidirectional Long product class shipments; approximately 99 percent of the Integrated Directional product class shipments; approximately 97 percent of the Non-Integrated Omnidirectional Short product class shipments; and approximately 74 percent of the Non-Integrated Directional product class shipments will meet or exceed the ELs required at TSL 1 in 2029, the 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 the years leading up to 2029 than in 2029, the first full year of compliance of new and amended standards. DOE estimates approximately $87 million in product conversion costs. Most, but not all, LED lamps would meet the ELs required at TSL 1, and therefore would not need to be re-modeled.

At TSL 1, the shipment weighted-average MPC slightly increases by approximately 0.9 percent relative to the no-new-standards case MPC. In the preservation of gross margin scenario, this slight increase in MPC causes a marginal increase in manufacturer free cash flow. However, the $87 million in conversion costs estimated at TSL 1, ultimately results in a slightly negative change in INPV at TSL 1 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. This slightly lower average manufacturer markup and the $87 million in conversion costs result in a slightly negative change in INPV at TSL 1 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 January 2023 NOPR, 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 first full year of compliance for GSL standards. 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. DOE predicts that CFLs would not be able to meet energy conservation standards set at TSL 2 or higher.

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. EEI recalled that domestic light bulb factories shut down due to Federal action around 2010–2011, and that with other products, manufacturers have moved production overseas to lower costs. EEI inquired whether the employment analysis accounted for the percentage of GSLs manufactured in the United States versus overseas. (EEI, Public Meeting Transcript, No. 27 at p. 119–121)

Additionally, DOE received comments from private citizens [96] that stated heavy regulation of lamps has forced many American-based factories to shut down, removing a number of jobs for American manufacturers. Commenters stated that DOE should be trying to keep these manufacturers in the United States instead of relying on subpar products from overseas.

DOE estimated that over 90 percent of GSLs sold in the United States are manufactured abroad. The previous lamp factory shutdowns referenced by the interested parties were specifically caused by changes in lighting technologies being manufactured. All GSL manufacturing that occurs domestically that is covered by this rulemaking uses LED technology. DOE assumes that all GSL manufacturers manufacturing LED lamps in the U.S. would continue to manufacture LED lamps in the U.S. after compliance with standards and therefore would not reduce or eliminate any domestic production or non-production employees involved in manufacturing or selling of LED lamps.

DOE did not estimate a 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. Therefore, DOE estimates that GSL manufacturers could reduce or eliminate up to 30 domestic non-production employees (that are associated with the non-production of CFLs) for all TSLs higher than TSL 2 (*i.e.,* at TSLs 3–6).

c. Impacts on Manufacturing Capacity

Based on the final rule shipments analysis, the quantity of LED lamps sold for all product classes reaches approximately 566 million in 2024 and then declines to approximately 400 million by 2029, the first full year of compliance for GSL standards, in the no-new-standards case. This represents a decrease of approximately 30 percent from 2024 to 2029. Based on the final rule 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

[96] Comments submitted in response to the January 2023 NOPR, including comments from private citizens can be found in the docket of DOE's rulemaking to develop energy conservation standards for GSLs at *www.regulations.gov/docket/EERE-2022-BT-STD-0022/comments.*

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 VI.B and in chapter 11 of the final rule TSD.

e. Cumulative Regulatory Burden

One aspect of assessing manufacturer burden involves looking at the cumulative impact of multiple DOE standards and the regulatory actions of other Federal agencies and States 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. Multiple regulations affecting the same manufacturer can strain profits and lead companies to abandon product lines or markets with lower expected future returns than competing products. For these reasons, DOE conducts an analysis of cumulative regulatory burden as part of its rulemakings pertaining to appliance efficiency.

DOE evaluates product-specific regulations that will take effect approximately 3 years before or after the first full year of compliance (*i.e.,* 2029) of the new and amended energy conservation standards for GSLs. This information is presented in table V.18.

Table V.18 Compliance Dates and Expected Conversion Expenses of Federal Energy Conservation Standards Affecting General Service Lamp Manufacturers

Federal Energy Conservation Standard	Number of Mfrs.*	Number of Manufacturers Affected from this Rule**	Approx. Standards Year	Industry Conversion Costs (millions)	Industry Conversion Costs / Product Revenue***
Ceiling Fans 88 FR 40932 (Jun. 22, 2023)†	91	2	2028	107.2 (2022$)	1.9%

* This column presents the total number of manufacturers identified in the energy conservation standard rule contributing to cumulative regulatory burden.

** This column presents the number of manufacturers producing GSLs that are also listed as manufacturers in the listed energy conservation standard contributing to cumulative regulatory burden.

*** This column presents industry conversion costs as a percentage of product revenue during the conversion period. Industry conversion costs are the upfront investments manufacturers must make to sell compliant products/equipment. The revenue used for this calculation is the revenue from just the covered product/equipment associated with each row. The conversion period is the time frame over which conversion costs are made and lasts from the publication year of the final rule to the compliance year of the energy conservation standard. The conversion period typically ranges from 3 to 5 years, depending on the rulemaking.

† Indicates a NOPR publication. Values may change on publication of a final rule.

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 V.19 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 IV.H of this document.

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Table V.19 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	0.098	0.140	2.405	2.944	3.206	3.206
	Integrated Omnidirectional Long	0.051	0.113	0.184	0.184	0.184	0.201
	Integrated Directional	0.004	0.235	0.493	0.493	0.493	0.493
	Non-integrated Omnidirectional	0.000	0.002	0.002	0.002	0.002	0.002
	Non-integrated Directional	0.010	0.010	0.010	0.010	0.020	0.020
	Total	0.162	0.500	3.092	3.632	3.905	3.921
FFC Energy Savings	Integrated Omnidirectional Short	0.100	0.144	2.470	3.024	3.293	3.293
	Integrated Omnidirectional Long	0.052	0.116	0.189	0.189	0.189	0.206
	Integrated Directional	0.004	0.241	0.506	0.506	0.506	0.506
	Non-integrated Omnidirectional	0.000	0.002	0.002	0.002	0.002	0.002
	Non-integrated Directional	0.010	0.010	0.010	0.010	0.021	0.021
	Total	0.167	0.513	3.176	3.730	4.010	4.027

OMB Circular A–4 [97] 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.[98] 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

[97] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. *obamawhitehouse.archives.gov/omb/circulars_a004_a-4* (last accessed Aug. 21, 2023).

[98] 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. (42 U.S.C. 6295(m)). 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.

analytical methodology. The NES sensitivity analysis results based on a 9-year analytical period are presented in table V.20. The impacts are counted over the lifetime of GSLs purchased during the period 2029–2037.

Table V.20 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	0.768	0.948	1.044	1.044
	Integrated Omnidirectional Long	0.025	0.055	0.085	0.085	0.085	0.083
	Integrated Directional	0.001	0.063	0.141	0.141	0.141	0.141
	Non-integrated Omnidirectional	0.000	0.002	0.002	0.002	0.002	0.002
	Non-integrated Directional	0.004	0.004	0.004	0.004	0.008	0.008
	Total	0.059	0.165	1.000	1.180	1.280	1.278
FFC Energy Savings	Integrated Omnidirectional Short	0.029	0.042	0.789	0.974	1.073	1.073
	Integrated Omnidirectional Long	0.026	0.057	0.087	0.087	0.087	0.085
	Integrated Directional	0.001	0.065	0.145	0.145	0.145	0.145
	Non-integrated Omnidirectional	0.000	0.002	0.002	0.002	0.002	0.002
	Non-integrated Directional	0.004	0.004	0.004	0.004	0.008	0.008
	Total	0.060	0.170	1.027	1.212	1.315	1.313

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,[99] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V.21 shows the consumer NPV results with impacts counted over the lifetime of products purchased during the period 2029–2058.

[99] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. *obamawhitehouse.archives.gov/omb/circulars_a004_a-4* (last accessed March 25, 2022).

Table V.21 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 2022$					
3 percent	Integrated Omnidirectional Short	0.80	1.17	12.74	15.31	16.59	16.59
	Integrated Omnidirectional Long	0.19	0.38	0.53	0.53	0.53	0.39
	Integrated Directional	0.06	2.37	5.09	5.09	5.09	5.09
	Non-integrated Omnidirectional	0.00	0.01	0.01	0.01	0.01	0.01
	Non-integrated Directional	0.04	0.04	0.04	0.04	0.07	0.07
	Total	1.09	3.96	18.41	20.99	22.29	22.16
7 percent	Integrated Omnidirectional Short	0.35	0.51	4.71	5.61	6.07	6.07
	Integrated Omnidirectional Long	0.08	0.15	0.18	0.18	0.18	0.06
	Integrated Directional	0.03	1.04	2.28	2.28	2.28	2.28
	Non-integrated Omnidirectional	0.00	0.01	0.01	0.01	0.01	0.01
	Non-integrated Directional	0.01	0.01	0.01	0.01	0.02	0.02
	Total	0.47	1.73	7.20	8.10	8.57	8.45

The NPV results based on the aforementioned 9-year analytical period are presented in table V.22. The impacts are counted over the lifetime of products purchased during the period 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 V.22 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 2022$					
3 percent	Integrated Omnidirectional Short	0.28	0.40	5.36	6.44	7.02	7.02
	Integrated Omnidirectional Long	0.11	0.20	0.26	0.26	0.26	0.13
	Integrated Directional	0.02	0.84	1.91	1.91	1.91	1.91
	Non-integrated Omnidirectional	0.00	0.01	0.01	0.01	0.01	0.01
	Non-integrated Directional	0.02	0.02	0.02	0.02	0.03	0.03
	Total	0.42	1.48	7.55	8.63	9.22	9.10
7 percent	Integrated Omnidirectional Short	0.16	0.23	2.64	3.13	3.39	3.39
	Integrated Omnidirectional Long	0.05	0.10	0.10	0.10	0.10	-0.01
	Integrated Directional	0.01	0.50	1.13	1.13	1.13	1.13
	Non-integrated Omnidirectional	0.00	0.01	0.01	0.01	0.01	0.01
	Non-integrated Directional	0.01	0.01	0.01	0.01	0.01	0.01
	Total	0.23	0.84	3.88	4.37	4.64	4.54

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The previous results reflect the use of a default trend to estimate the change in price for GSLs over the analysis period (*see* sections IV.G and IV.H of this document). As part of the NIA, DOE also analyzed high and low benefits scenarios that use inputs from variants of the *AEO2023* Reference case. For the high benefits scenario, DOE uses the *AEO2023* 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 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 *AEO2023* 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 9D of the final rule TSD.

c. Indirect Impacts on Employment

DOE estimates that amended energy conservation standards for GSLs will 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 IV.N of this document, DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered. 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 adopted standards are likely to have a negligible impact on the net demand for labor in the economy. The net change in jobs is so small that it would be imperceptible in national labor statistics and might be offset by other, unanticipated effects on employment. Chapter 15 of the final rule 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 concluded that the standards adopted in this final rule will not lessen the utility or performance of the GSLs under consideration in this rulemaking. Manufacturers of these products currently offer units that meet or exceed the adopted 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.F.1.e of this document, EPCA directs the Attorney General of the United States (''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 in writing 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. To assist the Attorney General in making this determination, DOE provided the Department of Justice (''DOJ'') with copies of the NOPR and the TSD for review. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for GSLs are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General's assessment at the end of this final rule.

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 final rule 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 additionally expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table V.23 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 IV.K of this document. DOE reports annual emissions reductions for each TSL in chapter 12 of the final rule TSD.

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Table V.23 Cumulative Emissions Reduction for GSLs Shipped During the Period 2029-2058

	Trial Standard Level					
	1	2	3	4	5	6
Power Sector Emissions						
CO_2 (million metric tons)	2.71	8.21	50.18	58.99	63.48	63.68
SO_2 (thousand tons)	0.90	2.76	17.08	20.11	21.65	21.70
NO_X (thousand tons)	1.30	3.88	23.44	27.60	29.74	29.82
Hg (tons)	0.01	0.02	0.12	0.14	0.15	0.15
CH_4 (thousand tons)	0.20	0.61	3.77	4.44	4.78	4.79
N_2O (thousand tons)	0.03	0.09	0.52	0.62	0.66	0.67
Upstream Emissions						
CO_2 (million metric tons)	0.28	0.85	5.23	6.14	6.61	6.63
SO_2 (thousand tons)	0.02	0.05	0.31	0.36	0.39	0.39
NO_X (thousand tons)	4.31	13.23	81.57	95.81	103.03	103.43
Hg (tons)	0.00	0.00	0.00	0.00	0.00	0.00
CH_4 (thousand tons)	25.15	77.15	475.78	558.83	600.92	603.26
N_2O (thousand tons)	0.00	0.00	0.02	0.03	0.03	0.03
Total FFC Emissions						
CO_2 (million metric tons)	2.98	9.06	55.41	65.14	70.09	70.31
SO_2 (thousand tons)	0.92	2.81	17.39	20.47	22.05	22.09
NO_X (thousand tons)	5.61	17.11	105.01	123.42	132.77	133.25
Hg (tons)	0.01	0.02	0.12	0.14	0.15	0.15
CH_4 (thousand tons)	25.35	77.76	479.55	563.27	605.70	608.05
N_2O (thousand tons)	0.03	0.09	0.55	0.64	0.69	0.70

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As part of the analysis for this rule, 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 IV.L.1.a of this document discusses the estimated SC–CO_2 values that DOE used. Table V.24 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 selected TSL in chapter 14 of the final rule TSD.

Table V.24 Present Value of CO_2 Emissions Reduction for GSLs Shipped During the Period 2029-2058

TSL	SC-CO_2 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	Billion 2022$			
1	0.03	0.13	0.21	0.41
2	0.09	0.39	0.61	1.19
3	0.54	2.32	3.63	7.04
4	0.64	2.74	4.28	8.30
5	0.69	2.95	4.61	8.95
6	0.69	2.96	4.62	8.97

As discussed in section IV.L.1.b of this document, DOE estimated the climate 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 V.25 presents the value of the CH_4 emissions reduction at each TSL, and table V.26 presents the value of the N_2O emissions reduction at each TSL. The time-series of annual values is presented for the selected TSL in chapter 13 of the final rule TSD.

Table V.25 Present Value of Methane Emissions Reduction for GSLs Shipped During the Period 2029-2058

TSL	SC-CH_4 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	Billion 2022$			
1	0.01	0.04	0.05	0.10
2	0.04	0.11	0.15	0.29
3	0.22	0.65	0.91	1.72
4	0.25	0.76	1.07	2.02
5	0.27	0.82	1.15	2.18
6	0.27	0.83	1.15	2.18

Table V.26 Present Value of Nitrous Oxide Emissions Reduction for GSLs Shipped During the Period 2029-2058

TSL	SC-N_2O Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	Billion 2022$			
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.01	0.01	0.02
4	0.00	0.01	0.02	0.03
5	0.00	0.01	0.02	0.03
6	0.00	0.01	0.02	0.03

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 global and U.S. economy continues to evolve rapidly. 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 adopted standards would be economically justified even without inclusion of monetized benefits of reduced GHG emissions.

DOE also estimated the monetary value of the economic 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 IV.L of this document. Table V.27 presents the present value for NO_X emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates, and table V.28 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 selected TSL in chapter 13 of the final rule TSD.

Table V.27 Present Value of NO_X Emissions Reduction for GSLs Shipped During the Period 2029-2058

TSL	3% Discount Rate	7% Discount Rate
	million 2022$	
1	277.22	117.22
2	810.97	325.22
3	4,776.79	1,818.87
4	5,633.35	2,154.03
5	6,077.28	2,332.11
6	6,089.81	2,325.81

Table V.28 Present Value of SO_2 Emissions Reduction for GSLs Shipped During the Period 2029-2058

TSL	3% Discount Rate	7% Discount Rate
	million 2022$	
1	62.82	26.79
2	185.41	74.86
3	1,106.42	424.74
4	1,307.27	504.02
5	1,411.35	546.15
6	1,412.69	544.16

Not all the public health and environmental benefits from the reduction of greenhouse gases, NO_X, 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 direct PM and other co-pollutants may be significant. DOE has not included monetary benefits of the reduction of Hg emissions because the amount of reduction is very small.

DOE emphasizes that the emissions analysis, including the SC–GHG analysis, presented in this final rule 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 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 V.29 presents the NPV values that result from adding the estimates of the economic benefits resulting from reduced GHG and NO_X and SO_2 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 during the period 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 during the period 2029–2058.

Table V.29 Consumer NPV Combined with Present Value of Climate Benefits and Health Benefits

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Using 3% discount rate for Consumer NPV and Health Benefits (billion 2022$)						
5% Average SC-GHG case	1.47	5.09	25.05	28.82	30.75	30.63
3% Average SC-GHG case	1.60	5.46	27.27	31.44	33.56	33.45
2.5% Average SC-GHG case	1.69	5.72	28.85	33.29	35.56	35.45
3% 95th percentile SC-GHG case	1.93	6.44	33.07	38.28	40.94	40.84
Using 7% discount rate for Consumer NPV and Health Benefits (billion 2022$)						
5% Average SC-GHG case	0.66	2.26	10.20	11.65	12.41	12.28
3% Average SC-GHG case	0.79	2.63	12.42	14.27	15.23	15.11
2.5% Average SC-GHG case	0.88	2.89	13.99	16.12	17.23	17.11
3% 95th percentile SC-GHG case	1.12	3.61	18.22	21.11	22.61	22.50

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 final rule, DOE considered the impacts of amended standards for GSLs at each TSL, beginning with the maximum technologically feasible level, to determine whether that level was economically justified. Where the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficiency level that is both technologically feasible and economically justified and saves a significant amount of energy.

To aid the reader as DOE discusses the benefits and/or burdens of each TSL, tables in this section present a summary of the results of DOE's quantitative analysis for each TSL. In addition to the quantitative results presented in the tables, DOE also considers other burdens and benefits that affect economic justification. These include the impacts on identifiable subgroups of consumers who may be disproportionately affected by a national standard and impacts on employment.

DOE also notes that the economics literature provides a wide-ranging discussion of how consumers trade off upfront costs and energy savings in the absence of government intervention. Much of this literature attempts to explain why consumers appear to undervalue energy efficiency improvements. There is evidence that consumers undervalue future energy savings as a result of (1) a lack of information; (2) a lack of sufficient salience of the long-term or aggregate benefits; (3) a lack of sufficient savings to warrant delaying or altering purchases; (4) excessive focus on the short term, in the form of inconsistent weighting of future energy cost savings relative to available returns on other investments; (5) computational or other difficulties associated with the evaluation of relevant 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.

Consumers value a variety of attributes in general service lamps. These attributes can factor into consumer purchasing decisions along with initial purchase and operating costs. For example, DOE analyzed consumer preferences for lifetime, presence of mercury, and dimmability in its modeling of consumer purchasing decisions for GSLs. Non-efficiency preferences such as consumer loyalty to a particular brand is not captured by DOE's model. DOE also does not explicitly model shape or color temperature as the former is typically a function of a fixture and DOE assumes the latter does not typically impact price or efficiency; though both could theoretically factor into consumer decisions. General considerations for consumer welfare and preferences, consumer choice decision modeling, and discrete choice estimation are areas DOE plans to explore further in a forthcoming rulemaking action related to the agency's updates to its overall analytic framework.

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 final rule 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.[100]

While DOE is not prepared at present to provide a fuller quantifiable framework for estimating the benefits and costs of changes in consumer

[100] 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.*

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.[101] 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 GSL Standards

Table V.30 and table V.31 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 is presenting monetized benefits of GHG emissions reductions in accordance with the applicable Executive Orders and DOE would reach the same conclusion presented in this document in the absence of the social cost of greenhouse gases, including the Interim Estimates presented by the Interagency Working Group. The efficiency levels contained in each TSL are described in section V.A of this document.

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[101] Sanstad, A.H. *Notes on the Economics of Household Energy Consumption and Technology Choice.* 2010. Lawrence Berkeley National Laboratory. Available at *www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf* (last accessed July 1, 2021).

Table V.30 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	0.167	0.513	3.176	3.730	4.010	4.027
Cumulative FFC Emissions Reduction						
CO_2 (*million metric tons*)	2.98	9.06	55.41	65.14	70.09	70.31
CH_4 (*thousand tons*)	25.35	77.76	479.55	563.27	605.70	608.05
N_2O (*thousand tons*)	0.03	0.09	0.55	0.64	0.69	0.70
SO_2 (*thousand tons*)	0.92	2.81	17.39	20.47	22.05	22.09
NO_X (*thousand tons*)	5.61	17.11	105.01	123.42	132.77	133.25
Hg (*tons*)	0.01	0.02	0.12	0.14	0.15	0.15
Present Value of Benefits and Costs (*3% discount rate, billion 2022$*)						
Consumer Operating Cost Savings	1.13	3.46	21.30	25.20	27.21	27.25
Climate Benefits*	0.17	0.50	2.98	3.51	3.78	3.79
Health Benefits**	0.34	1.00	5.88	6.94	7.49	7.50
Total Benefits†	1.64	4.95	30.16	35.65	38.49	38.54
Consumer Incremental Product Costs‡	0.04	-0.50	2.89	4.22	4.92	5.09
Consumer Net Benefits	1.09	3.96	18.41	20.99	22.29	22.16
Total Net Benefits	1.60	5.46	27.27	31.44	33.56	33.45
Present Value of Benefits and Costs (*7% discount rate, billion 2022$*)						
Consumer Operating Cost Savings	0.52	1.49	8.79	10.45	11.33	11.30
Climate Benefits*	0.17	0.50	2.98	3.51	3.78	3.79
Health Benefits**	0.14	0.40	2.24	2.66	2.88	2.87
Total Benefits†	0.83	2.40	14.01	16.62	17.99	17.96
Consumer Incremental Product Costs‡	0.04	-0.23	1.60	2.35	2.76	2.85
Consumer Net Benefits	0.47	1.73	7.20	8.10	8.57	8.45
Total Net Benefits	0.79	2.63	12.42	14.27	15.23	15.11

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

* 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 3percent discount rate are shown; however, DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim 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 IWG.

** 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. The health benefits are presented at real discount rates of 3 and 7 percent. *See* section IV.L of this document for more details.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.
‡ Costs include incremental equipment costs as well as installation costs. Negative incremental 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 V.31 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 2022$) (No-new-standards case INPV = 2,108)	2,047 - 2,053	1,941 - 1,947	1,904 - 1,946	1,886 - 1,955	1,789 - 1,951	1,783 - 1,950
Industry NPV (% change)	(2.8) – (2.6)	(7.9) – (7.6)	(9.5) – (7.5)	(10.4) – (7.1)	(15.0) – (7.3)	(15.3) – (7.3)
Consumer Average LCC Savings (2022$)						
Integrated Omnidirectional Short	1.81	2.53	0.51	0.57	0.60	0.60
Integrated Omnidirectional Long	1.22	2.03	3.24	3.24	3.24	4.00
Integrated Directional	9.87	1.69	3.23	3.23	3.23	3.23
Non-Integrated Omnidirectional	4.80	6.67	6.67	6.67	6.67	6.67
Non-Integrated Directional	0.41	0.41	0.41	0.41	0.37	0.37
Shipment-Weighted Average*	2.78	2.36	1.13	1.18	1.20	1.24
Consumer Simple PBP (years)						
Integrated Omnidirectional Short	0.6	0.2	0.5	0.8	0.9	0.9
Integrated Omnidirectional Long	3.8	2.8	3.2	3.2	3.2	3.4
Integrated Directional	0.0	0.0	0.0	0.0	0.0	0.0
Non-Integrated Omnidirectional	7.6	2.4	2.4	2.4	2.4	2.4

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6
Non-Integrated Directional	2.8	2.8	2.8	2.8	3.8	3.8
Shipment-Weighted Average*	0.8	0.5	0.7	0.9	1.0	1.0
Percent of Consumers that Experience a Net Cost						
Integrated Omnidirectional Short	0.8%	1.1%	20.3%	21.7%	22.3%	22.3%
Integrated Omnidirectional Long	5.2%	7.8%	5.5%	5.5%	5.5%	5.7%
Integrated Directional	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Non-Integrated Omnidirectional	10.4%	0.1%	0.1%	0.1%	0.1%	0.1%
Non-Integrated Directional	18.0%	18.0%	18.0%	18.0%	31.0%	31.0%
Shipment-Weighted Average*	1.3%	1.8%	16.3%	17.3%	17.9%	18.0%

Parentheses indicate negative (-) values.
* Weighted by shares of each product class in total projected shipments in 2029.

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DOE first considered TSL 6, which represents the max-tech efficiency levels. TSL 6 would save an estimated 4.03 quads of energy, an amount DOE considers significant. Under TSL 6, the NPV of consumer benefit would be $8.45 billion using a discount rate of 7 percent, and $22.16 billion using a discount rate of 3 percent.

In the alternative analysis scenario discussed in section IV.G.1.a of this document wherein the market for linear lamps declines at a lower rate than in the reference scenario, energy savings at TSL 6 would be higher by 0.57 quads, while the total NPV of consumer benefit would increase by $0.55 billion using a discount rate of 7 percent, and $1.75 billion using a discount rate of 3 percent. See Appendix 9D of the final rule TSD for details.

The cumulative emissions reductions at TSL 6 are 70 Mt of CO_2, 22 thousand tons of SO_2, 133 thousand tons of NO_X, 0.15 tons of Hg, 608 thousand tons of CH_4, and 0.70 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 $3.79 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 6 is $2.87 billion using a 7-percent discount rate and $7.50 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 $15.11 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 6 is $33.45 billion.

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 92 percent of annual shipments. The average LCC impact is a savings of $0.55 and $3.17 and a simple payback period of 0.9 years and 0.0 years, respectively, for those product classes. The fraction of purchases associated with a net LCC cost is 24.0 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 81 percent of annual shipments. The average LCC impact is a savings of $0.94 and $4.16 and a simple payback period of 0.6 years and 3.3 years, respectively, for those product classes. The fraction of purchases associated with a net LCC cost is 10.8 and 2.9 percent, respectively. Overall, 18.0 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 23.9 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 23.9 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 nearly 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) and the average fraction of lamps in the residential sector that are Integrated Omnidirectional Short GSLs (78 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 that 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 7 years (corresponding to the average service life of the baseline Integrated Omnidirectional Short lamp), DOE estimates that only 9.0 percent of low-income households would experience a net cost and 91.0 percent would experience a net benefit.

At TSL 6, the projected change in INPV ranges from a decrease of $322 million to a decrease of $155 million, which corresponds to decreases of 15.3 percent and 7.3 percent, respectively. DOE estimates that approximately 83 percent of the Integrated Omnidirectional Short product class shipments; approximately 86 percent of the Integrated Omnidirectional Long product class shipments; approximately 65 percent of the Integrated Directional product class shipments; approximately 46 percent of the Non-Integrated Omnidirectional Short product class shipments; and approximately 74 percent of the Non-Integrated Directional product class shipments will not meet the ELs required at TSL 6 in 2029, the first full year of compliance of new and amended standards. DOE estimates that industry must invest $430 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 publication of this final rule and the compliance date, 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 costs 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 (the first full year of compliance) 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 concluded that at a standard set at TSL 6 for GSLs is economically justified. At this TSL, the average LCC savings for all product classes is positive. An estimated 18.0 percent of all GSL purchases are associated with a net cost. While 23.9 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 nearly 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 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 cost to manufacturers. 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 $3.79 billion in climate benefits (associated with the average SC–GHG at a 3-percent discount rate), and $7.50 billion (using a 3-percent discount rate) or $2.87 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 analysis to select the amended energy conservation standards, DOE notes that the selected standard level represents the maximum improvement in energy efficiency for all product classes and is only $0.1 billion less than the maximum consumer NPV, represented by TSL 5, at both 3 and 7 percent discount rates. Additionally, compared to TSL 5, Integrated Omnidirectional Long purchases are 0.2 percent more likely to be associated with a net cost at TSL 6, but NES is an additional 0.02 quads in the reference scenario and an additional 0.2 quads in the scenario where the linear lamp market persists longer. 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 $1.2 billion at 3 percent discount rate and $0.3 billion at 7 percent discount rate. Compared to TSL 1 or 2, while 22 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 $18 billion at 3 percent discount rate and more than $6 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.

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 maximum NES and differs from the maximum consumer NPV by only $0.1 billion.

Therefore, based on the previous considerations, DOE adopts the energy conservation standards for GSLs at TSL 6. The amended energy conservation standards for GSLs, which are expressed as lm/W, are shown in table V.32.

Table V.32 Amended Energy Conservation Standards for GSLs

Product Class	Efficacy Equation (lm/W)
Integrated Omnidirectional Short GSLs, No Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + 25.9$
Integrated Omnidirectional Short GSLs, With Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + 17.1$
Integrated Directional GSLs, No Standby Power	$\text{Efficacy} = \frac{73}{0.5 + e^{-0.0021(\text{Lumens}+1000)}} - 47.2$
Integrated Directional GSLs, With Standby Power	$\text{Efficacy} = \frac{73}{0.5 + e^{-0.0021(\text{Lumens}+1000)}} - 50.9$
Integrated Omnidirectional Long GSLs, No Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + 71.7$
Non-integrated Omnidirectional Long GSLs, No Standby Power	$\text{Efficacy} = \frac{123}{1.2 + e^{-0.005(\text{Lumens}-200)}} + 93.0$
Non-integrated Omnidirectional Short GSLs, No Standby Power	$\text{Efficacy} = \frac{122}{0.55 + e^{-0.003(\text{Lumens}+250)}} - 83.4$
Non-integrated Directional GSLs, No Standby Power	$\text{Efficacy} = \frac{67}{0.45 + e^{-0.00176(\text{Lumens}+1310)}} - 53.1$

2. Annualized Benefits and Costs of the Adopted Standards

The benefits and costs of the adopted standards can also be expressed in terms of annualized values. The annualized net benefit is (1) the annualized national economic value (expressed in 2022$) of the benefits from operating products that meet the adopted 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.

Table V.33 shows the annualized values for GSLs under TSL 6, expressed in 2022$. 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 reductions, and the 3-percent discount rate case for GHG social costs, the estimated cost of the adopted standards for GSLs is $301.4 million per year in increased equipment installed costs, while the estimated annual benefits are $1,193.6 million from reduced equipment operating costs, $217.7 million in GHG reductions, and $303.2 million from reduced NO_X and SO_2 emissions. In this case, the net benefit amounts to $1,413.1 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the adopted standards for GSLs is $292.2 million per year in increased equipment costs, while the estimated annual benefits are $1,564.6 million in reduced operating costs, $217.7 million from GHG reductions, and $430.8 million from reduced NO_X and SO_2 emissions. In this case, the net benefit amounts to $1,920.9 million per year.

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Table V.33 Annualized Benefits and Costs of Adopted Standards (TSL 6) for GSLs

	Million 2022$/year		
	Primary Estimate	**Low Net Benefits Estimate**	**High Net Benefits Estimate**
3% discount rate			
Consumer Operating Cost Savings	1,564.6	1,473.8	1,639.9
Climate Benefits*	217.7	213.0	220.6
Health Benefits**	430.8	421.6	436.3
Total Benefits†	2,213.1	2,108.4	2,296.8

	Million 2022$/year		
	Primary Estimate	**Low Net Benefits Estimate**	**High Net Benefits Estimate**
Consumer Incremental Product Costs‡	292.2	279.0	304.4
Net Benefits	1,920.9	1,829.5	1,992.4
Change in Producer Cashflow (INPV‡‡)	(22.5) – (10.8)	(22.5) – (10.8)	(22.5) – (10.8)
7% discount rate			
Consumer Operating Cost Savings	1,193.6	1,129.5	1,248.5
Climate Benefits* (3% discount rate)	217.7	213.0	220.6
Health Benefits**	303.2	297.4	306.7
Total Benefits†	1,714.5	1,639.9	1,775.8
Consumer Incremental Product Costs‡	301.4	288.9	312.8
Net Benefits	1,413.1	1,351.0	1,463.0
Change in Producer Cashflow (INPV‡‡)	(22.5) – (10.8)	(22.5) – (10.8)	(22.5) – (10.8)

Note: This table presents the costs and benefits associated with GSLs shipped during the period 2029−2058. These results include consumer, climate, and health benefits that accrue after 2058 from the products shipped during the period 2029−2058. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the *AEO2023* 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 V.B.3.b of this document for discussion. The methods used to derive projected price trends are explained in section IV.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 IV.L of this document). For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3-percent discount rate are shown; however, DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim 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 IWG.

** 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 IV.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.

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

‡‡ Operating cost savings are calculated based on the life cycle costs analysis and national impact analysis as discussed in detail below. *See* sections IV.F and IV.H of this document. DOE's national impact analysis includes all impacts (both costs and benefits) along the distribution chain beginning with the increased costs to the manufacturer to manufacture the product and ending with the increase in price experienced by the consumer. DOE also separately conducts a detailed analysis on the impacts on manufacturers (*i.e.*, manufacturer impact analysis, or "MIA"). *See* section IV.J of this document. In the detailed MIA, DOE models manufacturers' pricing decisions based on assumptions regarding investments, conversion costs, cashflow, and margins. The MIA produces a range of impacts, which is the rule's expected impact on the INPV. The change in INPV is the present value of all changes in industry cash flow, including changes in production costs, capital expenditures, and manufacturer profit margins. The annualized change in INPV is calculated using the industry weighted average cost of capital value of 6.1 percent that is estimated in the MIA (*see* chapter 11 of the final rule TSD for a complete description of the industry weighted average cost

of capital). For GSLs, the annualized change in INPV ranges from -$22.5 million to -$10.8 million. DOE accounts for that range of likely impacts in analyzing whether a trial standard level is economically justified. *See* section V.C of this document. DOE is presenting the range of impacts to the INPV under two markup scenarios: the Preservation of Gross Margin scenario, which is the manufacturer markup scenario used in the calculation of Consumer Operating Cost Savings in this table; and the Preservation of Operating Profit scenario, where DOE assumed manufacturers would not be able to increase per-unit operating profit in proportion to increases in manufacturer production costs. DOE includes the range of estimated annualized change in INPV in the above table, drawing on the MIA explained further in section IV.J of this document to provide additional context for assessing the estimated impacts of this final rule to society, including potential changes in production and consumption, which is consistent with OMB's Circular A-4 and E.O. 12866. If DOE were to include the change in INPV into the annualized net benefit calculation for this final rule, the net benefits would range from $1,898.4 million to $1,910.1 million at a 3-percent discount rate and would range from $1,390.6 million to $1,402.3 million at a 7-percent discount rate. Parentheses () indicate negative values.

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VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866, 13563, and 14094

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) and amended by E.O. 14094, "Modernizing Regulatory Review," 88 FR 21879 (April 11, 2023), 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 final 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 final regulatory action constitutes a "significant regulatory action" within the scope of section 3(f)(1) of E.O. 12866, as amended by E.O. 14094. 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 final 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") and a final regulatory flexibility analysis ("FRFA") 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 FRFA for the products that are the subject of this rulemaking.

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 North American Industry Classification System ("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 fewer for an entity to be considered as a small business for this category.

1. Need for, and Objectives of, Rule

EPCA directs DOE to conduct two rulemaking cycles to evaluate energy conservation standards for GSLs. (42 U.S.C. 6295(i)(6)(A)–(B)) If DOE failed to complete the first 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 the May 2022 Backstop Final Rule. 87 FR 27439.

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)) DOE is publishing this final rule pursuant to this second cycle of rulemaking, as well as section (m) of 42 U.S.C. 6295.

2. Significant Issues Raised by Public Comments in Response to the Initial Regulatory Flexibility Analysis (''IRFA'')

DOE did not receive any substantive comments on the IRFA that was published in the January 2023 NOPR.

3. Description and Estimated Number of Small Entities Affected

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. 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,[102] EPA's ENERGY STAR Certified Light Bulbs Database,[103] manufacturers' websites, and retailer websites. DOE found over 800 companies that sell GSLs covered in this rulemaking. Using information from D&B Hoovers, DOE screened out companies that have more than 1,250 employees, are completely foreign owned and operated, or do not manufacture GSLs in the United States. Based on the results of this analysis, DOE estimates there are approximately 261 small businesses that assemble GSLs covered by this rulemaking. Even though these small entities do not manufacture the main technological components that comprise the GSL and instead import the LEDs, LED packages, and LED drivers for inclusion in the GSLs, DOE is identifying them because they are doing some type of assembling in the United States. In the January 2023 NOPR, DOE included several small businesses that sell CFLs in the IRFA. However, as previously stated in section V.B.2.b of this document, there are no CFLs that are manufactured in the United States. The 21 companies identified in the January 2023 NOPR IRFA that sell CFLs do not manufacture any covered GSLs in the United States and therefore, do not meet the definition of a small business manufacturer. Based on DOE's updated analysis, DOE identified approximately 261 small businesses that assemble covered GSLs in the United States and do not manufacture the LEDs, LED packages, or LED drivers that are used in the LED lamps that they assemble. Instead, all of these small businesses purchase LEDs, LED packages, and LED drivers as components from component manufacturers abroad and then assemble these purchased components into the LED lamps that they sell.

4. Description of Reporting, Recordkeeping, and Other Compliance Requirements

For the 261 small businesses that assemble GSLs covered by this rulemaking, these small businesses will be required to remodel many of the LED lamps they assemble due to the adopted energy conservation standards. However, since the primary driver of efficacy is the LEDs, LED packages, and LED drivers, these GSL assemblers are believed to be minimally impacted by the adopted energy conservation standards. Small businesses assembling GSLs could be required to spend additional engineering time to integrate the more efficacious components that they purchase from component manufacturers to be able to meet the adopted energy conservation standards for any LED lamp models that do not meet the adopted energy conservation standards. DOE anticipates that most small businesses will be able to meet the adopted energy conservation standards by using more efficacious components such as LEDs, LED packages, and/or LED drivers in the LED lamp models that they assemble. DOE was not able to identify any small businesses that manufacturer their own LEDs, LED packages, or LED drivers that are used in the LED lamps that they assemble. Therefore, small businesses would most likely be able to meet the adopted energy conservation standards by purchasing more efficacious LEDs, LED packages, and/or LED drivers as a purchased part to their LED lamps. Additionally, the process of assembling LED lamps is not likely to require any additionally production equipment or tooling in the assembly process, or any significant changes to the assembly process when using more efficacious LEDs, LED packages, or LED drivers in their LED lamps.

The methodology DOE used to estimate product conversion costs for this final rule analysis is described in section IV.J.2.c of this document. At the adopted standards, TSL 6, DOE estimates that all manufacturers would incur approximately $430 million in product conversion costs. These estimated product conversion costs, at TSL 6, represent approximately 4.1 percent of annual revenue over the compliance period.[104] While small manufacturers are likely to have lower per-model sales volumes than larger manufacturers, DOE was not able to identify any small business that manufacturers the LEDs, LED packages, or LED drivers used in their LED lamps—which is the primary technology driving the conversion expenses. Therefore, small businesses that assemble GSLs would most likely spend less engineering resources compared to GSL manufacturers that do manufacture their own LEDs, LED packages and/or LED drivers. Additionally, GSL manufacturer revenue from LED lamps is estimated to be approximately $1,735 million in 2029, the first full year of compliance, at TSL 6 compared to $1,547 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 adopted standards. DOE conservatively estimates that small GSL manufacturers exclusively selling LED lamps would incur no more than 4.1 percent of their annual revenue over the compliance period to redesign non-compliant LED lamps into compliant LED lamps that will meet the adopted standards (*i.e.,* TSL 6).

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

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

[104] The total estimated revenue between 2024, the final rule publication year, and 2028, the compliance year, is approximately, $10,465 million. $430 (million) ÷ $10,465 (million) = 4.1%.

5. Significant Alternatives Considered and Steps Taken To Minimize Significant Economic Impacts on Small Entities

The discussion in the previous section analyzes impacts on small businesses that would result from the adopted standards, represented by TSL 6. In reviewing alternatives to the adopted standards, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1 through TSL 5 would reduce the impacts on small business manufacturers, it would come at the expense of a reduction in energy savings. TSL 1 achieves 96 percent lower energy savings compared to the energy savings at TSL 6. TSL 2 achieves 87 percent lower energy savings compared to the energy savings at TSL 6. TSL 3 achieves 21 percent lower energy savings compared to the energy savings at TSL 6. TSL 4 achieves 7 percent lower energy savings compared to the energy savings at TSL 6. TSL 5 achieves 0.4 percent lower energy savings compared to the energy savings at TSL 6.

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. Accordingly, DOE is not adopting one of the other TSLs considered in the analysis, or the other policy alternatives examined as part of the regulatory impact analysis and included in chapter 16 of the final rule 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. (42 U.S.C. 6295(t)) Additionally, manufacturers subject to DOE's energy efficiency standards may apply to DOE's Office of Hearings and Appeals for exception relief under certain circumstances. Manufacturers should refer to 10 CFR part 430, subpart E, and 10 CFR 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

Pursuant to the National Environmental Policy Act of 1969 (''NEPA''), DOE has analyzed this proposed action rule in accordance with NEPA and DOE's NEPA implementing regulations (10 CFR part 1021). DOE has determined that this rule qualifies for categorical exclusion under 10 CFR part 1021, subpart D, appendix B5.1 because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, none of the exceptions identified in B5.1(b) apply, no extraordinary circumstances exist that require further environmental analysis, and it meets the requirements for application of a categorical exclusion. *See* 10 CFR 1021.410. Therefore, DOE has determined that promulgation of this rule is not a major Federal action significantly affecting the quality of the human environment within the meaning of NEPA, and does not require an environmental assessment or an environmental impact statement.

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 rule and has 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 final 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 E.O. 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 E.O. 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 final 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, sec. 201 (codified at 2 U.S.C. 1531). For a 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 ''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 *www.energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf.*

DOE has concluded that this final rule 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 GSLs 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 final 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. This **SUPPLEMENTARY INFORMATION** section and the TSD for this final rule respond to those requirements.

Under section 205 of UMRA, DOE 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 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 final rule establishes 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 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 final rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

Pursuant to E.O. 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (March 18, 1988), DOE has determined that this 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 final rule 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 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 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 concluded that this regulatory action, which sets forth amended energy conservation standards for GSLs, is not a significant energy action because the 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 final 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 prepared a report describing that peer review.[105] 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 DOE's analyses. DOE is in the process of evaluating the resulting report.[106]

M. Description of Materials Incorporated by Reference

UL 1598C–2016 is an industry accepted test standard that provides requirements for LED downlight retrofit kits. To clarify the scope of the standards adopted in this final rule, DOE is updating the definition for "LED Downlight Retrofit Kit" to reference UL 1598C–2016 in the definition. UL 1598C–2016 is reasonably available on UL's website at *www.shopulstandards.com/Default.aspx.*

ANSI C78.79–2014 (R2020) ("ANSI C78.79–2020") is referenced in the amendatory text of this document but has already been approved for the sections where it appears. No changes are being made to the IBR material.

[105] The 2007 "Energy Conservation Standards Rulemaking Peer Review Report" is available at: *energy.gov/eere/buildings/downloads/energy-conservation-standards-rulemaking-peer-review-report-0* (last accessed March 24, 2022).

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

N. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule prior to its effective date. The report will state that the Office of Information and Regulatory Affairs has determined that the rule meets the criteria set forth in 5 U.S.C. 804(2).

VII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this final rule.

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, Reporting and recordkeeping requirements, Small businesses.

Signing Authority

This document of the Department of Energy was signed on April 9, 2024, by Jeffrey M. Marootian, Principal Deputy 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 April 9, 2024.

Treena V. Garrett,

Federal Register Liaison Officer, U.S. Department of Energy.

For the reasons set forth in the preamble, DOE amends part 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. Amend § 430.2 by:
■ a. Revising the definitions for "General service incandescent lamp" and "General service lamp";
■ b. Removing the definition "LED Downlight Retrofit Kit" and adding the definition "LED downlight retrofit kit" in its place;
■ c. Revising the definitions of "Reflector lamp", "Showcase lamp", and "Specialty MR lamp".

The revisions and addition read as follows:

§ 430.2 Definitions.

* * * * *

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 C78.79–2020 (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 set out in this definition), or is able to operate at any voltage for non-integrated lamps (as set out in this definition); 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 C78.79–2020 (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 C78.79–2020 (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 set out in this definition) that have a first number symbol less than 16 (diameter less than 2 inches) as defined in ANSI C78.79–2020 (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 C78.79–2020 (incorporated by reference; see § 430.3), nominal overall length less than 12 inches, and that are not compact fluorescent lamps (as set out in this definition);
(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–2016 (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 C78.79–2020 (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 C78.79–2020 (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 C78.79–2020 (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.

* * * * *

■ 3. Amend § 430.3 by adding paragraph (y)(4) to read as follows:

§ 430.3 Materials incorporated by reference.

* * * * *

(y) * * *

(4) UL 1598C (''UL 1598C–2016''), *Standard for Safety for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits,* First edition, dated January 16, 2014 (including revisions through November 17, 2016); IBR approved for § 430.2.

■ 4. Amend § 430.32 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) Subject to the sales prohibition in paragraph (dd) of this section, each candelabra base incandescent lamp shall not exceed 60 rated watts.

(2) Subject to the sales prohibition in paragraph (dd) of this section, each intermediate base incandescent lamp shall not exceed 40 rated watts.

* * * * *

(dd) *General service lamps.* Beginning July 25, 2022, the sale of any general service lamp that does not meet a minimum efficacy standard of 45 lumens per watt is prohibited.

(1) Energy conservation standards for general service lamps:

(i) General service incandescent lamps manufactured after the dates specified in the following tables, 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 of this chapter to determine compliance with this standard.

(ii) Modified spectrum general service incandescent lamps manufactured after the dates specified in the following table 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 [1] (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

[1] Use lifetime determined in accordance with § 429.66 of this chapter 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		Requirements
Configuration [1]	Labeled wattage (watts)	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

[1] 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 medium base compact fluorescent lamps (as defined in § 430.2); and

(B) A lamp efficacy greater than or equal to the values shown in the table as follows:

Lamp type	Length	Standby mode operation [3]	Efficacy (lm/W)
(*1*) Integrated Omnidirectional.	Short (<45 inches)	No Standby Mode Operation.	$123/(1.2+e^{-0.005*(Lumens\ 200))}) + 25.9$
(*2*) Integrated Omnidirectional.	Long (≥45 inches)	No Standby Mode Operation.	$123/(1.2+e^{-0.005*(Lumens\ 200))}) + 71.7$
(*3*) [1] Integrated Directional	All Lengths	No Standby Mode Operation.	$73/(0.5+e^{-0.0021*(Lumens+1000))}) - 47.2$
(*4*) [2] Non-integrated Omnidirectional.	Short (<45 inches)	No Standby Mode Operation.	$122/(0.55+e^{-0.003*(Lumens+250))}) - 83.4$
(*5*) [1] Non-integrated Directional.	All Lengths	No Standby Mode Operation.	$67/(0.45+e^{-0.00176*(Lumens+1310))}) - 53.1$
(*6*) Integrated Omnidirectional.	Short (<45 inches)	Standby Mode Operation	$123/(1.2+e^{-0.005*(Lumens\ 200))}) + 17.1$
(*7*) [1] Integrated Directional	All Lengths	Standby Mode Operation	$73/(0.5+e^{-0.0021*(Lumens+1000)}) - 50.9$
(*8*) Non-integrated Omnidirectional.	Long (≥45 inches)	No Standby Mode Operation.	$123/(1.2+e^{-0.005*(Lumens\ 200))}) + 93.0$

[1] This lamp type comprises of directional lamps. A directional lamp is a lamp that meets the definition of reflector lamp as defined in § 430.2.
[2] This lamp type comprises of, but is not limited to, lamps that are pin base compact fluorescent lamps (''CFLs'') and pin base light-emitting diode (''LED'') lamps designed and marketed as replacements of pin base CFLs.
[3] Indicates whether or not lamps are capable of operating in standby mode operation.

(C) The standards described in paragraph (dd)(1)(iv) of this section do not apply to a general service lamp that:

(*1*) Is a general service organic light-emitting diode (OLED) lamps (as defined in § 430.2);

(*2*) Is a non-integrated lamp that is capable of operating in standby mode and is sold in packages of two lamps or less;

(*3*) Is designed and marketed as a lamp that has at least one setting that allows the user to change the lamp's correlated color temperature (CCT) and has no setting in which the lamp meets the definition of a colored lamp (as defined in § 430.2); and is sold in packages of two lamps or less;

(*4*) Is designed and marketed as a lamp that has at least one setting in which the lamp meets the definition of a colored lamp (as defined in § 430.2) and at least one other setting in which it does not meet the definition of colored lamp (as defined in § 430.2) and is sold in packages of two lamps or less; or

(*5*) Is designed and marketed as a lamp that has one or more component(s) offering a completely different functionality (*e.g.,* a speaker, a camera, an air purifier, etc.) where each component is integrated into the lamp but does not affect the light output of the lamp (*e.g.,* does not turn the light on/off, dim the light, change the color of the light, etc.), is capable of operating in standby mode, and is sold in packages of two lamps or less.

(2) Medium base CFLs (as defined in § 430.2) manufactured on or after the dates specified in the following table shall meet or exceed the following standards:

Metrics	Requirements for MBCFLs manufactured on or after January 1, 2006	Requirements for MBCFLs manufactured on or after July 25, 2028
(i) Lumen Maintenance at 1,000 Hours	≥90.0%	≥90.0%.
(ii) Lumen Maintenance at 40 Percent of Lifetime[1].	≥80.0%	≥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[1].	At least 5 lamps must meet or exceed the minimum number of cycles. MBCFLs with start time >100 ms: Cycle once per hour of lifetime[1] or a maximum of 15,000 cycles. MBCFLs with a start time of ≤100 ms: Cycle once per every two hours of lifetime.[1]
(iv) Lifetime[1]	≥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.

[1] Lifetime refers to lifetime of a compact fluorescent lamp as defined in § 430.2.

Note: The following appendix will not appear in the Code of Federal Regulations.

Appendix A—Letter From Department of Justice to the Department of Energy

U.S. Department of Justice
Antitrust Division
RFK Main Justice Building
950 Pennsylvania Avenue NW
Washington, DC 20530–0001

March 13, 2023

Ami Grace-Tardy
Assistant General Counsel for Legislation, Regulation and Energy Efficiency
U.S. Department of Energy
1000 Independence Avenue SW
Washington, DC 20585

Dear Assistant General Counsel Grace-Tardy:

I am responding to your January 11, 2023 letter seeking the views of the Attorney General about the potential impact on competition of proposed energy conservation standards for general service lamps.

Your request was submitted under Section 325(o)(2)(B)(i)(V) of the Energy Policy and Conservation Act, as amended (ECPA), 42 U.S.C. 6295(o)(2)(B)(i)(V), which requires the Attorney General to make a determination of the impact of any lessening of competition that is likely to result from the imposition of proposed energy conservation standards. The Attorney General's responsibility for responding to requests from other departments about the effect of a program on competition has been delegated to the Assistant Attorney General for the Antitrust Division in 28 CFR 0.40(g). The Assistant Attorney General for the Antitrust Division has authorized me, as the Policy Director for the Antitrust Division, to provide the Antitrust Division's views regarding the potential impact on competition of proposed energy conservation standards on his behalf.

In conducting its analysis, the Antitrust Division examines whether a proposed standard may lessen competition, for example, by substantially limiting consumer choice or increasing industry concentration. A lessening of competition could result in higher prices to manufacturers and consumers.

We have studied in detail the Notice of Proposed Rulemaking (NOPR) regarding energy conservation standards for general service lamps, as well as the Technical Support Document (TSD) that accompanied it, both of which you transmitted to us under cover of your January 11 letter. We also attended via Webinar the February 1, 2023 Public Meeting held by the Department of Energy on the general service lamps NOPR and reviewed the related public comments.

The Division previously reviewed a related standard, contained in a Notice of Proposed Rulemaking published at 81 FR 14,528, on Mar. 17, 2016. Subsequently, the Division advised that it did not have evidentiary basis to conclude that that proposed standard for general service lamps was likely to adversely impact competition. The Division also advised that its conclusion was subject to significant uncertainty due to substantial marketplace changes that the standard would likely cause. Similarly, based on our review of the new standard, the Division does not have evidence that the new proposed standard for general service lamps are substantially likely to adversely impact competition.

Sincerely,

David G.B. Lawrence,

Policy Director.

[FR Doc. 2024–07831 Filed 4–18–24; 8:45 am]

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