DEPARTMENT OF ENERGY

10 CFR Part 430

[Docket Number EERE–2011–BT–STD–0006]

RIN 1904–AC43

Energy Conservation Program: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps

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

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

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

DATES: DOE will hold a public meeting on Thursday, May 1, 2014, from 9 a.m. to 4 p.m., in Washington, DC. The meeting will also be broadcast as a webinar. See section IX Public Participation for webinar registration information, participant instructions, and information about the capabilities available to webinar participants.

DOE will accept comments, data, and information regarding this NOPR before and after the public meeting, but no later than June 30, 2014. See section IX Public Participation for details.

ADDRESSES: The public meeting will be held at the U.S. Department of Energy, Forrestal Building, Room 8E–089, 1000 Independence Avenue SW., Washington, DC 20585. To attend, please notify Ms. Brenda Edwards at (202) 586–2945. Please note that foreign nationals visiting DOE Headquarters are subject to advance security screening procedures. Any foreign national wishing to participate in the meeting should advise DOE as soon as possible by contacting Ms. Edwards to initiate the necessary procedures. Please also note that those wishing to bring laptops into the Forrestal Building will be required to obtain a property pass. Visitors should avoid bringing laptops, or allow an extra 45 minutes. Persons can attend the public meeting via webinar. For more information, refer to the Public Participation section near the end of this notice.

Any comments submitted must identify the NOPR for Energy Conservation Standards for general service fluorescent lamps and incandescent reflector lamps and provide docket number EE–2011–BT–STD–0006 and/or regulatory information number (RIN) number 1904–AC43. Comments may be submitted using any of the following methods:

1. *Federal eRulemaking Portal: www.regulations.gov*. Follow the instructions for submitting comments.
2. *Email:GSFL-IRL_2011-STD-0006@ee.doe.gov*. Include the docket number and/or RIN in the subject line of the message.
3. *Mail:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, Mailstop EE–2J, 1000 Independence Avenue SW., Washington, DC 20585–0121. If possible, please submit all items on a CD. It is not necessary to include printed copies.
4. *Hand Delivery/Courier:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, 950 L'Enfant Plaza SW., Suite 600, Washington, DC 20024. Telephone: (202) 586–2945. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

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

For detailed instructions on submitting comments and additional information on the rulemaking process, see section IX of this document (Public Participation).

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

A link to the docket Web page can be found at: *www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/24*. This Web page contains a link to the docket for this notice on the regulations.gov site. The regulations.gov Web page contains instructions on how to access all documents, including public comments, in the docket. See section IX for further information on how to submit comments through *www.regulations.gov*.

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

FOR FURTHER INFORMATION CONTACT:

Ms. Lucy deButts, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, EE–2J, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 287–1604. Email: *General_Service_Fluorescent_Lamps@ee.doe.gov*.

Ms. Elizabeth Kohl, U.S. Department of Energy, Office of the General Counsel, GC–71, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 586–7796. Email: *Elizabeth.Kohl@hq.doe.gov*.

SUPPLEMENTARY INFORMATION:

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I. Summary of the Proposed Rule

Title III, Part B [1] of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (42 U.S.C. 6291–6309, as codified), established the

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

Energy Conservation Program for Consumer Products Other Than Automobiles. Pursuant to EPCA, any new or amended energy conservation standard that DOE prescribes for certain products, such as GSFLs and IRLs, must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)). Furthermore, the new or amended standard must result in a significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)). In accordance with these and other statutory provisions discussed in this notice, DOE proposes amended energy conservation standards for GSFLs and IRLs. The proposed standards, which are the minimum lumen output per watt of a lamp, are shown in Table I.1 and Table I.2. These proposed standards, if adopted, would apply to all products listed in Table I.1 and manufactured in, or imported into, the United States on or after the date three years after the publication of the final rule for this rulemaking.

With the exception of certain IRLs, these proposed standards, if adopted, would apply to all products listed in Table I.2 and manufactured in, or imported into, the United States on or after the date three years after the publication of the final rule for this rulemaking. The Consolidated Appropriations Act, 2014 (Public Law 113–76, Jan. 17, 2014), in relevant part, restricts the use of appropriated funds in connection with several aspects of DOE's incandescent lamps program. Specifically, section 322 states that none of the funds made available by the Act may be used to implement or enforce standards for BPAR incandescent reflector lamps, BR incandescent reflector lamps, and ER incandescent reflector lamps. The majority of IRLs in this rulemaking are PAR IRLs and therefore do not fall into category of lamps prohibited by section 322. The small number of lamps that are BPAR, ER, and BR IRLs are not included in this rulemaking pursuant to section 322. DOE had initiated a separate rulemaking for lamps rated 50 watts or less that are ER30, BR30, BR40, or ER40; lamps rated 65 watts that are BR30, BR40, or ER40 lamps; and R20 IRLs rated 45 watts or less, but has suspended activity on this rulemaking as a result of section 322 of Public Law 113–76. (See section II.B.3 for further details.)

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

Lamp type	Correlated color temperature	Proposed level *lm/W*	Percent increase over current standards or baseline
4-Foot Medium Bipin	≤4,500 K	92.4	3.8
	>4,500 K	90.6	3.0
2-Foot U-Shaped	≤4,500 K	86.9	3.5
	>4,500 K	84.3	4.1
8-Foot Slimline	≤4,500 K	99.0	2.1
	>4,500 K	94.1	1.2
8-Foot Recessed Double Contact High Output	≤4,500 K	97.6	6.1
	>4,500 K	95.6	8.6
4-Foot Miniature Bipin Standard Output	≤4,500 K	97.1	12.9
	>4,500 K	91.3	12.7
4-Foot Miniature Bipin High Output	≤4,500 K	82.7	8.8
	>4,500 K	78.6	9.2

TABLE I.2—PROPOSED ENERGY CONSERVATION STANDARDS FOR INCANDESCENT REFLECTOR LAMPS

Lamp type	Diameter *inches*	Voltage *V*	Proposed level* *lm/W*	Percentage increase over current standards or baseline *%*
Standard Spectrum 40 W—205 W	>2.5	≥125	$7.1P^{0.27}$	4.4
		<125	$6.2P^{0.27}$	5.1
	≤2.5	≥125	$6.0P^{0.27}$	5.3
		<125	$5.2P^{0.27}$	4.0
Modified Spectrum 40 W—205 W	>2.5	≥125	$6.0P^{0.27}$	3.4
		<125	$5.2P^{0.27}$	4.0
	≤2.5	≥125	$5.1P^{0.27}$	4.1
		<125	$4.4P^{0.27}$	4.8

* P = lamp rated wattage.
Note 1: BPAR, ER, and BR IRLs and R20 IRLs rated 45 watts or less are not subject to the proposed standards for IRLs.

A. Benefits and Costs to Consumers

DOE calculates a range of life-cycle cost (LCC) savings and mean payback period (PBP) results for various purchasing events and sectors. These results are presented in section VII.B.1 and chapter 8 of the NOPR TSD. Table I.3 presents DOE's evaluation of the economic impacts of the proposed standards on consumers of GSFLs, as measured by the weighted average LCC savings and the weighted average mean PBP. The weighted average LCC savings are positive for all product classes with the exception of the 8-foot recessed double contact high output (HO) product class. Table I.4 presents DOE's evaluation of economic impacts of the proposed standards on consumers of IRLs, as measured by the weighted average LCC and mean PBP. The weighted average LCC savings are positive for all product classes.

TABLE I.3—IMPACTS OF PROPOSED STANDARDS ON CONSUMERS OF GENERAL SERVICE FLUORESCENT LAMPS

Product class	Weighted average LCC savings *2012$*	Weighted average mean payback period * *years*
4-foot medium bipin ≤4,500 K	3.14	3.6
4-foot T5 miniature bipin standard output ≤4,500 K	2.76	4.3
4-foot T5 miniature bipin high output ≤4,500 K	2.28	3.0
8-foot single pin slimline ≤4,500 K	2.08	4.5
8-foot recessed double contact HO ≤4,500 K	−16.76	NER

* Does not include weighting for "NER" Scenarios. "NER" indicates standard levels that do not reduce operating costs, which prevents the consumer from recovering the increased purchase cost.

TABLE I.4—IMPACTS OF PROPOSED STANDARDS ON CONSUMERS OF INCANDESCENT REFLECTOR LAMPS

Product class	Weighted average LCC savings *2012$*	Weighted average mean payback period *years*
Standard spectrum, >2.5 inches, <125 V	2.95	5.4

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 (2013 to 2046). Using a real discount rate of 9.2 percent, DOE estimates that the INPV for manufacturers of GSFLs is $1,542.5 million in 2012$. Under the proposed standards, DOE expects that manufacturers may lose up to 2.6 percent of their INPV, which is approximately $39.9 million in 2012$. Additionally, based on DOE's interviews with the manufacturers of GSFLs, DOE does not expect any plant closings or significant loss of employment based on the energy conservation standards proposed for GSFLs.

For IRLs, DOE estimates that the INPV for manufacturers of IRLs is $176.0 million in 2012$ using a real discount rate of 9.2 percent. Under the proposed standards, DOE expects that manufacturers may lose up to 29.5 percent of their INPV, which is approximately $51.8 million in 2012$. Additionally, manufacturers of IRLs stated in interviews with DOE that there is the potential for IRL manufacturers to close existing U.S. manufacturing plants or for a potential loss of domestic IRL manufacturing employment based on the energy conservation standards proposed for IRLs.

C. National Benefits [2]

DOE's analyses indicate that the proposed standards for GSFLs would save a significant amount of energy. The lifetime savings for GSFLs purchased in the 30-year period that begins in the year of compliance with amended standards (2017–2046) amount to 3.5 quads.

DOE's analyses indicate that the proposed standards for IRLs would save a significant amount of energy. The lifetime savings for IRLs purchased in the 30-year period that begins in the year of compliance with amended standards (2017–2046) amount to 0.013 quads.

The cumulative net present value (NPV) of total consumer costs and savings of the proposed standards for GSFLs ranges from $3.1 billion (at a 7-percent discount rate) to $8.1 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product costs for products purchased in 2017–2046.

The NPV of total consumer costs and savings of the proposed standards for IRLs ranges from $0.18 billion (at a 7-percent discount rate) to $0.28 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 products purchased in 2017–2046.

In addition, the proposed standards for GSFLs would have significant environmental benefits. The energy savings would result in cumulative emission reductions of 170 million metric tons (Mt) [3] of carbon dioxide (CO_2), 730 thousand tons of methane, 250 thousand tons of sulfur dioxide (SO_2), 210 thousand tons of nitrogen oxides (NO_X), 2.8 thousand tons of nitrous oxide (N_2O), and 0.32 tons of mercury (Hg). The energy savings would result in cumulative emission reductions of 98 Mt of CO_2 through 2030.

The proposed standards for IRL would also have significant environmental benefits. The energy savings would result in cumulative emission reductions of 0.70 Mt of CO_2, 2.7 thousand tons of methane, 0.69 thousand tons of SO_2, 0.79 thousand tons of NO_X, 0.01 thousand tons of N_2O, and 0.001 tons of Hg. The energy savings would result in cumulative emission reductions of 1 Mt of CO_2 through 2030.

The value of the CO_2 reductions for the proposed standards for GSFLs is calculated using a range of values per metric ton of CO_2 (otherwise known as the Social Cost of Carbon, or SCC) developed by an interagency process. The derivation of the SCC values is discussed in section VI.M. Using discount rates appropriate for each set of SCC values, DOE estimates the present monetary value of the CO_2 emissions reduction is between $1.3 billion and $17 billion. DOE also estimates the present monetary value of the NO_X emissions reduction, is $200 million at a 7-percent discount rate and $340 million at a 3-percent discount rate.[4]

The value of the CO_2 reductions for the proposed standards of IRL is calculated using the same SCC values and discount rates used for GSFLs. DOE

[2] All monetary values in this section are expressed in 2012$ and are discounted to 2013.

[3] A metric ton is equivalent to 1.1 short tons. Results for NO_X and Hg are presented in short tons.

[4] DOE is currently investigating monetary valuation of avoided Hg and SO_2 emissions.

estimates the present monetary value of the CO_2 emissions reduction is between $0.0062 billion and $0.076 billion. DOE also estimates the present monetary value of the NO_X emissions reduction, is $1.1 million at a 7-percent discount rate and $1.6 million at a 3-percent discount rate.[4]

Table I.5 and Table I.6 summarize the national economic costs and benefits expected to result from the proposed standards for GSFLs and IRLs.

TABLE I.5—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GENERAL SERVICE FLUORESCENT LAMPS *

Category	Present value *Billion 2012$*	Discount rate (percent)
Benefits		
Operating Cost Savings	12	7
	22	3
CO_2 Reduction Monetized Value ($11.8/t case) **	1.3	5
CO_2 Reduction Monetized Value ($39.7/t case) **	5.6	3
CO_2 Reduction Monetized Value ($61.2/t case) **	8.9	2.5
CO_2 Reduction Monetized Value ($117/t case) **	17	3
NO_X Reduction Monetized Value (at $2,639/ton) **	0.2	7
	0.3	3
Total Benefits †	18	7
	28	3
Costs		
Incremental Installed Costs	8.8	7
	13	3
Total Net Benefits		
Including Emissions Reduction Monetized Value †	9.0	7
	14	3

* This table presents the costs and benefits associated with GSFL shipped in 2017–2046. These results include benefits to consumers which accrue after 2046 from the products purchased in 2017–2046. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule.

** The CO_2 values represent global monetized values of the SCC, in 2012$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series used by DOE incorporate an escalation factor. The value for NO_X is the average of the low and high values used in DOE's analysis.

† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to average SCC with 3-percent discount rate.

TABLE I.6—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR INCANDESCENT REFLECTOR LAMPS

Category	Present value *Billion 2012$*	Discount rate (Percent)
Benefits		
Operating Cost Savings	0.07	7
	0.11	3
CO_2 Reduction Monetized Value ($11.8/t case) **	0.006	5
CO_2 Reduction Monetized Value ($39.7/t case) **	0.03	3
CO_2 Reduction Monetized Value ($61.2/t case) **	0.04	2.5
CO_2 Reduction Monetized Value $117/t case) *	0.08	3
NO_X Reduction Monetized Value (at $2,639/ton) **	0.001	7
	0.002	3
Total Benefits†	0.10	7
	0.13	3
Costs		
Incremental Installed Costs‡	−0.11	7
	−0.17	3
Total Net Benefits		
Including Emissions Reduction Monetized Value†	0.20	7
	0.31	3

* This table presents the costs and benefits associated with IRLs shipped in 2017–2046. These results include benefits to consumers which accrue after 2046 from the products purchased in 2017–2046. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule.

** The CO_2 values represent global monetized values of the SCC, in 2012$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series used by DOE incorporate an escalation factor. The value for NO_X is the average of the low and high values used in DOE's analysis.

† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to average SCC with 3-percent discount rate.

‡ This reduction in product costs occurs because the more efficacious products have substantially longer lifetimes than the products that would be eliminated by the proposed standard.

The benefits and costs of today's proposed standards, for products sold in 2017–2046, can also be expressed in terms of annualized values. The annualized monetary values are the sum of (1) the annualized national economic value of the benefits from consumer operation of products that meet the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in product purchase and installation costs, which is another way of representing consumer NPV), and (2) the annualized monetary value of the benefits of emission reductions, including CO_2 emission reductions.[5]

Although combining the values of operating savings and CO_2 emission reductions provides a useful perspective, two issues should be considered. First, the national operating savings are domestic U.S. consumer monetary savings that occur as a result of market transactions while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and CO_2 savings are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of GSFLs and IRLs shipped in 2017–2046. The SCC values, on the other hand, reflect the present value of some future climate-related impacts resulting from the emission of one ton of CO_2 in each year. These impacts continue well beyond 2100.

Estimates of annualized benefits and costs of the proposed standards for GSFLs are shown in Table I.7. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, for which DOE used a 3-percent discount rate along with the average SCC series that uses a 3-percent discount rate, the cost of the standards proposed in today's rule is $873 million per year in increased product costs; while the estimated benefits are $1,180 million per year in reduced product operating costs, $314 million per year in CO_2 reductions, and $19.3 million per year in reduced NO_X emissions. In this case, the net benefit would amount to $642 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series, the estimated cost of the standards proposed in today's rule is $751 million per year in increased product costs; while the estimated benefits are $1,200 million per year in reduced operating costs, $314 million per year in CO_2 reductions, and $18.9 million per year in reduced NO_X emissions. In this case, the net benefit would amount to approximately $783 million per year.

Estimates of annualized benefits and costs of the proposed standards for IRLs are shown in Table I.8. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, for which DOE used a 3-percent discount rate along with the average SCC series that uses a 3-percent discount rate, the annualized cost of today's proposed standards is negative $10.4 million per year in reduced product costs,[6] and the annualized benefits are $7.2 million per year in reduced product operating costs, $1.4 million per year in CO_2 reductions, and $0.11 million per year in reduced NO_X emissions. In this case, the net benefit would amount to $19 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series, the estimated annualized cost of the standards proposed in today's rule is negative $9.7 million per year in reduced product costs, and the annualized benefits of the standards proposed in today's rule are $5.9 million per year in reduced operating costs, $1.4 million per year in CO_2 reductions, and $0.09 million per year in reduced NO_X emissions. In this case, the net benefit would amount to approximately $17 million per year.

TABLE I.7—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GENERAL SERVICE FLUORESCENT LAMPS

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
		million 2012$/year		
Benefits				
Operating Cost Savings	7%	1,180	1,160	1,220
	3%	1,200	1,170	1,250
CO_2 Reduction Monetized Value ($11.8/t case) **	5%	98	98	98
CO_2 Reduction Monetized Value ($39.7/t case) **	3%	314	314	314
CO_2 Reduction Monetized Value ($61.2/t case) **	2.5%	456	456	456
CO_2 Reduction Monetized Value ($117/t case) **	3%	968	968	968
NO_X Reduction Monetized Value (at $2,639/ton) **	7%	19.3	19.3	19.3
	3%	18.9	18.9	18.9
Total Benefits†	7% plus CO_2 range	1,300 to 2,160	1,280 to 2,140	1,340 to 2,210
	7%	1,520	1,490	1,560

[5] DOE used a two-step calculation process to convert the time-series of costs and benefits into annualized values. First, DOE calculated a present value in 2013, the year used for discounting the NPV of total consumer costs and savings, for the time-series of costs and benefits using discount rates of three and seven percent for all costs and benefits except for the value of CO_2 reductions. For the latter, DOE used a range of discount rates, as shown in Table I.5 and Table I.6. From the present value, DOE then calculated the fixed annual payment over a 30-year period (2017 through 2046) that yields the same present value. The fixed annual payment is the annualized value. Although DOE calculated annualized values, this does not imply that the time-series of cost and benefits from which the annualized values were determined is a steady stream of payments.

[6] This negative cost represents a reduction in product costs compared to the base case, because the more efficacious products have substantially longer lifetimes than the products that would be eliminated by the proposed standard.

TABLE I.7—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR GENERAL SERVICE FLUORESCENT LAMPS—Continued

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
		million 2012$/year		
	3% plus CO_2 range	1,320 to 2,180	1,290 to 2,160	1,370 to 2,230
	3%	1,530	1,510	1,580
Costs				
Incremental Product Costs	7%	873	910	873
	3%	751	785	751
Net Benefits				
Total †	7% plus CO_2 range	426 to 1,291	367 to 1,232	469 to 1,330
	7%	642	583	685
	3% plus CO_2 range	567 to 1,432	505 to 1,370	615 to 1,480
	3%	783	722	831

* This table presents the annualized costs and benefits associated with GSFLs shipped in 2017 − 2046. These results include benefits to consumers which accrue after 2046 from the products purchased in 2017 − 2046. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary Benefits Estimate assumes the central energy prices from *AEO 2013* and a decreasing incremental product cost, due to price learning. The Low Benefits Estimate assumes the low estimate of energy prices from *AEO 2013* and constant real product prices. The High Benefits Estimate assumes the high energy price estimates from *AEO 2013* and decreasing incremental product costs, due to price learning.

** The CO_2 values represent global monetized values of the SCC, in 2012$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series used by DOE incorporate an escalation factor. The value for NO_X is the average of the low and high values used in DOE's analysis.

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

TABLE I.8—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR INCANDESCENT REFLECTOR LAMPS

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
		million 2012$/year		
Benefits				
Operating Cost Savings	7%	7.2	7.1	10
	3%	5.9	5.8	5.8
CO_2 Reduction Monetized Value ($11.8/t case) **	5%	0.5	0.5	0.5
CO_2 Reduction Monetized Value ($39.7/t case) **	3%	1.4	1.4	1.4
CO_2 Reduction Monetized Value ($61.2/t case) **	2.5%	2.0	2.0	2.0
CO_2 Reduction Monetized Value ($117/t case) *	3%	4.2	4.2	4.2
NO_X Reduction Monetized Value (at $2,639/ton) **	7%	0.11	0.11	0.16
	3%	0.09	0.09	0.09
Total Benefits †	7% plus CO_2 range	7.8 to 12	7.7 to 11	7.8 to 12
	7%	8.7	8.6	8.7
	3% plus CO_2 range	6.4 to 10	6.4 to 10	6.4 to 10
	3%	7.4	7.3	7.3
Costs				
Incremental Product Costs ‡	7%	−10.4	−10.5	−10.4
	3%	−9.7	−9.8	−9.7
Net Benefits				
Total †	7% plus CO_2 range	18 to 22	18 to 22	18 to 22
	7%	19	19	19
	3% plus CO_2 range	16 to 20	16 to 20	16 to 20
	3%	17	17	17

* This table presents the annualized costs and benefits associated with IRLs shipped in 2017 − 2046. These results include benefits to consumers which accrue after 2046 from the products purchased in 2017 − 2046. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary Benefits Estimate assumes the central energy prices from *AEO 2013* and a decreasing incremental product cost, due to price learning. The Low Benefits Estimate assumes the low estimate of energy prices from *AEO 2013* and constant real product prices. The High Benefits Estimate assumes the high energy price estimates from *AEO 2013* and decreasing incremental product costs, due to price learning.

** The CO_2 values represent global monetized values of the SCC, in 2012$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series used by DOE incorporate an escalation factor. The value for NO_X is the average of the low and high values used in DOE's analysis.

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

‡ This reduction in product costs occurs because the more efficacious products have substantially longer lifetimes than the products that would be eliminated by the proposed standard.

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

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

II. Introduction

The following section briefly discusses the statutory authority underlying today's proposal, as well as some of the relevant historical background related to the establishment of standards for GSFLs and IRLs.

A. Authority

Title III, Part B of the EPCA, Public Law 94–163 (42 U.S.C. 6291–6309, as codified) established the Energy Conservation Program for Consumer Products Other Than Automobiles,[7] a program covering most major household appliances (collectively referred to as ''covered products''), which includes the types of GSFLs and IRLs that are the subject of this rulemaking. (42 U.S.C. 6292(a)(14)) EPCA prescribed energy conservation standards for these products (42 U.S.C. 6295(i)(1)), and directed DOE to conduct two cycles of rulemakings to determine whether to amend these standards. (42 U.S.C. 6295(i)(3)–(5)) On July 14, 2009, DOE published a final rule in the **Federal Register**, which completed the first rulemaking cycle to amend energy conservation standards for GSFLs and IRLs (hereafter the ''2009 Lamps Rule''). 74 FR 34080. That rule adopted standards for additional GSFLs, amended the definition of ''colored fluorescent lamp'' and ''rated wattage,'' and also adopted test procedures applicable to the newly covered GSFLs. Information regarding the 2009 Lamps Rule can be found on regulations.gov, docket number EERE–2006–STD–0131 at *www.regulations.gov/#!docketDetail;D=EERE-2006-STD-0131*.

This rulemaking encompasses DOE's second cycle of review to determine whether the standards in effect for GSFLs and IRLs should be amended, including whether the standards should be applicable to additional GSFLs.

Pursuant to EPCA, DOE's energy conservation program for covered products consists essentially of four parts: (1) testing; (2) labeling; (3) the establishment of Federal energy conservation standards; and (4) certification and enforcement procedures. The Federal Trade Commission (FTC) is primarily responsible for labeling, and DOE implements the remainder of the program. Subject to certain criteria and conditions, DOE is required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each covered product. (42 U.S.C. 6293) 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. *Id.* The DOE test procedures for GSFLs and IRLs currently appear at title 10 of the Code of Federal Regulations (CFR) part 430, subpart B, appendix R.

DOE must follow specific statutory criteria for prescribing amended standards for covered products. As indicated above, any amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) 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 GSFLs and IRLs, if no test procedure has been established for the product, or (2) if DOE determines by rule that the proposed 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 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 imposition of the standard;
3. The total projected amount of energy, or as applicable, water, savings likely to result directly from the imposition of the standard;
4. Any lessening of the utility or the performance of the covered products likely to result from the imposition of 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 imposition of 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))

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

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

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 of 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))

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. See 42 U.S.C. 6295(o)(2)(B)(iii).

Additionally, 42 U.S.C. 6295(q)(1) specifies requirements when promulgating a standard for a type or class of covered product that has two or more subcategories. DOE must specify a different standard level than that which applies generally to such type or class of products for any group of covered products that have 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. 6294(q)(1)) In determining whether a performance-related feature justifies a different standard for a group of products, DOE must consider such factors as the utility to the consumer of the feature and other factors DOE deems appropriate. *Id.* Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 6295(q)(2))

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

Any final rule for new or amended energy conservation standards promulgated after July 1, 2010, must also 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 the 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 has determined that standby mode and off mode do not apply to GSFLs and IRLs and that their energy use is accounted for entirely in the active mode. Therefore, DOE is not addressing standby and off modes, and will only address active mode in this rulemaking.

DOE has also reviewed this regulation pursuant to Executive Order 13563, issued on January 18, 2011. 76 FR 3281 (Jan. 21, 2011). EO 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in Executive Order 12866. To the extent permitted by law, agencies are required by Executive Order 13563 to: (1) Propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.

DOE emphasizes as well that Executive Order 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, the Office of Information and Regulatory Affairs has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, DOE believes that today's NOPR is consistent with these principles, including the requirement that, to the extent permitted by law, benefits justify costs and that net benefits are maximized. Consistent with EO 13563, and the range of impacts analyzed in this rulemaking, the energy efficiency standard proposed herein by DOE achieves maximum net benefits.

B. Background

1. Current Standards

In the 2009 Lamps Rule, DOE prescribed the current energy conservation standards for GSFLs and IRLs manufactured on or after July 14, 2012 (hereafter the ''July 2012 standards''). 74 FR 34080. The current standards are set forth in Table II.1 and Table II.2.

TABLE II.1—JULY 2012 STANDARDS FOR GENERAL SERVICE FLUORESCENT LAMPS

Lamp type	Correlated color temperature	Minimum average lamp efficacy *lm/W*
Four-Foot Medium Bipin	≤4,500 K	89
	>4,500 K and ≤7,000 K	88
Two-Foot U-Shaped	≤4,500 K	84
	>4,500 K and ≤7,000 K	81
Eight-Foot Slimline	≤4,500 K	97
	>4,500 K and ≤7,000 K	93
Eight-Foot High Output	≤4,500 K	92

TABLE II.1—JULY 2012 STANDARDS FOR GENERAL SERVICE FLUORESCENT LAMPS—Continued

Lamp type	Correlated color temperature	Minimum average lamp efficacy *lm/W*
	>4,500 K and ≤7,000 K	88
Four-Foot Miniature Bipin Standard Output	≤4,500 K	86
	>4,500 K and ≤7,000 K	81
Four-Foot Miniature Bipin High Output	≤4,500 K	76
	>4,500 K and ≤7,000 K	72

TABLE II.2—JULY 2012 STANDARDS FOR INCANDESCENT REFLECTOR LAMPS

Rated lamp wattage	Lamp spectrum	Lamp diameter *inches*	Rated voltage	Minimum average lamp efficacy *lm/W*
40–205	Standard Spectrum	>2.5	≥125 V	$6.8*P^{0.27}$
			<125 V	$5.9*P^{0.27}$
		≤2.5	≥125 V	$5.7*P^{0.27}$
			<125 V	$5.0*P^{0.27}$
40–205	Modified Spectrum	>2.5	[8] ≥125 V	$5.8*P^{0.27}$
			<125 V	$5.0*P^{0.27}$
		≤2.5	≥125 V	$4.9*P^{0.27}$
			<125 V	$4.2*P^{0.27}$

Note 1: P is equal to the rated lamp wattage, in watts.
Note 2: Standard Spectrum means any incandescent reflector lamp that does not meet the definition of modified spectrum in 430.2.

2. Corrections to Codified Standards

In this rulemaking, DOE is proposing to correct errors in the codified standards for GSFLs and IRLs. In particular, DOE is proposing to correct the typographical errors in the sections of the CFR that lay out the GSFL standards specified in EPCA and the IRL standards established by the 2009 Lamps Rule. Specifically, for the GSFL standards codified at 10 CFR 430.32(n)(1), the ''less than or equal to 35 W'' associated with the 8-foot single pin (SP) slimline lamp type should instead be associated with the 2-foot U-shaped lamp type. For 8-foot SP slimline product class with a minimum color rendering index (CRI) of 45 and a minimum average lamp efficacy of 80.0 lumens per watt (lm/W), the rated wattage should be less than or equal to 65 W, not greater than 65 W. The revised table should read as follows:

TABLE II.3—GSFL STANDARDS PRESCRIBED BY EPACT

Lamp type	Nominal lamp wattage	Minimum CRI	Minimum average lamp efficacy *lm/W*	Effective date
4-foot medium bipin	>35 W	69	75.0	Nov. 1, 1995.
	≤35 W	45	75.0	Nov. 1, 1995.
2-foot U-shaped	>35 W	69	68.0	Nov. 1, 1995.
	≤35 W	45	64.0	Nov. 1, 1995.
8-foot slimline	>65 W	69	80.0	May 1, 1994.
	≤65 W	45	80.0	May 1, 1994.
8-foot high output	>100 W	69	80.0	May 1, 1994.
	≤100 W	45	80.0	May 1, 1994.

For the IRL standards adopted by the 2009 Lamps Rule that are codified in 10 CFR 430.32(n)(5), the minimum lamp efficacy of $5.8P^{0.27}$ is for lamps with a rated wattage of 40–205 W, modified spectrum, diameter greater than 2.5 inches, and rated voltage of ''greater than or equal to 125 V'' rather than ''less than or equal to 125 V.'' The revised table should read as follows:

[8] Shown correctly in this table; erroneously written as ''≤125V'' in the CFR.

TABLE II.4—IRL STANDARDS ADOPTED BY THE 2009 LAMPS RULE

Rated lamp wattage	Lamp spectrum	Lamp diameter *inches*	Rated voltage	Minimum average lamp efficacy *lm/W*
40–205	Standard Spectrum	>2.5	≥125 V	$6.8*P^{0.27}$
			<125 V	$5.9*P^{0.27}$
		≤2.5	≥125 V	$5.7*P^{0.27}$
			<125 V	$5.0*P^{0.27}$
40–205	Modified Spectrum	>2 .5	≥125 V	$5.8*P^{0.27}$
			<125 V	$5.0*P^{0.27}$
		≤2.5	≥125 V	$4.9*P^{0.27}$
			<125 V	$4.2*P^{0.27}$

3. History of Standards Rulemaking for General Service Fluorescent Lamps and Incandescent Reflector Lamps

As mentioned in the previous section, EPCA, as amended, established energy conservation standards for certain classes of GSFLs and IRLs, and required DOE to conduct two rulemaking cycles to determine whether these standards should be amended. (42 U.S.C. 6291(1), 6295(i)(1) and (3)–(4)) EPCA also authorized DOE to adopt standards for additional GSFLs if such standards were warranted. (42 U.S.C. 6295(i)(5))

DOE completed the first cycle of amendments by publishing a final rule in the **Federal Register** in July 2009. 74 FR 34080 (July 14, 2009). The 2009 Lamps Rule amended existing GSFL and IRL energy conservation standards and adopted standards for additional GSFLs. That rule also amended the definition of ''colored fluorescent lamp'' and ''rated wattage,'' and adopted test procedures applicable to the newly covered GSFLs.

The Energy Policy Act of 1992 (EPAct 1992, Pub. L. 102–486) amendments to EPCA added as covered products IRLs with wattages of 40 watts (W) or higher. In defining the term ''incandescent reflector lamp,'' EPAct 1992 excluded lamps with elliptical reflector (ER) and bulged reflector (BR) bulb shapes, and with diameters of 2.75 inches or less. Therefore, such IRLs were neither included as covered products nor subject to EPCA's standards for IRLs.

Section 322(a)(1) of the Energy Independence and Security Act of 2007 (EISA 2007) subsequently amended EPCA to expand the Act's definition of ''incandescent reflector lamp'' to include lamps with a diameter between 2.25 and 2.75 inches, as well as lamps with ER, BR, bulged parabolic aluminized reflector (BPAR), or similar bulb shapes. (42 U.S.C. 6291(30)(C)(ii) and (F)) Section 322(b) of EISA 2007, in amending EPCA to set forth revised standards for IRLs in new section 325(i)(1)(C), exempted from these standards the following categories of IRLs: (1) lamps rated 50 W or less that are ER30, BR30, BR40, or ER40; (2) lamps rated 65 W that are BR30, BR40, or ER40 lamps; and (3) R20 IRLs rated 45 W or less. (42 U.S.C. 6295(i)(C)) DOE refers to these three categories of lamps collectively as certain R, ER, and BR IRLs.

DOE has concluded, for the reasons that follow, that it has the authority under EPCA to adopt standards for these R, ER, and BR IRLs, and that these lamps are covered by the directive in 42 U.S.C. 6295(i)(3) to amend EPCA's standards for IRLs. First, by amending the definition of ''incandescent reflector lamp'' (42 U.S.C. 6291(30)(C)(ii) and (F)), EISA 2007 effectively brought these R, ER, and BR IRLs into the federal energy conservation standards program as covered products, thereby subjecting them to DOE's regulatory authority. Second, although 42 U.S.C. 6295(i)(1)(C) exempts these R, ER, and BR IRLs from the standards specified in 42 U.S.C. 6295(i)(1)(B), EPCA directs that DOE amend the standards laid out in 42 U.S.C. 6295(i)(1), which includes subparagraph (C). As a result, the statutory text exempted these bulbs only from the standards specified in 42 U.S.C. 6295(i)(1), not from future regulation. Consequently, DOE began considering energy conservation standards for these R, ER, and BR IRLs. DOE initiated a new rulemaking for these products by completing a framework document and publishing a notice announcing its availability. 75 FR 23191 (May 3, 2010). DOE held a public meeting on May 26, 2010 to seek input from interested parties on its methodologies, assumptions, and data sources.[9]

To initiate the second rulemaking cycle to consider amended energy conservation standards for GSFLs and IRLs (other than the certain R, ER, and BR IRLs discussed in the preceding paragraphs), on September 14, 2011, DOE published a notice announcing the availability of the framework document, ''Energy Conservation Standards Rulemaking Framework Document for General Service Fluorescent Lamps and Incandescent Reflector Lamps,'' and a public meeting to discuss the proposed analytical framework for the rulemaking. 76 FR 56678. DOE also posted the framework document on its Web site, in which DOE described the procedural and analytical approaches DOE anticipated using to evaluate the establishment of energy conservation standards for GSFLs and IRLs.

DOE held the public meeting for the framework document on October 4, 2011,[10] to present the framework document, describe the analyses it planned to conduct during the rulemaking, seek comments from stakeholders on these subjects, and inform stakeholders about and facilitate their involvement in the rulemaking. At the public meeting, and during the comment period, DOE received many comments that both addressed issues raised in the framework document and identified additional issues relevant to this rulemaking.

DOE issued the preliminary analysis for this rulemaking on February 20, 2013 and published it in the **Federal Register** on February 28, 2013. 78 FR 13563 (February 28, 2013). DOE posted the preliminary analysis, as well as the complete preliminary technical support document (TSD), on its Web site.[11] The preliminary TSD includes the results of the following DOE preliminary analyses: (1) market and technology assessment; (2) screening analysis; (3) engineering analysis; (4) energy use characterization;

[9] DOE has suspended activity on this rulemaking as a result of section 315 of Public Law (Pub. L.) 112–74 (Dec. 23, 2011), which prohibits DOE from using appropriated funds to implement or enforce standards for ER, BR, and bulged parabolic reflector IRLs.

[10] The framework document and public meeting information are available at regulations.gov under docket number EERE–2011–BT–STD–0006.

[11] The preliminary analysis, preliminary TSD, and preliminary analysis public meeting information are available at regulations.gov under docket number EERE–2011–BT–STD–0006.

(5) product price determinations; (6) LCC and PBP analyses; (7) shipments analysis; and (8) national impact analysis (NIA).

In the preliminary analysis, DOE described and sought comment on the analytical framework, models, and tools (*e.g.,* LCC and national energy savings [NES] spreadsheets) DOE used to analyze the impacts of energy conservation standards for GSFLs and IRLs. Specifically, DOE invited comment on the following issues: (1) consideration of additional GSFLs; (2) amended definitions; (3) market trends; (4) technology options; (5) product classes; (6) market and technology assessment methodology; (7) screening of design options; (8) representative product classes; (9) baseline lamps; (10) more efficacious substitutes; (11) lamp-and-ballast systems; (12) 4-foot T5 miniature bipin (MiniBP) HO model lamp; (13) candidate standard levels (CSLs); (14) compliance requirements; (15) scaling to product classes not analyzed; (16) engineering analysis methodology; (17) product price determination; (18) GSFL ballast prices; (19) dimmed GSFL systems; (20) lighting controls market penetration; (21) lighting controls performance characteristics; (22) operating profiles for energy use characterization; (23) residential GSFL LCC analysis; (24) sales tax in the LCC analysis; (25) spacing adjustments in the LCC analysis; (26) LCC analysis overall methodology and results; (27) T5s in the residential market; (28) the shipments and national impact analyses; (29) LCC subgroups; (30) small businesses that manufacture GSFLs and IRLs; (31) manufacturer subgroup analysis; (32) key issues and data for the manufacturer impact analysis (MIA); (33) valuing airborne emission reductions; (34) data and programs for the regulatory impact analysis (RIA); and (35) TSLs. (See executive summary and chapter 2 of the preliminary TSD.)

DOE held a public meeting on April 9, 2013, to present the methodologies and results for the preliminary analyses. Manufacturers, trade associations, and environmental advocates attended the meeting. The participants discussed multiple issues, including the methodology and results of the market and technology assessment, screening analysis, engineering analysis, product price determination, energy use, LCC analysis, shipments analysis, and NIA. Other issues brought up during the public meeting included regulatory authority and rulemaking schedule. Finally, the MIA and additional analyses that are undertaken during the NOPR stage were discussed. The comments received during the public meeting, along with the written comments submitted to DOE since publication of the preliminary analysis, have contributed to DOE's proposed resolution of the issues in this rulemaking. This NOPR responds to the issues raised in these public comments.

4. Test Procedure

EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6293) Manufacturers of covered products must use these test procedures to certify to DOE that their product complies with EPCA energy conservation standards and to quantify the efficiency of their product. Similarly, DOE uses the test procedure to determine compliance with energy conservation standards. DOE's test procedures for fluorescent and incandescent reflector lamps are set forth in title 10 of the CFR, part 430, subpart B, appendix R. These test procedures provide instructions for measuring GSFL and IRL performance, largely by incorporating industry standards. The test procedures were updated in a final rule published in July 2009. 74 FR 31829 (July 6, 2009). The rule updated citations to industry standards and made several other modifications. DOE further amended the test procedures to update references to industry standards for GSFLs in a final rule published in January 2012. 77 FR 4203 (January 27, 2012).

Standby and Off Mode Energy Consumption

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

To satisfy the EPCA definitions of standby mode and off mode (42 U.S.C. 6295(gg)(1)), the lamp must not be providing any active mode function (*i.e.,* emitting light). However, to reach such a state, the lamp must be entirely disconnected from the main power source (*i.e.,* switched off), thereby not satisfying the requirements of operating in off mode or standby mode. Further, neither GSFLs nor IRLs covered under this rulemaking provide any secondary user-oriented or protection functions or continuous standby mode functions. Thus, these lamps do not satisfy the EPCA definition of standby mode. While EPCA allows DOE to amend the mode definitions (42 U.S.C. 6295(gg)(1)(B)), DOE believes that the energy use of GSFLs and IRLs is accounted for entirely in the active mode. Therefore, DOE is not addressing lamp operation in the standby and off modes in this rulemaking.

III. General Discussion

A. Product Classes and Scope of Coverage

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

B. Technological Feasibility

1. General

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

After DOE has determined that particular technology options are technologically feasible, it further evaluates each technology option in light of the following additional screening criteria: (1) practicability to manufacture, install, or service; (2) adverse impacts on product utility or availability; and (3) adverse impacts on health or safety. Section VI.B of this notice discusses the results of the screening analysis for GSFLs and IRLs, particularly the designs DOE considered, those it screened out, and those that are the basis for the TSLs in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the NOPR TSD.

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt an amended standard for a type or class of covered product, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such product. (42 U.S.C. 6295(p)(1)) Accordingly, in the engineering analysis, DOE determined the maximum technologically feasible (''max tech'') improvements in energy efficiency for GSFLs and IRLs, using the design parameters for the most efficient products available on the market or in working prototypes. (See chapter 5 of the NOPR TSD.) The max tech levels that DOE determined for this rulemaking are described in section VI.D.2.f for GFSLs and VI.D.3.e for IRLs of this proposed rule.

C. Energy Savings

1. Determination of Savings

For each TSL, DOE projected energy savings from the products that are the subject of this rulemaking purchased in the 30-year period that begins in the year of compliance with any amended standards (2017–2046). The savings are measured over the entire lifetime of products purchased in the 30-year period.[12] DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the base case. The base case represents a projection of energy consumption in the absence of amended mandatory efficiency standards, and considers market forces and policies that affect demand for more efficient products.

DOE used its NIA spreadsheet model to estimate energy savings from amended standards for the products that are the subject of this rulemaking. The NIA spreadsheet model (described in section VI.J of this notice) calculates energy savings in site energy, which is the energy directly consumed by products at the locations where they are used. For electricity, DOE reports NES in terms of the savings in the energy that is used to generate and transmit the site electricity. To calculate this quantity, DOE derives annual conversion factors from the model used to prepare the U.S. Energy Information Administration's (EIA's) *Annual Energy Outlook* (*AEO*).

DOE also estimates full-fuel-cycle (FFC) energy savings. 76 FR 51282 (Aug. 18, 2011), as amended at 77 FR 49701 (August 17, 2012). 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 efficiency standards. DOE's approach is based on calculation of an FFC multiplier for each of the energy types used by covered products. For more information on FFC energy savings, see section VI.J.

2. Significance of Savings

As noted above, 42 U.S.C. 6295(o)(3)(B) prevents DOE from adopting a standard for a covered product unless such standard would result in ''significant'' energy savings. Although the term ''significant'' is not defined in the Act, the U.S. Court of Appeals, in *Natural Resources Defense Council* v. *Herrington,* 768 F.2d 1355, 1373 (D.C. Cir. 1985), indicated that Congress intended ''significant'' energy savings in this context to be savings that were not ''genuinely trivial.'' The energy savings for all of the TSLs considered in this rulemaking (presented in section VII.A) are nontrivial, and, therefore, DOE considers them ''significant'' within the meaning of section 325 of EPCA.

D. Economic Justification

1. Specific Criteria

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)) 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 an amended standard on manufacturers, 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 INPV, which values the industry on the basis of expected future cash flows; cash flows by year; changes in revenue and income; and 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 this rulemaking, these impacts include those resulting from the 2009 Lamps Rule.

For individual consumers, measures of economic impact include the changes in LCC and PBP associated with new or amended standards. These measures are discussed further in the following section. For consumers in the aggregate, DOE also calculates the national NPV of the economic impacts applicable to a particular rulemaking. DOE also evaluates the LCC impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a national standard.

b. Savings in Operating Costs Compared to Increase in Price

EPCA requires DOE to consider the savings in operating costs throughout the estimated average life of the covered product compared to any increase in the price of the covered product that is likely to result from the imposition of the standard. (42 U.S.C. 6295(o)(2)(B)(i)(II)) DOE conducts this comparison in its LCC and PBP analysis. The LCC is the sum of the purchase price of a product (including its installation) and the operating expense (including energy, maintenance, and repair expenditures) discounted over the lifetime of the product. To account for uncertainty and variability in specific inputs, such as product lifetime and discount rate, DOE uses a

[12] DOE previously presented energy savings results for the 30-year period that begins in the year of compliance. In the calculation of economic impacts, however, DOE considered operating cost savings measured over the entire lifetime of products purchased in the 30-year period. DOE has modified its presentation of NES to be consistent with the approach used for its national economic analysis.

distribution of values, with probabilities attached to each value. For its analysis, DOE assumes that consumers will purchase the covered products in the first year of compliance with amended standards.

The LCC savings and the PBP for the considered efficacy levels (ELs) are calculated relative to a base case that reflects projected market trends in the absence of amended standards. DOE identifies the percentage of consumers estimated to receive LCC savings or experience an LCC increase, in addition to the average LCC savings associated with a particular standard level.

c. Energy Savings

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

d. Lessening of Utility or Performance of Products

In establishing classes of products, and in evaluating design options and the impact of potential standard levels, DOE evaluates standards that would not lessen the utility or performance of the considered products. (42 U.S.C. 6295(o)(2)(B)(i)(IV)) The standards proposed in today's notice will 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 the imposition of 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 proposed standard and to transmit such determination to the Secretary, together with an analysis of the nature and extent of the impact. (42 U.S.C. 6295(o)(2) (B)(ii)) DOE will transmit a copy of today's proposed rule to the Attorney General with a request that the U.S. Department of Justice (DOJ) provide its determination on this issue. DOE will address the Attorney General's determination in the final rule.

f. Need for National Energy Conservation

The energy savings from the proposed standards are likely to provide improvements to the security and reliability of the nation's energy system. Reductions in the demand for electricity also may result in reduced costs for maintaining the reliability of the nation's electricity system. DOE conducts a utility impact analysis to estimate how standards may affect the nation's needed power generation capacity.

The proposed standards also are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases (GHGs) associated with energy production. DOE reports the emissions impacts from today's standards, and from each TSL it considered, in section VI.L of this notice. DOE also reports estimates of the economic value of emissions reductions resulting from the considered TSLs.

g. Other Factors

EPCA allows the Secretary, in determining whether a standard is economically justified, to consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII))

2. Rebuttable Presumption

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

IV. Issues Affecting Rulemaking Schedule

In the schedule presented in the framework document of this rulemaking, the preliminary analysis was scheduled to be published in September 2012, the NOPR in August 2013, and the final rule establishing any amended standards in 2014. During the framework stage, stakeholders expressed concerns that because the 2009 Lamps Rule standards would require compliance July 14, 2012, the preliminary analysis published in September 2012 would not be able to account for the impacts of the July 2012 standards. DOE noted these concerns and extended the schedule, publishing the preliminary analysis in February 2013. DOE received additional comments regarding the timing of this rulemaking in the preliminary analysis phase.

Philips questioned whether this rulemaking is statutorily required to be completed at this time, specifically asking if EPAct 1992 provided a date by which the final rule of the second cycle of energy conservation standards for GSFLs and IRLs has to be published. (Philips, Public Meeting Transcript, No. 30 at pp. 27–28)

In a Joint Comment, the Appliance Standards Awareness Project (ASAP), the Natural Resources Defense Council (NRDC), the Alliance to Save Energy, the American Council for an Energy-Efficient Economy (ACEEE), the Consumer Federation of America, and the National Consumer Law Center, (hereafter the ''Joint Comment'') and Northeast Energy Efficiency Partnerships (NEEP) emphasized that EPAct 1992 requires DOE to complete two rounds of rulemakings for IRLs and GSFLs. The Joint Comment noted that final rule of the first cycle was required to be published by April 1997. (42 U.S.C. 6295(i)(3)) DOE was required to publish the final rule of the second cycle five years later. (42 U.S.C. 6295(i)(4)) NEEP and the Joint Comment stated that as DOE failed to publish a final rule for the first cycle until July 2009, it is not possible for DOE to meet the required deadline date for the second cycle. Therefore, NEEP and the Joint Comment agreed that the second cycle should occur within the interval contemplated by Congress when it set out the original deadlines, and a final rule should be issued no later than 2014. (NEEP, No. 33 at p. 1; Joint Comment, No. 35 at pp. 1–2) ASAP agreed stating that given that the 2009 Lamps Rule was complete, it was not discretionary for DOE to have any other schedule than the one currently in place for this rulemaking. (ASAP, Public Meeting Transcript, No. 30 at pp. 192–193)

General Electric (GE) stated its concern that this rulemaking is occurring too soon after the 2009 Lamps Rule, making it difficult for manufacturers to recover investments in new technologies or to develop products meeting even higher standards. GE indicated that the close proximity of the rulemakings will have a severe and negative impact on manufacturers. (GE, Public Meeting Transcript, No. 30 at p. 192) National Electrical Manufacturers Association (NEMA) noted that for certain GSFL product classes, Office of Hearing and Appeals (OHA) issued waivers providing a stay of enforcement for many manufacturers due to the limited availability of rare earth phosphors. NEMA pointed out that as a result, the July 2012 standards still have not been fully implemented. (Philips, Public Meeting Transcript, No. 30 at pp. 27–28; NEMA, No. 36 at p. 1) Therefore, NEMA stated that the market has not fully shifted to reflect the impacts of the July 2012 standards and there is little to no accurate information available regarding future market shares and technology capability. Hence, NEMA concluded that as it is too soon after the 2009 Lamps Rule to set new energy conservation standards, DOE and the Secretary should declare no new standard in this rulemaking. (NEMA, No. 36 at p. 1) Further, NEMA called attention to DOE's newer authority to review energy conservation standards six years after a final rule is published. NEMA found that this review will provide an opportunity to better assess standards for GSFLs and IRLs. (NEMA, No. 36 at pp. 1–2)

The California investor-owned utilities, including Pacific Gas and Electric Company (PG&E), Southern California Gas Company (SCGC), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE), (hereafter the ''CA IOUs'') approved of the current timeline for this rulemaking. They commented that because DOE waited until after the July 2012 standards required compliance before completing the preliminary analysis and due to the amount of time before standards promulgated by this rulemaking would require compliance, now is the correct time to proceed with the second cycle of energy conservation standards for these products. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 30–31)

The Joint Comment emphasized the significance of this rulemaking as a reason to proceed within the five-year timeframe. They stated that according to the 2010 U.S. Lighting Market Characterization (2010 LMC),[13] the U.S. inventory of installed IRLs was estimated to be in excess of 641 million lamps, representing almost 8 percent of the total installed lighting base, consuming an estimated 39 terawatt hours (TWh) annually. The 2010 LMC estimated an inventory of nearly 2.4 billion GSFLs, representing 29 percent of the total installed base, consuming approximately 294 TWh annually. While the Joint Comment recognized that these numbers will likely begin to decrease over time with the increased prevalence of light-emitting diode (LED) alternatives, they noted that IRLs and GSFLs will still likely command a significant portion of the lighting market for decades to come, as a perceived cheaper alternative to LEDs. Due to this and the findings of the preliminary analysis that this rulemaking offers the potential for significant, cost-effective savings for U.S. consumers and businesses, the Joint Comment urged DOE to place this rulemaking's completion as a high priority. (Joint Comment, No. 35 at p. 2)

DOE is obligated to conduct this second review of GSFL and IRL standards. EPCA required DOE to initiate the first review of standards no earlier than three years after October 24, 1992, and publish a final rule no later than four years and six months after that date. 42 U.S.C. 6295(i)(3) The second review of standards was to be initiated no earlier than eight years after October 24, 1992, and the final rule published no later than nine years and six months after that date. 42 U.S.C. 6295(i)(4) DOE published the final rule for the first review of standards in July 2009. DOE is conducting this rulemaking to satisfy the EPCA requirement for a second review of the standards. Applying the schedule DOE developed for the second review of standards would result in an interval of five years between the publications of the final rules for the first and second review of standards, and any final rule for this rulemaking would be published in 2014.

To address comments that product availability, product pricing, and investment decisions in response to the July 2012 standards would not be finalized within the proposed scheduled, DOE delayed the publication of the preliminary analysis to update its product databases and assessments based on changes that took place after the compliance date on July 14, 2012. Additionally, for the preliminary analysis stage, DOE obtained information during interviews with manufacturers regarding new product lines they were preparing to launch to ensure that DOE's analysis captured the initial market impacts of the July 2012 standards. The analysis presented in this NOPR was updated and finalized more than a year after the July 2012 standards required compliance, reflecting the most recent data available. Further, in manufacturer interviews conducted for this NOPR, DOE learned that most manufacturers were not planning to introduce any additional covered products to market. Therefore, DOE believes that the revised schedule for this GSFL and IRL rulemaking has allowed the preliminary analysis and NOPR analysis to be conducted so as to have adequately captured the impacts of the July 2012 standards for these products. Any additional data received will be considered in the development of any final rule.

V. Issues Affecting Scope

A. Clarifications of General Service Fluorescent Lamp Definition

The scope of this rulemaking for GSFLs is defined by the terms ''fluorescent lamp'' and ''general service fluorescent lamp.'' 10 CFR 430.2 The definition of general service fluorescent lamp includes certain exemptions. DOE has received several questions on the application of these exemptions. Therefore, in the preliminary analysis DOE evaluated each exemption and determined that the following exemption categories could be further clarified: ''impact-resistant fluorescent lamps,'' ''reflectorized or aperture lamps,'' ''fluorescent lamps designed for use in reprographic equipment,'' and ''lamps primarily designed to produce radiation in the ultra-violet region of the spectrum.'' For these exemption categories, the terminology was either not defined elsewhere or the application of the exemption could be further clarified. DOE examined product literature and industry reference sources to determine language that would further explain these exemptions. DOE determined that the exemptions should be clarified as follows:

Impact-resistant fluorescent lamp means a lamp that:

a. Has a coating or equivalent technology that is compliant with NSF/ANSI 51 (incorporated by reference; *see* § 430.3) and designed to contain the glass if the glass envelope of the lamp is broken; and

[13] U.S. Department of Energy. *2010 U.S. Lighting Market Characterization.* January 2012. Available at *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.*

b. Is designated and marketed for the intended application, with:

i. The designation on the lamp packaging; and

ii. Marketing materials that identify the lamp as being impact-resistant, shatter-resistant, shatter-proof, or shatter-protected.

Reflectorized or aperture lamp means a fluorescent lamp that contains an inner reflective coating on the bulb to direct light.

Fluorescent lamp designed for use in reprographic equipment means a fluorescent lamp intended for use in equipment used to reproduce, reprint, or copy graphic material.

Lamps primarily designed to produce radiation in the ultra-violet region of the spectrum mean fluorescent lamps that primarily emit light in the portion of the electromagnetic spectrum where light has a wavelength between 10 and 400 nanometers.

In the preliminary analysis, DOE also considered clarifications of the terms ''designed'' and ''marketed'' as applied to definitions of lighting products covered under DOE standards. These terms are generally used to ensure that exemptions from applicable standards apply only to lamps used in certain intended applications and/or functions. Therefore, DOE considered the terms ''designed,'' ''designated,'' ''designation,'' ''designated and marketed,'' and ''designed and marketed,'' for covered lighting products to mean that manufacturers explicitly state the intended application of the lamp in a publicly available document (*e.g.,* product literature, catalogs, packaging labels, and labels on the product itself).

NEMA agreed with the proposed clarifications to definitions for GSFLs. (NEMA, Public Meeting Transcript, No. 30 at p. 45; NEMA, No. 36 at pp. 4–5) NEMA noted that the definitions have been in use since the early 1990s and are well understood within the industry; the additional clarification suggested is in line with current industry practice. NEMA stated that no further definitions are required beyond this clarification. (NEMA, No. 36 at pp. 4–5)

The CA IOUs agreed that DOE should clearly define the lamp types exempted from standards. Specifically, the CA IOUs recommended further clarifying the definition for fluorescent lamps ''designed for cold temperature applications.'' (CA IOUs, Public Meeting Transcript, No. 30 at pp. 31–32; CA IOUs, No. 32 at p. 12) The CA IOUs expressed concern that that many common GSFLs are currently being designed with amalgam to be operated in lower temperatures, but without a negative effect on the lamps' efficacy and not intended to be exempt from standards. The CA IOUs stated their understanding that the exemption for cold temperature lamps has been preserved to accommodate uncommon lamps designed to be used outdoors in extreme, sub-freezing temperatures that cannot meet the efficacy requirements established for GSFLs. (CA IOUs, No. 32 at p. 12)

The Northwest Energy Efficiency Alliance (NEEA) and Northwest Power and Conservation Council (NPCC) agreed with the CA IOUs and found the descriptor ''designed for cold temperature applications'' to be too vague to adequately differentiate between products that are covered currently and those that have design features that make it impossible for them to meet the standards. NEEA and NPCC commented that this lack of clarity seems to create a significant loophole. (NEEA and NPCC, No. 34 at p. 3) In addition to clearly defining the exempt cold temperature lamps, the CA IOUs asked DOE to revisit the market share and performance of these lamps to confirm that they do in fact justify an exemption. (CA IOUs, No. 32 at p. 12)

The exemption for cold temperature lamps is stated in the CFR as ''Fluorescent lamps specifically designed for cold temperature applications.'' Further the CFR provides a definition for ''cold temperature fluorescent lamp'' stated as follows:

Cold temperature fluorescent lamp means a fluorescent lamp specifically designed to start at −20 °F when used with a ballast conforming to the requirements of American National Standards Institute (ANSI) C78.81 (incorporated by reference; see § 430.3) and ANSI C78.901 (incorporated by reference; see § 430.3), and is expressly designated as a cold temperature lamp both in markings on the lamp and in marketing materials, including catalogs, sales literature, and promotional material. 10 CFR 430.2

Cold weather starting is accomplished through both the lamp and ballast design. Product literature indicates that cold temperature fluorescent lamps paired with the appropriate ballast can be started at temperatures as low as -20 °F. Therefore, the existing definition, which includes the specific starting temperature and the requirement of being marketed and designed for cold temperature applications, is a sufficient description of fluorescent lamps designed to be operated in cold temperatures. Additionally, product offerings of cold temperature fluorescent lamps remain limited, indicating their specialty use. Hence, DOE is not proposing any further clarification for the exemption category of fluorescent lamps designed for cold temperature applications.

DOE did not receive any further comment on definitions considered in the preliminary analysis. In this NOPR, DOE is also considering providing a definition for 700 series fluorescent lamps. OHA has granted several manufacturers waivers from standards for their 700 series T8 products. (See section VI.D.2.a for further discussion regarding OHA waivers.) A definition for 700 series lamps would provide clarification regarding these lamp types.

The term ''700 series'' is widely used in industry when referring to fluorescent lamps with a CRI in the range of 70 to 79. The Illuminating Engineering Society of North America (IESNA) Lighting Handbook [14] presents fluorescent lamp nomenclature and states that color is represented by a three digit number (*i.e.,* 735 or 835) beginning with the first digit of the lamp's CRI (*i.e.,* 7 or 8) and followed by the first two digits of the lamp's correlated color temperature (CCT) (*e.g.,* 30, 35, 41). DOE explained this nomenclature in chapter 3 of the 2009 Lamps Rule TSD,[15] stating that typically lamps with a CRI in the 60s use only less efficient halophosphors, while lamps with a CRI in the 70s (700 series phosphor) and in the 80s (800 series phosphor) use more efficient rare earth phosphors. The DOE test procedure at 10 CFR part 430, subpart B, appendix R requires CRI to be measured and reported to demonstrate compliance with standards. Thus, the measured CRI of a lamp is used to determine if the lamp qualifies as a 700 series lamp. Hence DOE is proposing to define 700 series fluorescent lamps to mean a fluorescent lamp with a CRI that is in the range of 70 to 79.

In this NOPR, DOE is proposing the definitions as previously specified in this section and in the preliminary analysis for ''impact-resistant fluorescent lamps,'' ''reflectorized or aperture lamps,'' ''fluorescent lamps designed for use in reprographic equipment,'' and ''lamps primarily designed to produce radiation in the ultra-violet region of the spectrum.'' DOE is also proposing a definition of ''designed and marketed.'' This definition is intended to apply to the use of these and similar terms (i.e., designated or labeled) in any

[14] DiLaura, D. L., K. W. Houser, R. G. Mistrick, and G. R. Steffy. *Lighting Handbook: Reference and Application, 10th Edition.* New York: IESNA, 2011.

[15] The 2009 Lamps Rule TSD is available at *www.regulations.gov/#!documentDetail;D=EERE–2006–STD–0131–0147.*

grammatical form or combination. In addition, DOE is proposing a definition for ''700 series fluorescent lamp.''

B. General Service Fluorescent Lamp Scope of Coverage

1. Additional General Service Fluorescent Lamp Types

In this rulemaking, DOE evaluates energy efficiency standards for additional GSFLs beyond those for which standards have already been established. (42 U.S.C. 6295(i)(5)) Any additional GSFLs considered for coverage under standards must meet the definition of a fluorescent lamp in 42 U.S.C. 6291(30)(A); satisfy the majority of fluorescent lighting applications; not be within the exclusions specified in 42 U.S.C. 6291(30)(B); and not already be subject to energy conservation standards. 73 FR 13620, 13629 (March 13, 2008). For each additional GSFLs that meets these criteria, DOE then assesses whether standards could result in significant energy savings and are technologically feasible and economically justified. Standards for any applicable additional GSFLs are adopted based on the same criteria used to set new or amended standards for products pursuant to 42 U.S.C. 6295(o).

Using these criteria, DOE evaluated whether the following GSFL types warranted coverage under standards: (1) pin base compact fluorescent lamps (CFLs); (2) non-linear fluorescent lamps (*e.g.,* circline); and (3) fluorescent lamps with alternate lengths (*e.g.,* 2-, 3-, and 5-foot lamps).

For pin base CFLs, DOE determined that these lamp types fall within the definition of ''general service lamps,'' which excludes GSFLs. (42 U.S.C. 6291(30)(BB)) Therefore, these lamp types cannot be considered under this rulemaking. DOE is evaluating these lamp types in the rulemaking for general service lamps. Documents related to this rulemaking can be found on regulations.gov, docket number EERE–2013–BT–STD–0051.

For non-linear fluorescent lamps, DOE considered circline fluorescent lamps, the primary shape not currently covered under standards. DOE used the miscellaneous category of fluorescent lamps reported by the 2010 LMC to determine market share and energy consumption of circline fluorescent lamps. This category included fluorescent lamps other than the T5, T8, T12 linear lamps, and T8 and T12 U-shaped lamps, and is therefore mainly comprised of circline lamps and lamps with unknown characteristics. The 2010 LMC reported this category made up 2.1 percent of lighting and consumed 4 TWh of electricity in 2010. Interviews with manufacturers also confirmed the low market share of these lamp types. Therefore, DOE tentatively concluded that coverage should not be expanded to non-linear fluorescent lamps as standards would not likely result in significant energy savings.

For linear lengths not already covered by standards, DOE focused on linear medium bipin (MBP) fluorescent lamps ranging from 1 to 6 feet, with the exception of the 4-foot MBP, which is already subject to standards. DOE's analysis showed that 5- and 6-foot lengths comprise a very low percentage of the linear MBP product offerings. For the T8 [16] MBP lamps with lengths less than 4 feet, according to the 2010 LMC, these lamps comprised about 0.2 percent of all installed lighting and consumed 1 TWh of electricity in 2010. Feedback from manufacturers also indicated a low market share for these lamp types. Therefore, DOE tentatively concluded that coverage should not be expanded to linear fluorescents of lengths not covered by standards as standards would not likely result in significant energy savings.

DOE received several comments on its assessment not to extend coverage to linear fluorescent lamps of lengths not already covered. In particular, several stakeholders asserted that the 2-foot linear fluorescent lamps comprised a market share that warranted coverage under standards. The CA IOUs urged DOE to reassess the 2-foot linear fluorescent lamp market share and recommended that they be included in the scope of coverage of this rulemaking. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 32–33; CA IOUs, No. 32 at pp. 11–12) NEEA and NPCC advised that 2-foot linear fluorescent lamps be included under scope of coverage and in their own product class, if appropriate. (NEEA and NPCC, No. 34 at pp. 2–3) Specifically, the CA IOUs asserted that DOE should have considered the proportion of GSFL market share that these lamps represent and also included T12 lamps in its assessment, as these lamps would be covered by standards for 2-foot linear lamps. (CA IOUs, No. 32 at pp. 11–12)

In assessing whether additional GSFL types should be included under coverage of standards in the preliminary analysis, DOE evaluated the market share and energy consumption of the lamp type relative to the entire lighting market. DOE's analysis provided a comprehensive representation of the lamp type and the energy savings potential of standards for the lamp type. In the NOPR, DOE also evaluated market share relative to the entire fluorescent lamp market. Based on the 2010 LMC, T8 MBP lamps less than 4 feet comprised 0.7 percent of the fluorescent lamp market versus 0.2 percent of the entire lighting market. Therefore, the evaluation of these lamps relative to the fluorescent lamp market also indicates that 2-foot MBP linear lamps have a very low market share.

DOE excluded T12 lamps from this analysis to reflect future market trends. The 2011 final rule amending energy conservation standards for fluorescent lamp ballasts (hereafter the ''2011 Ballast Rule''), which will require compliance on November 14, 2014, set standards difficult for T12 ballasts to meet.[17] 76 FR 70548 (Nov. 14, 2011). Therefore, the market will likely shift away from T12 lamps. Additionally, historical shipments of most T12 lamps have been decreasing steadily and manufacturer feedback from interviews suggests that this trend will continue. Therefore, DOE focused on T8 lamps when evaluating the energy savings of additional GSFL types to include under coverage of standards.

The CA IOUs also asserted that in the 2010 LMC, T8 and T12 lamps less than 4 feet have GSFL market shares very similar to the market shares for three other product types currently subject to DOE standards: T8 lamps greater than 4 feet (1.4 percent of the linear fluorescent market), T8 U-shaped lamps (2 percent of the linear fluorescent market), and T12 U-shaped lamps (0.5 percent of the linear fluorescent market). (CA IOUs, No. 32 at pp. 11–12; NEEA and NPCC, No. 34 at pp. 2–3)

The standards for GSFL types cited by the CA IOUs, specifically, the 2-foot U-shaped lamps, 8-foot SP slimline lamps, and 8-foot recessed double contact (RDC) HO lamps, were established in EPAct 1992. (42 U.S.C. 6295(i)(1)) As noted, for this rulemaking, in determining whether additional GSFL types should be covered under standards pursuant to 42 U.S.C. 6295(i)(5) DOE considers several criteria. In particular, DOE assesses whether a potential standard for an additional GSFL type would result in significant energy savings. Therefore, DOE examined parameters such as market share and energy consumption of each lamp type under consideration relative to the fluorescent lighting

[16] The majority of T12 MBP lamps with lengths less than 4 feet do not comply with the July 2012 standards.

[17] The full text and all related documents of the 2011 Ballast Rule can be found on regulations.gov, docket number EERE–2007–BT–STD–0016 at *www.regulations.gov/#!docketDetail;D=EERE-2007-BT-STD-0016*.

market. DOE believes that this evaluation of each potential additional GSFL provides the most useful indication of whether significant energy savings could be gained from regulation of the lamp type.

Stakeholders also cited data sources in addition to the 2010 LMC indicating that 2-foot linear lamps should be included under coverage of standards. The CA IOUs asserted that an anecdotal survey from their lighting audit teams suggest 2-foot linear lamps may be 5 to 10 percent of lamps installed in the CA IOUs' service territory, which is higher than suggested by the 2010 LMC. The CA IOUs also reported that the vast majority of commercial buildings in California have some two-by-two fixtures, and many of these have been retrofitted from U-shaped to 2-foot linear lamps within the last several years, indicating a growing trend toward 2-foot linear lamps over U-shaped lamps. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 32–34; CA IOUs, No. 32 at pp. 11–12) NEEA and NPCC stated that they would submit field data to DOE and asserted that currently available data indicates 2-foot linear GSFLs make up a notably larger fraction of the market than the preliminary analysis suggests. (NEEA and NPCC, No. 34 at pp. 2–3)

The CA IOUs and NEEA and NPCC referred to a Navigant Consulting, Inc. (Navigant) study published in October 2012 that surveyed existing commercial and industrial building stock in Vermont, the *2011 Vermont Market Characterization and Assessment Study.*[18] The raw data from the Navigant study, obtained in May 2013 from the state of Vermont by NEEP, shows that of more than 136,000 lamps surveyed, 2-foot lamps represented 6.3 percent of installed fluorescent lamps. This included 3.6 percent of high performance T8s, 9.3 percent of standard efficiency T8s, 3.9 percent of T12s, and 5.2 percent of T5s. Behind 4-foot lamps, 2-foot lamps were by far the most common lamp length in these sectors. The CA IOUs stated that 6.3 percent of fluorescent lamp sales represent a significant amount of energy and, as explained in previous comments submitted by the CA IOUs, 2-foot lamps are available in a wide range of efficacies. (CA IOUs, No. 32 at pp. 11–12; NEEA and NPCC, No. 34 at pp. 2–3)

NEMA, however, stated that the 2010 LMC showed a low market share[19] for these products, which does not justify standards for these lamps. (NEMA, No. 36 at p. 4) Edison Electric Institute (EEI) stated its belief that 2-foot linear lamps were mainly installed in task lighting applications. (EEI, Public Meeting Transcript, No. 30 at p. 34) GE advised that 2-foot linear lamps should not be included in the scope of this rulemaking. While installing these lamps may be customary in California, GE stated that they are not very common across the nation. Further, GE commented that DOE had received shipment data in preliminary manufacturer interviews that showed the sales of 2-foot straight lamps to be significantly less than the sales of 4-foot lamps. (GE, Public Meeting Transcript, No. 30 at pp. 35–36) ASAP requested DOE make the shipment data publicly available so stakeholders could determine the significance. (ASAP, Public Meeting Transcript, No. 30 at pp. 36–39)

DOE did not receive shipment data specifically for 2-foot linear lamps and based its assessment of market share and energy consumption provided in the 2010 LMC report and feedback received in manufacturer interviews. The anecdotal survey and the Vermont study cited by the CA IOUs are focused on very specific areas of the nation, while the 2010 LMC is the most recent assessment of installed stock and energy use of fluorescent lighting at the national level. The Vermont study collected primary data through on-site visits from a random selection of 120 commercial and industrial buildings in specific regions in Vermont. Therefore, DOE found the 2010 LMC provided a more comprehensive basis for its assessment. A comparison of the installed stock provided in the 2000 LMC report[20] and the 2010 LMC report shows that installed stock for both T8 and T12 lamps less than 4 feet has declined by about 50 percent over that 10-year period. DOE also received feedback from manufacturers in interviews stating that 2-foot linear lamps, both in the MBP and MiniBP categories, comprise a low market share that will either stay the same or decline. Further, manufacturers noted in interviews that the 2-foot linear lamps are generally used for kitchens, bathrooms, vanity lighting, hospitality applications, cabinets, and to round out edges of ceilings in commercial spaces.

Given the above, DOE finds insufficient evidence to indicate that the market share or energy consumption of 2-foot linear fluorescent lamps would result in significant energy savings if DOE established standards for these lamps. DOE is not proposing standards for any additional GSFL types that are not currently covered.

2. Additional General Service Fluorescent Lamp Wattages

DOE specifies a certain minimum wattage for each lamp type included in the definition of ''fluorescent lamp.'' In this rulemaking, DOE also evaluates whether coverage should be extended to additional wattages of these lamp types. (42 U.S.C. 6295(i)(5)) As part of this assessment, DOE reviewed product offerings for covered lamp types to determine if any new, lower wattage products had been introduced since publication of the 2009 Lamps Rule. DOE found the following reduced wattage lamps not covered under standards: 49 W, 50 W, 51 W 8-foot SP slimline, 25 W 4-foot T5 MiniBP standard output (SO), and 44 W, 47 W 4-foot T5 MiniBP HO lamps. DOE currently covers 8-foot SP slimline lamps with wattages of 52 W or more; 4-foot T5 MiniBP SO lamps with wattages of 26 W or more; and 4-foot T5 MiniBP HO lamps with wattages of 49 W or more. Therefore, in the preliminary analysis, DOE considered extending coverage to the following GSFLs:

- 8-foot SP slimline lamps with wattages ≥49 W and <52 W;
- 4-foot T5 MiniBP SO lamps with wattages ≥25 W and <26 W; and
- 4-foot T5 MiniBP HO lamps with wattages ≥44 W and <49 W.

These reduced wattage lamps are generally more efficacious than their full wattage counterparts and offer the potential for increased energy savings.

Philips commented that if a product is already highly efficacious, DOE does not need to consider standards for the product. (Philips, Public Meeting Transcript, No. 30 at pp. 44–45)

The emergence of these new reduced wattage lamps on the market since the 2009 Lamps Rule and the number of product offerings indicate that there is significant consumer demand for these lamps. Further, because reduced wattage lamps are often incentivized by utilities and promoted as an easy

[18] Navigant Consulting, Inc. *2011 Vermont Market Characterization and Assessment Study.* October 2012. Available at *http://publicservice.vermont.gov/sites/psd/files/Topics/Energy_Efficiency/EVT_Performance_Eval/VT%20CI%20Existing%20Buildings%20Market%20Assessment%20and%20Characterization_2012-10-6_FINAL.pdf*

[19] DOE's assessment indicated that the T8 MBP lamps less than 4 feet comprised 0.2 percent of the entire lighting market. NEMA's written comment had incorrectly quoted this number as 0.02 percent.

[20] U.S. Department of Energy. *U.S. Lighting Market Characterization Volume I: National Lighting Inventory and Energy Consumption Estimate.* September 2002. Available at *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lmc_vol1_final.pdf.*

pathway to energy savings, they are likely to increase in market share. DOE's review of product catalogs indicated that lamps with these wattages generally have a range of efficacies. The lower wattages of these lamps and their potential to achieve higher efficacies indicate that including these wattages under energy conservation standards have the potential to realize significant energy savings.

NEMA agreed with expanding the GSFL wattages covered by this rulemaking, but cautioned DOE that reduced wattage GSFLs are often ''energy saver'' models. These lamps do not have the same performance as full wattage GSFLs. Specifically, NEMA stated that reduced wattage GSFLs have difficulty operating in low-temperature applications and do not have full dimming functionality, a performance feature that is highly desired considering the proliferation of dimming systems. (NEMA, Public Meeting Transcript, No. 30 at pp. 23–24; NEMA, No. 36 at p. 4)

DOE acknowledges there are certain issues related to dimming associated with ''energy saver'' or reduced wattage lamps. Therefore, in this rulemaking, DOE has ensured that full wattage lamps can achieve the levels proposed for GSFLs. See section VI.D.2.g for further details on this issue.

C. Incandescent Reflector Lamp Scope of Coverage

1. Incandescent Reflector Lamp Types

In this rulemaking, DOE does not consider the following IRL types: (1) Lamps rated 50 W or less that are ER30, BR30, BR40, or ER40; (2) lamps rated 65 W that are BR30, BR40, or ER40 lamps; and (3) R20 IRLs rated 45 W or less. (42 U.S.C. 6295(i)(C)) These IRLs are the subject of a separate rulemaking on which further information can be found on regulations.gov under docket ID EERE–2010–BT–STD–0005 at *www.regulations.gov/#!docketDetail;D=EERE-2010-BT-STD-0005*. DOE has suspended activity on this rulemaking as a result of section 315 of Public Law (Pub. L.) 112–74 (Dec. 23, 2011), which prohibits DOE from using appropriated funds to implement or enforce standards for ER, BR, and bulged parabolic reflector IRLs.

2. Incandescent Reflector Lamp Wattages

In this rulemaking, DOE also does not consider IRLs with wattages lower than 40. EPCA defines an incandescent reflector lamp as a lamp that ''has a rated wattage that is 40 watts or higher.'' (42 U.S.C. 6291(30)(C), (C)(ii), and (F))

DOE received several comments on this lower limit on wattage for IRLs. EEI reported that highly efficacious 39 W halogen IRLs capable of replacing less efficacious 60 W IRLs are on the market. (EEI, Public Meeting Transcript, No. 30 at pp. 24–25) The CA IOUs considered the presence of commercially available 39 W lamps to suggest that DOE should extend the IRL wattage range covered. (CA IOUs, Public Meeting Transcript, No. 30 at p. 33) EEI also noted that the 39 W IRLs are close to covered lamps in efficacy and serve as replacements for IRLs of higher wattages, possibly increasing efficacy by 30 to 40 percent. (EEI, Public Meeting Transcript, No. 30 at pp. 34–35) The CA IOUs responded that in the California market there is a wide range of efficacy for the 39 W products. (CA IOUs, Public Meeting Transcript, No. 30 at p. 35)

GE stated that EPAct 1992 gave 40 W as the lower wattage limit for IRLs and that this limit is appropriate. GE asserted that there was no need to cover lower wattage IRLs as they use less energy, and a market shift to them would still fulfill the purpose of this rulemaking. (GE, Public Meeting Transcript, No. 30 at p. 36) ASAP questioned whether DOE had the authority to cover lower wattages if the 40 W limit was a statutorily defined scope. (ASAP, Public Meeting Transcript, No. 30 at p. 39) NEMA asserted that because the CFR stipulates coverage for 40 W IRLs and above, DOE does not have the authority to expand the scope to lower wattages. (NEMA, No. 36 at p. 2)

NEEA noted that if the 40 W limit was statutory, it is doubtful DOE would change it. However, NEEA found that a lower wattage limit is an increasingly less useful way to describe coverage as technologies shift. Additionally, NEEA noted that a wattage limit was not an appropriate qualifier for products subject to a lm/W standard that drives products to use fewer watts to deliver a certain lumen output, such as a 20 W IRL that has the same lumen output as a 60 W IRL. NEEA commented that it had seen a similar shift occur in the market for street lighting. (NEEA, Public Meeting Transcript, No. 30 at pp. 43–44)

As described by commenters, the 40 W limit is included in the EPCA definition of IRLs. (42 U.S.C. 6291(30)(C), (C)(ii), and (F)) Therefore, proposed standards in this notice apply only to covered IRLs 40 W or higher. Additionally, while the definition of IRLs does not provide an upper wattage limit, DOE did not assess covered IRLs higher than 205 W in this proposed rule. DOE research indicated that wattages greater than 205 W comprise a very small portion of the market and are typically designed for specialty uses, and therefore, do not represent significant energy savings.

D. Summary of Scope of Coverage

In conclusion, in this rulemaking DOE is proposing extending the scope of coverage for GSFLs to certain wattages but not additional GSFL types. Further, DOE is proposing clarifying certain exemptions noted under the definition of ''general service fluorescent lamp.'' DOE is not considering IRLs less than 40 W or greater than 205 W and is also not considering the following IRL types: (1) Lamps rated 50 W or less that are ER30, BR30, BR40, or ER40; (2) lamps rated 65 W that are BR30, BR40, or ER40 lamps; and (3) R20 IRLs rated 45 W or less.

VI. Methodology and Discussion

In the preliminary phase of this rulemaking, DOE conducted a market and technology assessment, screening analysis, engineering analysis, product price determination, energy-use characterization, LCC and PBP analyses, shipments analysis and NIA, as well as a preliminary MIA. These analyses were then updated and revised as appropriate based on feedback received for this NOPR. Further, in this NOPR DOE conducted an LCC subgroup analysis, a complete MIA, a utility impact assessment, an employment impact assessment, an emissions analysis, a determination of monetization of reduced emissions from proposed standard levels, and an RIA.

DOE used three spreadsheet tools to estimate the impact of standards proposed in this NOPR. The first spreadsheet calculates LCCs and payback periods of potential new energy conservation standards. The second provides shipments forecasts and then calculates NES and NPV impacts of potential new energy conservation standards. The Department also assessed manufacturer impacts, largely through use of the Government Regulatory Impact Model (GRIM).

DOE used a version of EIA's National Energy Modeling System (NEMS) for the utility and environmental analyses. The NEMS model simulates the energy sector of the U.S. economy. EIA uses NEMS to prepare its *AEO,* a widely known baseline energy forecast for the United States. The version of NEMS used for appliance standards analysis is called NEMS–BT [21], and is based on the

[21] The EIA approves the use of the name ''NEMS'' to describe only an *AEO* version of the model without any modification to code or data. Because the present analysis entails some minor code modifications and runs the model under various policy scenarios that deviate from *AEO*

AEO 2013 version with minor modifications. The NEMS–BT accounts for the interactions between the various energy supply and demand sectors and the economy as a whole.

NEEA and NPCC stated that analyses presented in the preliminary analysis phase need further development before stakeholders will be able to comment in depth. NEEA and NPCC also offered to provide DOE field data from 2012–2013 on lamp and fixture types from their Residential Building Stock Assessment (RBSA) and the survey data from their Commercial Building Stock Assessment (CBSA). (NEEA and NPCC, No. 34 at p. 6) NEEA and NPCC strongly support the comments provided by the CA IOUs for this rulemaking. (NEEA and NPCC, No. 34 at p. 2)

In the preliminary analyses, DOE assessed the products that are the subject of this rulemaking, as well as the achievable levels of efficiency and their impacts. As noted, DOE has updated these analyses with more recent data and, where appropriate, made adjustments based on comments received from stakeholders in the preliminary analysis phase. DOE will also consider any additional data submitted by commenters in response to the NOPR.

A. Market and Technology Assessment

In the energy conservation standards rulemaking process, DOE conducts a market and technology assessment to provide an overall picture of the market for products concerned. Based primarily on publicly available information, the analysis provides both qualitative and quantitative information. The market and technology assessment includes the major manufacturers, product classes, retail market trends, shipments of covered products, regulatory and non-regulatory programs, and technologies that could be used to improve the efficacy of GSFLs and IRLs. DOE identified several technology options after conducting this assessment for the preliminary analysis.

DOE received a general comment from NEMA on the market and technology assessment questioning why a rulemaking is justified given the lack of technological innovations and changes since the 2009 Lamps Rule, the steep decline in GSFL and IRL sales expected, as shown in DOE's projections, and the waivers still providing certain products a stay of enforcement from the July 2012 standards. (NEMA, No. 36 at p. 6)

As explained in II.A, EPCA directs DOE to complete a rulemaking that examines whether current GSFL and IRL standards should be amended and if so, amend them as appropriate based on its analysis. Further, in any rulemaking DOE must adopt standard levels that achieve the maximum energy savings that is technologically feasible (see chapter 3 of the NOPR TSD) and economically justified (see chapters 8 and 12 of the NOPR TSD). Additionally, as noted previously, DOE understands that OHA has granted numerous manufacturers 2-year waivers from standards for their 700 series T8 products that expire in 2014. Because standards from this rulemaking would become effective in 2017, DOE conducts its analysis assuming that the waivers will not be in place.

NEMA also added that whether there are any technological innovations that have happened since the 2009 Lamps Rule is a valid point of discussion, but each potential technology would have to be given the same level of rigor regarding whether it is a feasible pathway or not. (NEMA, Public Meeting Transcript, No. 30 at pp. 178–179) DOE examines the latest industry literature and patents, and receives feedback from manufacturers to develop viable technology options that can increase the efficacy of GSFLs and IRLs. The identified technology options are then subjected to rigorous screening criteria before they can be considered as design options in the engineering analysis (see section VI.B). For further details on the technology options and the screening process, see, respectively, chapters 3 and 4 of the NOPR TSD.

1. General Service Fluorescent Lamp Technology Options

DOE received comments specific to the GSFL technology options put forth in the preliminary analysis. Specifically, stakeholders provided feedback on higher efficiency lamp diameters, higher efficiency lamp fill gas composition, and higher efficiency phosphors.

Higher Efficiency Lamp Diameters

DOE considered more efficient lamp diameters as one of the technology options to increase GSFL efficacy in the preliminary analysis. This option is considered as there is an optimum design diameter for a specific fluorescent lamp type that can increase lamp efficacy.

NEMA stated that strictly speaking the reduction of lamp diameter does not necessarily increase efficacy and that T5 and T8 lamps are already at their optimum diameters. Further, NEMA and GE stated that the market has already shifted to the most efficient diameters. (NEMA, Public Meeting Transcript, No. 30 at pp. 73; NEMA, No. 36 at p. 5; GE, Public Meeting Transcript, No. 30 at pp. 71–72) While NEMA did not believe higher efficiency diameter should be retained as a technology option, NEMA and Philips requested additional clarifying information about DOE's underlying analysis of this option. (NEMA, No. 36 at p. 5; Philips, Public Meeting Transcript, No. 30 at p. 70)

In small diameter lamps, an increase in diameter decreases the number of electrons and mercury ion recombination at the bulb wall, increasing ultraviolet (UV) output and lamp efficacy. In large diameter lamps, this recombination may already be minimal and a further enlargement in diameter causes a greater imprisonment of radiation within the lamp, decreasing light output and efficacy. Therefore, DOE understands this technology option should be applied only in cases where there is a potential to optimize the lamp diameter in order to achieve higher lamp efficacy gain. Based on DOE's assessment there are less efficacious lamps on the market that can be improved by using a higher efficiency diameter. For example, standards-compliant T12 diameter product offerings remain in the 4-foot MBP and 8-foot SP slimline product classes. Therefore, DOE continues to consider higher efficiency lamp diameter as a technology option to increase the efficacy of GSFLs.

Higher Efficiency Lamp Fill Gas Composition

Higher efficiency lamp fill gas composition was another technology option identified in the preliminary analysis. Lamp fill gases in fluorescent lamps increase mobility of mercury ions and electrons, facilitating recombination and resulting in increased UV output and higher lamp efficacy. Gases with lower molecular weight, such as argon, generally result in higher lamp efficacy. Full wattage lamps generally use argon gas. Reduced wattage lamps use a mixture of krypton and argon. Krypton, while a higher molecular weight gas, lowers the wattage of the lamp, thereby resulting in a higher lamp efficacy. NEMA stated that GSFLs are already optimized for the tradeoff of argon and krypton mixes and further efficacy gains are not possible using krypton. (NEMA, No. 36 at p. 14)

Based on DOE's research and feedback from manufacturers in interviews, the type and ratios of fill gases remain a mechanism to increase

assumptions, the name ''NEMS–BT'' refers to the model as used here. (BT stands for DOE's Building Technologies Program.) For more information on NEMS, refer to *The National Energy Modeling System: An Overview,* DOE/EIA–0581 (2009), available at: *http://www.eia.gov/oiaf/aeo/overview/index.html.*

lamp efficacy. Because lamps are present on the market at more than one level of efficacy, DOE believes lamp fill gas is one option that can be utilized to improve the efficacy of less efficacious products. Therefore, DOE continues to consider higher efficiency lamp fill gas as a means to improve the efficacy of fluorescent lamps covered under this rulemaking.

Higher Efficiency Phosphors

DOE also identified higher efficiency phosphors as an option for increasing efficacy in GSFLs. The main purpose of phosphor in a fluorescent lamp is to absorb the UV radiation and reemit it as visible radiation. In particular, the lamp efficacy can be improved in this manner by using triband phosphors containing rare earth elements, which can greatly increase UV absorption and emission of radiation in the visible spectrum relative to other phosphors. In response to this technology option, NEMA stated that GSFLs are already optimized for rare earth phosphors. (NEMA, No. 36 at p. 14)

Based on DOE's research and feedback from manufacturers in interviews, the blend, weight, and thickness of rare earth phosphors in fluorescent lamps is a key element in increasing the lamp efficacy. Because lamps are present on the market at more than one level of efficacy, DOE believes higher efficiency phosphor is one option that can be utilized to improve the efficacy of less efficacious products. Therefore, DOE continues to consider higher efficiency phosphors as a means to improve the efficacy of fluorescent lamps covered under this rulemaking.

Summary of GSFL Technology Options

In summary, DOE has developed the list of technology options shown in Table VI.1 to increase efficacy of GSFLs.

TABLE VI.1—GSFL TECHNOLOGY OPTIONS IN THE NOPR ANALYSIS

Name of technology option	Description
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.	Phosphors increase the conversion of ultraviolet light into visible light.
Glass Coatings	Coatings on inside of bulb enable the phosphors to absorb more UV energy, so that they emit more visible light.
Higher Efficiency Lamp Diameter.	Optimal lamp diameters improve lamp efficacy.
Multi-Photon Phosphors.	Phosphors emit more than one visible photon for each incident UV photon.

2. Incandescent Reflector Lamp Technology Options

DOE received comments specific to the IRL technology options put forth by DOE in the preliminary analysis. Specifically, stakeholders provided feedback on efficient filament placement, higher efficiency inert fill gas, and integrally ballasted low voltage lamps.

Efficient Filament Placement

Efficient filament placement is one of the technology options presented in the preliminary analysis that can increase the efficacy of IRLs. An optimally placed filament allows a portion of the spectrum emitted by the filament to focus back onto it. The additional heat provided to the filament increases the operating temperature and thereby increases lamp efficacy.

NEMA disagreed that efficient filament placement should be considered a technology option for improving efficacy. NEMA commented that filament placement determines the beam spread of a lamp, which is considered a performance characteristic, not a degree of efficacy. If the filament placement were changed to make a lamp more efficacious, it would also change the beam spread, thereby altering a lamp's utility. (NEMA, Public Meeting Transcript, No. 30 at pp. 74–75) Understanding that efficient filament placement refers to the placement of the filament in an infrared (IR) capsule, the CA IOUs stated that filament placement impacts the amount of reflected radiation that hits the filament, which in turn impacts the amount of light emitted by the lamp. (CA IOUs, Public Meeting Transcript, No. 30 at p. 81–82) GE responded that filaments must be placed as close to the center of IR capsules as possible, and their placement has already been optimized. (GE, Public Meeting Transcript, No. 30 at pp. 82) Philips noted that manufacturers do not know how to place filaments any more precisely than they are now, although there is manufacturing variation. (Philips, Public Meeting Transcript, No. 30 at pp. 82–83)

DOE acknowledges that it is theoretically well understood where the filament should be placed to achieve higher efficacy in IRLs. Additionally, the above comments and feedback during manufacturer interviews indicate that lamps are being designed so that the filament is placed in the most optimal position. Therefore, because the optimal filament placement design has been identified and is being applied in all commercially available products, DOE proposes to not consider efficient filament placement as a technology option.

Higher Efficiency Inert Fill Gas

DOE presented high efficiency inert fill gas as another technology option to increase IRL efficacy in the preliminary analysis. Fill gases such as krypton and xenon have low thermal conductivity that decreases the convective cooling of the filament, allowing for higher temperature operation and therefore higher efficacy. These gas molecules are larger relative to other gases, and can more effectively slow down the evaporation of tungsten and thereby extend the life of the lamp. Xenon, having even lower heat conductivity and larger mass than krypton, can more drastically change efficacy and life, but has a higher cost. Most lamps compliant with the July 2012 standards use xenon as a fill gas.

NEEA and NPCC indicated that xenon fill gas should not be considered a technology option as it is already used in all, or nearly all, halogen-based technologies, including those at the lower end of the efficacy scale. Comparatively, there is an approximately 3 percent drop in efficacy when using a fill gas like krypton, and accordingly the market has clearly adopted xenon and uses it almost exclusively. (NEEA and NPCC, No. 34 at p. 2, 5) The CA IOUs also stated that their research indicated that most, if not all, commercially available parabolic aluminized reflector (PAR) lamps, including those that are lower efficacy products or minimally compliant with the 2009 Lamps Rule, are already using xenon as their fill gas. The CA IOUs, therefore, concluded that additional xenon would not be required to meet higher standards. (CA IOUs, No. 32 at pp. 9–10)

Based on feedback from manufacturer interviews, DOE confirmed that the majority of covered standards-compliant

IRLs are utilizing xenon. However, DOE also learned that the amount of xenon used in lamp can vary based on several factors. Because lamps are present on the market at more than one level of efficacy, higher efficiency inert fill gas is one option that can be utilized to improve the efficacy of less efficacious products. Therefore, DOE continues to consider high efficiency inert fill gas as a technology option.

Integrally Ballasted Low Voltage Lamps

DOE also considered integrally ballasted low voltage lamps as a technology option in the preliminary analysis. The use of an integral ballast in an incandescent lamp allows an increase in the efficacy because it converts the line voltage to lower lamp operating voltages, thereby reducing the lamp wattage.

NEMA stated that integrally ballasted low voltage lamps are not viable at high wattages, and the technology is expensive and rarely used. Therefore, NEMA asserted that this technology is for a niche product, and cannot be applied across the board. (NEMA, Public Meeting Transcript, No. 30 at p. 74–75; NEMA, No. 36 at p. 7)

While the technology is not appropriate for higher wattage products, the CA IOUs argued that it is still a valid design option for reduced wattage lamps. The CA IOUs explained that in halogen infrared reflector (HIR) lamps, making the filament a denser target increases the amount of radiation that is successfully reflected back to it, thereby increasing the lamp efficacy. At line voltage, a higher wattage halogen burner incorporates a relatively large diameter filament; however a lower wattage capsule must use a finer filament. For these low wattage lamps, reducing the line voltage to low voltage allows the use of a shorter, fatter filament, which is ideal for HIR technology. While a lamp greater than 50 W is suited for line voltage and may operate at too high of a temperature for an integral ballast, a lamp less than 50 W is better suited for low voltage operation and run at temperatures compatible with an integral transformer. Particularly, as halogen lamps are designed to be more efficacious, lower reduced wattage products will be more common; for this reason, the CA IOUs envisioned integrally ballasted low voltage halogen products to be the predominant design strategy for very high efficacy halogen products going forward. (CA IOUs, No. 32 at p. 9)

In interviews, manufacturers stated that the use of an integral ballast to lower voltage is not a feasible technology in higher wattage lamps due to issues with dissipating heat generated by the electronic components. Manufacturers indicated that heat dissipation becomes a problem at wattages ranging from 20 to 35 W. DOE research also indicated that in converting to a lower voltage, current is increased and greater heat generated from the filament. In higher wattage IRLs, the resulting increased temperature can be damaging to the voltage conversion circuitry. Further, based on manufacturer interviews there are no covered IRLs that currently utilize this technology option. Because the lower limit of IRL wattages covered under standards is 40 W, DOE is no longer considering integrally ballasted low voltage lamps as a technology option for improving lamp efficacy.

Higher Efficiency Burner

DOE did not consider a higher efficiency halogen burner as a technology option in the preliminary analysis. DOE acknowledged that use of a double-ended burner in an IRL can increase the efficacy compared to a single-ended burner. Further, because double-ended burners could not fit into small diameter IRLs (*i.e.,* diameters less than or equal to 2.5 inches), DOE applied a 3.5 percent reduction when scaling efficacy levels from large diameter lamps (*i.e.,* all diameters greater than 2.5 inches) that could utilize a double-ended burner to small diameter lamps. (For further discussion on IRL scaling factor see section VI.D.3.g and chapter 5 of the NOPR TSD.)

Based on further research and interviews with manufacturers, DOE confirmed in the NOPR analysis that a key aspect of higher efficiency IRLs is HIR technology. Because the type of burner utilized is an important component of an HIR lamp, in this NOPR analysis, DOE is considering higher efficiency burners as a technology option to increase IRL efficacy. Single-ended burners feature a lead wire inside of the capsule that carries current between the filament and the electrical connection in the base of the lamp. The presence of this wire inside of the capsule prevents a certain amount of energy from reaching the capsule wall and being reflected (recycled) back to the capsule filament. However, double-ended burners have a lead wire outside of the capsule that does not interfere with the reflectance of energy back to the filament, allowing for a more efficacious lamp. Hence, DOE is proposing higher efficiency burner as a technology option that can increase efficacy of IRLs.

Summary of IRL Technology Options

Of the IRL technology options presented in the preliminary analysis, DOE is no longer considering integrally ballasted low voltage lamps as a technology option. In addition to the IRL technology options identified in the preliminary analysis, DOE is proposing the inclusion of the higher efficiency burner as a technology option. In summary, in this NOPR analysis, DOE is proposing the IRL technology options listed in Table VI.2.

TABLE VI.2—IRL TECHNOLOGY OPTIONS IN THE NOPR ANALYSIS

Name of technology option	Description
Higher Temperature Operation	Operating the filament at higher temperatures, the spectral output shifts to lower wavelengths, increasing its overlap with the eye sensitivity curve.
Microcavity Filaments	Texturing, surface perforations, microcavity holes with material fillings, increasing surface area and thereby light output.
Novel Filament Materials	More efficient filament alloys that have a high melting point, low vapor pressure, high strength, high ductility, or good radiating characteristics.
Thinner Filaments	Thinner filaments to increase operating temperature. This measure may shorten the operating life of the lamp.
Efficient Filament Coiling	Coiling the filament to increase surface area, thus increasing light output.
Crystallite Filament Coatings	Layers of micron or submicron crystallites deposited on the filament surface that increases emissivity of the filament.
Efficient Filament Orientation	Positioning (horizontal or vertical) the incandescent filament to increase light emission from the lamp. Vertical orientation, used by majority of lamps, allows for greater light emission.
Higher Efficiency Inert Fill Gas	Filling lamps with alternative gases, such as Krypton, to reduce heat conduction.
Higher Pressure Tungsten-Halogen Lamps	Increased halogen bulb capsule pressurization, allowing higher temperature operation.

TABLE VI.2—IRL TECHNOLOGY OPTIONS IN THE NOPR ANALYSIS—Continued

Name of technology option	Description
Non-Tungsten-Halogen Regenerative Cycles	Novel filament materials that regenerate.
Infrared Glass Coatings	When used with a halogen capsule, this is referred to as a HIR lamp. Infrared coatings on the inside of the bulb to reflect some of the radiant energy back onto the filament.
IR Phosphor Glass Coatings	Phosphor coatings that can absorb IR radiation and re-emit it at shorter wavelengths (visible region of light), increasing the lumen output.
UV Phosphor Glass Coatings	Phosphor coatings that convert UV radiation into longer wavelengths (visible region of light), increasing the lumen output.
Electron Stimulated Luminescence	A low voltage cathodoluminescent phosphor that emits green light (visible region of light) upon impingement by thermally ejected electrons, increasing the lumen output.
Higher Efficiency Reflector Coatings	Alternative reflector coatings such as silver, with higher reflectivity increase the amount of directed light.
Corner Reflectors	Individual corner reflectors in the cover glass that reflect light directly back in the direction from which it came.
High Reflectance Filament Supports	Filament supports that include a reflective face that reflects light to another filament, the reflective face of another filament support, or radially outward.
Permanent Infrared Reflector Coating Shroud	Permanent shroud with an IR reflector coating and a removable and replaceable lamp can increase efficiency while reducing manufacturing costs by allowing IR reflector coatings to be reused.
Higher Efficiency Burners	A double-ended burner that features a lead wire outside of the capsule, where it does not interfere with the reflectance of energy from the capsule wall back to the capsule filament in HIR lamps.

B. Screening Analysis

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

- *Technological Feasibility:* DOE will consider technologies incorporated in commercially available products or in working prototypes to be technologically feasible.
- *Practicability to Manufacture, Install, and Service:* If mass production of a technology and reliable installation and servicing of the technology could be achieved on the scale necessary to serve the relevant market at the time the standard comes into effect, then DOE will consider that technology practicable to manufacture, install, and service.
- *Adverse Impacts on Product Utility or Product Availability:* If DOE determines a technology to have significant adverse impact on the utility of the product to significant subgroups of consumers, or to result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not further consider this technology.
- *Adverse Impacts on Health or Safety:* If DOE determines that a technology will have significant adverse impacts on health or safety, it will not further consider this technology.

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

1. General Service Fluorescent Lamp Design Options

In the preliminary analysis, of the GSFL technology options identified, DOE did not consider screening out higher efficiency lamp fill gas composition and glass coatings; however, DOE received several comments on these two design options. DOE did not receive any feedback on the other GSFL design options put forth in the preliminary analysis.

Higher Efficiency Lamp Fill Gas Composition

In the preliminary analysis, DOE determined that higher efficiency lamp fill gas composition met the screening criteria and considered it as a design option. As previously described, lamp fill gases such as argon increase mobility of mercury ions and electrons, facilitating recombination and thereby increasing UV output and resulting in higher lamp efficacy. Krypton is primarily used as a fill gas in reduced wattage lamps because it lowers lamp wattage, thereby resulting in higher lamp efficacy. NEMA noted that the resulting reduced wattage lamps have issues with cold temperature applications, striations, and dimmability due to the use of krypton and pointed out that these items are performance characteristics that should be considered in the screening analysis. NEMA encouraged DOE to explore the trade-offs to ensure the right balance is obtained. (NEMA, Public Meeting Transcript, No. 30 at pp. 78–79)

Based on previous manufacturer feedback, DOE is aware that the presence of krypton in reduced wattage lamps causes issues with lamp starting and striations in cold temperature applications below 60–65 °F. Feedback from manufacturers in interviews has also indicated that problems encountered with dimming linear fluorescent lamps, including lamp starting, striations, and dropout, are exacerbated by the use of krypton in reduced wattage lamps. Krypton, which lowers the wattage of a fluorescent lamp, is the primary fill gas used in reduced wattage fluorescent lamps. Based on feedback from manufacturers the use of any amount of krypton will result in dimming issues and increase with the amount of krypton.

Philips noted that issues with dimming reduced wattage lamps could also be related to the ballast as well as compatibility with the dimmer and lamp. Philips further noted that they had observed that a lamp-ballast system would dim successfully in one building but fail when put in a different building.

(Philips, Public Meeting Transcript, No. 30 at p. 225)

Despite the issues with dimming and operation in cold temperatures, DOE has determined that reduced wattage lamps using krypton can be found on the market in various wattages. Feedback from manufacturers in interviews also indicates that reduced wattage lamps comprise a significant portion of their GSFL shipments. Additionally, consumers have other options, as more reliable dimming can be attained using full wattage lamps and fluorescent lamps designed to be operated in cold temperature applications exist on the market.

Therefore, DOE has determined that higher efficiency lamp fill gas composition, specifically in the form of krypton, meets the criteria of being technologically feasible and practicable to manufacture as it is used in commercially available products. DOE has found no evidence to indicate it has adverse impacts on health and safety. Because DOE is considering standard levels that ensure the availability of both full and reduced wattage lamps, DOE has determined that the use of this technology does not have an adverse impact on product utility or availability. Therefore, DOE proposes to maintain higher efficiency lamp fill gas as a design option for GSFLs.

Glass Coatings

In the preliminary analysis, DOE determined that glass coatings met the screening criteria and considered them as a design option. To increase the UV absorption by the phosphors, the lamp glass can be covered with an antireflective coating. This coating is a refractory oxide, such as aluminum oxide (Al_2O_3), silicon oxide (SiO_2), and titanium oxide (TiO_2) that reflects any UV radiation that passes through the phosphor back onto the phosphor, allowing a greater portion of UV to be absorbed, thereby increasing light output and lamp efficacy. NEMA stated that glass coatings should be screened out as the techniques are not feasible, which is the reason they are not already widely used. (NEMA, No. 36 at p. 7; NEMA, Public Meeting Transcript, No. 30 at pp. 70)

DOE determined that most modern lamps utilize glass coatings that minimize the absorption of mercury and act as reflectors of UV radiation.[22] An undercoat layer, preferably composed of aluminum oxide and a getter material, reflects UV radiation that has passed through the luminescent material of the lamp back onto the material for increased visible light output and also reduces the contaminants in the lamp. A patent relevant to this technology notes that such undercoating is a common feature of modern fluorescent lamps.[23]

Because this technology option is being used in commercially available fluorescent lamps, DOE considers it to be practicable to manufacture. DOE is not aware of any evidence indicating that the technology has adversely impacted product utility or health and safety. Therefore, DOE proposes to maintain glass coatings as a design option for GSFLs.

In summary, in this NOPR analysis DOE is proposing as design options the following GSFL technologies that have met the screening criteria:

- Highly Emissive Electrode Coatings
- Higher Efficiency Lamp Fill Gas Composition
- Higher Efficiency Phosphors
- Glass Coatings
- Higher Efficiency Lamp Diameter

See chapter 4 of the NOPR TSD for further details on the GSFL screening analysis.

2. Incandescent Reflector Lamp Design Options

DOE did not receive any feedback on IRL design options put forth in the preliminary analysis.

Higher Efficiency Burners

As mentioned previously, in this NOPR analysis DOE is proposing the additional technology option of a higher efficiency burner as a means to improve IRL efficacy. DOE evaluated the higher efficiency burner technology against the screening criteria. DOE found that higher efficiency burners, such as the double-ended burner, are currently being utilized in commercially available lamps and have demonstrated that they are technologically feasible, practicable to manufacture, install, and service on a commercial scale by the compliance date of any amended standards, and do not result in adverse impacts on product utility or availability, or health and safety. DOE acknowledges that double-ended burners cannot be used in small diameter lamps without changing the physical shape of the lamp, which may impact whether the lamp can fit standard fixtures, and thereby affect product utility. Therefore, DOE is proposing higher efficiency burners as a design option only for IRLs with diameters greater than 2.5 inches.

In summary, in this NOPR analysis DOE is proposing as design options the following IRL technologies that have met the screening criteria:

- Higher Temperature Operation
- Thinner Filaments
- Efficient Filament Coiling
- Efficient Filament Orientation
- Higher Efficiency Inert Fill Gas
- Higher Pressure Tungsten-Halogen Lamps
- Infrared Glass Coatings
- Higher Efficiency Reflector Coatings (with the exception of gold reflector coatings)
- Higher Efficiency Burner

See chapter 4 of the NOPR TSD for further details on the IRL screening analysis.

C. Product Classes

DOE divides covered products into classes by: (a) The type of energy used; (b) the capacity of the product; or (c) other performance-related features that justify different standard levels, considering the consumer utility of the feature and other relevant factors. (42 U.S.C. 6295(q)) In a general comment, NEMA requested that DOE ensure CSLs do not potentially eliminate utility from the market. (NEMA, No. 36 at p. 20) As noted, when assessing factors for product class divisions, DOE considers consumer utility.

DOE received several comments regarding product classes considered in the preliminary analysis.

1. General Service Fluorescent Lamp Product Classes

In the preliminary analysis DOE considered product classes for GSFLs based on the following three factors: (1) CCT; (2) physical constraints of lamps (*i.e.,* lamp shape and length); and (3) lumen package. DOE received comments regarding the CCT product class division and a suggestion to establish a product class division based on a lamp's dimming functionality. DOE did not receive feedback on the other product class divisions put forth for GSFLs in the preliminary analysis.

CCT

In the preliminary analysis, DOE considered CCT, noted in degrees Kelvin (K), as a class setting factor, specifically, product classes for GSFLs with a CCT less than or equal to 4,500 K and a product class for GSFLs with a CCT greater than 4,500 K. NEEA and NPCC noted that while DOE stated that GSFLs with a CCT greater than 4,500 K show a decline in efficacy, DOE did not

[22] DiLaura, D. L., K. W. Houser, R. G. Mistrick, and G. R. Steffy. *IESNA Lighting Handbook: Reference and Application, 10th Edition.* New York: IESNA, 2011.

[23] Trushell, Charles and Liviu Magean. *Method of manufacturing a fluorescent lamp having getter on a UV reflective base coat.* U.S. Patent No. 7,500,896 B2, filed May 9, 2005, and issued Mar 10, 2009.

state the degree of the decline of efficacy, whether it was consistent across manufacturers, or if the decline was inherent in the phosphor mixes required to produce the higher CCT values. NEEA and NPCC noted that they may support having a separate product class for these lamps, but that additional data is needed. (NEEA and NPCC, No. 34 at p. 3)

CCT is a measure of the perceived color of white light emitted from a lamp. The lower CCTs correspond to warm light and are in the red wavelengths while the higher CCTs correspond to cooler light and are in blue wavelengths. The human eye is less responsive to light in the blue wavelengths and therefore, efficacy decreases in lamps with higher CCTs. The phosphor blend used in a lamp substantially impacts the lamp's CCT. For example, the use of rare earth phosphors results in light emitted at wavelengths to which the human eye is most sensitive, thereby increasing the lamp efficacy. Therefore, different phosphor blends in lamps achieve different CCTs. (See chapter 3 of the NOPR TSD for further details on fluorescent lamp technology.)

DOE determined through analysis and confirmed with manufacturers that lamps with CCTs greater than 4,500 K start showing a decline in efficacy. Feedback from manufacturers varied regarding the exact efficacy reduction correlated with CCT and whether it was consistent across GSFL types. DOE's evaluation of catalog and compliance efficacies for similar lamp types at different CCTs for various manufacturers has shown that in general, there is a reduction in the range of 2–6 percent going from a CCT of 4,500 K or less to a CCT greater than 4,500 K. (See section VI.D.2.h and chapter 5 of the NOPR TSD for scaling to higher CCT product classes.)

Therefore, because consumers are afforded a different perception of light at different CCTs and efficacy is impacted with varying CCTs, DOE proposes to maintain CCT as a product class division factor. Specifically DOE is proposing to establish a product class of lamps with CCTs less than or equal to 4,500 K and a product class with CCTs greater than 4,500 K.

Dimming Utility

NEMA noted that DOE may not set standards that would eliminate full wattage GSFLs because the Secretary may not prescribe standards ''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 at the time of the Secretary's finding.'' (42 U.S.C. 6295(o)(4)) NEMA emphasized that as dimmability and uniformity of light (absence of flicker or striation) are all performance characteristics highly desirable in the marketplace, they must be maintained. (NEMA, No. 36 at p. 4) Further, NEMA stated that potential energy savings from dimming will be reduced or lost if DOE eliminates full wattage 32 W GSFLs from the market. (NEMA, No. 36 at p. 15) Lutron agreed that elimination of full wattage lamps that are argon-filled would also get rid of dimming. (Lutron, Public Meeting Transcript, No. 30 at pp. 25)

EEI noted that the increase of lighting controls requirements in building codes such as those put out by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and International Energy Conservation Code (IECC) means that dimmability is a performance characteristic necessary for operation in commercial buildings. (EEI, Public Meeting Transcript, No. 30 at p. 79–80) The CA IOUs reiterated the importance of not eliminating dimming products from the market. They suggested that if there are two sets of products, one with dimming capability and one with higher efficacy, there may be grounds to create separate product classes so that covered products will comply with standards either by having higher efficacy or by dimming. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 135)

DOE acknowledges that there are issues with dimming reduced wattage lamps that do not typically manifest in full wattage lamps. DOE is aware that unreliable dimming is in part due to the use of krypton as the fill gas in reduced wattage lamps as well as other factors. (See the discussion on higher efficiency lamp fill gas composition in VI.A.1.) Therefore, DOE is ensuring that any proposed level can be met by full wattage lamps. Because the utility of dimming is being preserved in the existing product class structure and for the analyzed standard levels, DOE is not proposing fill gas that allows for reliable dimming as a product class setting factor. (See section VI.D.2.g and chapter 5 of the NOPR TSD for the GSFL engineering analysis.)

Summary of GSFL Product Classes

In this NOPR analysis, DOE is proposing the product classes for GSFLs summarized in Table VI.3. See chapter 3 of the NOPR TSD for further details on each GSFL product class.

TABLE VI.3—GSFL PRODUCT CLASSES IN NOPR ANALYSIS

Lamp type	CCT
4-foot medium bipin	≤4,500 K
	>4,500 K
2-foot U-shaped	≤4,500 K
	>4,500 K
8-foot single pin slimline	≤4,500 K
	>4,500 K
8-foot recessed double contact high output	≤4,500 K
	>4,500 K
4-foot T5, miniature bipin standard output	≤4,500 K
	>4,500 K
4-foot T5, miniature bipin high output	≤4,500 K
	>4,500 K

2. Incandescent Reflector Lamp Product Classes

In the preliminary analysis, DOE considered product classes for IRLs based on the following three factors: (1) Rated voltage, separating lamps less than 125 V from lamps greater than or equal to 125 V; (2) lamp spectrum, separating lamps with a standard spectrum from lamps with a modified spectrum; and (3) lamp diameter, separating lamps with a diameter greater than 2.5 inches from lamps with a diameter less than or equal to 2.5 inches. DOE received several comments on the rated voltage class setting factor. DOE did not receive feedback on the other product class divisions put forth for IRLs in this preliminary analysis.

Rated Voltage

In the preliminary analysis, DOE considered rated voltage as a class setting factor, establishing a product class for IRLs with voltages less than 125 V and a product class for IRLs with voltages greater than or equal to 125 V. IRLs mainly come in rated voltages of 120 or 130. This product class division establishes two separate product classes for the 120 V IRLs and the 130 V IRLs.

NEEA and NPCC stated that DOE should maintain separate product classes for lamps that are less than 125 V and those that are greater than or equal to 125 V. They indicated that if there were demand for 130 V lamps, it would be highly likely that standards compliant 130 V lamps would enter the market, as there is nothing inherent in the standard levels that would eliminate 130 V lamps. (NEEA and NPCC, No. 34 at p. 4)

Advanced Lighting Technologies (ADLT) agreed, pointing out that combining lamps less than 125 V and greater than or equal to 125 V lamps into one product class would allow 130 V lamps on the market that fall below the July 2012 efficacy requirement of $5.9P^{0.27}$ when operated at 120 V. ADLT gave the example that a 130 V 70 W lamp would be required to produce 19.5 lm/W under DOE's CSL 1 of $6.2P^{0.27}$ for less than 125 V lamps. However, operating the same 130 V, 70 W lamp in a 120 V socket would result in lowering the wattage to 61.5 W and efficacy to 16.8 lm/W,[24] which equates to $5.4P^{0.27}$. Therefore, a 130 V, 70 W lamp operating at 120 V would fall well below the July 2012 requirement of $5.9P^{0.27}$. (ADLT, No. 31 at p. 2)

Existing DOE test procedures provide for lamps rated at 130 V to be tested at 130 V and for lamps rated at 120 V to be tested at 120 V. However, DOE is aware that a large number of consumers actually operate 130 V lamps at 120 V, which results in longer lifetime but lower efficacy. With a single EL for lamps rated at each voltage, this situation would effectively lead to a lower efficacy requirement for these 130 V lamps run at 120 V, compared to 120 V lamps run at 120 V. The 130 V lamps would not require the same level of technology as 120 V lamps to meet the same standard, and, thus, would be cheaper to produce. Therefore, setting higher standards for IRLs without accounting for voltage differences could result in increased migration to 130 V lamps instead of the 120 V lamps. When consumers operate these lamps at 120 V, they may need to purchase more lamps to obtain sufficient light output, thereby increasing energy consumption. Hence, in order to preserve energy savings, DOE proposes to maintain the rated voltage class division that separates covered IRLs less than 125 V from those that are greater than or equal to 125 V.

Summary of IRL Product Classes

In this NOPR analysis, DOE is proposing the product classes for IRLs summarized in Table VI.4. See chapter 3 of the NOPR TSD for further details on each IRL product class.

TABLE VI.4—IRL PRODUCT CLASSES IN NOPR ANALYSIS

Lamp type	Diameter (in inches)	Voltage
Standard Spectrum	>2.5	≥125 V
		<125 V
	≤2.5	≥125 V
		<125 V
Modified Spectrum	>2.5	≥125 V
		<125 V
	≤2.5	≥125 V
		<125 V

D. Engineering Analysis

1. General Approach

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

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

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

More efficacious substitutes: DOE selects higher efficacy lamps as replacements for each of the baseline models considered. When selecting higher efficacy lamps, DOE considers only design options that meet the criteria outlined in the screening analysis (see section VI.B or chapter 4 of the NOPR TSD). For GSFLs, DOE pairs each lamp with an appropriate ballast because fluorescent lamps are a component of a system, and their performance is related to the ballast on which they operate.

Efficacy levels: After identifying the more efficacious substitutes for each baseline lamp, DOE develops ELs. DOE bases its analysis on three factors: (1) The design options associated with the specific lamps studied; (2) the ability of lamps across wattages to comply with the standard level of a given product class;[25] and (3) the max tech EL. DOE then scales the ELs of representative product classes to those classes not directly analyzed.

DOE received a general comment on the methodology used in this rulemaking to develop efficacy levels for both GSFLs and IRLs. NEMA noted that additional adjustments for variation of product performance for manufacturing and testing variations must be afforded not only to compliance but to interpretations of published catalog data. NEMA referred DOE to NEMA LSD–63 Measurement Methods and Performance Variation for Verification Testing of General Purpose Lamps and Systems for guidance on proper application of statistical analysis for lighting products. (NEMA, No. 36 at pp. 11–12; Philips, Public Meeting Transcript, No. 30 at pp. 134)

DOE reviewed NEMA LSD–63 to determine whether additional adjustments due to manufacturing and testing variation were needed based on the guidance provided in the document. DOE determined that the guidance was not applicable to the datasets utilized by DOE to conduct the analysis,

[24] DiLaura, D. L., K. W. Houser, R. G. Mistrick, and G. R. Steffy. *IESNA Lighting Handbook: Reference and Application, 10th Edition.* New York: IESNA, 2011.

[25] ELs span multiple lamps of different wattages. In selecting ELs, DOE considered whether these multiple lamps can meet the standard levels.

specifically lamp manufacturer catalog data and DOE's certification database. DOE received feedback from manufacturers that catalog data represents the long term average performance of products. In comparison, LSD–63 provides guidance for comparing a small sample set of test data to rated catalog values through statistical analysis to determine if the small sample set is part of the long term rating distribution. Because the guidance prescribed in LSD–63 is relevant for small sample sets and DOE is basing its analysis on catalog data representing long term performance data, DOE did not make adjustments for variation using this guidance.

Further, as discussed in section VI.D.2.a, DOE considers certification data provided in DOE's database to account for variation when establishing the minimum efficiency requirements for each efficacy level. By accounting for the compliance requirements when establishing efficacy levels, DOE incorporates manufacturing and testing variation and therefore uses values representative of the energy use of the products.

Stakeholders had several comments regarding the engineering analysis presented in the preliminary TSD specific to GSFLs and IRLs. The following sections discuss and address feedback received from stakeholders for each product. DOE requests comment on the overall methodology, assumptions, and results of the GSFL and IRL engineering analyses.

2. General Service Fluorescent Lamp Engineering

DOE received comments on the engineering analysis for GSFLs presented in the preliminary TSD. Stakeholders provided feedback on DOE's data approach, representative product classes, baseline lamps, selection of more efficacious substitutes, lamp-and-ballast pairings, max tech levels, CSLs, and scaling. The following sections summarize the comments and responses received on these topics, and present the proposed GSFL engineering for this NOPR analysis.

a. Data Approach

For the preliminary analysis, DOE considered commercially available lamps when possible. DOE used performance data of the commercially available lamps presented in manufacturer catalogs to identify potential baseline lamps and develop initial efficacy levels. DOE calculated efficacy as the initial lumen output published in manufacturer catalogs divided by the ANSI rated wattage. For lamp types that do not have a defined ANSI rated wattage, DOE utilized the lamp's nominal wattage to calculate catalog efficacy. However, DOE also analyzed publicly available data submitted to DOE by manufacturers to demonstrate compliance with existing energy conservation standards.[26] DOE adjusted efficacy levels to account for certification data when available.

Usability of Certification Data and Catalog Data

The CA IOUs noted statements made during the public meeting indicated that the catalog data may not be precise as it is not subject to any reporting regulations and further the certification database may be inaccurate. The CA IOUs asked that clarification be provided regarding the data used in the GSFL analysis. (CA IOUs, No. 32 at pp. 12–13) The CA IOUs also noted that a large number of products in DOE's certification database did not seem to have been included in this rulemaking analysis for GSFLs. In particular, the CA IOUs noted that there were about 20 or 30 products that are above 96 lm/W for the representative 4-foot MBP product class from about ten manufacturers including MaxLite, Satco, Philips, and Westinghouse, as well as a product exceeding 100 lm/W. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 114–115)

GE suggested that because such high measured lm/W values are not achievable, the issue may be that the information in the certification database is being misread or there may be confusion among manufacturers about what exactly to report in each column which could be resulting in false calculations. (GE, Public Meeting Transcript, No. 30 at p. 115, pp. 141) GE noted that manufacturers have questions pending to DOE regarding certification reporting. (GE, Public Meeting Transcript, No. 30 at pp. 141) The CA IOUs agreed with GE that there could be inconsistencies or confusion with which values to report and encouraged DOE to look into these issues further. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 115–116) ASAP pointed out that there may be possible enforcement issues if there are products in the certification database that are non-compliant. (ASAP, Public Meeting Transcript, No. 30 at pp. 139) GE added that it could be that the lamps are in compliance but the claims being made are aggressive. (GE, Public Meeting Transcript, No. 30 at pp. 141)

[26] The publicly available compliance information for GSFLs can be found in DOE's Compliance Certification Database available here: *www.regulations.doe.gov/certification-data/.*

NEEA disagreed that the certification database was being misread. NEEA recommended the use of a consistent set of data and requested general clarification on the data utilized in the analysis. (NEEA, Public Meeting Transcript, No. 30 at pp. 139–140) ASAP asked if there is a discrepancy between catalog and certification values for products. (ASAP, Public Meeting Transcript, No. 30 at pp. 146–147) Philips explained that values initially published in catalogs are based on a small set of samples and these values change as the sample size increases and is more representative of manufacturing. The initially published catalog values are eventually synched with values based on the greater sample size but catalogs are updated only every two or three years. Further there is some allowable difference between the marketed efficacy values and the certification efficacy values. (Philips, Public Meeting Transcript, No. 30 at pp. 147–148)

NEEA and NPCC stated that they are unable to comment extensively on the GSFL analysis due to DOE's use of catalog efficacy values and ANSI rated wattages instead of measured and/or certified values including using test data at appropriate test conditions such as testing at 25 °C. (NEEA and NPCC, No. 34 at p. 2, 3) Noting that comments by manufacturers during the public meeting indicated that catalog and certification values will be different, NEEP as well as NEEA and NPCC recommended DOE use measured and/or certified values for its analysis, and not use catalog values for any part of the analysis. (NEEA and NPCC, No. 34 at p. 2, 3; NEEP, No. 33 at p. 2) NEEA and NPCC stated that once it had seen measured and/or certified values, it suspected the range of lamp performance will be much narrower than presented in the preliminary analysis. (NEEA and NPCC, No. 34 at p. 2, 3) NEEP stated that while there appear to be significant energy savings for GSFLs at CSL1, DOE's use of catalog data puts the accuracy of these estimates into question. (NEEP, No. 33 at p. 2)

DOE understands the concerns raised by stakeholders regarding the difference between catalog and certification values and their subsequent recommendations to utilize certification data. At the time of the preliminary analysis, DOE's certification database consisted of data for only 38 percent of covered GSFLs. Because not all commercially available products had associated certification data, DOE was unable to rely solely on certification data in the preliminary analysis. At the time of the NOPR analysis, DOE's certification database contained data for 68 percent of the covered commercially available lamps. While this was an increase from the preliminary analysis, it still did not represent a comprehensive dataset on which to base an engineering analysis. Therefore, in this NOPR analysis, DOE again utilized catalog data to identify baseline products and develop initial efficacy levels. This approach ensured consideration of all available products. DOE then used available certification data to adjust the initial efficacy levels, if necessary, thereby ensuring that the proposed levels can be met based on the certification values submitted by manufacturers to demonstrate compliance with standards.

Wattage

The CA IOUs asked why DOE is using ANSI rated wattage to calculate efficacy when the certification database lists specific wattages for products. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 96) The CA IOUs stated that using a rated wattage of 32.5 W gives an expected average efficacy and recommended looking at whether lamps are performing at different levels of efficacy than projected and setting baselines and standards around more measured data rather than a rated wattage. (CA IOUs, Public Meeting Transcript, No. 30 at p. 100)

NEMA noted the rated wattage is based on a very large number of samples that are averaged out and manufacturers produce lamps to fall on and around that point. Therefore, the individual lamp tested wattage will differ from this rated value of that lamp. NEMA stated that it would defer to its members, but in general it supported using the ANSI rated wattage rather than the measured wattage. (NEMA, Public Meeting Transcript, No. 30 at pp. 98) GE did not think industry had a firm position on the issue, recognizing different wattages can be used. (GE, Public Meeting Transcript, No. 30 at pp. 99–100; NEMA, Public Meeting Transcript, No. 30 at pp. 98–99)

For the preliminary analysis and the NOPR analysis, DOE used catalog data to develop initial CSLs and ELs and assessed certification data to make any adjustments to the levels. As noted, DOE's certification database does not include data for all covered GSFLs; therefore, the measured wattages of all commercially available covered lamps are not readily accessible. Additionally, DOE identified inconsistencies with the values reported for wattage, specifically in some cases nominal wattage may be reported rather than the measured wattage in DOE's certification database. Therefore, as mentioned previously, DOE used manufacturer lamp catalogs to establish initial CSLs in the preliminary analysis and ELs in the NOPR. To determine catalog efficacies, DOE used catalog lumen output and ANSI rated wattage instead of the nominal wattage provided by manufacturers in catalogs. ANSI rated wattage is the result of standardized ANSI testing and represents an industry agreed upon wattage, as explained by NEMA. If an ANSI standard did not provide a rated wattage for a lamp type analyzed, efficacy was calculated using the nominal wattage.

For the assessment of certification values, DOE used the reported values for efficacy, which are based on measured lumen output and measured wattage as specified in DOE's test procedures for GSFLs set forth at 10 CFR part 430, subpart B, appendix R. Utilizing ANSI rated wattage to calculate catalog efficacy and reported efficacy for developing final efficacy levels eliminates the uncertainty associated with the wattages reported for compliance.

Using Data at 25 Degrees Celsius

NEMA stated that DOE should conduct all its analyses, payback and feasibility equations based on data referenced to and measured at 25 °C, not 35 °C, otherwise, results will be skewed because efficiency can ''appear'' higher at 35 °C for certain products made (optimized) for those conditions. NEMA noted that DOE's test procedure, existing and previous rules, as well as reporting and catalogs, use 25 °C data. (NEMA, No. 36 at p. 18; NEMA, Public Meeting Transcript, No. 30 at p. 127) GE noted that discussions during the 2009 Lamps Rule had concluded that T5 lamps should be tested at 25 °C as currently done by labs because testing becomes very unreliable at 35 °C. Therefore, it is not appropriate to have a lm/W level based on 35 °C. (GE, Public Meeting Transcript, No. 30 at pp. 89–90) Philips stated that lamps for which efficacy values are provided at 35 °C operating temperature in catalogs are particular amalgam lamps that were designed specifically for that environment. (Philips, Public Meeting Transcript, No. 30 at p. 127)

In the preliminary analysis, DOE developed efficacy levels based on performance at 25 °C because the DOE test procedure for GSFLs requires the lamps to be tested at 25 °C, including T5 lamps. However, because all manufacturers do not provide lumen output data at 25 °C for T5 lamps in their catalogs but do provide it at 35 °C, DOE developed initial efficacy levels based on 35 °C catalog data for T5 lamps. This allowed DOE to evaluate performance for all T5 lamps based on data provided by manufacturers at the same operating temperature. As noted, because the DOE test procedure used to determine compliance with standards requires GSFLs to be tested at 25 °C, DOE adjusted the initial efficacy levels to reflect operation at 25 °C. To do this, DOE utilized information in lamp manufacturer catalogs that provided performance characteristics for lamp operation at both 25 °C and 35 °C. In cases where this information was not available, DOE adjusted the 35 °C data to reflect lamp operation at 25 °C. Specifically, when operated at 25 °C, the lumen output of T5 lamps is approximately 10 percent lower than the lumen output of such lamps when operated at 35 °C. For this NOPR analysis, DOE has maintained this approach and developed efficacy levels based on performance at 25 °C.

Decimal Usage for lm/W

Philips stated that the CSLs analyzed in the preliminary analysis are to the tenths decimal place which provides an artificial measure of accuracy that doesn't even exist and Philips doesn't think it can be measured accurately. (Philips, Public Meeting Transcript, No. 30 at p. 146) Regarding this comment that reporting lm/W to one significant digit is not conducive to repeated and reliable measurements, the CA IOUs stated the rulemaking must adhere to the existing DOE test procedure that calculates an efficacy value using a specific sample size and confidence limit procedure. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 149–151)

As specified in DOE's test procedures for GSFLs set forth at 10 CFR part 430, subpart B, appendix R, lamp efficacy is the ratio of measured lumen output in lumens to the measured lamp electrical power input in watts rounded to the nearest tenth in units of lumens per watt. In the 2009 final rule for the GSFL and IRL test procedure, DOE amended the test procedure to require reported efficacy measurements for GSFLs to be rounded to the nearest tenth of a lumen per watt allowing for future energy conservation standards to be rounded to the nearest tenth of a lumen per watt. 74 FR 31829, 31836 (July 6, 2009). DOE concluded this amendment to the test procedure was feasible because manufacturers routinely generate test results that would allow reporting to at least the tenth of a lumen per watt level. 74 FR at 31836 (July 6, 2009). Therefore, DOE is analyzing efficacy levels in this rulemaking rounded to the nearest tenth of a lumen per watt as DOE maintains that this is an achievable level of accuracy.

Using High Frequency Test Data

According to NEMA, in recognition of the marketplace shift to electronic high frequency (HF) ballasts, the American National Standards Institute Lighting Group has drafted new standards for the electrical and photometric characterization of GSFL T8 lamps that are based on HF rather than the former low frequency 60 Hz reference ballasts. When these new standards are published later in 2013, the industry will comply and begin characterizing their products using HF-based photometry. (NEMA, No. 36 at p. 2) NEMA also stated that current test procedures unfairly compare energy-saver lamps to standard lamps, owing to the removal of cathode heat voltage from the energy-efficiency calculation of energy-saver lamps, thus they cannot be compared without unfairly skewing the numbers in favor of low-wattage lamps. High frequency measurement standards account for this difference. (NEMA, No. 36 at pp. 14–15) Therefore, NEMA recommends that this rulemaking should be based on the new ANSI HF standards. (NEMA, No. 36 at p. 2)

The current GSFL test procedure as specified in 10 CFR part 430, subpart B, appendix R requires lamps be tested at low frequency unless only high frequency ballast specifications are available for the lamp. The test procedure also specifies that for high frequency testing, cathode heat should not be used when the lamp is in operation. DOE acknowledges that high frequency reference specifications may be in development for additional lamp types and may consider standards based on high frequency operation after ANSI publishes the revised industry standard.

700 Series Waiver

NEMA also noted that 700 series lamps are under the U.S. Office of Hearings and Appeals (OHA) compliance waivers from the July 2012 standards. Therefore, their performance and market changes are still several years away from being known. (NEMA, No. 36 at p. 1)

In April of 2012, several manufacturers [27] were granted exception relief exempting their 700 series T8 lamps from the July 2012 standards for a period of two years. The waiver was granted due to the global supply restrictions on rare earth phosphors, the rising world demand of these phosphors, and the resulting impacts on producing higher efficacy GSFLs.[28] Because this waiver will expire in 2014, and any standards adopted by this rulemaking are expected to require compliance in 2017, DOE has conducted this analysis for GSFLs assuming that the waiver would not be in place and has therefore not considered non-compliant 700 series lamps in its analysis. DOE notes that the term ''700 series'' is widely used in industry when referring to fluorescent lamps with a CRI in the range of 70 to 79. See section V.A for the proposed definition of a 700 series lamp.

b. Representative Product Classes

When a covered product has multiple product classes, DOE identifies and selects certain product classes as representative and analyzes those product classes directly. DOE chooses these representative product classes primarily due to their high market volumes. For GSFLs, in the preliminary analysis DOE identified all GSFLs with CCTs less than or equal to 4,500 K with the exception of the 2-foot U-shaped lamps as representative product classes as shown (in gray) in Table VI.5. NEMA agreed with the representative product classes presented for GSFLs. (NEMA, No. 36 at p. 7)

TABLE VI.5—GSFL REPRESENTATIVE PRODUCT CLASSES

Lamp type	CCT
4-foot medium bipin	≤4,500 K
	>4,500 K
2-foot U-shaped	≤4,500 K
	>4,500 K
8-foot single pin slimline	≤4,500 K
	>4,500 K
8-foot recessed double contact high output	≤4,500 K
	>4,500 K
4-foot T5, miniature bipin standard output	≤4,500 K
	>4,500 K
4-foot T5, miniature bipin high output	≤4,500 K
	>4,500 K

NEEA questioned why none of the products with CCT greater than 4,500 K were being directly analyzed and noted that at least one should be assessed in order to ensure the analysis is accounting for the magnitude of difference between greater than and less than or equal to 4,500 K CCT products. (NEEA, Public Meeting Transcript, No. 30 at p. 88)

As noted previously, DOE chose representative product classes based on high market volumes. DOE received feedback from manufacturers in interviews indicating that the volume of lamps with CCT greater than 4,500 K is considerably lower than the volume of lamps with CCT less than or equal to 4,500 K. In addition, DOE used manufacturer feedback and catalog data to quantify the difference in performance between lamps with higher CCTs and lamps with lower CCTs. For these reasons, DOE did not directly analyze lamps with CCT greater than 4,500 K in the preliminary analysis and this NOPR analysis. DOE scaled the directly analyzed product classes with CCTs less than or equal to 4,500 K to those with CCTs greater than 4,500 K in the preliminary and NOPR analyses. See section VI.D.2.h and chapter 5 of the NOPR TSD for further information.

EEI stated it thought that the 2-foot U-shaped lamps would have sales comparable to some of the other product classes. EEI also did not agree with determining the efficiency standard for the 2-foot U-shaped lamps using the 4-foot MBP lamps as a proxy. (EEI, Public Meeting Transcript, No. 30 at p. 86–88)

In the preliminary analysis, DOE utilized the 4-foot MBP linear fluorescent products to scale to the 2-foot U-shaped products, as both products use the same fluorescent technology, span the same range of wattages, and, without its bent curve, the 2-foot U-shaped lamp would be approximately the same length as the 4-foot MBP linear lamp. Thus, DOE could determine impact on efficacy from the bent curve and scale from the 4-foot MBP product class. Further, the market share of 2-foot U-shaped lamps is significantly lower than 4-foot MBP lamps. As indicated in the LMC, T8 4-foot linear lamps comprise 44 percent of all linear fluorescent lighting, whereas T8 2-foot U-shaped lamps make up just 2 percent. Therefore, in this NOPR analysis, DOE did not directly analyze the 2-foot U-shaped lamps and scaled ELs from the 4-foot MBP product class to the 2-foot U-shaped product class. See section VI.D.2.h and chapter 5 of the NOPR TSD for further information.

c. Baseline Lamps

Once DOE identifies the representative product classes for analysis, it selects baseline lamps to analyze in each class. Typically, a

[27] At the time of this analysis, the following manufacturers had been granted exception relief exempting their 700 series T8 lamps from current standards: Philips, GE, OSI, Ushio America, Halco Lighting Technologies, Premium Quality Lighting, Inc., Tailored Lighting, Inc., Litetronics International, Inc., Satco Products, Inc., DLU Lighting USA, Westinghouse Lighting Corporation, Ascent Battery Supply, LLC, Eiko, Ltd, Topaz Lighting Corporation, Technical Consumer Products, Feit Electric Company.

[28] *Philips Lighting Company, et al.* OHA Case Nos. EXC–12–0001, EXC–12–0002, EXC–12–0003 (2012). Accessible here: *http://energy.gov/sites/prod/files/oha/EE/EXC-12-0001thru03.pdf.*

baseline lamp is the most common, least efficacious lamp that just meets existing energy conservation standards. For fluorescent lamps, the most common lamps were determined based on characteristics such as wattage, lumen output, lifetime, and CCT. To identify baseline lamps, DOE reviews product offerings in catalogs, shipment information, and manufacturer feedback obtained during interviews.

In the preliminary analysis, DOE considered commercially available lamps as baselines. In some cases, the most common, least efficacious commercially available product was at an efficacy above the existing standard level. Specifically, for the 8-foot RDC HO, T5 MiniBP SO, and T5 MiniBP HO product classes, DOE was unable to identify a commercially available product at the existing standard level. DOE received several comments regarding the selection of these lamps with efficacies higher than the existing standard levels as baselines.

NEMA stated that the arguments for baseline, CSL 0 in the preliminary TSD, are based on predictions of market shift that erroneously justify a new baseline higher than the minimum requirements put forth by the 2009 Lamps Rule. (NEMA, No. 36 at p. 1) NEMA questioned why the baselines for product classes were not set at the standard level adopted in the 2009 Lamps Rule. (NEMA, Public Meeting Transcript, No. 30 at pp. 85–85) The CA IOUs recommended DOE use the efficacy levels set in the 2009 Lamps Rule as the baselines for all GSFL product classes because minimum product performance generally gravitates to the minimum standards set for the product. (CA IOUs, No. 32 at p. 13) GE concurred, stating that the market will move to lamps at that level due to the cost of rare earth materials. Therefore, GE asserted that it is easy to make the assumption that lamps will gravitate towards that minimum level over time and that that should be the analysis going forward over the next six to ten years. (GE, Public Meeting Transcript, No. 30 at pp. 93–94)

NEEA and NPCC agreed that DOE should use products that minimally comply with existing standards as baselines and this would be validated by the measured and/or certified values. (NEEA and NPCC, No. 34 at p. 1, 4) The CA IOUs also noted that the certification database shows that there are products right at the level, particularly for the 4-foot MBP class. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 93–94)

As noted previously, DOE assesses commercially available products on the market and chooses baseline lamps representative of the common characteristics within that product class and just meet existing standards. However, feedback from stakeholders and manufacturer interviews has indicated that manufacturers will likely produce lamps at the existing standard level even if no products are currently available. Further, after the 2009 Lamps Rule, DOE observed the introduction of products that were not previously available at the newly adopted standard levels for some product classes. Thus, DOE believes this trend could continue and additional lamps may be offered that just meet the existing standard level for the remaining product classes.

Therefore, in this NOPR analysis DOE is proposing baselines at the existing standard levels for all product classes. For the 4-foot MBP product class, DOE determined the baseline selected in the preliminary analysis to be the least efficient product on the market at the existing standards. For the 8-foot SP slimline product class, DOE also changed the baseline lamp to be the least efficient product on the market at the existing standards. For representative product classes in which there were no commercially available lamps at the existing standard level, DOE modeled baseline lamps. To determine the performance characteristics of these lamps, DOE took the ANSI rated wattage of the most common, least efficacious commercially available lamp and calculated the lumen output required to develop an efficacy at the existing standard level. DOE assumed the modeled baseline lamp would have similar characteristics as the most common commercially available lamps in each product class, including lifetime and lumen depreciation. DOE modeled baseline lamps for the 8-foot RDC HO, T5 MiniBP SO, and T5 MiniBP HO product classes.

If DOE considered additional types of GSFLs in the scope of this rulemaking, NEEA and NPCC recommended that for product classes that do not currently have a standard, DOE should establish the baseline at the lowest level of efficiency commonly found in the marketplace. (NEEA and NPCC, No. 34 at p. 1, 4) In this NOPR analysis, DOE is not considering additional types of GSFLs that are not subject to standards. See section V.B for more details.

NEEP noted that the *2011 Vermont Market Characterization and Assessment Study* conducted by Navigant for Vermont's Public Service Department (mentioned previously in this notice) established baselines for certain products in the state's commercial sector. NEEP urged DOE to utilize the fluorescent lighting data collected to corroborate DOE's findings. (NEEP, No. 33 at p. 3)

DOE reviewed the study and found that, given the level of detail provided, it was difficult to use the results to corroborate DOE's baseline selections. The study aims to characterize the prevalence of T8 lamps, high performance T8 lamps, T12 lamps, and T5 lamps in the state of Vermont. While it provides market share information for standard T8s and high performance T8s, it does not provide this information by level of efficiency for T5 lamps. Further, the lengths of these lamp types are not included, and thus DOE was unable to compare the results on a product class basis.

When considering general overall trends, the study confirmed that T8 lamps are significantly more prevalent than T12 lamps, and T8 standard efficiency lamps are more commonly installed than high performance T8 lamps. These high level results support certain aspects of the baseline selections, namely the selection of T8 standard performance lamps at the baseline. However, the study covers a very limited service area and therefore cannot be regarded as indicative of the most commonly installed lamp types at a national level.

DOE is proposing the baseline lamps for GSFLs specified in Table VI.6. See chapter 5 of the NOPR TSD for further details on this assessment. DOE requests comment on the baseline lamps analyzed in the NOPR analysis, in particular the modeled baseline lamps in the 8-foot RDC HO, T5 MiniBP SO, and T5 MiniBP HO product classes.

Table VI.6 GSFL Baseline Lamps

Representative Product Class	Lamp Diameter	Nominal Wattage	ANSI Rated Wattage	Rated Efficacy**	Initial Lumen Output†	Mean Lumen Output‡	Life (IS)	Life (PS)	CRI
		W	W	lm/W	lm	lm	hr	hr	
4-foot MBP	T8	32	32.5	89.2	2,900	2,725	24,000	40,000	83
8-foot SP slimline	T8	59	60.1	96.5	5,800	5,220	24,000	-	80
8-foot RDC HO	T8	86	84.0	92.0	7,728	7,342	18,000	-	-
4-foot T5 MiniBP SO*	T5	28	27.8	86.0	2,391	2,223	-	30,000	-
4-foot T5 MiniBP HO*	T5	54	53.8	76.0	4,089	3,884	-	25,000	-

* 4-foot T5 MiniBP SO and HO rated efficacy, initial lumen output, and mean lumen output given at 25 °C.

** Rated efficacy is catalog initial lumen output divided by the ANSI rated wattage.

† Initial lumen output is a lamp's light output after 100 hours of seasoning.

‡ Mean lumen output is a measure of light output midway through the rated life of a lamp.

d. More Efficacious Substitutes

DOE selects more efficacious replacements for the baseline lamps considered within each representative product class. DOE considers only design options identified in the screening analysis. In the preliminary analysis, these selections were made such that potential substitutions maintained light output within 10 percent of the baseline lamp's light output with similar performance characteristics, when possible. DOE also sought to keep other characteristics of substitute lamps as similar as possible to the baseline lamps, such as rated life, CRI, and CCT. In identifying the more efficacious substitutes, DOE utilized a database of commercially available lamps. DOE received comments regarding its choices for more efficacious substitutes in the preliminary analysis.

T5 HO Product Class

For the preliminary analysis, in its assessment of commercially available products, DOE was unable to find a full wattage T5 HO lamp with an efficacy higher than the baseline. However, DOE did find several more efficacious, reduced wattage T5 HO lamps at higher levels of efficacy. As discussed in section VI.D.2.e, DOE is only analyzing efficacy levels that can be met by full wattage lamps. Therefore, in the preliminary analysis, DOE modeled a more efficacious full wattage T5 HO lamp. Specifically, DOE created a higher efficacy model lamp using a more efficacious commercially available reduced wattage T5 HO lamp to calculate the characteristics of a full wattage T5 HO lamp of comparable efficacy. The CSL considered for the T5 HO product class was set according to the efficacy of this modeled full wattage lamp.

DOE received several comments regarding this approach. NEMA stated that it could not comment on the manufacturability or functionality of the T5 HO model lamp put forth in the preliminary analysis because the product does not exist, and it is poor practice to invent new products. (NEMA, No. 36 at p. 8) NEMA stated that if DOE is unable to use a commercially available lamp for analysis for this product class it should not pursue an increased efficiency level. However, in the case that DOE does intend to further regulate this product class, NEMA stated DOE should arrange for the construction and testing of a representative number of this modeled lamp to obtain information on manufacturing feasibility. (NEMA, No. 36 at p. 8–9) Philips agreed, stating that DOE is designing and inventing new lamps and it is not known whether they are even feasible. This approach could potentially result in a product class where there are no products available. (Philips, Public Meeting Transcript, No. 30 at p. 124)

GE stated it had to get more information but noted that its engineers had significant concerns regarding the T5 MiniBP HO model lamp and the high efficacy of the max tech level being considered for this product class. Noting that it had not seen DOE take this approach before, GE stated that DOE seems to be going from T5 efficacy levels that are relatively easy to meet to efficacy levels that may not even be technically feasible. (GE, Public Meeting Transcript, No. 30 at pp. 125–126)

In the preliminary analysis, DOE concluded that the higher efficacy level achieved by reduced wattage T5 HO lamps demonstrated the potential for a full wattage lamp to achieve an efficacy level above the baseline. Accordingly, DOE modeled the lamp efficacy of a higher efficacy full wattage lamp using commercially available reduced wattage lamps. DOE acknowledged in the preliminary analysis that in determining whether it is appropriate to consider a CSL based on this model lamp, DOE would gather additional information on the manufacturability and functionality of this lamp, as well as its projected efficacy, when measured according to the DOE test procedure. DOE does not have the necessary information to determine whether the higher efficacy full wattage T5 HO model lamp was technologically feasible, and therefore is not considering the higher efficacy modeled T5 HO lamp in the NOPR analysis.

As noted previously, in response to the stakeholder comments discussed in section VI.D.2.c, DOE modeled a baseline lamp for the NOPR analysis because the T5 HO product class does not have a commercially available lamp that just meets the existing standard. Because there are full wattage products that have demonstrated efficacy higher than the existing standard, DOE believes the modeled baseline lamp is feasible. Based on this new baseline, in the NOPR analysis DOE was able to identify a more efficacious full wattage T5 HO substitute that is commercially available. The more efficacious T5 HO lamps are shown in Table VI.7.

Lifetime Characteristics

NEEP stated that Energy Efficiency Program Administrators from Efficiency Vermont and National Grid noted that the rated life values for the lamps DOE has identified as more efficacious substitutes (for 4-foot MBP) are low. They specifically pointed out that GE's reduced wattage 25 and 28 W lamps and their high lumen 32 W lamps are all rated between 40–50,000 hours (instant start [IS], 3 hours per start). Further Philips rates their reduced wattage 25 and 28 W lamps at 32,000 hours (IS, 3 hours per start). ''Extended life'' lamps offer even longer rated lifetimes. (NEEP, No. 33 at p. 3)

As noted in section VI.D.2.c, baseline lamps are selected in part based on the most common characteristics of their respective product classes, and DOE selects more efficacious substitutes with similar performance characteristics as the baseline representative unit when possible. Thus, the baseline and more efficacious substitutes selected represent the most common lifetimes for each product class. In the case of the 4-foot MBP product class, DOE found that a 24,000 hour lifetime on IS ballasts with 3 hour starts and a 40,000 hour lifetime on programmed start ballasts with 3 hour starts were the most common lifetimes for the product class. DOE notes that the rated lifetime values cited by NEEP for GE's reduced wattage 25 and 28 W lamps and high lumen 32 W lamps represent rated lifetime on a programmed start ballast with 3 hour starts rather than an IS ballast. Therefore the 40–50,000 hour lifetimes cited by NEEP do align with the rated lifetimes (programmed start, 3 hours per start) of the more efficacious substitutes selected. Further, DOE received manufacturer feedback during interviews that the lifetime values of the more efficacious substitutes were representative of their respective product classes. Therefore, in this NOPR analysis, DOE is maintaining the same more efficacious substitutes as selected in the preliminary analysis. DOE requests comment on the rated lifetimes of the GSFL baselines and more efficacious substitutes.

Summary of GSFL Representative Lamps

DOE received no other comments regarding the selection of more efficacious substitutes for GSFLs. The GSFL representative lamps analyzed in the NOPR are shown in Table VI.7.

TABLE VI.7—GSFL REPRESENTATIVE LAMPS

Product classes	EL	Lamp diameter	Nominal wattage	Rated wattage	Rated efficacy	Initial light output	Mean light output	Life	CRI
			W	W	lm/W	lm	lm	hr	
4-foot MBP	EL 1	T8	32	32.5	90.0	2,925	2,770	21,000	85
	EL 2	T8	25	26.6	93.0	2,475	2,350	24,000	85
	EL 2	T8	32	32.5	95.4	3,100	2,945	24,000	85
	EL 2	T8	28	28.4	96.0	2,725	2,590	24,000	85
8-foot SP slimline	EL 1	T8	59	60.1	98.2	5,900	5,490	24,000	85
	EL 2	T8	59	60.1	99.0	5,950	5,650	24,000	85
	EL 2	T8	54	54.0	105.6	5,700	5,415	24,000	85
	EL 2	T8	50	50.0	108.0	5,400	5,075	24,000	85
8-foot RDC HO	EL 1	T8	86	84.0	95.2	8,000	7,600	18,000	78
	EL 2	T8	86	84.0	97.6	8,200	7,800	18,000	86
T5 MiniBP SO*	EL 1	T5	28	27.8	93.5	2,600	2,418	30,000	85
	EL 2	T5	28	27.8	98.2	2,730	2,594	30,000	85
	EL 2	T5	26	26.0	100.0	2,600	2,470	30,000	85
	EL 2	T5	25	25.0	104.0	2,600	2,475	35,000	85
T5 MiniBP HO*	EL 1	T5	54	53.8	82.7	4,450	4,275	25,000	85
	EL 1	T5	49	49.0	90.8	4,450	4,140	35,000	85
	EL 1	T5	47	47.0	91.9	4,320	3,969	30,000	84

* 4-foot T5 MiniBP SO and HO rated efficacy, initial lumen output, and mean lumen output given at 25 °C.

e. General Service Fluorescent Lamp Systems

Because fluorescent lamps operate on a ballast in practice, in the preliminary analysis, DOE analyzed lamp-and-ballast systems, thereby more accurately capturing real-world energy use and light output. In the DOE test procedure for GSFLs, and therefore in this rulemaking, lamp efficacy is based on the initial lumen output. However, because light output decreases over time, in the preliminary analysis DOE analyzed more efficacious systems that maintain mean lumen output [29] within 10 percent of the baseline system, when possible. Further, in the preliminary analysis, DOE selected replacement systems that do not have higher energy consumption than the baseline system.

DOE considered two different scenarios in the preliminary analysis: (1) A lamp replacement scenario in which the consumer selects a reduced wattage replacement lamp that can operate on the installed ballast and (2) a lamp-and-ballast replacement scenario in which the consumer selects a lamp that has the same or lower wattage compared to the baseline lamp and also selects a new ballast with potentially different performance characteristics, such as ballast factor [30] (BF) or ballast

[29] Mean lumen output is a measure of light output midway through the rated life of a lamp.

[30] BF is defined as the output of a ballast delivered to a reference lamp in terms of power or light divided by the output of the relevant reference ballast delivered to the same lamp (ANSI C82.13–2002). Because BF affects the light output of the system, manufacturers design ballasts with a range of ballast factors to allow consumers to vary the light output, and thus power consumed, of a fluorescent system. See the 2011 Ballast Rule final rule TSD Chapter 3. The Ballast Rule materials are

Continued

luminous efficiency [31] (BLE). In the preliminary analysis, for the second scenario DOE attempted to select a ballast that would result in energy savings and still maintain the mean lumen output within 10 percent of the baseline. In cases where energy savings were not possible without going beyond the 10 percent threshold of the baseline mean lumen output, DOE gave priority to energy savings. This resulted in the mean lumen output being either 10 percent above or below the baseline lumens for certain lamp-and-ballast scenarios.

DOE received several comments regarding its methodology in identifying more efficacious lamp-and-ballast systems, specifically regarding selection of ballasts, maintenance of mean lumen output within 10 percent of the baseline, and energy saving options not explored in the preliminary analysis.

Ballast Selection

NEMA agreed with the lamp and ballast pairings presented in the preliminary analysis. (NEMA, No. 36 at p. 8) However, NEMA also stated that GSFL performance is highly dependent on ballast selection and pairing. NEMA pointed out that NES of lighting systems will not be affected significantly by this proposed rulemaking on GSFL efficacy due to the overwhelming influence of ballast selection on final performance. (NEMA, No. 36 at p. 1)

As mentioned, because fluorescent lamps operate on a ballast in practice, DOE analyzed lamp-and-ballast systems in the engineering analysis. The impacts of these systems on NES were analyzed in the NIA. See section VI.I for more information on the NES of the proposed GSFL systems.

The CA IOUs expressed concern regarding some of the replacement systems identified, including lamps operating on residential ballasts and programmed start ballasts. The CA IOUs questioned why a residential ballast with a ballast factor of 0.83 was selected when DOE could have chosen a ballast with a lower ballast factor of 0.77 and still stayed within five percent of initial lumens. (CA IOUs, Public Meeting Transcript, No. 30 at p. 253–255) The CA IOUs also questioned a specific lamp-and-ballast replacement scenario considered in the preliminary analysis in which a nominal 32 W lamp with an efficacy of 95 lm/W, installed with a 0.88 BF ballast, replaced a 32 W lamp at 89.2 lm/W, also using a 0.88 BF ballast. (See table 8.5.3 of the preliminary TSD.) The CA IOUs noted that this retrofit results in a 7 percent increase in light output and no reduction in energy consumption. If DOE had paired a 0.78 BF ballast with the more efficacious lamp, the retrofit would have resulted in a reduction in light output of only 5 percent, and would achieve some reduction in energy consumption and some energy cost savings for the end user. (CA IOUs, No. 32 at pp. 13–14)

In the preliminary analysis, DOE considered only commercially available ballasts when selecting ballasts to pair with lamps. The CA IOUs suggested a ballast with a 0.77 BF for the residential 2-lamp instant start replacement scenario and a ballast with a 0.78 BF for the 2-lamp programmed start scenario, however, DOE found that these ballasts do not exist. Because there were no residential 2-lamp instant start low BF ballasts or 2-lamp programmed start low BF ballasts commercially available that would also maintain mean lumen output within 10 percent of the baseline system, DOE was unable to analyze ballasts with lower BFs than those selected for these scenarios. DOE instead selected the same ballast as the baseline as this was the lowest BF ballast commercially available.

Ten Percent Mean Lumen Output Threshold

NEMA explained that in the past it was common practice to reduce light levels by 10 percent or more when retrofitting from a T12 to a T8 lighting system because older lighting systems were typically designed to higher light levels. Over the years, IES light level requirements have been reduced, especially in office applications where the use of computers reduces the need for high light levels. DOE must analyze the future retrofit situation that will occur after 2018 in which 4-foot linear fluorescent systems will have been retrofitted to a T8 or better fluorescent system already operating at the appropriate lower light levels. Retrofits beyond this 2018 time period should be expected to maintain the new, lower recommended IES light levels where they are already in place. Therefore, unlike T12 to T8 conversions, projecting further light level reductions of 6 to 14 percent as is done in DOE's analysis cannot be justified against the T8 systems operating in 2018. For a fair economic comparison, DOE should seek to match the existing light levels within a +/− 5 percent range. (NEMA, No. 36 at p. 8; GE, Public Meeting Transcript, No. 30 at pp. 90–91; GE, Public Meeting Transcript, No. 30 at pp. 110–112; Philips, Public Meeting Transcript, No. 30 at pp. 105–106)

GE stated that it is not typical to replace lighting systems lamp for lamp that are more than 10 percent lower in light output unless the space is considered overlit to begin with or the space was repurposed. (GE, Public Meeting Transcript, No. 30 at pp. 90–91) For a fair comparison between lighting systems, GE recommended that DOE stay as close as possible to 10 percent and not to go beyond this threshold as some systems do in the analysis presented. (GE, Public Meeting Transcript, No. 30 at pp. 119–120)

EEI agreed that at this time, retrofits are being done from T8 to T8 and electronic ballast to electronic ballast and therefore lumen depreciation is limited, at most 10 percent versus 20 or 30 percent when replacing a T12. EEI noted that this could make a difference in design for a new building and total renovations that are meeting building codes. (EEI, Public Meeting Transcript, No. 30 at pp. 109–110) EEI recommended analyzing equal to or higher lumen output replacement systems to maximize consumer utility in terms of maintaining lumen output in retrofit scenarios. (EEI, Public Meeting Transcript, No. 30 at p. 121) Cooper Lighting added that light level is important in accurately and correctly doing a task in a space and the impact of light levels on efficiency in the workplace should be given consideration. (Cooper, Public Meeting Transcript, No. 30 at pp. 110)

The CA IOUs agreed with DOE's analysis of replacement systems that maintained mean lumen output within 10 percent of the mean lumens of the baseline system. Based on experience from offering rebate lamps through its programs, the CA IOUs had found that nine times out of ten after changing the lights in a commercial space, the complaints are that it is too bright. The CA IOUs asserted that most spaces were not designed exactly to IES standards but give a little extra light initially. Additionally, the CA IOUs noted that lumen maintenance is a significant issue with fluorescent systems, particularly because the replacement of older T12 systems with newer, more efficacious systems makes the space seem even brighter after a retrofit. The CA IOUs further stated that the scenarios where you increase light output by 5, 8, 12 percent are not going to work for consumers and reducing light output by 2, 4, 6, 8 percent will still seem too bright. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 106–108)

As stated previously, because light output decreases over time, DOE

available at *www.regulations.gov/#!docketDetail;D=EERE-2007-BT-STD-0016*.

[31] BLE is the ratio of the total lamp arc power to ballast input power multiplied by the appropriate frequency adjustment factor.

analyzed more efficacious systems that maintain mean lumen output within 10 percent of the baseline when possible. DOE established the 10 percent threshold based on feedback from manufacturers that, in general, consumers would not notice a change in light output that is up to 10 percent. Manufacturers noted during interviews that when a space needs to be relamped, lumen depreciation has already typically occurred and thus lower light levels of a newly installed lamp would likely not be detected. Manufacturers also noted that while application dependent, designing to achieve energy savings is common and a decreased lumen output as a result is generally accepted as long as it is somewhere in the range of 10 percent of the baseline system mean lumen output. DOE concluded that selecting lamp-and-ballast system replacements within 10 percent of the baseline system when possible ensures sufficient light levels are maintained and accurately reflects common practices. Therefore, in this NOPR analysis, DOE is continuing to utilize the criterion of maintaining 10 percent of the mean lumen output when possible in developing lamp-and-ballast replacement scenarios. If it was not possible to identify a lamp-and-ballast replacement that maintained the 10 percent mean lumen output criterion, DOE prioritized energy savings and analyzed a lamp-and-ballast system that reduced light output by more than 10 percent[32] but saved energy relative to the baseline system. DOE continued to do this in the NOPR analysis because feedback during manufacturer interviews confirmed that changes in mean lumen output outside 10 percent of the baseline system are acceptable in some applications.

In the preliminary analysis, some lamp-and-ballast replacement systems maintained light output within 10 percent of the baseline system but did not save energy. DOE analyzed these lamp and ballast combinations as the only replacement option because they met the 10 percent mean lumen output criterion. For the NOPR analysis, DOE considered additional scenarios for this situation based on feedback from stakeholders and manufacturer interviews. DOE added another replacement option in which the consumer could prioritize energy savings by selecting a lamp-and-ballast system that reduced lumen output by more than 10 percent but also reduced energy consumption. Therefore, for certain lamp-and-ballast replacement scenarios, two ballast selections may exist: (1) A ballast that maintains system mean lumen output within 10 percent of the baseline; and (2) a ballast that achieves energy savings but does not maintain system mean lumen output within 10 percent of the baseline. DOE added this option only if ballasts with the required lower ballast factor were commercially available. Thus, it remains possible that certain scenarios do not result in energy savings if a lower BF ballast or reduced wattage lamp is not available (*e.g.,* 8-foot RDC HO product class). See chapter 5 of the NOPR TSD for more information.

In response to the lamp-and-ballast system selections presented in the preliminary analysis, EEI commented that light output was being reduced between 8 and 13.8 percent. EEI stated this is important because even if it is possible to meet the watts per square requirements in new buildings, the lumen output requirements on the surface must also be met by putting in more fixtures. Therefore, EEI argued that system input power calculations presented in the preliminary analysis may show savings that disappear once the space is designed to put in more fixtures. (EEI, Public Meeting Transcript, No. 30 at pp. 103–105) Philips noted that putting in more fixtures is not going to help because fixtures are mainly in the middle of the room. (Philips, Public Meeting Transcript, No. 30 at pp. 105–106)

As noted, for the lamp-and-ballast replacement scenarios, DOE attempted to select a ballast that would result in energy savings and still maintain the mean lumen output within 10 percent of the baseline when possible. DOE determined that maintaining 10 percent of mean lumen output allows for changes in lumen output within an acceptable range to the consumer. If this was not possible, DOE prioritized energy savings and analyzed a lamp-and-ballast system that reduced light output by more than 10 percent but saved energy relative to the baseline system. DOE did not analyze the installation of additional fixtures due to feedback received from stakeholders that spacing adjustments are not practical (for a discussion of this conclusion, see section VI.G.9).

Energy Savings Over Light Output

The CA IOUs and NEEA and NPCC did not agree with DOE's consideration of lamp-and-ballast system replacements where the light output increases without a reduction in system wattage. (CA IOUs, No. 32 at pp. 13–14; NEEA and NPCC, No. 34 at p. 2, 4) The CA IOUs stated that commercial occupants are sensitive to changes in workplace lighting, and react negatively to light increases. Furthermore, commercial building operators are very sensitive to operating costs; and will choose the retrofit option that results in energy cost savings without significantly reducing the light levels unless the space was known to be underlit. Therefore, where DOE is presented with a choice between a lighting retrofit that would result in an increase of light levels between 0–10 percent, with no energy savings, and another that would result in a decrease of light levels between 0–10 percent, with energy savings, DOE should model the energy saving option as the most likely scenario for consumers. (CA IOUs, No. 32 at p. 14)

The CA IOUs and NEEA and NPCC cited the following available options for reducing system wattage without reducing system lumen output by more than 10 percent: installing reduced wattage lamps, reducing ballast factors, delamping, and installing dimming ballasts. Though some reduced wattage T8 lamps currently have some difficulty dimming as well as their full wattage counterparts, this is only an issue for lamps installed with dimming ballasts. (Although, they noted that this may be improving in the future through the use of dimming ballasts designed to operate reduced wattage lamps.) The CA IOUs noted that reduced wattage lamps, lower ballast factor ballasts, or delamping are valid options, when not using a dimming ballast. Further even if a dimming ballast is installed, higher efficacy (brighter), full wattage lamps can be installed and tuned to the appropriate light level, which reduces system wattage. (CA IOUs, No. 32 at pp. 13–14)

The CA IOUs and NEEA and NPCC noted that using these measures to achieve energy savings for the end user is a far more likely scenario for a real-world lighting retrofit project. (CA IOUs, No. 32 at pp. 13–14; NEEA and NPCC, No. 34 at p. 2, 4) NEEA and NPCC added that resulting energy cost savings also help pay for the retrofit, and retrofits may only infrequently result in increased light levels. (NEEA and NPCC, No. 34 at p. 2, 4)

DOE acknowledges that consumers may prioritize energy savings over maintaining light output in some applications. DOE also observes that several options exist to reduce system wattage while maintaining lumen output. DOE analyzed reduced wattage lamps and low BF ballasts as

[32] Light output was reduced up to 18 percent in some replacement scenarios. The percent reduction in light output was based on the ballast factor of the commercially available ballasts analyzed. For more information, see chapter 5 of the NOPR TSD.

replacement options in the engineering analysis. DOE also analyzed the use of dimming ballasts paired with both reduced wattage and full wattage lamps (for applicable product classes) to achieve energy savings in a lighting controls scenario conducted as a sensitivity in the LCC and NIA. See appendix 6A and chapter 12 of the NOPR TSD for further information on the dimming analysis.

In addition to the above mentioned approaches utilized in the preliminary analysis, DOE added scenarios in the NOPR to incorporate the feedback from stakeholders that some consumers would prioritize energy savings over increasing or maintaining light output. As discussed previously, for the lamp-and-ballast replacement scenarios that resulted only in increased light output, DOE added another replacement option for this situation in which the consumer could prioritize energy savings by selecting a lamp-and-ballast system that reduced lumen output by more than 10 percent but also reduced energy consumption. DOE received feedback from manufacturers that maintenance of less than 10 percent of lumen output of the baseline system is more likely than increasing lumen output when replacing systems in order to achieve energy savings. Thus, DOE added the option for a consumer to select a lower BF ballast, if commercially available, that results in mean lumen output outside 10 percent of the baseline system in order to provide an energy-saving option if possible. As in the preliminary analysis, DOE did not consider delamping in this NOPR because manufacturer feedback confirmed that delamping is not common practice when retrofitting existing T8 systems.

Summary

DOE maintained its overall methodology from the preliminary analysis for selecting lamp-and-ballast systems with the addition of new replacement options in some scenarios for the NOPR analysis to incorporate stakeholder feedback. To develop representative lamp-and-ballast system pairings, DOE used manufacturer feedback and information provided in the 2011 Ballast Rule to determine the most common fluorescent lamp ballasts. In the preliminary and NOPR analyses, DOE paired the representative ballasts utilized in the 2011 Ballast Rule with the representative lamps selected in this analysis to characterize the most common lamp-and-ballast combinations present in the market.

In events where consumers needed to replace both the lamp and the ballast, DOE identified a new lamp-and-ballast system by pairing a more efficacious lamp with a commercially available ballast that had the lowest BF possible that still maintained system mean lumen output within 10 percent of the baseline system. When multiple ballast options with the same BF existed, DOE selected the most efficient ballast based on the BLE metric, as this was considered to be the most likely ballast substitute in a lamp-and-ballast replacement scenario designed to achieve energy savings. If it was not possible to identify a lamp-and-ballast replacement that maintained the 10 percent mean lumen output criterion, DOE prioritized energy savings and analyzed a lamp-and-ballast system that reduced light output by more than 10 percent [33] but saved energy relative to the baseline system.

In the preliminary analysis, some lamp-and-ballast replacement systems maintained light output within 10 percent of the baseline system but did not save energy. In the preliminary analysis, DOE analyzed these lamp-and-ballast combinations as the only replacement option because they met the 10 percent mean lumen output criterion. However, in the NOPR analysis, DOE added another replacement option for this situation in which the consumer could prioritize energy savings by selecting a lamp-and-ballast system that reduced lumen output by more than 10 percent but also reduced energy consumption. DOE added this option only if ballasts with the required lower BF were commercially available. See chapter 5 of the NOPR TSD for more information. DOE welcomes comments on its methodology for developing lamp-and-ballast systems and as well as the results of these GSFL systems.

f. Maximum Technologically Feasible

DOE received several comments on the max tech level presented in the preliminary analysis for GSFLs. Lutron commented that with the exception of the 4-foot MBP class, CSLs presented in the preliminary analysis were higher than the max tech levels identified in the 2009 Lamps Rule. Lutron noted that for the 8-foot SP slimline product class the max tech level in the 2009 Lamps Rule was 98 lm/W while the CSL level being considered is at 99 lm/W; for the 8-foot RDC HO product class the 2009 Lamps Rule max tech was 95 lm/W while the preliminary analysis CSL is 97 lm/W; for the T5 MiniBP SO product class the 2009 Lamps Rule max tech level was 90 lm/W while the preliminary analysis CSL is 98.2 lm/W; for the T5 MiniBP HO product class the 2009 Lamps Rule max tech level was 76 lm/W and the preliminary analysis CSL is 86.2 lm/W. (Lutron, Public Meeting Transcript, No. 30 at pp. 129–130) NEEA and NPCC doubted the data used because CSLs presented were at higher efficacy levels than the max tech levels identified in the 2009 Lamps Rule. (NEEA and NPCC, No. 34 at p. 2, 3) NEMA also commented that having one CSL eliminates DOE's ability to analyze standard levels other than the baseline and max tech and makes it more likely that max tech will become the new standard. (NEMA, Public Meeting Transcript, No. 30 at p. 350)

NEMA asked for an explanation of CSL levels higher than the max tech identified in the 2009 Lamps Rule for the 8-foot lamps. (NEMA, Public Meeting Transcript, No. 30 at pp. 12–13) Lutron stated and NEMA concurred that unless there had been major technological breakthrough in fluorescent lamps, adopting standards more stringent than the max tech levels identified in the 2009 Lamps Rule would not be justified. (Lutron, Public Meeting Transcript, No. 30 at pp. 129–130; NEMA, Public Meeting Transcript, No. 30 at pp. 137) Philips and GE confirmed that there had been no recent technology changes in fluorescent lamp technology to warrant higher levels being considered than the max tech levels identified in the 2009 Lamps Rule. (Philips, Public Meeting Transcript, No. 30 at p. 130; GE, Public Meeting Transcript, No. 30 at p. 130–131) NEMA concluded that because there have been no noteworthy technological breakthroughs since the last rulemaking or great changes in the market, the maximum-feasible performance levels of the previous rule have not changed (NEMA, No. 36 at p. 1)

GE noted that because the 2009 Lamps Rule was moving from relatively modest efficiency levels, the discussion did not center around what lm/W are being reported and what is stated in catalogs. However, GE noted that in this rulemaking because the levels being considered are at very high levels it is important to consider whether the lm/W numbers are actually achievable. GE recommended that for max tech levels DOE use test data that show exactly what these products are capable of and not base levels on marketing claims to avoid situations where the established efficacy turns out to be unachievable, resulting in the elimination of a product class. (GE, Public Meeting Transcript,

[33] Light output was reduced up to 18 percent in some replacement scenarios. The percent reduction in light output was based on the ballast factor of the commercially available ballasts analyzed. For more information, see chapter 5 of the NOPR TSD.

No. 30 at pp. 144–146) Specifically, GE noted that it was concerned that the CSLs presented were based on more aggressive marketing claims in catalogs and not on any real change in technology. (GE, Public Meeting Transcript, No. 30 at pp. 138–139)

DOE identified several commercially available lamps performing at efficacy levels higher than the max tech levels established in the 2009 Lamps Rule. Thus, manufacturers appear to be utilizing more advanced technologies or to be more efficiently utilizing existing technologies. The efficacy values provided in manufacturer product catalogs and certification data supplied by manufacturers indicate that these levels are achievable. DOE welcomes comment on the max tech levels identified in this analysis and more information on the accuracy of catalog and certification data.

g. Efficacy Levels

After identifying more efficacious substitutes for each of the baseline lamps, in the preliminary analysis DOE developed CSLs based on the consideration of several factors, including: (1) The design options associated with the specific lamps being studied (*e.g.,* grades of phosphor for GSFLs); (2) the ability of lamps across wattages to comply with the standard level of a given product class;[34] and (3) the max tech level. When evaluating CSLs in the preliminary analysis, DOE considered only CSLs at which a full wattage version of the lamp type was available because reduced wattage lamps have limited utility. DOE received several comments on the CSLs considered in the preliminary analysis.

NEMA recommended revisions to the CSLs presented in the preliminary analysis. Specifically, NEMA proposed a level at 89 lm/W for the 4-foot MBP product class, 97 lm/W for the 8-foot SP slimline product class, 94 lm/W for the 8-foot RDC HO product class, 90 lm/W for the 4-foot T5 MiniBP SO product class, and 80 lm/W for the 4-foot T5 MiniBP HO product class. (NEMA, No. 36 at p. 9) Further, in reference to T5 lamps, NEMA noted that regardless of whether DOE had presented CSLs at 25 °C or 35 °C, the efficacies of the analyzed products are too high to serve as representative products. (NEMA, No. 36 at p. 10)

In the preliminary analysis, DOE considered two CSLs for the 4-foot MBP product class. DOE found two levels of efficacy above the existing standard that commercially available lamps were able to achieve. The baseline represented a standard 800 series full wattage T8 lamp. CSL 1 (90.0 lm/W) represented an improved 800 series full wattage T8 lamp in which the phosphor mix and/or coating was enhanced to increase efficacy. CSL 2 (93.0 lm/W) represented an 800 series full wattage T8 high lumen lamp able to achieve a higher efficacy with even more advanced phosphors. Reduced wattage lamps also met CSL 2. DOE analyzed publicly available certification data to determine if any adjustments were needed to ensure that proposed levels can be met based on the certification data. DOE determined that the representative units and/or equivalent lamps complied with the CSLs for the 4-foot MBP product class. DOE therefore concluded that no adjustments were necessary in the preliminary analysis based on the available certification data.

In response to the preliminary analysis CSLs, NEMA proposed revising CSL 1 to 89 lm/W for the 4-foot MBP product class, which is equivalent to the existing standard. In the NOPR analysis, DOE continued to identify two levels of efficacy above the baseline. Manufacturer-provided information in catalogs indicates that there are two distinct product lines available with efficacies higher than the baseline products. The baseline level represents a standard 800 series full wattage T8 lamp. In the NOPR analysis, DOE maintained EL 1 (90.0 lm/W) which represents an improved 800 series full wattage T8 lamp. DOE also maintained EL 2 (93.0 lm/W) which represents an 800 series high lumen output full wattage T8 lamp and the 25 W and 28 W reduced wattage lamps. DOE analyzed available certification information and found that EL 1 did not need to be adjusted from 90.0 lm/W. DOE adjusted EL 2 from the preliminary analysis value of 93.0 lm/W to 92.4 lm/W based on additional certification data.

DOE considered one CSL for the 8-foot SP slimline product class at 99.0 lm/W in the preliminary analysis. The baseline represented a standard 800 series full wattage T8 lamp, and DOE identified one level of efficacy above the baseline. CSL 1 represented an improved 800 series full wattage (59 W) T8 lamp in which the phosphor mix and/or coating is enhanced to increase efficacy. Reduced wattage lamps also met this CSL. DOE determined through publicly available compliance reports that the 54 W representative unit and/or equivalent lamps complied with CSL 1. Thus, DOE concluded that no adjustment was necessary to CSL 1 in the preliminary analysis.

NEMA recommended revising CSL 1 to 97 lm/W for the 8-foot SP slimline product class, which is equivalent to the existing standard, in response to the preliminary analysis. For the NOPR analysis, as mentioned previously, DOE selected a new baseline lamp that just complies with the existing standard level of 97 lm/W. The baseline level represents a less efficient 800 series full wattage T8 lamp. DOE then identified two levels of efficacy above this baseline that commercially available lamps are able to achieve. Manufacturer-provided information in catalogs indicates that there are two distinct product lines available with efficacies higher than the baseline product. EL 1 represents a standard 800 series full wattage T8 lamp. EL 2 represents an improved 800 series full wattage T8 lamp in which the phosphor mix and/or coating is enhanced to increase efficacy. Reduced wattage lamps also meet EL 2. DOE found no adjustments were necessary based on certification data and established EL 1 at 98.2 lm/W and EL 2 at 99.0 lm/W.

For the 8-foot RDC HO product class, DOE had put forth CSL 1 at 97.0 lm/W in the preliminary analysis. The baseline represented a 700 series full wattage (86 W) T8 lamp, and DOE identified one level of efficacy above the baseline. CSL 1 represented a shift from 700 series to 800 series full wattage T8 lamps. Based on available certification data for the 86 W T8 representative unit and/or equivalent lamps at CSL 1, DOE adjusted CSL 1 from 97.6 lm/W to 97.0 lm/W for 800 series full wattage T8 lamps.

In response to the CSL proposed in the preliminary analysis for the 8-foot RDC HO product class, NEMA suggested changing CSL 1 to 94 lm/W. DOE revised its analysis for the NOPR and modeled a baseline that just met the existing standard level of 92 lm/W, as described in section VI.D.2.c. DOE then identified two levels of efficacy above the baseline level. EL 1 now represents a 700 series full wattage T8 lamp with basic coating, gas composition, and phosphor mix. EL 2 represents a shift to an 800 series full wattage T8 lamp. DOE again analyzed publicly available certification data and determined that EL 1 should be adjusted from 95.2 lm/W to 94.0 lm/W for 700 series full wattage T8 lamps based on available certification data. EL 2 was not adjusted based on available certification data and remains 97.6 lm/W. DOE notes that this level representing the 800 series design option in the preliminary analysis (previously CSL 1) was adjusted to 97.0 lm/W; however, based on additional

[34] ELs span multiple lamps of different wattages. In selecting CSLs, DOE considered whether these multiple lamps can meet the ELs.

certification data, an adjustment is not necessary.

In the preliminary analysis, DOE had considered one CSL at 98.2 lm/W for the 4-foot T5 MiniBP SO product class. The baseline represented an 800 series full wattage (28 W) T5 lamp with basic coating, gas composition, and phosphor mix. CSL 1 represented an improved 800 series full wattage T8 lamp in which the phosphor mix and/or coating was enhanced to increase efficacy. Reduced wattage lamps also met this level. DOE then compared the certification data to the initial efficacy level at 25 °C to determine if adjustments were necessary. DOE determined through publicly available compliance reports that the representative unit and/or equivalent lamps complied with CSL 1. Therefore, DOE did not adjust the initial CSL considered for this product class.

NEMA recommended revising CSL 1 to 90 lm/W for the 4-foot T5 MiniBP SO product class. DOE updated its analysis for the NOPR and modeled a baseline that just met the existing standard level of 86 lm/W, as described in section VI.D.2.c. The baseline level represents a less efficient full wattage (28 W) lamp. Based on a review of commercially available products, DOE then identified two levels of efficacy above the baseline level at which lamps were consistently performing. Manufacturer-provided information in catalogs indicates that there are two distinct product lines available with efficacies higher than the baseline product. EL 1 represents an 800 series full wattage T5 lamp with basic coating, gas composition, and phosphor mix. EL 2 represents an improved 800 series full wattage T8 lamp in which the phosphor mix and/or coating is enhanced to increase efficacy. Reduced wattage lamps also meet this level. DOE found that no adjustments were necessary for EL 1 and therefore established EL 1 at 93.5 lm/W. For EL 2 representing improved 800 series full wattage T8 lamps, DOE adjusted EL 2 from 98.2 lm/W to 97.1 lm/W based on additional certification data.

In the preliminary analysis, DOE considered one CSL for the 4-foot T5 MiniBP HO product class at 86.2 lm/W. The baseline represented an 800 series full wattage (54 W) T5 lamp with basic coating, gas composition, and phosphor mix. CSL 1 represented reduced wattage lamps, including 50 W T5 and 47 W T5 lamps, or an improved 800 series full wattage T8 lamp in which the phosphor mix and/or coating is enhanced to increase efficacy. Because there were no commercially available full wattage higher efficacy replacements for the 4-foot T5 MiniBP HO baseline lamps, DOE modeled a more efficacious full wattage lamp. DOE determined through publicly available compliance reports that the commercially available reduced wattage representative units and/or equivalent lamps complied with CSL 1. Therefore, DOE did not adjust the initial CSL considered for this product class.

For the T5 MiniBP HO product class, NEMA suggested revising CSL 1 to 80 lm/W. DOE agrees with NEMA that there is only one level of efficacy above the baseline level for this product class; however, performance based on commercially available lamps corresponded to 76 lm/W. DOE revised its analysis for the NOPR and modeled a baseline that just met the existing standard level of 76 lm/W, as described in section VI.D.2.c. The baseline level represents a less efficient full wattage (54 W) lamp. Manufacturer-provided information in catalogs indicates that there is one distinct product line available with efficacy higher than the baseline product. EL 1 represents an 800 series full wattage T5 lamp with basic coating, gas composition, and phosphor mix. Reduced wattage lamps also meet this level. DOE did not adjust this level based on certification data and is therefore evaluating EL 1 at 82.7 lm/W.

NEMA commented that having one CSL eliminates DOE's ability to analyze standard levels other than the baseline and max tech and makes it more likely that max tech will become the new standard. (NEMA, Public Meeting Transcript, No. 30 at p. 350) EEI also expressed concern that besides the 4-foot MBP product class, only one CSL was being considered for all other product classes which was also representative of the max tech level based on the criteria that full wattage lamps had to meet every CSL being considered. EEI further noted that it was not aware of any other rulemaking where no other levels were proposed between the baseline and max tech. (EEI, Public Meeting Transcript, No. 30 at pp. 124, 135–137)

As described in the preceding paragraphs, DOE revised its engineering analysis for the NOPR analysis. DOE surveyed the market, analyzed product catalogs, and took into account feedback from manufacturers to develop ELs. Based on this assessment, DOE identified varying levels of efficacy that reflected technology changes and met the criteria for developing ELs outlined above. In the NOPR, DOE is considering two ELs in each product class with the exception of the T5 MiniBP HO product class.

DOE also received several comments regarding full wattage lamps meeting efficacy levels under consideration. NEMA stated that if the efficacy level at CSL 2 for the 4-foot MBP lamp can be achieved only with more efficient krypton-filled (*i.e.,* reduced wattage) fluorescent lamps, it will come at the cost of reliable dimming that will have an impact on energy savings compared to the baseline. Lutron stated that the full wattage lamps in both the T8 and T5 categories are the only ones for which there are dimming standards in the industry. Lutron expressed concern that the CSLs being considered by DOE would eliminate full wattage lamps and that would result in a loss of significant energy savings, not just the theoretical energy savings associated with the lamp efficacy, which may or may not result in any actual energy savings in buildings. (Lutron, Public Meeting Transcript, No. 30 at pp. 133–134) NEMA strongly cautioned DOE to bear in mind that reduced wattage lamps are often "energy saver" models, which lack the robust performance of full wattage models. Full functionality for dimming, a desirable characteristic, is typically only available in full wattage models. (NEMA, No. 36 at p. 11)

DOE acknowledges that there are limitations with using reduced wattage fluorescent lamps. DOE received feedback during manufacturer interviews that reduced wattage lamps cannot act as replacements for full wattage lamps in all applications, particularly in cold temperature applications below 60–65 °F. Manufacturers also noted that striations remain an issue for reduced wattage lamps because not all ballasts contain striation control circuitry, and those equipped with striation control circuitry do not completely eliminate striation. Further, manufacturers identified issues with dimming reduced wattage lamps indicating that these lamps dim unreliably in certain applications. Manufacturers noted that problems encountered with dimming linear fluorescent lamps, including lamp starting, striations, and dropout, are exacerbated by the use of krypton in reduced wattage lamps (see section VI.C.1 for more information). Therefore, DOE has continued to ensure that full wattage lamps can meet all ELs under consideration in this NOPR analysis.

For the NOPR analysis, DOE used updated catalog and certification data, which resulted in slightly different ELs than those considered in the preliminary analysis. The ELs for the representative product classes of GSFLs are presented in Table VI.8. For further information on the development of ELs, please refer to chapter 5 of the NOPR TSD. DOE welcomes comments on the methodology used to develop ELs for GSFLs as well as on the ELs.

TABLE VI.8—SUMMARY OF ELS FOR GSFL REPRESENTATIVE PRODUCT CLASSES

CCT	Lamp type	Efficacy level *lm/W*	
		1	2
≤4,500 K	4-foot MBP	90.0	92.4
	8-foot SP slimline	98.2	99.0
	8-foot RDC HO	94.0	97.6
	4-foot T5 MiniBP SO	93.5	97.1
	4-foot T5 MiniBP HO	82.7	N/A

h. Scaling to Other Product Classes

As noted previously, DOE analyzes the representative product classes directly. DOE then scales the levels developed for the representative product classes to determine levels for product classes not analyzed directly. For GSFLs, the representative product classes analyzed were all lamp types with CCTs ≤4,500 K, with the exception of 2-foot U-shaped lamps. For the 2-foot U shaped product class DOE scaled the efficacy levels developed for the 4-foot MBP product class.

Therefore, efficacy levels developed for lamp types with CCTs less than or equal to the 4,500 K were scaled to obtain levels for higher CCT product classes not analyzed. In the preliminary analysis, DOE developed this scaling factor by identifying pairs of the same lamp type manufactured by the same manufacturer, within the same product family, and differed only by CCT. DOE determined the average difference in efficacy between these lamp pairs to be 2 percent. DOE received several comments on this approach and resulting scaling factor.

CCT Scaling

NEMA stated that the 2 percent decrease for lamps with CCT >4,500 K is insufficient to reflect the actual drop in lm/W that occurs. NEMA stated it is well known in the industry that as CCT increases above 4,500 K, the lumen output and consequently the lm/W continues to decrease. Actual performance data for the common F32T8 5,000 K tri-phosphor lamps indicates the decrease in lm/W to be in the 4–6 percent range and in the 6–8 percent rage for an F32T8 6,500 K tri-phosphor lamp. NEMA noted that this reduction in lm/W at >4,500 K CCT becomes more significant for higher targets of lm/W. (NEMA, No. 36 at pp. 12–13)

NEMA also noted that the 1 percent reduction from the 4-foot MBP product class with ≤4,500 K CCT to the higher CCT lamps set by the 2009 Lamps Rule was a significant error in the analysis. NEMA stated that because of the resulting high lm/W target for the 4-foot MBP lamps, the T8 tri-phosphor 6,500 K products were almost eliminated from the market. Further, NEMA asserted that when the waiver of standards for 700 series lamps is lifted this product may be eliminated because manufacturers may not be able to reliably meet current regulations for the high CCT products. (NEMA, No. 36 at pp. 12–13)

GE stated that the 2 percent decrease for the high chromaticity lamps is probably accurate. (GE, Public Meeting Transcript, No. 30 at pp. 153–154) NEMA recommended a scaling factor that allows a decrease of at least 7 percent to accommodate the average performance of the higher CCT's. These highly efficient high CCT families of products have been growing in importance and sales in recent years due to results from studies (*i.e.,* IESNA TM–24) indicating that lighting that has more blue component actually provides for better visual capabilities, especially for the aging population. NEMA stated that this has resulted in a noticeable shift in the market to >4,500 K products. Any increase in the lm/W requirements for the >4,500 K lamps will eliminate some, and possibly all, of these higher performing high CCT lamps in the remaining classifications. While the prior ruling may have already destined the elimination of the 6,500 K tri-phosphor 4-foot T8–T12 linear classification of GSFLs, there is still the opportunity to protect the 5,000 K tri-phosphor family of lamps by not changing the lm/W targets for this group. (NEMA, No. 36 at pp. 12–13)

Based on comments received from stakeholders and feedback in manufacturer interviews, DOE reassessed the scaling analysis for the higher CCT lamps. DOE examined the differences in efficacies between lower and higher CCT lamps in each product class based on performance data provided in manufacturer catalogs. Finding substantial variation in the percent reduction in efficacy associated with increased CCT among product classes, DOE is proposing a separate scaling factor for each product class. DOE is proposing to maintain a 2 percent scaling factor for the 4-foot MBP product class in order to ensure that any proposed level does not allow for more energy use than the current minimum standard.[35] Based on its assessment, DOE is proposing a 3 percent scaling factor for the 2-foot U-shaped product class, 5 percent for the 8-foot SP slimline product class, 2 percent for the 8-foot RDC HO product class, 6 percent for the T5 SO product class, and 5 percent for the T5 HO product class. DOE also verified the scaling factors developed against certification data. Further, DOE confirmed that lamps with CCT greater than 4,500 K will meet the scaled levels. See chapter 5 of the NOPR TSD for more information on CCT scaling. DOE welcomes comments on the scaling factors developed to scale GSFL product classes from the less than or equal to 4,500 K CCT lamps to the greater than 4,500 K CCT lamps.

2-Foot U-Shaped Scaling

NEMA stated that the scaling factor for 2-foot U-shaped lamps of 2 percent is too small. Because no technology changes or improvements have been made to U-shaped lamps during the past three years, NEMA recommended remaining consistent with the 2009 Lamp Rule scaling factor and use 6 percent. NEMA added that the efficiency of these lamps cannot be significantly, feasibly raised, so the minimum efficiency of these products should remain 84 lm/W. (NEMA, No. 36 at p. 12) GE noted there are some confounding factors for which DOE needs to account if the scaling factor analysis for the 2-foot U-shaped class is

[35] Current standards for the 4-foot MBP product classes are 89 lm/W for CCT ≤4,500 K and 88 lm/W for CCT >4,500 K. Because the difference between existing standards is small, the allowable scaling factor is restricted to 2 percent.

based on catalog data and even manufacturer to manufacturer data. GE stated that efficacy difference was more likely in the 4–6 percent range as opposed to what is found in catalog data. (GE, Public Meeting Transcript, No. 30 at p. 154)

DOE reassessed the scaling analysis for 2-foot U-shaped lamps based on comments received. In the preliminary analysis, DOE had based its scaling assessment on lamp performance data found in catalogs. However, DOE revised its analysis to utilize certification data for the NOPR based on feedback received from manufacturers indicating that confounding factors exist that are not reflected in catalog data. By comparing certification data for 2-foot U-shaped lamps with equivalent 4-foot MBP lamps, DOE determined an average efficacy reduction of 6 percent for the 2-foot U-shaped lamps from the 4-foot MBP lamps was appropriate. DOE confirmed that the technology impacts of the scaled ELs for the 2-foot U-shaped lamps were consistent with those of the proposed ELs for the 4-foot MBP product class. See chapter 5 of the NOPR TSD for more information on 2-foot U-shaped scaling. DOE welcomes comments on the scaling factor developed to scale from the 4-foot MBP product class to the 2-foot U-shaped product class.

i. Rare Earth Phosphors

NEMA restated its support of previous submitted comments of its concerns regarding the rare earth phosphor issue. (NEMA, No. 36 at p. 14) NEMA asked how the analysis accounts for the current shortage of rare earth elements and the existing practice of waivers and further how these factors impact compliance capability. (NEMA, Public Meeting Transcript, No. 30 at pp. 131–132) NEMA recommended the DOE confer with Dr. Alan King of the Critical Materials Institute of the AMES Laboratories to fully understand and predict the availability of critical materials, including rare earth elements. He observed to the NEMA Lighting Systems Division recently that once a material becomes critical, it tends to stay critical, with fluctuations, but no slacking of demand/criticality until the product demand disappears altogether. (NEMA, No. 36 at p. 14)

DOE notes that manufacturers, in their applications for exception relief, stated that they expected an improvement in the rare earth market, specifically noting that supplies of key rare earth phosphors used in fluorescent lamps will become more equal to estimated demand beginning in 2014. Manufacturers also stated that the two-year relief would provide time for potential development of additional supplies outside of China, for progress in technology advancements and development of alternative technologies that use lesser amounts of rare earth material, and for the expansion of recycling and reclamation initiatives.[36] DOE understands a constrained supply of rare earth phosphors may have impacts on the production of higher efficiency fluorescent lamps. DOE also acknowledges that supply and demand of rare earth phosphors should continue to be considered when evaluating amended standards for GSFLs. Thus as in the preliminary analysis, for this NOPR analysis DOE is considering a scenario of increased rare earth phosphor prices in the LCC and NIA. See appendices 7B and 9B of the NOPR TSD for more information.

3. Incandescent Reflector Lamp Engineering

For IRLs, DOE received comments on the engineering analysis presented in the preliminary TSD. Stakeholders provided feedback on the metric used to measure IRL efficacy, as well as feedback on DOE's representative product classes, selection of more efficacious substitutes, baseline lamps, max tech level, CSLs, scaling, and proposing standards for IRLs. The following sections summarize the comments and responses received on these topics, and present the IRL engineering methodology for this NOPR analysis.

a. Metric

Existing IRL standards are based on lamp efficacy measured as the lumen output of the lamp per watt supplied to the lamp. Further, the scope of coverage for existing IRL standards includes lamps that are equal to or greater than 40 W and less than or equal to 205 W. (See section V.C for further information on IRL scope.) Noting that wattage is a factor in defining the scope of IRLs covered, The CA IOUs recommended moving in the direction of lumen-based standards because lumens are useful to a consumer, whereas watts are no longer a useful metric. For example, the CA IOUs noted that lamp packaging that says that the lamp's rated 55 W equals 70 W does not make sense. The CA IOUs recommended that in general, DOE should do as much as possible to help shift discourse to be lumen-based instead of wattage-based, and standards are one way to help do so. Additionally, the CA IOUs stated that for a specific product type, manufacturers are accustomed to designing to a wattage because that is what consumers are used to (*e.g.,* designing to 50 W regardless of the product efficacy), which produces a volume of products giving more or less light. However, the CA IOUs asserted that efficacy should be improved by reducing wattage rather than increasing light output. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 45–48)

EEI, however, noted that the wattage equivalency provided on packaging is useful to the consumer. They noted that the standards are in lumens per watt, which is a formula that provides a requirement for lamps to be more efficient on an efficacy, rather than wattage, basis. However, especially for incandescent lamps, packaging stating that the 72 W halogen lamp is equal to an old 100 W incandescent lamp lets consumers know what they are getting, including the associated light output. Otherwise, as historically higher watts produce higher lumens, consumers would be confused, especially with CFLs and LED lamps. (EEI, Public Meeting Transcript, No. 30 at pp. 48–50)

Energy conservation standards must prescribe either a minimum level of energy efficiency or a maximum quantity of energy use, where the former is a ratio of the useful output of services to the energy use of the product. 42 U.S.C. 6291(5)(6) The existing standard for IRLs is a lumens per watt, or lamp efficacy, metric. Setting a standard based on lumens alone would not capture the efficiency of the product nor allow for a true comparison of efficiency across lamp wattages. By relating the input power to the light output, this metric appropriately measures the efficiency of the lamp.

Regarding setting standards that would drive manufacturers to meet energy conservation standards by reducing wattage and not increasing light output, DOE standards do not aim to favor any one design pathway for achieving energy efficiency and saving energy. DOE employs an equation that relates lumens to wattage and sets a minimum efficacy requirement across all wattages for IRLs. This power law equation captures the potential efficacy using a particular design option for all wattages. DOE acknowledges that manufacturers may choose to increase lumen output rather than decrease wattage to meet the minimum efficacy requirement. Therefore, the engineering analysis considers energy-saving options. Further, lumen outputs that are not within 10 percent of the baseline lumens are not considered in the

[36] *Philips Lighting Company, et al.* OHA Case Nos. EXC–12–0001, EXC–12–0002, EXC–12–0003 (2012). Accessible here: *http://energy.gov/sites/prod/files/oha/EE/EXC-12-0001thru03.pdf.*

analysis. (See chapter 5 of the NOPR TSD for further details on the engineering analysis.) The NIA considers all available options for consumers in choosing IRLs. (See section VI.J and chapter 12 of the NOPR TSD.)

DOE acknowledges consumer understanding of the relationship between watts and lumens could be improved through labeling and marketing of lamps. However, this is not within the scope of DOE's authority in this rulemaking. Therefore, because the lumens per watt metric is an appropriate measure of the energy efficiency of IRLs and DOE considers energy savings when developing efficacy levels, DOE is not proposing to change this metric for IRLs in this rulemaking.

b. Representative Product Classes

When a product has multiple product classes, DOE identifies and selects certain product classes as representative and analyzes those product classes directly. DOE chooses these representative product classes primarily due to their high market volumes. For IRLs, in the preliminary analysis DOE identified standard spectrum lamps, with diameters greater than 2.5 inches, and input voltage less than 125 V as the representative product class, shown in gray in Table VI.9. NEMA agreed with the representative product classes presented for IRLs. (NEMA, No. 36 at p. 7) DOE did not receive any other comments regarding representative product classes for IRLs. In this NOPR, DOE is maintaining the same IRL representative product classes as presented in the preliminary analysis.

TABLE VI.9—IRL REPRESENTATIVE PRODUCT CLASSES

Lamp type	Diameter (in inches)	Voltage
Standard spectrum	>2.5	≥125
		* <125
	≤2.5	≥125
		<125
Modified spectrum	>2.5	≥125
		<125
	≤2.5	≥125
		<125

* Representative.

c. Baseline Lamps

Once DOE identifies representative product classes for analysis, it selects baseline lamps to analyze in each representative product class. Typically, a baseline lamp is the most common, least efficacious lamp that meets existing energy conservation standards. To identify baseline lamps, DOE reviews product offerings in catalogs, shipment information, and manufacturer feedback obtained during interviews. For IRLs, the most common lamps were determined based on characteristics such as wattage, diameter, lifetime, lumen package, and efficacy.

In the preliminary analysis, DOE identified a PAR38 lamp as the most prevalent lamp shape and diameter in the representative product class. From all PAR38 lamps with the most common characteristics, DOE selected two lamps that just met existing standards as baselines. One was a 60 W halogen lamp with a lifetime of 1,500 hours that utilized a higher efficiency inert fill gas and a higher efficiency reflector coating, and had an efficacy right at the existing standard, $5.9P^{0.27}$. The other was a 60 W HIR lamp with a lifetime of 3,000 hours that utilized IR glass coatings and had an efficacy very close to the existing standard. DOE received several comments on its selection of two baselines for IRLs.

The CA IOUs and NEEA and NPCC stated that DOE should use only one baseline lamp which should have an efficacy that just meets the current IRL standards, and it should provide the minimum lamp life expected of these products. (CA IOUs, Public Meeting Transcript, No. 30 at p. 163; CA IOUs, No. 32 at p. 2; NEEA and NPCC, No. 34 at pp. 2, 4–5) The Joint Comment stated that DOE must select the least efficacious lamp meeting current conservation standards as its baseline for IRLs. (Joint Comment, No. 35 at p. 2) ASAP also stated that DOE should not consider two baselines and pointed out that typically, a baseline is the commercially available product with the lowest efficiency. ASAP provided the example of a dishwasher rulemaking, where the most common dishwasher was an ENERGY STAR compliant product. As this product was above the minimum of the last standard, the previous standard itself was used as the baseline. Thus, using the most common product is different than using the least efficient product available. (ASAP, Public Meeting Transcript, No. 30 at p. 158)

NEMA also disagreed with two baselines for IRLs, stating that the two baseline products being compared are not identical, and a dual-baseline will eliminate a product class. NEMA further recommended that rather than expend numerous resources trying to interpolate what the market ''might'' be, DOE should simply employ the baseline selection criteria from the 2009 Lamps Rule and use the standard from that rulemaking as the baseline. (NEMA, No. 36 at p. 7) NEMA stated that the arguments for baseline, CSL 0 in the preliminary TSD, are based on predictions of market shift that erroneously justify a new baseline higher than the minimum requirements put forth by the 2009 Lamps Rule. (NEMA, No. 36 at p. 1)

The CA IOUs, NEEA and NPCC, and GE agreed that the true baseline is the less efficient product with the shorter lifetime (*i.e.,* the 60 W halogen lamp with a 1,500-hour lifetime). (CA IOUs, Public Meeting Transcript, No. 30 at p. 163; NEEA and NPCC, No. 34 at p. 5; GE, Public Meeting Transcript, No. 30 at pp. 159–161) The CA IOUs and the Joint Comment noted that the 60 W halogen lamp with a 1,500-hour lifetime is representative of the minimum performance that is compliant with July 2012 standards, which require an efficacy of 17.8 lm/W for a 60 W lamp. (CA IOUs, No. 32 at p. 2; Joint Comment, No. 35 at p. 2)

The CA IOUs, NEEA and NPCC, the Joint Comment, and GE also agreed that the 60 W HIR lamp with a 3,000-hour lifetime was not a baseline lamp because it was using more advanced technology. (CA IOUs, No. 32 at pp. 2–3; NEEA and NPCC, No. 34 at pp. 2, 4–

5; Joint Comment, No. 35 at p. 2) The CA IOUs, ASAP, and NEEA and NPCC noted there is a trade-off between lifetime and efficacy in incandescent lamp designs and absent other design improvements, an increase in lamp life results in a decrease in efficacy, and vice versa. (CA IOUs, No. 32 at pp. 2–3; ASAP, Public Meeting Transcript, No. 30 at p. 159; NEEA and NPCC, No. 34 at pp. 4–5) Because the second lamp proposed as a baseline lamp in DOE's analysis has a longer life and a higher efficacy, it clearly includes some other advanced design features that have allowed for improved performance in both metrics. (CA IOUs, No. 32 at pp. 2–3) The Joint Comment added that if the lifetime of the second baseline lamp was reduced to 1,500 hours to allow for an accurate comparison to the first baseline lamp, its efficacy would be even greater than 18.3 lm/W. (Joint Comment, No. 35 at p. 2) Further, the CA IOUs and NEEA and NPCC pointed out that the higher cost of the HIR lamp indicated that it was a more technologically advanced product than the halogen lamp. (CA IOUs, No. 32 at pp. 2–3, NEEA and NPCC, No. 34 at pp. 2, 4–5)

The CA IOUs also noted that minimum product performance generally gravitates towards the minimum standards set for a product and such IRL products are on the market. Therefore, the CA IOUs contended it is inaccurate to define a baseline product that is higher than the minimum standard. (CA IOUs, No. 32 at p. 2) ASAP further added that by introducing the 60 W HIR, 3,000-hour lifetime lamp as a baseline, DOE took that first, most cost effective improvement and averaged it into the baseline. (ASAP, Public Meeting Transcript, No. 30 at p. 161)

DOE recognizes that the HIR baseline lamp with the longer lifetime considered in the preliminary analysis is using more advanced technology than the halogen baseline lamp. Therefore, in this NOPR, DOE is not proposing to analyze the 60 W HIR lamp with a 3,000-hour lifetime as a baseline lamp. DOE is proposing one baseline represented by the 60 W halogen lamp with a 1,500-hour lifetime.

The CA IOUs noted that, historically, many reflector lamps have been offered with a minimum lifetime of 1,000 hours, and generally no fewer. Therefore, DOE could even more accurately represent the baseline by lowering the baseline lifetime to 1,000 hours. (CA IOUs, No. 32 at p. 2)

DOE reviewed product offerings in catalogs, shipment trends, and information obtained during manufacturer interviews to identify the common characteristics of lamps that meet standards. Based on DOE's analysis, the 1,500-hour lamps are much more common than other lower lifetime lamps, including 1,000-hour lamps, among the covered IRLs. Therefore, DOE is proposing a 1,500-hour lamp as the baseline.

Stakeholders also commented on whether it was necessary to have different lamp lifetimes for different sectors. GE stated that the consumer market, which does not necessarily need the long lifetime, is looking for a less expensive opening price point. However, the 60 W HIR with the 3,000-hour lifetime would be sold to a commercial customer who is more concerned about long operating hours and does not want to replace lamps frequently. Therefore, the commercial consumer will gravitate more towards the higher technology lamp, trying to reduce maintenance costs. (GE, Public Meeting Transcript, No. 30 at pp. 159–161)

The CA IOUs disagreed that a shorter lifetime lamp was appropriate for only the residential sector and a longer lifetime lamp for the commercial sector. They stated that products with shorter lifetimes are commonly marketed and sold into various market segments, including the commercial sector. They provided the examples of Halco Haloxen SPAR Series product line and the Satco Xenon Halogen line,[37] both of which are standards-compliant 1,500-hour life lamps specifically marketed for use in the commercial sector. According to the CA IOUs, this suggests that the shorter lifetime products (1,000–1,500 hours) are appropriate to represent the baseline lamp for both the residential and commercial sectors. (CA IOUs, No. 32 at p. 2) NEEA and NPCC added that both the 60 W halogen lamp with a 1,500-hour lifetime and the 60 W HIR lamp with a 3,000-hour lifetime can be found at typical do-it-yourself (DIY) stores and in commercial lamp catalogs. (NEEA and NPCC, No. 34 at p. 5)

Several stakeholders asked for further information about the market share breakdown of these lamps by sector. EEI asked about the percentage of the IRL market that is residential versus commercial. (EEI, Public Meeting Transcript, No. 30 at pp. 163–164) EEI also asked how the baseline characteristics put forth in the preliminary analysis compared to those in the marketplace in terms of what is actually being sold using 2012 or 2013 data. (EEI, Public Meeting Transcript, No. 30 at p. 157) Noting that it was difficult to determine where a lamp going through distribution channels such as Home Depot or Lowe's ends up, NEEA asked how DOE determines which lamps are in the residential sector and which are in the commercial sector (*e.g.,* by distribution channel or socket). (NEEA, Public Meeting Transcript, No. 30 at p. 164) NEMA asked if the 2010 LMC contained data on sockets in specific sectors so as to determine what percentage of those tend to be the higher technology. (NEMA, Public Meeting Transcript, No. 30 at pp. 165–166)

ASAP agreed that the market is important but noted that it is factored into the downstream analyses. ASAP provided an example that if 100-percent of commercial shipments are already at this level, then this will be reflected in the shipments analysis and it would flow through to the LCC and NIA, rather than be built into the baseline. (ASAP, Public Meeting Transcript, No. 30 at pp. 162–163)

DOE acknowledges that different lamps may be popular in different market sectors. The 2010 LMC provides data on the inventories of halogen reflector lamps in each sector. However, because there is nothing that would limit the use of a covered IRL in a specific sector, DOE does not conduct sector-based assessments in the engineering analysis. Rather, the LCC and NIA consider lamp use in different market sectors. The LCC analysis provides results for each analyzed lamp in each relevant sector. The shipments analysis accounts for the number of shipments by sector and the popularity of analyzed lamps in each sector. The results are subsequently used in the NIA analysis. Please see section VI.J for more detail.

Summary of IRL Baseline Lamps

DOE is proposing the baseline lamp for IRLs specified in Table VI.10. For further information, please see chapter 5 of the NOPR TSD. DOE requests comments on its selection of baseline lamps for IRLs.

[37] More information on these lamps is provided in the written comment available on regulations.gov under docket number EERE–2011–BT–STD–0006.

TABLE VI.10—IRL BASELINE LAMP

Representative product class	Baseline lamp					
	Lamp type	Descriptor	Wattage	Efficacy	Initial light output	Lifetime
			W	lm/W	lm	hr
Standard Spectrum, Voltage <125 V, Diameter >2.5 Inches.	PAR38	Improved Halogen	60	17.8	1,070	1,500

d. More Efficacious Substitutes

DOE selects more efficacious replacements for the baseline lamps considered within each representative product class. DOE considers only design options identified in the screening analysis. In the preliminary analysis, DOE considered substitute lamps that saved energy and, where possible, had a light output within 10 percent of the baseline lamp's light output. In identifying the more efficacious substitutes, DOE utilized a database of commercially available lamps. In the preliminary analysis, DOE identified a higher efficacy, lower wattage lamp, referred to in this analysis as an improved HIR lamp with a lifetime of 4,400 hours, as a more efficacious substitute for the two baseline lamps. DOE received several comments regarding its choice for a more efficacious substitute.

ASAP expressed concern that two dependent variables, lumens per watt and lifetime, are changed so that the more efficacious substitute is providing not just greater efficacy but also more light, more hours of lighting, and greater utility. The product is different and is designed to meet some commercial consumers' desire for a long-lived product. If the hours were reduced for that product to be equivalent to the baseline lamp lifetime, it would have a significantly higher efficacy from an engineering perspective. ASAP concluded that lifetime is a limiting factor on the efficacies that can be used for the selection of more efficacious, commercially available lamps. (ASAP, Public Meeting Transcript, No. 30 at p. 169)

The CA IOUs provided information on the relationship between lifetime and efficacy in incandescent lamps, noting that a lamp's efficacy could be improved by increasing current, but if no other design options are employed, the lamp will have a shorter lifetime. On the other hand, decreasing current can increase lamp lifetime, but if no other design changes are made, the resulting product would have a reduced efficacy. The CA IOUs also put forth a relationship where life = life0 × {lpw/lpw0}$^{-7.1}$ to show that the efficacy of a lamp could be improved at the expense of lamp life rather than investment or improvement in the lamp design.[38] (CA IOUs, No. 32 at pp. 3–4)

DOE recognizes that there is an inverse relationship between efficacy and lifetime for IRLs. The engineering analysis focuses on commercially available products. DOE is aware that to meet higher efficacy levels, manufacturers can choose to produce lamps with a shorter lifetime than the baseline lamp to achieve higher efficacy. Given that manufacturers responded to the July 2012 standards by introducing IRLs with shorter lifetimes, DOE understands that this is a likely path manufacturers may take in response to higher standards. To capture the impacts of the relationship between lifetime and efficacy in IRLs, DOE determined how much the lifetime of a lamp with the same wattage as the baseline lamp must be shortened to achieve each efficacy level under consideration in the NOPR analysis. (See chapter 5 of the NOPR TSD for further information.) The impact of these shortened lifetime lamps are assessed as sensitivities in the LCC, NIA, and MIA. (See respectively, appendix 8B, chapter 12, and appendix 13C of the NOPR TSD).

In the main engineering analysis, DOE did not model IRLs with shortened lifetimes at efficacy levels higher than those at which they are currently commercially available because DOE believes that lifetime is a feature valued by consumers. DOE believes typical lifetimes of IRLs regulated by this rulemaking are between 1,500 and 4,400 hours. The longest lifetime products are available at EL 1, the highest analyzed efficacy level in this NOPR analysis. While manufacturers can choose to introduce shorter lifetime products in the future, DOE does not require shortening of lamp lifetime to meet any analyzed level.

In the preliminary analysis, DOE had put forth a representative lamp with a 4,400-hour lifetime and improved HIR technology as the more efficacious substitute. For the NOPR analysis, after reassessing updated catalog and compliance information, DOE identified an alternative representative lamp that better reflected the minimum efficacy level for lamps with improved HIR technology. This representative lamp has a lifetime of 4,200 hours. Because there is a range of lifetimes available at a higher efficacy, in addition to the 4,200-hour representative lamp, DOE is proposing a second representative lamp as a more efficacious substitute at EL 1 in this NOPR analysis. The 2,500-hour lamp offers a different technology pathway to achieve EL 1, namely IR glass coating without the use of higher efficiency reflector coatings. Therefore DOE analyzes the 2,500-hour lamp as a representative lamp at EL 1. DOE requests comment on the lifetimes of the IRL baseline and more efficacious substitutes.

Summary of IRL Representative Lamps

DOE is proposing the representative lamps for IRLs specified in Table VI.11. For further information please see chapter 5 of the NOPR TSD. DOE requests comments on its selection of representative lamps for IRLs.

[38] In the equation, ''life$_0$'' is equal to the design life at the designed efficacy (lpw$_0$), while ''life'' is the resultant life when the designed efficacy is altered to a new operational efficacy (lpw).

TABLE VI.11—IRL REPRESENTATIVE LAMPS

Representative product class	Representative lamps					
	Lamp type	Descriptor	Wattage	Efficacy *	Initial light output	Lifetime
			W	*lm/W*	*lm*	*hr*
Standard Spectrum, Voltage <125 V, Diameter >2.5 Inches.	PAR38	HIR	55	18.5	980	2,500
	PAR38	Improved HIR	55	18.5	1120	4,200

* Efficacy values are based on data from DOE's certification database.

e. Maximum Technologically Feasible

DOE presented one efficacy level (CSL 1) for consideration in the preliminary analysis. Therefore, this level was also the max tech level identified for IRLs. DOE received several comments on the max tech level presented in the preliminary analysis.

The CA IOUs expressed their belief that DOE had not captured the total potential energy savings from IRL standards. They noted that according to the 2010 LMC, IRLs represent a sizable end use, an estimated 39 TWh of annual energy use in the United States. (CA IOUs, No. 32 at pp. 1–2) The CA IOUs cited the case of *Natural Resources Defense Council* v. *Herrington,* 768 F.2d 1355, 1391–92 (D.C. Cir. 1985), in which the D.C. Circuit Court explained the EPCA provision that requires DOE to identify and analyze the ''maximum technology feasible level'' to determine whether that level is both cost-effective and feasible. The ruling further stated that DOE must explain why a standard achieving max tech was rejected. (CA IOUs, No. 32 at p. 4) Specifically, CA IOUs made the following assertions regarding the max tech for IRLs presented in the preliminary analysis: (1) There are commercially available IRLs higher than the max tech; (2) advanced technology being used in other lamp types can be transferred to produce higher efficacy IRLs; and (3) there are prototype IRLs that demonstrate the feasibility of higher efficacy IRLs. (CA IOUs, No. 32 at pp. 4–7)

The CA IOUs commented that there is a wide array of currently, commercially available products that are significantly more efficient, by 13–20 percent, than the CSL proposed by DOE. (CA IOUs, No. 32 at p. 4) In the DOE certification database there is a Philips 70 W PAR38 at 22 lm/W, which is 13 percent better than CSL 1; a Philips 55 W lamp at 20.1 lm/W, which is 10 percent better than CSL 1; and a GE lamp at 23 lm/W, which is 12 percent better. The CA IOUs noted that OSI's best products are not yet in DOE's certification database. They also noted that smaller manufacturers with products such as one with 25 percent higher performance than CSL 1 are not represented in the analysis. (CA IOUs, Public Meeting Transcript, No. 30 at p. 172) ASAP stated it is important that DOE analyze a max tech level chosen from all lamps on the market and then examine the impacts of that level on utility. (ASAP, Public Meeting Transcript, No. 30 at pp. 181–182) NEEA and NPCC stated products that should be commercially available in 2013 range in efficacy from the minimum federal standard to over 30 lm/W, and max tech is probably over 35 lm/W, even at lower wattages, far above what DOE has acknowledged. (NEEA and NPCC, No. 34 at pp. 2, 5) NEMA, however, stated that there have been no noteworthy technological breakthroughs since the last rulemaking or great changes in the market. Therefore, the maximum-feasible performance levels of the previous rule have not changed. (NEMA, No. 36 at p. 1)

In the preliminary analysis, DOE evaluated the latest catalogs and DOE's certification database to identify the most efficacious IRLs to develop the max tech level. DOE selected more efficacious replacements with a similar reflector shape (PAR38) and lumen output (within 10 percent) as the baseline lamp. In the engineering analysis, DOE considered only replacements that saved energy. Based on DOE's analysis, the max tech presented in the preliminary analysis represented the highest-efficacy commercially available lamp meeting these criteria.

The CA IOUs noted that over the last few years, a number of products have been designed and tested using improved halogen IR capsules with new mixes and more layers of materials in the thin-film coatings. IRLs have demonstrated efficacies above 30 to 35 lm/W, with efficacies of 45 lm/W (with a 1,000-hour lifetime) having also been achieved for omni-directional lamps in lab settings.[39] The CA IOUs cited a November 2012 Electric Power Research Institute (EPRI) study [40] that conducted extensive photometric, electrical, and durability testing on a 32 lm/W A-lamp, including extended lifetime measurements and testing of the lamp's ability to withstand sudden changes in voltage, to assess its performance. All lamps were still functional at 1,000 hours and 70 percent of the test samples exceeded 2,000 hours. The independent study concluded that the high efficacy lamps were ''a true 100 watt incandescent-equivalent with respect to all output/performance values, lifespan.'' The CA IOUs argued that the high efficiency halogen IR capsules in those lamps could be inserted into reflector lamps as well. (CA IOUs, No. 32 at pp. 5–6)

The CA IOUs further noted that Venture Lighting is offering 2X halogen A-lamps ($6.98, 32 lm/W, 1,500 hours) [41] and 2X halogen MR–16 lamps ($6.90, 22 lm/W, 6,000 hours) [42] on the Web site, *www.2XLightDirect.com.* The 2X lamps are deemed to be two times as efficient as their typical incandescent counterparts. (CA IOUs, No. 32 at pp. 5–6) CA IOUs emphasized that the 2X MR–16 is a commercially available product using technology that can be used in other lamp form factors. The CA IOUs acknowledged, however, that the MR–16 lamp, which is not a covered product, cannot be used for a direct comparison with the lamps covered under this rulemaking due to different design parameters, coatings on the lenses, and low voltage operation. Additionally, the CA IOUs stated that the challenges encountered with designing a smaller form factor lamp

[39] ETCC presentation, Dec 2010, slide 2. *www.etcc-ca.com/pdfs/10_2X_Incandescent_ET_Open_Forum_121207_R1.pptx.*

[40] EPRI report # 1025779; *www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001025779&Mode=download.*

[41] *www.2xlightdirect.com/product-categories/a-line.*

[42] *www.2xlightdirect.com/product-categories/2x-mr16.*

such as an MR–16 may be more easily overcome with PAR lamps. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 170–173, 179–180) The CA IOUs noted that the Web site *www.2Xlightdirect.com*, where these 2X lamps can be found, states that PAR lamps are ''coming soon.'' [43] (CA IOUs, No. 32 at pp. 5–6)

Philips stated that it is unknown if IRLs utilizing the 2X lamp technology are technically viable. Philips provided the example that a 37 lm/W lamp can be demonstrated, but that it could only last 24 hours. (Philips, Public Meeting Transcript, No. 30 at pp. 173–174)

DOE acknowledges that efficacious A-shape and MR–16 lamps are currently being offered on the market. However, DOE cannot assume that lamp designs and technologies that work for certain lamp shapes (*e.g.,* MR–16 and A-shape lamps) and at low voltages will achieve the same efficacies in the IRLs that are the subject of this rulemaking. The incandescent lamps studied by EPRI and available from Venture Lighting (the 2X A-lamps and MR–16s) are not covered IRLs. They do not utilize the same reflector shapes and the MR–16s do not operate at the same input voltage as the covered IRLs. Therefore, DOE cannot consider these lamp types to determine a max tech for IRLs.

The CA IOUs asserted that covered IRLs exist in prototype form that are dramatically more efficient than DOE's proposed CSL. (CA IOUs, No. 32 at p. 4) The CA IOUs stated that, in 2009, they funded the development of a super-efficient PAR lamp achieving 37 lm/W at 57 W with a lifetime of 1,500 hours. The CA IOUs provided information about the lamp and its testing completed in 2009.[44] (CA IOUs, No. 32 at p. 6; CA IOUs, Public Meeting Transcript, No. 30 at p. 173)

Additionally, the CA IOUs pointed out a presentation from the Emerging Technologies Coordinating Council (ETCC) site [45] that includes information about the market potential for advanced IR coatings. Several PAR lamps achieving approximately 30 lm/W are forecasted to be available by mid-2013, at a price point of $8 to $9.[46] The CA IOUs stated that they are tracking the development of these products and intend to obtain samples to submit to DOE. The CA IOUs encouraged DOE to reach out to manufacturers of these products directly to understand more specifics about product development schedules, manufacturing capability, likely cost points, technical potential, and to potentially obtain prototypes of these lamps. (CA IOUs, No. 32 at p. 6)

The CA IOUs concluded that DOE needs to look at max tech and then identify what is cost effective, feasible and can be scaled up for production. The CA IOUs noted that this was not adequately addressed in the preliminary analysis. Further, the CA IOUs suggested that one of the CSLs should be set in line with the max tech level and another should be set in line with the maximum commercially available level. NEEP agreed with this recommendation. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 170–173; CA IOUs, No. 32 at pp. 6–7; NEEP, No. 33 at p. 3) The Joint Comment also stated that to properly identify the max tech level, DOE should examine those sources referenced in the CA IOUs' comments, namely, EPRI, 2Xlightdirect.com, and ETCC. (Joint Comment, No. 35 at p. 3)

NEMA stated that if DOE chooses to consider higher performance levels based on any recently introduced technologies, they are obligated to conduct actual testing of these lamps for all performance parameters, such as reliability, lifetime, dimmability, beam spread, light pattern, and any other performance features expected of new/substitute lamps in this class. (NEMA, No. 36 at p. 11) NEMA also cautioned DOE that emerging technology and prototype models do not reliably represent the market, only market attempts. NEMA further stated that technologies on which to base the future of an entire product class must be demonstrated and proven for long-term feasibility and market acceptance. (NEMA, No. 36 at p. 11)

For the NOPR analysis, DOE contacted manufacturers producing high efficacy prototype IRLs and conducted independent testing of these lamps. The testing indicated that these lamps were more efficacious than the max tech level determined by DOE in this analysis.[47] DOE notes that the lamps tested were prototype lamps and were not manufactured during commercial scale production runs. However, the measured efficacy of the prototype lamps greatly exceeded the efficacy of commercially available lamps with similar lumen packages. DOE does not, however, have the necessary information to do a cost analysis to determine if an efficacy level based on these lamps would be economically justified. In appendix 5A of the NOPR TSD, DOE provides an assessment of these higher efficacy prototypes (including test data), conducts a further examination of the highly efficacious lamps relevant to this rulemaking noted by stakeholders in comments, and specifies the additional information it would need to consider prototypes in a rulemaking analysis. DOE welcomes comments on the max tech level as well as any further information on prototype lamps.

While DOE received several comments stating that the max tech level is greater than that analyzed in the preliminary analysis, DOE also received comments that the max tech level is not higher than the analyzed level. GE stated that it did not believe technology existed that would triple the efficiency of these lamps. GE noted that although there may be a few more players in the market, the technology itself or what can be done with it has not changed in the last three or four years. GE asserted that the baseline technology represents the highest technology available today that meets many different needs in the marketplace. As efficacy requirements increase, even to the CSL 1, utility is lost, potentially leading to only one product that works for one consumer and one application. GE stated that CSL 1 represents the max tech of what is available today that could cover all the different market needs. (GE, Public Meeting Transcript, No. 30 at pp. 176–178)

As discussed previously, based on DOE's analysis of commercially available lamps and because it does not have the adequate information to conduct a full analysis on any lamp that represents an efficacy level higher than EL 1, DOE is proposing $6.2P^{0.27}$ as EL 1 and the max tech level.

Proprietary Technology

In response to the max tech level presented in the preliminary analysis, DOE received several comments regarding the use of proprietary technology. NEMA stated that for all IRLs, no further elevations in product performance are possible. As support, NEMA quoted from the final rule notice of the 2009 Lamps Rule, in which DOE had noted that the max tech level was possible with the use of the highest-efficiency technologically feasible reflector, halogen IR coating, and filament design and because this would require the use of proprietary technology, DOE could not consider this

[43] *www.2xlightdirect.com/product-categories/2x-par.*

[44] Appendix A is available at the end of the CA IOUs written comment in the docket for this rulemaking.

[45] ETCC presentation, Dec 2010, slide 5. *http://www.etcc-ca.com/pdfs/10_2X_Incandescent_ET_Open_Forum_121207_R1.pptx*

[46] At the time of the NOPR analysis, these lamps were not commercially available.

[47] While DOE independently verified efficacy values, the manufacturer's testing for lifetime was still ongoing at the time of the NOPR analysis.

level further in its analyses. 74 FR 34080, 34096 (July 14, 2009). NEMA stated that if DOE proposes to raise the CSL above the existing level set by the 2009 Lamps Rule, DOE must explain why the proprietary technology hurdle no longer exists, and then explain how to achieve those higher CSLs. (NEMA, No. 36 at p. 11) Specifically, Philips expressed concern that the improved reflector technology option, such as a silver reflector coating, was proprietary. (Philips, Public Meeting Transcript, No. 30 at p. 169) GE added that requiring proprietary technology could impact competition. (GE, Public Meeting Transcript, No. 30 at pp. 169–170)

EEI expressed similar concerns as NEMA and stated that during the 2009 Lamps Rule, the Department of Justice was concerned about the higher standard levels because certain technologies for HIR lamps were proprietary and that because only a few companies made the highest efficacy lamp, competition in the industry could be impacted. EEI asked whether there were issues with the particular technology used in the more efficacious substitute, such that it might be a proprietary technology and made only by a very limited number or even one manufacturer, which could limit its availability and result in an extremely high price point. (EEI, Public Meeting Transcript, No. 30 at pp. 167–168)

The CA IOUs noted that they had provided a number of comments to that rulemaking's docket about alternate silverized reflector technologies, and suggested that manufacturers would be able to utilize them to improve efficacy of their lamps. The CA IOUs reported that since the 2009 Lamps Rule, several manufacturers have begun making lamps with silver reflectors, including, but not limited to, Halco, Satco, Ushio, and Osram Sylvania.[48] Further, the CA IOUs noted that the Lawrence Livermore Lab has a patent; GE and DSI likely also have patents related to reflector technology. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 170–171) Given the wide variety of major PAR lamp manufacturers that are utilizing silverized reflectors, the CA IOUs encouraged DOE to consider this a viable design option for all IRL manufacturers. (CA IOUs, No. 32 at pp. 8–9)

In the 2009 Lamps Rule, the highest level analyzed for IRLs was based on a commercially available lamp that employed a silver reflector, an improved IR coating, and a filament design that resulted in a lifetime of 4,200 hours. While DOE had determined that the silver reflector was patented technology, DOE research indicated that there were alternate pathways to achieve this level, such as filament redesign to achieve higher temperature operation (thus reducing the lifetime), non-proprietary higher efficiency reflectors, and a higher efficiency IR coating. 74 FR 34080, 34133 (July 14, 2009). In interviews conducted in the preliminary analysis for this rulemaking, manufacturers indicated that there were no specific patent or intellectual property barriers to obtaining commercially available IRL technologies. Further, in the preliminary analysis, DOE put forth a CSL 1 that was based on a commercially available improved HIR lamp that does not necessarily require a silverized reflector coating to achieve its efficacy. Several manufacturers have found means of designing more efficacious IRLs that are commercially available, such as through the use of IR glass coatings and higher efficiency reflector coatings that do not use proprietary technology. In the NOPR analysis, DOE confirmed during interviews that proprietary technology is not a barrier to achieving the proposed max tech level, which is also EL 1. Therefore, in this NOPR analysis, DOE is proposing the same efficacy level put forth in the preliminary analysis. DOE has determined that this level can be achieved without the use of proprietary technology.

f. Efficacy Levels

For IRLs, DOE developed a continuous equation that specifies a minimum efficacy requirement across wattages and represents the potential efficacy a lamp achieves using a particular design option. DOE observed an efficacy division among commercially available IRL products that corresponded to the design options utilized to increase lamp efficacy. Based on this efficacy division, DOE considered one CSL in the preliminary analysis. DOE received several comments regarding the CSL presented for IRLs in the preliminary analysis.

The CA IOUs expressed concern that there is only one CSL. The CA IOUs stated that DOE is not capturing the huge potential in the IRL market for efficacy gains, both for commercially available and non-commercially available products. The CA IOUs stated that based on commercially available IRL products and other known high-performing products, DOE should add at least three additional, higher efficacy CSLs to its IRL analysis. (CA IOUs, No. 32 at p. 4)

The Joint Comment agreed with the CA IOUs, stating that DOE should add multiple high efficacy CSLs to its analysis; ASAP suggested two or three additional levels. (Joint Comment, No. 35 at p. 3; ASAP, Public Meeting Transcript, No. 30 at pp. 171–172) NEEP noted that the higher efficacies in DOE's certification database for standard levels should be included in the analysis at this stage. NEEP suggested DOE consider adding at least two additional CSLs to the analysis between CSL 1 and the maximum commercially available level. (NEEP, No. 33 at p. 3) NEEA and NPCC stated there is more than enough rationale to examine at least two or three additional CSLs, if not three or four, including a ''max tech'' level, which DOE has not included for this family of products. (NEEA and NPCC, No. 34 at pp. 2, 5)

To demonstrate the feasibility of potential efficacy improvements beyond the CSL 1 presented in the preliminary analysis, the CA IOUs provided a graph that showed efficacy levels of commercially available lamps from four manufacturers based on catalog data, plotted against the considered CSL 1 and the standard from the 2009 Lamps Rule. In further support, the CA IOUs provided another graph showing efficacy levels of over 20 manufacturers from DOE's certification database, also plotted against the considered CSL 1 and the standard from the 2009 Lamps Rule. Both graphs show a number of lamps above the considered CSL 1. (CA IOUs, No. 32 at pp. 4–5) ASAP asked how old the data DOE used in its preliminary analysis was and why the lamps with higher efficacies in DOE's database were not captured. (ASAP, Public Meeting Transcript, No. 30 at pp. 171–172)

For the preliminary analysis, DOE conducted a thorough review of the latest catalog and certification data provided for covered IRLs. Because PAR38 lamps are the most popular products on the market and a PAR38 lamp was selected as the baseline, DOE considered only PAR38 lamps when selecting more efficacious substitutes. Further, DOE selected more efficacious substitutes with a lumen output within 10 percent of the baseline lumens, as this is the amount of change in light output deemed acceptable to consumers. (See section VI.D.2.e for further information.)

To ensure energy savings, DOE also chose higher efficacy lamps with a lower wattage than the baseline lamp. DOE also did not consider any lamp that could not be purchased in the United

[48] More information on associated products can be found in the written comment available on regulations.gov under docket number EERE–2011–BT–STD–0006.

States. Some of the products with the highest efficacies in DOE's certification database were not found for sale in the United States.

Thus, although there are certain lamps with efficacies higher than the levels proposed by DOE, DOE did not consider them in the preliminary analysis for the reasons stated above. DOE maintained this methodology for the NOPR analysis.

NEMA stated that the CSL 1 presented in the preliminary analysis was infeasible given that there have been no technological breakthroughs since the 2009 Lamps Rule. (NEMA, No. 36 at pp. 9–11) NEMA also commented that having one CSL eliminates DOE's ability to analyze standard levels other than the baseline and max tech and makes it more likely that max tech will become the new standard. (NEMA, Public Meeting Transcript, No. 30 at p. 350)

DOE based CSL 1 on commercially available products that achieved catalog efficacies above the existing standard. Specifically, the representative lamp for CSL 1 was a commercially available 55 W IRL with a catalog efficacy of 20 lm/W. Acknowledging that the catalog efficacy of a lamp varies from its certified efficacy, DOE also reviewed certification data for IRLs. Based on certification data, DOE accordingly adjusted CSL 1, resulting in an efficacy level of $6.2P^{0.27}$. Because DOE based CSL 1 on a commercially available lamp and accounted for variances in efficacies between catalog and certification data when establishing CSL 1, DOE believes that CSL 1 is technologically feasible and is also the appropriate max tech level.

The CA IOUs recommended that DOE revisit the slope of the candidate standard lines to better reflect the performance of lamps on the market. The CA IOUs provided graphs that demonstrated three possible additional CSLs that could be used to more effectively evaluate potential standards at higher, technically feasible efficacy tiers. The CA IOUs adjusted the slopes of the curves to account for higher efficacy potential at higher wattage. (CA IOUs, No. 32 at pp. 7–8)

DOE examined the possibility of changing the exponent of the existing equation for IRL standards to better reflect the performance of lamps on the market. DOE conducted a best fit analysis and determined that the current equation accurately reflects the wattages and associated efficacies of commercially available products. Thus, DOE retained the current standard equation.

Summary of IRL Efficacy Levels

For the NOPR analysis, DOE again reviewed the most updated catalog and certification data available for covered IRLs. As in the preliminary analysis, DOE used the catalog data to determine initial efficacy levels and then adjusted the ELs to ensure that commercially available IRLs would meet proposed levels based on compliance information provided in DOE's certification database. In the preliminary analysis, DOE had found there to be certification data for only 36 percent of covered IRL products compliant with the July 2012 standards. For the NOPR analysis, DOE found that updates to DOE's certification database resulted in certification data for 51 percent of covered IRL products. Using certification data reported for the PAR38 2,500 hour HIR and 4,200 hour improved HIR representative lamps, DOE adjusted EL 1. As mentioned previously, DOE developed a continuous equation that specifies a minimum efficacy requirement across wattages for IRLs. The proposed EL based on the representative lamps is a curve that represents a standard across all wattages.

Table VI.12 presents the proposed efficacy level for IRLs. See chapter 5 of the NOPR TSD for additional information on how the engineering analysis was conducted.

TABLE VI.12—EFFICACY LEVELS FOR STANDARD SPECTRUM, VOLTAGE <125 V, DIAMETER >2.5 INCHES IRLS

Efficacy level	Efficacy requirement *lm/W*
EL 1	$6.2P^{0.27}$

P = rated wattage.

g. Scaling to Other Product Classes

When more than one product class exists for a covered product, DOE identifies and selects representative product classes to analyze directly. Efficacy levels developed for these representative product classes are then scaled to products not analyzed directly. For IRLs, DOE analyzed directly standard spectrum lamps greater than 2.5 inches in diameter and with input voltages less than 125 V. The efficacy levels developed for this representative product class were then scaled to product classes not analyzed, using a scaling factor to adjust levels for modified spectrum lamps, smaller diameter lamps, and lamps with higher input voltages. DOE received several comments specific to the scaling factors applied to develop efficacy levels for the product classes analyzed directly.

Diameters Less Than or Equal to 2.5 Inches

In the preliminary analysis, DOE scaled from the CSLs developed for the IRLs with diameters greater than 2.5 inches (hereafter ''large diameter lamps'') to IRLs with diameters less than or equal to 2.5 inches (hereafter ''small diameter lamps''). Based on catalog data, DOE determined the reduction in efficacy caused by the smaller lamp diameter to be approximately 12 percent. DOE also determined that the more efficient double-ended HIR burners could not fit into small diameter lamps. Therefore, in the preliminary analysis, DOE applied an additional 3.5 percent reduction to account for the ability of small diameter lamps to utilize only less efficient single-ended HIR burners.

Asserting that double-ended burners can be utilized in small diameter lamps, NEEA and NPCC and the CA IOUs urged DOE not to use an additional scaling factor to account for the use of a single-ended burner in a small diameter lamp. (CA IOUs, No. 32 at p. 10, NEEA and NPCC, No. 34 at p. 6) The CA IOUs noted that by providing a PAR20 lamp with a double ended burner at the public meeting, they had demonstrated that double-ended burners can be used in small diameter lamps. At the preliminary analysis public meeting, the CA IOUs had presented two small diameter lamps with double-ended burners. One was a commercially available Philips MR–16 lamp, which the CA IOUs acknowledged to be out of the scope of this rulemaking, but asserted that the MR–16 burner would fit into a covered IRL. The other was a PAR20 lamp covered under this rulemaking that was not yet commercially available. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 195–197) GE noted that the MR16 uses a 12 V filament, which is much shorter than the filament at 120 V, and NEMA stated that many technical features are not transferrable between 12 V and 120 V products. (GE, Public Meeting Transcript, No. 30 at pp. 196–197, NEMA, No. 36 at p. 11) The CA IOUs acknowledged that the MR16 used a 12 V filament, but noted that the PAR20 lamp with a double-ended burner was designed for operation at 120 V. (CA IOUs, Public Meeting Transcript, No. 30 at p. 197) Further, the CA IOUs noted that the PAR20 lamp with a double-ended burner achieved an efficacy of 16.1 lm/W, which is 12 percent higher than the CSL proposed by DOE for this lamp type in the preliminary analysis. (CA IOUs, No. 32 at p. 10)

ADLT agreed with the CA IOUs, noting that these double-end burners have a length of 52 mm and new double-end burners are being introduced to the market that are 45 mm in length, which further mitigates mechanical fit problems related with smaller reflectors. (ADLT, No. 31 at pp. 2–3) However, NEMA contended that double-ended burners will not fit into existing small diameter PAR20 lamps without extending the lens cover. The extension of the lens cover would lessen the utility as the product would not fit into all fixtures designed to use PAR20 lamps, and therefore could not be considered as an acceptable substitute. (NEMA, No. 36 at p. 12) GE agreed that there were difficulties in fitting halogen IR burners into small PAR20 envelopes. (GE, Public Meeting Transcript, No. 30 at pp. 191–193)

Regarding the PAR20 lamp with a double-ended burner provided by the CA IOUs at the preliminary analysis public meeting, DOE notes that it must also consider how the use of a design option affects product utility and whether a more efficacious product is an appropriate substitute for the existing product. DOE must also consider whether the product can be manufactured at a commercial scale by the compliance date of any amended standards. Based on feedback given by manufacturers in interviews, fitting a double-ended burner into a small diameter lamp would require changes to the physical shape of the lamp, specifically requiring an extension of the reflector lens. While the modified lamp may still meet ANSI standards for a small diameter lamp such as a PAR20, it would be larger than any PAR20 lamps sold in the past and those currently installed. Because the lamp shape would be different from the standard sizes of commercially available small diameter lamps, the modified lamp may not fit in existing structures. Past a certain wattage threshold, heat dissipation in lamps with a smaller envelope using a double-ended burner could also become an issue. Further, manufacturers stated that even if the double-ended burner could fit into a small diameter lamp, it would be difficult to place the burner/filament in the optimal position.

Therefore, in this NOPR analysis DOE continues to apply an additional 3.5 percent reduction factor when scaling efficacies of large diameter to small diameter lamps to account for the limitation of small diameter lamps being able to utilize only single-ended burners.

The CA IOUs questioned DOE's methodology for determining the scaling factor for large diameter to small diameter lamps. The CA IOUs stated that it understood DOE compared the efficacies of small diameter lamps to larger diameter lamps on the market, and established that there was a 12 percent difference. Under the assumption that the single-ended burner could not fit in small diameter lamps, DOE then modeled the losses of using a single-ended burner. However, the CA IOUs did not understand why these losses were added to the original 12 percent difference which represents the efficacy reduction going from a large diameter to small diameter lamp. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 194–195)

ADLT stated that it supported a 12 percent scaling factor based on the impact of the less efficient diameter of the reflector because it was independent of capsule design. ADLT noted that a typical PAR30 aluminum-coated reflector with a front lens is approximately 75 percent optically efficient while the same type of PAR20 reflector (aluminum coated with a front lens) is approximately 66 percent efficient. Therefore, ADLT concluded that the 12 percent reduction in efficiency from large to small diameter lamps corresponds to DOE's findings when comparing catalog efficacy data of each lamp type from several lamp manufacturers (all other features remaining approximately the same). (ADLT, No. 31 at p. 2)

In the preliminary analysis, DOE compared the catalog efficacies of halogen PAR20 lamps (the most common IRL with a diameter less than or equal to 2.5 inches) and their PAR30 or PAR38 counterparts from several lamp manufacturers (all other lamp features remaining approximately the same). Based on these results, DOE found that the reduction in efficacy caused by the smaller lamp diameter was approximately 12 percent for IRLs. Because only halogen lamps were used (no HIR lamps were included), the 12 percent included the efficacy difference due only to lamp diameter because the additional impact of a single-ended versus double-ended burner on lamp efficacy is relevant only for HIR lamps. In the NOPR analysis, using the same methodology, DOE confirmed that the efficacy reduction from a large diameter to a small diameter lamp should be 12 percent.

ADLT stated that the 3.5 percent scaling factor going from double-ended to single-ended burners was also unnecessary because single-ended burners can be highly efficient within small diameter reflectors. They cited the example of an MR–16 lamp (2 inch diameter reflector) utilizing single-ended IR halogen burner with an 85 percent optical efficiency compared to a typical PAR38 (4.75 inch diameter reflector, aluminized) with a 78 to 80 percent optical efficiency. Therefore, ADLT urged DOE to consider a 12 percent reduction factor, which would equate to an efficacy requirement of $5.5P^{0.27}$ for small lamp diameters. (ADLT, No. 31 at pp. 2–3)

DOE cannot base its analysis on an MR–16 lamp because it is not designed to operate at the same voltage as covered IRLs, and MR–16 lamps are not the subject of this rulemaking; DOE can assess the efficiency of a single-ended burner only in a small diameter IRL covered under this rulemaking.

With regards to scaling, NEMA stated that DOE must ensure not only that the filaments and halogen burners must be able to be inserted into all lamps scaled, but also that the beam characteristics required for those lamps, a market-demanded performance characteristic, can be met. NEMA suggested that DOE develop demonstration models to verify performance; otherwise, scaling is not possible. (NEMA, No. 36 at p. 12)

As noted, DOE determined that double-ended burners cannot fit into small diameter lamps without changes to the lamp shape that could affect lamp characteristics and thereby product utility. Therefore, DOE scaled from large diameter lamps with double-ended burners to small diameter lamps with single-ended burners. DOE did not create demonstration models because the scaling was based on lamp designs in commercially available lamps.

Operating Voltages Greater Than or Equal to 125 Volts

In the preliminary analysis, DOE scaled from IRLs with voltages less than 125 V to IRLs with voltages greater than or equal to 125 V. DOE developed a scaling factor that would require 130 V lamps tested at 130 V to use the same technology and possess the same general performance characteristics as 120 V lamps tested at 120 V. DOE found that while there may be a slight decrease in efficacy, the lifetime of a 130 V lamp is doubled when it is operated at 120 V, giving it an advantage over 120 V lamps. Using the IESNA Lighting Handbook equations that relate lifetime, lumens, and wattage to voltage of incandescent lamps, DOE determined that a 15 percent scaling factor was necessary.

The CA IOUs stated that it can be assumed the primary utility of the 130

V lamps was long life. However, they noted that the utility has not been removed from the market, as there are still many other commercially available long-life lamps. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 66–67) NEMA clarified that the primary utility and selling point of the 130 V lamps was their ability to withstand voltage spikes. The additional lifetime was just an added benefit. (NEMA, Public Meeting Transcript, No. 30 at pp. 67) EEI agreed that in some areas where the line voltage can be higher than 120 V, the 130 V lamps provided a safeguard against the lamp blowing out. (EEI, Public Meeting Transcript, No. 30 at pp. 61–63) NEMA asserted that consumers have arguably lost a utility and noted that elimination of a market-desired performance characteristic is counter to requirements in EPCA. (NEMA, No. 36 at p. 1, 5) Additionally, according to EEI, consumers that now have to switch from 130 V to 120 V have to buy more lamps. (EEI, Public Meeting Transcript, No. 30 at pp. 61–63)

DOE received feedback in manufacturer interviews that in certain areas where voltage spikes may occur, a 130 V lamp will last longer than a 120 V lamp. DOE remains concerned, however, that the operation of 130 V lamps at 120 V has the potential to significantly affect energy savings. DOE's research has shown that 130 V lamps are usually operated by consumers at 120 V rather than at a higher voltage line. This could incentivize manufacturers to design a less efficient and less expensive 130 V lamp that would meet standards when tested at 130 V. Because they would be cheaper, there could be a market migration to 130 V lamps and due to the lower lumen output when 130 V lamps are operated at 120 V, consumers may purchase more 130 V lamps, resulting in increased energy consumption.

EEI noted that when 130 V lamps are operated at 120 V, their lifetime is increased by about 2.5 times. (EEI, Public Meeting Transcript, No. 30 at pp. 61) GE noted that as 130 V lamps are operated on higher voltages, their efficacy decreases. GE stated that this relationship was misanalysed in the 2009 Lamps Rule, and as a result, the July 2012 standards have eliminated 130 V lamps from the market. (GE, Public Meeting Transcript, No. 30 at pp. 60–61)

DOE's research indicates that operating 130 V lamps at 120 V increases lifetime and lowers efficacy compared to operating these lamps at 130 V. Therefore, to develop an appropriate scaling factor, DOE determined the efficacy of 130 V lamps operated at 120 V if their additional lifetime over that of 120 V lamps were instead used to increase their efficacy. DOE found this increase in efficacy to be 15 percent. Therefore in this NOPR analysis, DOE is proposing a scaling factor of a 15 percent efficacy increase from an IRL with voltages less than 125 V to voltages greater than or equal to 125 V.

Modified Spectrum

In the preliminary analysis, DOE established CSLs for modified spectrum IRLs by scaling from the CSLs developed for the standard spectrum product class. DOE determined that a reduction of 15 percent from the standard spectrum CSLs would be appropriate for modified spectrum IRLs.

The Joint Comment urged DOE to eliminate the 15 percent allowance for modified spectrum IRLs. The Joint Comment noted that a 2009 Ecos Consulting study [49] that found an average light loss of 9 to 11 percent associated with modified spectrum lenses. The study also highlighted the feasibility of modified spectrum IRLs exceeding the highest efficacy levels in the 2009 Lamps Rule. Therefore, the Joint Comment found that the 15 percent scaling factor should be eliminated, as there are high efficacy modified spectrum lamps, or DOE should reduce the factor to 10 percent to match the findings of the Ecos Consulting study. (Joint Comment, No. 35 at p. 3)

In the 2009 Lamps Rule, DOE assessed the efficacy differences between standard and modified spectrum IRLs by measuring the efficacies of commercially available standard and modified spectrum lamps. 74 FR 34080 (July 14, 2009). In that analysis, DOE correlated the measured color point data of the lamps with lamp light output reduction and lamp spectral power distribution. By analyzing the data, DOE established that a reduction of 15 percent from the standard spectrum to modified spectrum lamps was necessary.

In the preliminary analysis, DOE confirmed this 15 percent reduction by determining the difference between the catalog efficacies of the standards-compliant modified spectrum lamps to comparable standard spectrum lamps. Using the available data for standards-compliant modified spectrum lamps on the market, DOE compared the efficacies of these two lamps with standard spectrum lamps with the same wattage and lifetime by the same manufacturer and confirmed a 15 percent reduction in efficacy from a modified spectrum lamp to a standard spectrum lamp. Therefore, in this NOPR analysis DOE is proposing a 15 percent efficacy reduction from a standard spectrum IRL to a modified spectrum IRL.

h. Xenon

DOE identified higher efficiency inert fill gas as a design option for improving lamp efficacy of IRLs. Specifically, xenon, due to its low thermal conductivity, can greatly increase lamp efficacy and is utilized in most covered standards-compliant IRLs. NEMA commented that the availability of xenon is decreasing. If standards are set at a level requiring the use of xenon, it will increase its use, driving up prices and reducing availability, similar to the rare earth phosphor shortage issue. (NEMA, Public Meeting Transcript, No. 30 at pp. 80–81) NEMA noted that xenon is becoming increasingly scarce, and its loss is an automatic 5–7 percent efficacy reduction in IRLs. The loss of xenon will make it impossible to meet CSL 1. NEMA referred DOE to a February 2013 article in CryoGas International Magazine,[50] which provides additional information on the xenon supply and demand market. These estimates show a 2013 increase in demand of 15–20 percent followed by steady 10 percent demand growth in outyears, with a potential for dramatic spike if emerging demands from technology related to satellites, anesthesia and electronics are realized as anticipated. NEMA stated that DOE should add an investigation of xenon availability trends and pricing to its analysis. (NEMA, No. 36 at p. 3)

NEEA and NPCC disagreed, stating that as there is no current shortage of xenon fill gas, and a standard requiring it would not demand a significant increase in xenon use, then xenon price and supply should not be an issue for this rulemaking. (NEEA and NPCC, No. 34 at p. 2, 5) The CA IOUs further noted that xenon is already being used as the primary fill gas in virtually all IRLs, so a requirement of its use would not especially impact any constraints on supply or price instability in the market. (CA IOUs, No. 32 at pp. 9–10)

DOE acknowledges that xenon supply and prices are an important factor for the lighting industry, including IRLs. Therefore, in the preliminary analysis DOE conducted a market assessment of xenon supply, demand, and prices as

[49] Ecos Consulting (prepared for Pacific Gas & Electric, Natural Resources Defense Council, and the Appliance Standards Awareness Project), 2009. Optical Losses of Modified Spectrum Lenses on Incandescent Reflector Lamps.

[50] CryoGas International Magazine, February 4, 2013 ''Ever Changing Rare Gas Market'' Richard Betzendahl.

well as an LCC sensitivity to determine the impact of increased end user lamp prices due to increases in the price of xenon. DOE updated this assessment for the NOPR analysis.

For the NOPR analysis, DOE examined various industry sources relevant to the xenon market including the February 2013 article in CryoGas International Magazine cited by NEMA. While, the article did forecast increases in xenon demand in 2013 and 2014, it also stated that it expected this to flatten out due to penetration of LEDs into the market. A 2012 CryoGas International Magazine article noted that xenon price increases predicted for 2012 did not occur to the extent expected.[51] DOE understands that fluctuations in xenon supply and price are possible and difficult to predict. Based on its research, DOE did not find that there was currently a major shortage of xenon. To further inform the impact of xenon demand and prices, in the NOPR analysis, DOE conducted an LCC sensitivity that determines how high the xenon price would have to increase to result in zero LCC savings for the consumer at the proposed level. Based on the results of this analysis, DOE determined that EL 1 is achievable even with fluctuations in xenon price. See appendix 7C of the NOPR TSD for complete details on the xenon price sensitivity conducted in the LCC. Additionally, for this NOPR analysis, a xenon price sensitivity was also conducted in the NIA. Detailed results can be found in chapter 12 of the NOPR TSD.

i. Proposed Standard

DOE received several comments that no standards should be proposed for IRLs. NEMA indicated that the CSL 1, which was also the max tech level presented in the preliminary analysis should be eliminated. (NEMA, No. 36 at p. 1, 9) GE suggested that the existing standard for IRLs is appropriate, and DOE does not need to establish a higher standard. (GE, Public Meeting Transcript, No. 30 at pp. 176–178) DOE has identified that there are achievable efficacy levels higher than the existing standard and has developed an EL based on the latest catalog and certification information. See section VI.D.3.f for more details.

NEMA, in general, did not believe that any increase in efficacy for small diameter, modified spectrum, or greater than 125 V IRLs would be warranted. (NEMA, No. 36 at p. 5) NEMA expanded on the 130 V IRL, asserting that these lamps appear to have been eliminated by the 2009 Lamps Rule and arguing against further regulation. (NEMA, No. 36 at p. 1, 5) Further, NEMA found the lack of 130 V lamps on the market as evidence that current standards for these lamps are technically or economically infeasible. NEMA noted that there is still difficulty in making these IRLs comply with the July 2012 standards. (NEMA, No. 36 at p. 5) Therefore, NEMA strongly recommended that for IRLs with voltages greater than or equal to 125 V the CSL be ''No New Standard,'' not CSL 0, which implies there are products to regulate rather than acknowledging the inability to further raise efficiency requirements. (NEMA, No. 36 at pp. 10–11)

GE also strongly disagreed with applying another 15 percent increase on top of an already unachievable standard for the 130 V IRLs, particularly when it was not clear how energy savings could be justified and why products that don't meet existing standards would be further regulated. (GE, Public Meeting Transcript, No. 30 at pp. 191–193) EEI asked what percentage of the lighting market the 130 V lamps represent and questioned what can be gained by additional analysis if the standards adopted by the 2009 Lamps Rule have eliminated 130 V lamps from the market. (EEI, Public Meeting Transcript, No. 30 at pp. 58–60, 68)

DOE has not found evidence that more efficacious small diameter, modified spectrum, or 130 V IRLs are not technologically feasible or practicable to manufacture. DOE research indicates that the basic structure, components, and operating requirements of these lamps do not prevent the application of design options considered in the engineering analysis to achieve the proposed efficacy levels. Therefore, in this NOPR analysis, DOE is proposing efficacy levels for these lamp types. DOE requests comment on any technological barriers in manufacturing more efficacious small diameter, modified spectrum, or 130 V rated lamps for commercial production.

E. Product Pricing Determination

Typically, DOE develops manufacturer 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 GSFLs and IRLs are difficult to reverse-engineer (*i.e.,* not easily disassembled), DOE did not use this approach to derive end-user prices for the lamps covered in this rulemaking. In the preliminary analysis, DOE estimated end-user prices for lamps by establishing discounts from manufacturer suggested price lists (hereafter ''blue book prices''). DOE revised its methodology for the NOPR, as described below, to account for additional information that became available after publication of the preliminary analysis.

For this NOPR analysis, DOE gathered publicly available lamp pricing data after the compliance date of the July 2012 standards. Based on feedback from manufacturer interviews, DOE determined that GSFLs and IRLs are sold through three main channels (state procurement, large distributors including DIY stores (*i.e.,* Lowe's and Home Depot), and Internet retailers). Using these main channels and the pricing data, DOE developed three different end-user prices as representative of a range of publicly available prices: Low, based on the state procurement channel; medium, based on large distributors and DIY stores; and high, based on Internet retailers. In the preliminary analysis, the medium end-user prices were used in the main results of the LCC and NIA analysis while the low and high end-user prices were used in sensitivity analyses in the LCC. DOE received several comments on this methodology and the resulting end-user prices. NEMA deferred comment on product price determination to individual manufacturer interviews. (NEMA, No. 36 at p. 13)

Stakeholders had specific comments regarding the IRL prices. ASAP and the CA IOUs found the price estimates for IRL standards case lamps provided by DOE to be higher than the typical pricing they found on the market. (ASAP, Public Meeting Transcript, No. 30 at pp. 200–201; CA IOUs, No. 32 at pp. 10–11) The CA IOUs stated that low, medium, and high prices were provided for a 55 W IRL at 20 lm/W for CSL 1, however, CSL 1 required an efficacy of only 18.3 lm/W for a 55 W lamp. The CA IOUs suggested that DOE collect cost information more representative of the minimum efficacy needed for each CSL analyzed. The CA IOUs asserted high outlier price points should not be given equal weight in DOE's analysis; with minimal shopping, consumers will find lower priced products readily available. The CA IOUs provided a table showing some end-user price information gathered by ASAP and the CA IOUs. The information gathered includes price points for some of the higher performing IRLs from the major manufacturers collected from seven different retail outlets, including both online outlets

[51] Betzendahl, Richard. ''Still Bullish on Rare Gases: A CryoGas International Market Report.'' CryoGas International, February 2012. (Last accessed October 25, 2013.) <*www.cryogas-digital.com/cryogas/201202?pg=30#pg30*>

and brick and mortar stores, with the highest price at $16.49 and the average price of $13.03. (CA IOUs, No. 32 at pp. 10–11) NEEA and NPCC also questioned the high prices, specifically prices greater than $15 for 50–70 W halogen lamps with an efficacy of 20 lm/W or less. (NEEA and NPCC, No. 34 at p. 6)

In the preliminary analysis, while the representative lamp at CSL 1 had a 20 lm/W catalog efficacy, its compliance values indicated a lower tested efficacy, resulting in an adjustment of CSL 1 to the $6.2P^{0.27}$ coefficient that would result in an efficacy of 18.3 lm/W for a 55 W lamp. Therefore, in the preliminary analysis, DOE determined prices of a lamp that represented the minimum efficacy at CSL 1. Further, the representative lamp prices at CSL 1 for IRLs were determined to be $9.29 for the low price, $16.34 for the medium price, and $23.77 for the high price in the preliminary analysis. These prices were based on publicly available price data, including prices from available state procurement contracts and a substantive number of Internet retailers. Any lamp prices from only one Internet retailer or one state procurement contract were removed from the pricing analysis, as were any extremely high prices (*i.e.,* extreme outliers in the price trend observed for a lamp). DOE also examined the lamp prices cited by the CA IOUs and ASAP by identifying prices for these lamps at generally known lighting retailers, such as Home Depot, Lowe's, Grainger, and eLightBulbs, and found average prices up to $20. Regarding the CA IOUs' comment that consumers will find lower-priced products, DOE conducts the high price sensitivity in the LCC in part to address scenarios where consumers do not purchase lamps at the lowest price.

Several stakeholders provided general comments indicating that the prices based on Internet retail presented in the preliminary analysis were too high. ASAP questioned why the Internet prices were higher than the DIY store prices that make up DOE's medium case. ASAP noted that because such stores also sell products online, residential consumers would find these medium prices on the Internet. Additionally, ASAP mentioned that commercial customers would be educated enough to avoid the higher Internet prices, making it unlikely for anyone to purchase products at the high prices DOE presented. (ASAP, Public Meeting Transcript, No. 30 at pp. 204–205) GE, however, noted that DOE found the prices online, demonstrating that the channel does exist. GE also stated that some retailers, small stores or online sites set their own price points and these can be very high. (GE, Public Meeting Transcript, No. 30 at p. 201)

For this NOPR analysis, DOE updated its pricing database and its blue book information and developed updated high, medium, and low prices for the IRL representative lamps at CSL 1. These prices were slightly lower than those determined in the preliminary analysis because of updated price data collected from online retailers and updated blue book prices. DOE also received updated blue book prices for lamps covered under this rulemaking. DOE's pricing analysis intends to capture a full range of available prices. DOE believes that the medium prices used in the main results are representative of the average price paid by the consumer.

DOE also received comments regarding using a weighted price in its main results. NEEA and ASAP urged DOE to weight the high, medium, and low end-user prices rather than using sensitivities. (NEEA, Public Meeting Transcript, No. 30 at pp. 202–203; ASAP, Public Meeting Transcript, No. 30 at pp. 203–204) NEEA also emphasized the importance of weighting the different market prices in rulemakings, such as this one, where the nature of the product prohibits the typical markup analysis methodology. (NEEA, Public Meeting Transcript, No. 30 at p. 232) While it may be possible for some markets sources to charge more for the product, NEEA and NPCC contended that such pricing has nothing to do with the cost efficiency and should not impact the analysis. An ideal pricing proposal would be one based on sales-weighted average pricing. NEEA and NPCC urged DOE to seriously revisit this part of the analysis. (NEEA and NPCC, No. 34 at p. 6)

NEEA cautioned DOE to be careful in determining what fraction of the market is paying what price at each channel, and ASAP suggested DOE account for the end-user and volume of lamps specific to a channel. (NEEA, Public Meeting Transcript, No. 30 at p. 232; ASAP, Public Meeting Transcript, No. 30 at pp. 202–203) For the state procurement channel, NEEA noted that in the lighting market in their service area, state contract pricing is available for every government or semi-government entity, and therefore many lamps are sold at the low price. (NEEA, Public Meeting Transcript, No. 30 at pp. 231–232) ASAP also noted that many lamps are being sold through each state procurement contract but cautioned that accessibility to these contracts is limited and therefore, the low price they offer is available to only a very small number of consumers. (ASAP, Public Meeting Transcript, No. 30 at pp. 202–203)

Additionally, ASAP remarked that if a consumer pays the high price, they are probably doing so by choice, as the medium price is accessible. ASAP likened the scenario to purchasing a book, where large online retailers and bookstore chains will have the book significantly marked down, but a consumer could choose to pay a high price in order to support a small local bookstore. ASAP reasoned that very few lamps would be sold at the high price and suggested DOE weight the prices accordingly. (ASAP, Public Meeting Transcript, No. 30 at pp. 202–203)

Taking into consideration the above comments, in this NOPR analysis DOE developed an end-user price weighted by distribution channel. Using manufacturer feedback in interviews, DOE determined an aggregated percentage of shipments that go through each of the main channels for GSFLs and IRLs. The large distributors and DIY stores channel was estimated at 85 percent, the state procurement channel at 10 percent, and the Internet retail channel at 5 percent. DOE then applied these percentages respectively to the average medium price determined for large distributor and DIY stores, the average low price determined for state procurement contracts, and the average high price determined for Internet retailers. The sum of these weighted prices was used as the average consumer price for GSFLs and IRLs in the main LCC analysis and NIA. DOE continued to utilize the low prices and high prices in a sensitivity analysis in the LCC analysis. See chapter 7 of the NOPR TSD for further information on the pricing analysis. DOE welcomes feedback on the pricing methodology used in this analysis.

F. Energy Use

For the energy use analysis, DOE estimated the energy use of lamps in the field (*i.e.,* as they are actually used by consumers). The energy use analysis provided the basis for other DOE analyses, particularly assessments of the energy savings and the savings in consumer operating costs that could result from DOE's adoption of amended standard levels.

1. Operating Hours

To develop annual energy use estimates, DOE multiplied annual usage (in hours per year) by the lamp power (in watts) for IRLs and the lamp-and-ballast system input power (in watts) for GSFLs. DOE characterized representative lamp or lamp-and-ballast systems in the engineering analysis. To characterize the country's average use of lamps for a typical year, DOE developed annual operating hour distributions by sector, using data published in the 2010 U.S. Lighting Market Characterization report (2010 LMC),[52] the Commercial Building Energy Consumption Survey (CBECS),[53] the Manufacturer Energy Consumption Survey (MECS),[54] and the Residential Energy Consumption Survey (RECS).[55]

NEMA agreed with the considered operating profiles. (NEMA, No. 36 at p. 15) GE also stated that the operating hours looked reasonable. (GE, Public Meeting Transcript, No. 30 at p. 212) However, EEI found the similarity between the GSFL commercial and industrial operating hours to be surprising. (EEI, Public Meeting Transcript, No. 30 at pp. 212–213)

In the preliminary analysis, DOE calculated weighted average operating hours using the probability of a building type within each sector using the data sources described above. These sources provide the most accurate and recent data available on a national scale. DOE's approach resulted in similar operating hours for the commercial and industrial sectors.

DOE updated the methodology for determining operating hours in the NOPR analysis. The weighted average operating hours are based on the probability of a GSFL or IRL within a specific building type, rather than based on the probability of the building type. DOE used the average lamps per square foot and the percentage of lamps that are linear fluorescent or halogen from the 2010 LMC to calculate these values. The average operating hours using the revised methodology are similar to those found in the preliminary analysis. For further details on the operating hours, see chapter 6 of the NOPR TSD.

NEEA offered data from their residential sector energy use field survey of 2,200 lighting fixtures in 1,400 houses. NEEA noted that DOE could use the data to verify analyses and findings. NEEA also mentioned their commercial sector energy use field survey, but stated that they might not have those data in time for NOPR analyses. (NEEA, Public Meeting Transcript, No. 30 at pp. 210, 212) DOE examined NEEA's Residential Building Stock Assessment reports,[56] but continued to use the data sources described above in its analysis because NEEA's data is limited to the northwest region. DOE did not find any recent NEEA report regarding energy usage in the commercial sector at the publication of this notice.

2. Lighting Controls

DOE evaluated the impact of lighting controls on the energy use of GSFLs and IRLs. Most lighting controls have one of two impacts: Reducing operating wattage or reducing operating hours. DOE refers to these two groups of controls as dimmers or light sensors, and occupancy sensors, respectively. The calculated operating hours used in the reference case already account for the use of occupancy sensors because the 2010 LMC operating hour data are based on building surveys and metering data. In the preliminary analysis, DOE accounted for the use of dimmers or light sensors by modeling GSFLs and IRLs on dimmers and developing associated energy use results for both types of covered lamps as a sensitivity analysis. See appendix 6A of the NOPR TSD for further information.

Regarding the dimming scenarios, NEMA noted that the dimming systems save more energy than the standards considered in this rulemaking. NEMA asserted that this furthered their arguments that this rulemaking is unnecessary and a ''system approach'' would be more advantageous for energy efficiency. NEMA contended that DOE pursues diminishing returns through component standards and distracts resources from more beneficial efficiency efforts. (NEMA, No. 36 at p. 15) DOE did not consider a system approach in this rulemaking because EPCA directs DOE to undertake a review of standards for GSFLs and IRLs and determine if amended standards for these lamp types would result in energy savings. (42 U.S.C. 6295(i)(1) and (3)–(5))

a. General Service Fluorescent Lamp Lighting Controls

In the preliminary analysis, DOE assessed the impacts of dimmers on GSFLs by determining the reduction in system lumen output and system input power as a result of using dimming ballasts. Based on product research and manufacturer feedback, DOE analyzed dimming scenarios for 2-lamp 4-foot MBP systems, 4-lamp 4-foot MBP systems, 2-lamp 4-foot T5 MiniBP SO systems, and 2-lamp 4-foot T5 MiniBP HO systems operating in the commercial and industrial sectors. DOE determined that the average reduction of system lumen output for GSFLs was 33 percent based on research and manufacturer input.

GE asked for clarification on how DOE was incorporating the percentage to which the dimmed lamps were being dimmed. (GE, Public Meeting Transcript, No. 30 at pp. 211) DOE incorporated this assumption by decreasing the BF of the baseline ballast by 33 percent and subsequently calculating the system mean lumen output of the baseline lamp-and-ballast system. DOE then assumed that each higher efficacy lamp-and-ballast system would be dimmed to equal the mean lumen output of the baseline system and adjusted the BF accordingly. DOE calculated the percentage each higher efficacy lamp-and-ballast system was dimmed by dividing the BF at the dimmed light output by the catalog BF at full light output. For more information, see appendix 6A of the NOPR TSD.

Several commenters supported DOE's analysis of dimming systems for GSFLs, noting that dimming systems are growing in popularity and provide the potential for significant energy savings. NEMA stated that when it encourages high efficacy fluorescent retrofits through one of its marketing programs, it always tries to encourage lighting controls. Thus, when a retrofit results in increased brightness there is the option to dim, which is where the largest amount of savings lies. (NEMA, Public Meeting Transcript, No. 30 at pp. 108–109) Further, Lutron stated that it agreed that the 33 percent energy savings from dimming systems cited in the preliminary analysis is close to the actual savings that can be expected as opposed to the savings estimated from higher lamp efficacy. (Lutron, Public Meeting Transcript, No. 30 at pp. 73–74)

Commenters expressed concerns, however, regarding the calculated energy consumption of a dimmed lamp-and-ballast system and the inclusion of reduced wattage lamps in the dimming

[52] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Energy Conservation Program for Consumer Products: 2010 U.S. Lighting Market Characterization. 2012. Washington, DC. *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.*

[53] U.S. Department of Energy, Energy Information Administration. Commercial Building Energy Consumption Survey: Micro-level data, file 2 Building Activities, Special Measures of Size, and Multi-building Facilities. 2003. Washington, DC. *www.eia.gov/consumption/commercial/data/2003/index.cfm?view=microdata.*

[54] U.S. Department of Energy, Energy Information Administration. Manufacturing Energy Consumption Survey, Table 9.1: Enclosed Floorspace and Number of Establishment Buildings. 2006. Washington, DC. *www.eia.gov/consumption/manufacturing/data/2006/xls/Table9_1.xlsl.*

[55] U.S. Department of Energy, Energy Information Administration. RECS Public Use Microdata files. 2009. Washington, DC. *www.eia.gov/consumption/residential/data/2009/.*

[56] NEEA's Residential Building Stock Assessment available at *http://neea.org/resource-center/regional-data-resources/residential-building-stock-assessment.*

analysis. Lutron noted that GSFL light output and input power do not scale perfectly linearly from zero. Lutron explained that there is an offset at the low end that accounts for the required electrode heating, typically a few percent of the total maximum rated power. The light output and input power scale linearly after this point. (Lutron, Public Meeting Transcript, No. 30 at p. 220) NEMA referenced their white paper LSD–345 and added that the need for cathode heat skews efficacy calculations. The lower the light output, the more cathode heat power increases, lowering the efficacy of the system. The systems are the most efficacious at full power, but NEMA clarified that this does not mean that they do not save energy when dimmed, only that it is not a linear scale. (NEMA, No. 36 at p. 14)

DOE agrees that GSFL light output and input power do not scale linearly from zero for dimming systems. In the preliminary analysis, DOE utilized manufacturer-published performance characteristics of the dimming systems to develop the relationship between light output and input power. DOE plotted the minimum and maximum light output levels and associated system input powers published in catalogs, and then fit a linear equation to the points. The published system input power values at minimum light output reflected the presence of cathode heat at minimum light output and thus the linear equations did not originate at zero. This approach was maintained in the NOPR analysis. For more information, see appendix 6A of the NOPR TSD.

Regarding reduced wattage lamps, commenters noted that reduced wattage lamps, which contain krypton, did not provide the same dimming functionality as full wattage lamps. GE observed that if the GSFL standard is set at a level requiring a heavier fill gas, namely krypton, then the NES would start to decrease. GE and Lutron noted that even though controls and dimmers are already becoming required in buildings, the krypton eliminates the ability to control and dim the lamps, negatively affecting the energy savings. (GE, Public Meeting Transcript, No. 30 at pp. 220–221; Lutron, Public Meeting Transcript, No. 30 at pp. 73–74) Philips stated that there is no published testing of dimming with krypton fill gas and currently no standards for dimming ballasts. (Philips, Public Meeting Transcript, No. 30 at p. 222) NEMA further emphasized these points, cautioning DOE that reduced wattage 28 W lamps are less feasible to dim than 32 W lamps. NEMA suggested DOE model a 32 W lamp for their dimming analyses. NEMA further stated that CSLs should be set to retain the 32 W lamps. (NEMA, No. 36 at p. 14)

DOE acknowledges that reduced wattage lamps may dim unreliably in certain applications. DOE discusses the dimmability of reduced wattage lamps in VI.B.1. In the preliminary analysis and this NOPR analysis, however, DOE identified several manufacturers that published performance data of both 28 W and 25 W 4-foot MBP lamps when paired with dimming ballasts. This data indicates that these reduced wattage lamp types can be utilized in some dimming applications. For this reason, DOE continues to analyze reduced wattage 4-foot MBP lamps in its dimming analysis in addition to full wattage 4-foot MBP lamps. Regarding T5 lamps, DOE found that catalog information generally did not indicate that reduced wattage T5 lamps should be operated on dimming ballasts. Therefore, as in the preliminary analysis, DOE does not analyze reduced wattage T5 lamps in dimming systems. As noted in section VI.D.2.g, DOE has ensured that the full wattage lamps in all product classes meet the proposed ELs so that full wattage lamps are available in situations where reduced wattage fluorescent lamps are unacceptable.

b. Incandescent Reflector Lamp Lighting Controls

In the preliminary analysis, DOE research indicated that, on average, consumers using dimmers reduce lamp wattage by 20 percent, corresponding to a lumen reduction of 25 percent and an increase in lifetime by a factor of 3.94. DOE analyzed two scenarios in LCC sensitivity analyses: (1) The light output of the baseline lamp was reduced by 25 percent and more efficient lamps were dimmed to the same light output and (2) the characteristics of the lamps analyzed represented the distribution of dimmers across the nation. For the second scenario, DOE used the 2010 LMC to determine that 29 percent of halogen IRLs operate on dimmers or light sensors in the residential sector and 5 percent of halogen IRLs operate on dimmers in the commercial sector and used these percentages to calculate weighted-average performance characteristics. DOE received several comments on its IRL dimming analysis.

Lutron stated that they did not have independent data, but the estimate of five percent of lamps in the commercial sector operating on dimmers seems reasonably accurate. (Lutron, Public Meeting Transcript, No. 30 at p. 217) However, Lutron and NEMA disagreed with the value used for the lifetime multiplier.

Lutron commented that the lifetime multiplier given for IRLs appears to be based on the standard incandescent formula published in the IESNA Lighting Handbook. Lutron stated that the multiplier that should be used for halogen PAR lamps, while still between three and four, is lower than the multiplier DOE used. (Lutron, Public Meeting Transcript, No. 30 at pp. 214–215) NEMA also disagreed with DOE's assumption that the lamp life for halogen products follows the incandescent curve of ''Life ~ V^{-13},'' where V is the voltage across the filament. Based on NEMA's research, NEMA put forward the proper relationship as ''Life ~ V^{-10},'' which would result in a multiplier of 3 rather than 4 for the reduction in light output DOE considered. Therefore, NEMA recommended a multiplier of 3, instead of the multiplier of 4 suggested in the preliminary TSD. (NEMA, No. 36 at p. 15)

In the preliminary analysis, DOE did not use an equation in the IESNA Lighting Handbook to calculate the lifetime multiplier and therefore was not employing the incandescent curve referenced by NEMA or Lutron. Rather, DOE used Lutron's Energy Savings Calculator, available on the Lutron Web site.[57] The values provided in this calculator are based on experiments conducted on halogen lamps, which provide the most accurate representation of the lifetime increase that occurs as a result of dimming halogen IRLs because they are based on halogen technology instead of incandescent technology and use experimental data. In this NOPR analysis, DOE has continued to utilize Lutron's Energy Savings Calculator to determine the lifetime multiplier associated with various levels of dimmed light output.

G. Life-Cycle Cost Analysis and Payback Period Analysis

In the preliminary analysis, DOE conducted LCC and PBP analyses to evaluate the economic impacts of potential energy conservation standards for GSFLs and IRLs on individual consumers. The LCC is the total consumer expense over the life of a product, consisting of purchase, installation, and operating costs (operating costs are expenses for energy use, maintenance, and repair). To compute the operating costs, DOE discounted future operating costs to the time of purchase and summed them over the lifetime of the product. The

[57] *www.lutron.com/en-US/Education-Training/Pages/Tools/EnergySavingCalc.aspx.*

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 (normally higher) by the change in average annual operating cost (normally lower) that results from the more efficient standard. DOE used a ''simple'' PBP for this rulemaking, which does not take into account other changes in operating expenses over time or the time value of money.

For any given efficacy or energy use level, DOE measures the PBP and the change in LCC relative to an estimated base-case product efficacy or energy use level. The base-case estimate reflects the market without new or amended mandatory energy conservation standards, including the market for products that exceed the current energy conservation standards.

Inputs to the calculation of total installed cost include the cost of the product—which includes consumer product price and sales taxes—and installation costs. Inputs to the calculation of operating expenses include annual energy consumption, energy prices and price projections, repair and maintenance costs, product lifetimes, discount rates, and the year in which compliance with proposed standards would be required. DOE also incorporated a residual value calculation to account for any remaining lifetime of lamps at the end of the analysis period. The residual value is an estimate of the product's value to the consumer at the end of the LCC analysis period. In addition, this residual value recognizes that a lamp may continue to function beyond the end of the analysis period. DOE calculates the residual value by linearly prorating the product's initial cost consistent with the methodology described in the *Life-Cycle Costing Manual for the Federal Energy Management Program*.[58]

As inputs to the PBP analysis, DOE used the total installed cost of the product to the consumer for each efficacy level, as well as the first-year annual operating costs for each efficacy level. The calculation requires the same inputs as the LCC, except for energy price trends and discount rates; only energy prices for the year in which compliance with any new standard would be required (2017, in this case) are needed.

To account for uncertainty and variability, DOE created value distributions for inputs as appropriate, including operating hours, electricity prices, discount rates and sales tax rates, and disposal costs. For example, DOE created a probability distribution of annual energy consumption in its energy use analysis, based in part on a range of annual operating hours. The operating hour distributions capture variation across census divisions and large states, building types, and lamp or lamp-and-ballast systems for three sectors (commercial, industrial, and residential).

DOE conducted the LCC and PBP analyses using a spreadsheet model developed in Microsoft Excel. When combined with Crystal Ball (a commercially available software program), the spreadsheet model generates a Monte Carlo simulation[59] to perform the analysis by incorporating uncertainty and variability considerations. The Monte Carlo simulations randomly sample input values from the probability distributions and lamp user samples, performing 1,000 iterations per simulation run.

NEMA commented on the general LCC methodology used in the preliminary analysis, stating that it appears the 30-year payback period for LCC analysis timeline, about which they had previously expressed concern, has been stretched to a 70-year period for this rulemaking. NEMA assumed the time period was chosen to justify feasibility arguments that have miniscule payback estimates. NEMA requested that DOE clarify the 70-year forecasting and related analyses, and explain the justification for examining such a long period. (NEMA, No. 36 at pp. 3–4)

The PBP is the amount of time it takes the consumer to recover the assumed higher purchase cost of a more-efficacious product through lower operating costs. DOE calculates and presents the payback period for all LCC scenarios, regardless of the value of the payback period, including the long payback periods referenced by NEMA. Payback periods are one of the factors that DOE considers when weighing the benefits and burdens of TSLs.

In the NOPR analysis, DOE generally maintained the methodology from the preliminary analysis, with a few changes. Table VI.13 summarizes the approach and data DOE used to derive inputs to the LCC and PBP calculations for the preliminary analysis as well as the changes made for this NOPR. The NOPR TSD chapter 8 and its appendices provide details on the spreadsheet model and of all the inputs to the LCC and PBP analyses. The NOPR TSD appendix 8B provides results of the sensitivity analyses conducted using Monte Carlo simulation. The subsections that follow discuss the comments regarding each initial input and any changes made to them in the NOPR analysis.

TABLE VI.13—SUMMARY OF INPUTS AND KEY ASSUMPTIONS IN THE LCC AND PBP ANALYSES *

Inputs	Preliminary TSD	Changes for the proposed rule
Consumer Product Price	Applied discounts to manufacturer catalog (''blue book'') pricing in order to represent low, medium, and high prices for all lamp categories. Used medium prices in the main analysis.	Applied discounts to manufacturer catalog (''blue book'') pricing in order to represent low, medium, and high prices for all lamp categories. Used a weighted average price in the main analysis based on the percentage of shipments that go through the distribution channel having low, medium, or high prices.

[58] Fuller, Sieglinde K. and Stephen R. Peterson. *National Institute of Standards and Technology Handbook 135 (1996 Edition); Life-Cycle Costing Manual for the Federal Energy Management Program.* (Prepared for U.S. Department of Energy, Federal Energy Management Program, Office of the Assistant Secretary for Conservation and Renewable Energy.) February 1996. NIST: Gaithersburg, MD. Available at: *http://fire.nist.gov/bfrlpubs/build96/PDF/b96121.pdf*.

[59] Monte Carlo simulations model uncertainty by utilizing probability distributions instead of single values for certain inputs and variables.

TABLE VI.13—SUMMARY OF INPUTS AND KEY ASSUMPTIONS IN THE LCC AND PBP ANALYSES *—Continued

Inputs	Preliminary TSD	Changes for the proposed rule
Sales Tax	Derived population-weighted-average tax values for each census division and large state [60] from data provided by the Sales Tax Clearinghouse.	Derived sector-specific average tax values based on the probability of purchasing a GSFL or IRL in each census division and large state from data provided by the Sales Tax Clearinghouse.
Installation Cost	Derived costs using the RS Means Electrical Cost Data and U.S. Bureau of Labor Statistics to obtain average labor times for installation, as well as labor rates for electricians and helpers based on wage rates, benefits, and training costs.	No change.
Annual Operating Hours	Determined operating hours by associating building-type-specific operating hour data with regional distributions of various building types using the 2010 LMC and EIA's 2003 CBECS, 2009 RECS, and 2006 MECS.	Determined operating hours by associating operating hours for a GSFL or IRL in a specific building type using the average lamps per square foot and the percentage of lamps of each type with regional distributions of various building types using the 2010 LMC and EIA's 2003 CBECS, 2009 RECS, and 2006 MECS.
Product Energy Consumption Rate	Determined lamp input power for IRLs based on published manufacturer literature. Calculated system input power for GSFLs. Used lamp arc power, catalog BF, number of lamps per system, and tested BLE (when possible) to calculate system input power for each unique lamp-and-ballast combination.	No change.
Electricity Prices	Electricity: Based on EIA's Form 861 data for 2011.	Electricity: Based on EIA's Form 861 data for 2011 scaled to 2012 (the dollar year of the analysis) using *AEO 2013* and the consumer price index.
	Variability: Weighted average national price for each sector calculated from the probability of each building type within each census division or large state.	Variability: Weighted average national price for each sector and lamp type calculated from the probability of a GSFL or IRL purchased in each census division or large state
Electricity Price Projections	Forecasted using *AEO 2012*	Forecasted using *AEO 2013.*
Replacement and Disposal Costs	Commercial and industrial: Included labor and materials costs for lamp replacement, and disposal costs for failed GSFLs. Residential: Included only materials cost for lamps, with no lamp disposal costs.	No change.
Product Lifetime	Ballast lifetime based on average ballast life of 49,054 from 2011 Ballast Rule. Lamp lifetime based on published manufacturer literature where available.	No change.
Discount Rates	Commercial and industrial: Derived discount rates using the cost of capital of publicly traded firms in the sectors that purchase lamps, based on data in the 2003 CBECS, Damodaran Online,[61] Office of Management and Budget (OMB) Circular No. A–94,[62] and state and local bond interest rates [63]. Residential: Derived discount rates using the finance cost of raising funds to purchase lamps either through the financial cost of any debt incurred to purchase product or the opportunity cost of any equity used to purchase equipment, based on the Federal Reserve's Survey of Consumer Finances data [64] for 1989, 1992, 1995, 1998, 2001, 2004, 2007, and 2010.	No change.
Analysis Period	IRLs and commercial and industrial GSFLs: Based on the baseline lamp life in hours divided by the annual operating hours of that lamp.	IRLs and commercial and industrial GSFLs: No change.
	Residential GSFLs lamp failure: Based on the baseline lamp life in hours divided by the annual operating hours of that lamp.	Residential GSFLs lamp failure: Based on the lifetime of the ballast.

TABLE VI.13—SUMMARY OF INPUTS AND KEY ASSUMPTIONS IN THE LCC AND PBP ANALYSES *—Continued

Inputs	Preliminary TSD	Changes for the proposed rule
	Residential GSFLs ballast failure and new construction/renovation: Based on the lifetime of the ballast.	Residential GSFLs ballast failure and new construction/renovation: No change.
Compliance Date of Standards	2017	No change.
Lamp Purchase Events	Assessed three events: lamp failure, ballast failure (GSFLs only), and new construction/renovation.	No change.

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

1. Consumer Product Price

In the preliminary analysis, DOE used a variety of sources to develop consumer product prices, including lamp prices from manufacturers' blue books, state procurement contracts, large electrical supply distributors, hardware and home improvement stores, Internet retailers, and other similar sources. DOE then developed low, medium, and high prices based on its findings. Medium prices were used in the main analysis results. In the NOPR analysis, DOE maintained the same methodology but calculated a weighted average price based on the percentage of shipments going through the low discount (high price), medium discount (medium price), and high discount (low price) distribution channels. Because fluorescent lamps operate on a ballast in practice, DOE analyzed lamp-and-ballast systems in the engineering analysis and therefore also determined end-user prices for ballasts. DOE utilized the end-user prices from the 2011 Ballast Rule converted to 2012$ to develop prices for replacement ballasts.

On February 22, 2011, DOE published a notice of data availability (NODA; 76 FR 9696) stating that DOE may consider whether its regulatory analysis would be improved by addressing product price trends. Using three decades of historic data on the quantities and values of domestic shipments of fluorescent lamps and PAR lamps reported by the U.S. Census Bureau in their Current Industrial Reports, DOE examined product prices trends, fitting the data to an experience curve, as described in chapter 11 of the NOPR TSD. DOE found that the data are well-represented by the experience curve and consistent with price learning theory. Therefore, consistent with the NODA, DOE incorporated price trends into this rulemaking. In the LCC analysis, DOE adjusts prices for each year using the experience curve.

2. Sales Tax

In the preliminary analysis, DOE obtained state and local sales tax data from the Sales Tax Clearinghouse. The data represented weighted averages that included county and city rates. DOE used the data to compute population-weighted average tax values for each census division and four large states (New York, California, Texas, and Florida).

EEI asked if DOE had any information on local sales taxes, such as city or county taxes, which would be added to the state sales tax. EEI noted that without considering the additional local taxes, especially in urban areas with commercial buildings, DOE may be missing relevant sales tax data. (EEI, Public Meeting Transcript, No. 30 at pp. 230–231) NEEA added that there are some publicly available local tax data by county. (NEEA, Public Meeting Transcript, No. 30 at p. 231)

In the preliminary analysis, DOE used the Sales Tax Clearinghouse for sales tax data by state. Because the Sales Tax Clearinghouse specifies that the aggregate rates are weighted averages that include county and city rates, DOE accounts for the levels of taxes described in the comments.

In this NOPR analysis, DOE used updated sales tax data from the Sales Tax Clearinghouse.[65] DOE recognized that a population-weighted tax value may not accurately represent the probability of a lamp type purchased in each census division and large state. Therefore, in the NOPR analysis, DOE calculated a weighted average sales tax based on the probability of a GSFL or IRL purchased for a particular building type in each census division and large state. DOE used information in the 2010 LMC, such as the number of lamps per square feet and the percentage of lamps within a building that are linear fluorescent or halogen. In combination with this information, DOE used CBECS, MECS, and RECS respectively, for commercial, industrial, and residential building data on building types in each census division and large state. Thus, in the preliminary analysis, the sales tax was averaged based on the number of people in a region or state, whereas in the NOPR, the sales tax is averaged based on how many people purchase a GSFL or IRL in a region or state.

3. Installation Cost

The installation cost is the total cost to the consumer to install the product, excluding the consumer product price. Installation costs include labor, overhead, and any miscellaneous materials and parts. As detailed in the preliminary analysis, DOE considered the total installed cost of a lamp or lamp-and-ballast system to be the consumer product price (including sales taxes) plus the installation cost. For the commercial and industrial sectors, DOE assumed consumers must pay to install the lamp or lamp-and-ballast system and assumed the installation cost was the product of the average labor rate and the time needed to install a lamp or lamp and ballast. In the residential sector, DOE assumed that consumers must pay for only the installation of a lamp-and-ballast system. Therefore, the installation cost assumed was the product of the average labor rate and the time needed to install the lamp-and-ballast system. DOE assumed that residential consumers would install their own replacement lamps and, thus, would incur no installation cost when replacing their own lamp.

[60] The four large states are New York, California, Texas, and Florida.

[61] Damodaran Online, *The Data Page: Historical Returns on Stocks, Bonds, and Bills—United States* (2013). Available at: *http://pages.stern.nyu.edu/~adamodar*. (Last accessed September, 2013.)

[62] U.S. Office of Management and Budget, Circular No. A–94 Appendix C (2012). Available at: *www.whitehouse.gov/omb/circulars_a094/a94_appx-c*.

[63] Federal Reserve Board, Statistics: Releases and Historical Data—Selected Interest Rates—State and Local Bonds (2013). Available at: *http://www.federalreserve.gov/pubs/oss/oss2/scfindex.html*.

[64] The Federal Reserve Board, Survey of Consumer Finances. Available at: *www.federalreserve.gov/PUBS/oss/oss2/scfindex.html*.

[65] Sales Tax Clearinghouse. *Aggregate State Tax Rates.* (2013). Available at: *http://thestc.com/STrates.stm*.

DOE did not receive any comments on the installation cost. DOE retained this methodology for determining installation costs in this NOPR analysis.

4. Annual Energy Use

As discussed in section VI.F, DOE estimated the annual energy use of representative lamp or lamp-and-ballast systems by multiplying input power and sector operating hours. DOE maintained its methodology of determining annual energy use inputs in this NOPR analysis.

5. Product Energy Consumption Rate

As in the preliminary analysis, DOE determined lamp input power for IRLs based on published manufacturer literature. For GSFLs, DOE calculated the system input power using published manufacturer literature and test data. DOE used lamp arc power, catalog BF, number of lamps per system, and tested BLE (when possible) to calculate system input power for each unique lamp-and-ballast combination. The rated system input power was then multiplied by the annual operating hours of the system to determine the annual energy consumption. DOE did not receive any comments on energy consumption rate calculations. DOE retained this methodology for determining energy consumption in this NOPR analysis.

6. Electricity Prices

For the LCC and PBP in the preliminary analysis, DOE derived average energy prices for 13 U.S. geographic areas consisting of the nine census divisions, with four large states (New York, Florida, Texas, and California) treated separately. For census divisions containing one of these large states, DOE calculated the regional average excluding the data for the large state. The derivation of prices was based on data from EIA Form 861, ''Annual Electric Power Industry Database.'' DOE calculated a weighted average national electricity price for each sector using the probability of each building type within each census division or large state. DOE did not receive any comments on this approach.

In the NOPR analysis, DOE calculated weighted average electricity prices based on the probability of a GSFL or IRL purchased in each census division and large state. The same methodology as noted previously for determining average weighted sales tax was used to calculate average weighted electricity prices. DOE used data published in the 2010 LMC in combination with CBECS, MECS, and RECS to determine an average weighted electricity price based on the probability of a GSFL or IRL in a particular building type in each census division and large state. DOE requests comment on its methodology of determining average weighted electricity prices.

7. Electricity Price Projections

To estimate the trends in energy prices for the preliminary analysis, DOE used the price forecasts in *AEO 2012.* To arrive at prices in future years, DOE multiplied current average prices by the forecast of annual average price changes in *AEO 2012.* In this NOPR analysis, DOE used the same approach, but updated its energy price forecasts using *AEO 2013.* DOE intends to update its energy price forecasts for the final rule based on the latest available *AEO.* In addition, the spreadsheet tools that DOE used to conduct the LCC and PBP analyses allow users to select price forecasts from *AEO'*s low-growth, high-growth, and reference case scenarios to estimate the sensitivity of the LCC and PBP to different energy price forecasts. DOE did not receive any comments on its methodology for determining electricity price projections.

8. Replacement and Disposal Costs

In its preliminary analysis, DOE addressed lamp replacements occurring within the analysis period as part of installed costs for considered lamp or lamp-and-ballast system designs. Replacement costs in the commercial and industrial sectors included the labor and materials costs associated with replacing a lamp at the end of its lifetime, discounted to 2011$. For the residential sector, DOE assumed that consumers would install their own replacement lamps and incur no related labor costs.

Some consumers recycle failed GSFLs, thus incurring a disposal cost. In its research, DOE found average disposal costs of 10 cents per linear foot for GSFLs.[66] A 2004 report by the Association of Lighting and Mercury Recyclers noted that approximately 30 percent of lamps used by businesses and 2 percent of lamps in the residential sector are recycled nationwide.[67] DOE considered the 30 percent lamp-recycling rate to be significant and incorporated GSFL disposal costs into the LCC analysis for commercial and industrial consumers. Given the very low (2 percent) estimated lamp recycling rate in the residential sector, DOE assumed that residential consumers would be less likely to voluntarily incur the higher disposal costs. Therefore, DOE excluded the disposal costs for lamps or ballasts from the LCC analysis for residential GSFLs.

DOE received no comments concerning these assumed recycling rates, disposal costs, and their application in the LCC analysis. DOE maintained this approach in the NOPR analysis.

9. Lamp Purchase Events

DOE designed the LCC and PBP analyses for this rulemaking around scenarios where consumers need to purchase a lamp. Each of these events may give the consumer a different set of lamp or lamp-and-ballast designs and, therefore, a different set of LCC savings for a certain efficacy level. In the preliminary analysis, DOE evaluated three types of events that would prompt a consumer to purchase a lamp. These events are described below. DOE requests comments on these lamp purchasing events developed for this analysis. Though described primarily in the context of GSFLs, lamp purchase events can be applied to IRLs as well. However, considering that IRLs are not used with a ballast, the only lamp purchase events applicable to IRLs are lamp failure (Event I) and new construction and renovation (Event III).

- *Lamp Failure* (Event I): This event reflects a scenario in which a lamp has failed (spot relamping) or is about to fail (group relamping). In the base case, identical lamps are installed as replacements. In the standards case, the consumer installs a standards compliant lamp that is compatible with the existing ballast.
- *Ballast Failure* (Event II): This is a scenario in which the failure of the installed ballast triggers a lamp and ballast purchase.
- *New Construction and Renovation* (Event III): This event encompasses all fixture installations where the lighting design will be completely new or can be completely changed. During new construction and renovation, the spatial layout of fixtures in a building space is not constrained to any previous configuration. However, because DOE's higher efficacy replacements generally maintain lumen output within 10 percent of the baseline system, DOE did not assume that spacing was changed.

DOE received comments stating that fixture spacing is adjusted during new construction and renovation. NEEA related that during tenant improvement in their market, the ceiling is the first

[66] Environmental Health and Safety Online's fluorescent lights and lighting disposal and recycling Web page—Recycling Costs. Available at *www.ehso.com/fluoresc.php.* (Last accessed October 11, 2013.)

[67] Association of Lighting and Mercury Recyclers, ''National Mercury-Lamp Recycling Rate and Availability of Lamp Recycling Services in the U.S.'' Nov. 2004.

item to be stripped, and the lighting system is redesigned as part of the regular renovation between tenant occupancies. Therefore, NEEA contended, brand new ballasts and lamps are installed without regard to the previous fixture locations. NEEA added that T8 lamps are the only lighting element likely to be preserved in this scenario, and they would be used in a new fixture with a new ballast. (NEEA, Public Meeting Transcript, No. 30 at pp. 261–262) EEI commented that there are minimum foot-candle requirements to light spaces, and scenarios that result in lower lumen output from the baseline system will also include adjustments to the fixture spacing to maintain those lumens. (EEI, Public Meeting Transcript, No. 30 at pp. 257–258)

NEEA also argued that respacing would occur with a new renovation because the space would likely gain a whole new control system with daylighting and dimming fixtures not installed previously. Due to a different number people in a different office configuration, everything would have to be redesigned, making renovation more like new construction. (NEEA, Public Meeting Transcript, No. 30 at p. 263) However, Lutron stated that all the elements added in the described renovation were the result of design and technical changes unrelated to the lighting regulations. (Lutron, Public Meeting Transcript, No. 30 at p. 263) Lutron noted that even if the lighting design of a space was completely altered during renovation, there would still be the same number of lamps and the same load. (Lutron, Public Meeting Transcript, No. 30 at pp. 262–263)

DOE also received several comments indicating that the respacing of fixtures, even in new construction or renovation, is unlikely due to ceiling grid constraints. NEMA stated that respacing is not a practical assumption for this rulemaking, and would not happen in practice other than to existing ready-made dimensions. Spacing is effectively constrained by existing practices and ceiling grid construction, and not determined by the lighting selected. Further, NEMA clarified that spacing is almost always based on the available 1 by 1, 2 by 2, or 2 by 4 ceiling grids, and that must be factored into the analysis. The likelihood of other spacing is near zero. (NEMA, No. 36 at p. 16) GE agreed that the standard 2 by 4 ceiling grids make it nearly impossible to respace fixtures in response to a change of a few lumens per watt. (GE, Public Meeting Transcript, No. 30 at pp. 258–289)

NEMA also noted that there is an interdependence among the ceiling material, the modular wire strings, the fixtures, and the fixtures' performance. (NEMA, Public Meeting Transcript, No. 30 at pp. 259–260) Philips added that when adjusting fixture spacing, the hangers for the lights will also have to be changed in many scenarios. Given that this modification necessitates going into the ceiling, and the prevalence of asbestos, it is unlikely the consumer would want to make this adjustment. (Philips, Public Meeting Transcript, No. 30 at pp. 260–261) If consumers were not installing new lamps, GE believed they would more likely switch to a ballast with a better ballast factor rather than respace fixtures. (GE, Public Meeting Transcript, No. 30 at pp. 258–259)

NEMA further remarked that substantial changes in efficacy or lumen output are necessary to warrant space changes. (NEMA, No. 36 at p. 16) GE agreed that it would be very unlikely for users to respace fixtures to accommodate compliant lamps' lumen output. (GE, Public Meeting Transcript, No. 30 at pp. 258–289)

DOE agrees that spacing adjustments are not practical. Ceiling grid systems typically come in fixed layouts, and lamp fixtures are sized to be compatible with the commonly available grid options. Thus, DOE believes that consumers are limited in the spacing of fixtures by the ceiling grid and its associated components. DOE also agrees that consumers would be more likely to change light output levels by adjusting system components such as the ballast factor (*i.e.,* use a high BF or low BF ballast) or lamp lumen output levels (*e.g.,* 32 W 4-foot MBP high lumen lamp) rather than attempting to adjust fixture spacing using non-standard ceiling grids. DOE acknowledges that fixture spacing adjustments may be done in certain cases as cited by NEEA. Based on available information and the other comments discussed above, however, such adjustments are not a common practice nationwide. Thus, DOE did not include spacing adjustments as part of the LCC analysis.

10. Product Lifetime

a. Lamp Lifetime

In the preliminary analysis, DOE used manufacturer literature to determine lamp lifetimes. DOE also considered the impact of group relamping practices on GSFL lifetime in the commercial and industrial sectors. In the preliminary analysis, DOE assumed that a lamp subject to group relamping operates for 75 percent of its rated lifetime, an estimate obtained from the 2011 Ballast Rule. However, DOE received information from manufacturers in interviews that consumer behavior has changed and group relamping now occurs at 85–90 percent of rated life. Therefore, in the NOPR analysis DOE assumes that a lamp subject to group relamping operates for 85 percent of its rated lifetime. By considering lamp rated lifetimes and the prevalence of group versus spot relamping practices, DOE derived an average lifetime for a GSFL. This ranged from 94 percent of rated lifetime for 8-foot SP slimline lamps to 96 percent of rated lifetime for 4-foot MBP lamps. See chapter 8 of the NOPR TSD for further details. DOE requests comment on its spot and group relamping assumptions, particularly the percent of rated life at which group relamping occurs.

As stated above, DOE is using 15 years as the estimated fixture and ballast lifetime in the residential sector for purposes of its analyses. In the preliminary analysis, the lifetime of the baseline GSFL in the residential sector was calculated by dividing the life in hours by the average operating hours of a GSFL in the residential sector (648 hours per year), which resulted in a lifetime of 37 years for the baseline lamp. Because this lifetime of the baseline lamp was longer than the average lifetime of a fixture and ballast, for the lamp failure scenario, DOE assumed that residential sector GSFL consumers were able to realize the full rated lifetime of their lamps. Therefore, at the average operating hours of 648 hours per year, DOE utilized the full lifetime of the baseline lamp (37 years) as the analysis period. DOE assumed that when a ballast is removed in the middle of the analysis period, these consumers preserve their lamps, purchase a new ballast of the same type as the initial ballast, and then have the new ballast installed with the preserved lamps (incurring a lamp-and-ballast system installation cost). In contrast, for the ballast failure and new construction and renovation events, DOE assumed that the ballast or fixture lifetime limits the lifetime of an average lamp in the residential sector. Under average operating hours of 648 hours per year, DOE assumed that lamp lifetime of the baseline-case and standards-case lamps is limited to 9,723 hours or 15 years, due to a ballast or fixture failure. See section VI.G.9 and chapter 5 of the NOPR TSD for a description of lamp purchase events. DOE requests comment on its general approach to determining lamp lifetime for this analysis.

NEMA disagreed with the assumption that lamps will be retained upon ballast failure. NEMA stated that the most likely thing that occurs when a light fixture in the residential sector fails to provide light is that new lamps are purchased. The next step if the fixture still does not work is to replace the whole fixture, not just the ballast. As a result, NEMA contended that a failed ballast will result in the lamps (new and old) being scrapped (or returned) when the entire fixture is replaced. (NEMA, No. 36 at p. 16) GE explained that when a ballast fails, it can operate in such a way that damages the lamp, especially the cathodes. When a lamp goes out, a residential consumer will likely assume that the problem is the lamp itself; very rarely would a consumer understand that only the ballast needs to be replaced and instead replace the entire fixture. (GE, Public Meeting Transcript, No. 30 at pp. 235–237)

DOE evaluated the likely replacement scenarios suggested by stakeholders and agrees that it is more likely for a residential consumer to replace an entire lamp-and-ballast system rather than only the ballast because consumers would not necessarily be aware that only the ballast failed. Thus, in the NOPR analysis, DOE no longer assumes that consumers retain their lamp when the ballast fails. See Appendix 8B of the NOPR TSD for more details. DOE requests comment on its approach to determining lamp lifetime.

b. Ballast Lifetime

Chapter 8 of the preliminary analysis detailed DOE's development of average ballast lifetimes, which were based on assumptions used in the 2011 Ballast Rule. For ballasts in the commercial and industrial sectors, DOE used an average ballast lifetime of 49,054 hours. Consistent with the 2011 Ballast Rule, DOE assumed an average ballast lifetime of approximately 15 years in the residential sector. DOE received no comments on this approach. In this NOPR analysis DOE retained the ballast lifetimes used in the preliminary analysis.

11. Discount Rates

The calculation of consumer LCC requires the use of an appropriate discount rate. DOE used the discount rate to determine the present value of lifetime operating expenses. The discount rate used in the LCC analysis represents the rate from an individual consumer's perspective.[68]

In the preliminary analysis, for the residential sector, DOE derived discount rates from estimates of the interest or ''finance cost'' to purchase residential products. The finance cost of raising funds to purchase these products can be interpreted as: (1) The financial cost of any debt incurred to purchase products (principally interest charges on debt), or (2) the opportunity cost of any equity used to purchase products (principally interest earnings on household equity). Household equity is represented by holdings in assets such as stocks and bonds, as well as the return on homeowner equity. Much of the data required, which involves determining the cost of debt and equity, comes from the Federal Reserve Board's triennial ''Survey of Consumer Finances.'' [69] For the commercial and industrial sectors, DOE derived discount rates from the cost of capital of publicly traded firms in the business sectors that purchase lamps.

EEI pointed out residential consumers have a lower discount rate than industrial customers do. EEI noted that if residential consumers use any form of credit, the nominal interest rate typically will be above 10 percent. Thus, EEI questioned why a well-capitalized industrial company would have a higher discount rate than residential consumers with varying incomes and credit card interest rates. (EEI, Public Meeting Transcript, No. 30 at pp. 228–229)

The discount rate is the rate at which future expenditures are discounted to estimate their present value. The discount rate accounts for consumers placing a certain value on spending money now versus in the future. For residential consumers, DOE estimated the discount rate by looking across all possible debt or asset classes. Thus, the residential discount rate is not limited to credit. The residential discount rate analysis factors in 12 different methods to finance purchases and the rates for these methods vary from 0 to 10.4 percent. As DOE estimates the discount rate by looking across all 12 of these debt and asset classes, and the discount rate is not limited to credit, the average rate is lower than 10 percent. For the commercial and industrial consumers, DOE estimated the cost of capital for commercial and industrial companies by examining both debt and equity capital, and developed an appropriate weighted average of the cost to the company of equity and debt financing. After performing these calculations and averaging each discount rate across various types of consumers, the residential discount rate was calculated to be lower than the industrial discount rate. Therefore, DOE believes it is appropriately determining discount rates for all types of consumers and has maintained this methodology in this NOPR analysis. For further details on discount rates, see chapter 8 and appendix 8C of the NOPR TSD.

12. Analysis Period

The analysis period is the span of time over which the LCC is calculated. In the preliminary analysis, DOE used the longest baseline lamp life in a product class divided by the annual operating hours of that lamp as the analysis period. During Monte Carlo simulations for the LCC analysis, DOE selected the analysis period based on the longest baseline lamp life divided by the annual operating hours chosen by Crystal Ball. For GSFLs in the residential sector, the analysis period is based on the useful life of the baseline lamp for a specific event. DOE did not receive any comments on this methodology. DOE maintained this approach for determining the analysis period in the NOPR analysis. DOE requests comment on its LCC analysis period assumptions. In particular, DOE requests comment on basing the analysis period on the baseline lamp life divided by the annual operating hours of that lamp for the IRL and commercial and industrial sector GSFL analyses. DOE also requests comment on basing the analysis period on the useful life of the baseline lamp for a specific event for residential GSFLs.

13. Compliance Date of Standards

The compliance date is the date when a covered product is required to meet a new or amended standard. DOE expects to publish any amended standards for GSFLs and IRLs in 2014. As a result, consistent with 42 U.S.C. 6295(i)(5), DOE expects the compliance date to be 2017, three years after the publication of any final amended standards. DOE received no comments on its expected standards compliance date of 2017 and calculated the LCC for all end users as if each one would purchase a new lamp in the year compliance with the standard is required.

14. General Service Fluorescent Lamp Life-Cycle Cost Results in the Preliminary Analysis

NEMA and EEI noted that in the tables presented at the public meeting, the results for the GSFL LCC savings included instances of ''NR.'' (NEMA, No. 36 at pp. 15–16; EEI, Public Meeting Transcript, No. 30 at pp. 245–246) NEMA assumed NR indicated that the

[68] The consumer discount rate is in contrast to the discount rates used in the NIA, which are intended to represent the rate of return of capital in the U.S. economy as well as the societal rate of return on private consumption.

[69] The Federal Reserve Board. *Survey of Consumer Finances 1989, 1992, 1995, 1998, 2001, 2004, 2007, 2010.* Federal Reserve Board: Washington, DC. Available at: *www.federalreserve.gov/pubs/oss/oss2/scfindex.html.*

energy savings were zero or negative and stated that figures should be added to the results because missing data points would skew the findings. NEMA stated that DOE should factor CSLs' negative impacts into the analysis or give reasons why figures should not be included. (NEMA, No. 36 at pp. 15–16) EEI attributed the ''NR'' to the baseline and CSL 1 lamps having the same nominal and rated wattages. EEI urged DOE to show the energy savings for every event, even if they are zero. As the event is a possibility under standards, it will be an economic cost to the consumer and the results need to be factored into the analysis and reported numerically rather than ''NR.'' (EEI, Public Meeting Transcript, No. 30 at pp. 245–246)

In the preliminary analysis for the lamp replacement scenario, DOE utilized ''NR'' to indicate that no replacement option existed that reduced energy consumption at a given efficacy level because the lamp wattage at the higher efficacy level was the same as the baseline and the higher efficacy lamp was operated on the same ballast. DOE revised its NOPR engineering analysis to consider lamps that do not reduce energy consumption. These were incorporated into the NOPR LCC analysis. See section VI.D.2.e for further details on lamp-and-ballast systems developed in the engineering analysis.

Regarding the instant start 4-foot MBP results, EEI also noted that another lamp at CSL 2 had the same nominal and rated wattage as the baseline lamp, but shows positive energy savings. EEI asked for an explanation for the reported positive energy savings where EEI would not expect there to be any. (EEI, Public Meeting Transcript, No. 30 at pp. 245–246) For the 4-foot MBP instant start lamps at CSL 2 with the same nominal and rated wattage as the baseline lamp, the BF of the ballast on which the higher efficacy lamp was operating was lower than the BF of the ballast on which the baseline lamp was operating. A lamp-and-ballast system with a more efficacious, similar wattage lamp and lower BF ballast will consume less energy while maintaining similar light output compared to the baseline system. DOE considered ballasts with varying BFs in the ballast failure event and new construction and renovation event.

Lutron expressed concern that there were positive LCC savings only for reduced wattage lamp replacements. Lutron questioned whether DOE was taking into account the probable increased use of dimming systems in the future, especially in new construction and renovation. As reduced wattage lamps are not compatible with dimming, their LCC savings would likely be lower than shown, but would be greater if total energy use was taken into account. (Lutron, Public Meeting Transcript, No. 30 at p. 251) DOE accounts for lighting controls in the LCC in a sensitivity analysis. See section VI.F.2 and appendix 8B of the NOPR TSD for more details.

NEEP provided information that some of the ballast failure scenarios included in the analysis are very uncommon. For example, DOE analyzed T8 programmed start ballasts when the vast majority of existing ballasts are instant start. (NEEP, No. 33 at p. 3)

Although certain ballast scenarios may be less common, DOE's research indicates that they are already in use and increasing in market share. In the 2011 Ballast Rule,[70] DOE analyzed programmed start ballasts for 4-foot MBP lamps directly due to their increasing market share. Programmed start ballasts are typically used in applications with frequent switching such as those with occupancy sensors. Because lighting controls are becoming more common, as discussed in section I.A.1.a, the use of programmed start ballasts is expected to increase. Additionally, DOE notes that the start year of the analysis is 2017 and, therefore, it was appropriate to include programmed start ballasts because of their expected increase in market share. DOE continued to include these scenarios in the LCC NOPR analysis.

CA Utilities questioned why DOE had not considered delamping scenarios, using high ballast factors such as 1 or 1.15, adding reflectors, or other kinds of optimized retrofits. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 253–254) The CA IOUs stated that there would be scenarios where DOE could use such measures to optimize cost-effectiveness. (CA IOUs, Public Meeting Transcript, No. 30 at p. 254) However, EEI reasoned that there are too many other options and materials that could be included, and some of them would be possibilities for the baseline lamps as well, such as reflectors and ballasts with tandem wiring. EEI concluded that if DOE attempts to account for all possible scenarios, the analysis may no longer reflect what is actually happening with lamp efficacy or the most likely retrofit or new construction scenario in the presence of amended standards. (EEI, Public Meeting Transcript, No. 30 at pp. 254–256)

NEEA noted that delamping is a fairly common scenario, especially if DOE considers lighting retrofit as renovation, and NEEA stated they may have some data on such scenarios. (NEEA, Public Meeting Transcript, No. 30 at pp. 256) GE agreed that delamping is a very typical situation when moving from T12 to T8 systems. GE noted, however, that in a T8 to T8 analysis, delamping would be much less likely. GE agreed that the practice was common in the past, but did not anticipate it being that common going forward. (GE, Public Meeting Transcript, No. 30 at pp. 256–257)

DOE did not analyze delamping in the preliminary analysis. Available information indicates that delamping is not a common retrofit for T8 fluorescent systems. DOE received feedback during manufacturer interviews that delamping was previously very common with T12 systems as these systems were typically designed such that spaces were overlit. However, delamping is not common with T8 systems because lumen output levels have already been reduced to comply with newer recommended lighting levels and building codes. Therefore, DOE maintained its assumption and did not considering delamping in the NOPR analysis.

DOE also received comments regarding rare earth oxide prices and their impact on lamp prices and costs to the consumer. NEMA stated that to make products conforming to the 2009 Lamps Rule, the most efficacious rare earth phosphors are used. This leaves only the amount of rare earth phosphors in each lamp as a design option for achieving higher efficacy. Additionally, NEMA noted that while the phosphor weight is increased linearly, the correlating efficacy gain diminishes. NEMA pointed to the estimates for 4-foot T8 lamps, the most common GSFL analyzed in this rulemaking. The estimates show that to achieve the proposed 1.1 percent increase in efficacy from 89 lm/W (2009 Lamps Rule) to 90 lm/W (CSL 1), nearly 10 percent more of the associated rare earth oxide supply would be consumed. Further, to reach the CSL 2 level of 93 lm/W, more than 40 percent additional rare earth phosphors will be needed for GSFLs. NEMA anticipated that the increased demand for this critical material will impact rare earth oxide prices and increase the costs of GSFLs to U.S. consumers. (NEMA, No. 36 at p. 14)

In the preliminary analysis, DOE conducted a sensitivity analysis in the LCC using low and high rare earth oxide

[70] The final rule amending energy conservation standards for fluorescent lamp ballasts published in 2011 with a compliance date of November 14, 2014. 76 FR 70548 (Nov. 14, 2011). The full text and all related documents of the 2011 Ballast Rule can be found on regulations.gov, docket number EERE–2007–BT–STD–0016 at *www.regulations.gov/#!docketDetail;D=EERE-2007-BT-STD-0016*.

prices developed based on historical oxide price data to assess the impact on the cost to consumer purchasing a GSFL. Because the rare earth oxide prices have stabilized since hitting a peak in 2011, DOE conducted a sensitivity analysis using only a forecasted high rare earth oxide price in the NOPR analysis. See section VI.I and appendix 11B for further information on the methodology used to develop rare earth oxide prices. DOE also utilized information provided by NEMA on how the amount of phosphor varies with efficacy to develop rare earth oxide costs attributable to different ELs. The results of this sensitivity are presented in appendix 8B of the NOPR TSD. Further, DOE also assessed the maximum possible increase in rare earth oxide prices that would maintain positive LCC savings for consumers at each EL. See appendix 7B of the NOPR TSD for results of this analysis.

15. Incandescent Reflector Lamp Life-Cycle Cost Results in the Preliminary Analysis

A member of Congress commented that the July 2012 standards raised consumer prices on IRLs from approximately $4.50 to $8. The member anticipated that additional regulations would likely further increase the price to $10–12, while the return on investment based on energy savings would be 8 to 10 years. In this economic climate, the member believed imposing additional regulations on IRL manufacturers would be bad public policy. (Barr, No. 25 at p. 2)

The weighted average lamp prices that DOE calculated for IRLs in this NOPR analysis are similar to the prices the member of Congress provided. (See chapter 7 of the NOPR TSD for further information.) In the LCC analysis, DOE calculates the payback period, which is the amount of time it takes the consumer to recover the assumed higher purchase cost of a more-efficacious product through lower operating costs (*i.e.,* energy savings). DOE considers the calculated payback periods, as well as impacts on manufacturers when determining if a TSL is economically justified. Please see section VII.C of this NOPR for more details on the selection of the proposed TSL.

H. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended standards on consumers, DOE evaluates the impact on identifiable sub-groups of consumers (*e.g.,* low-income households) that a national standard may disproportionately affect. In the preliminary analysis, DOE stated it was considering the following subgroups for analysis: Low-income consumers, institutions of religious worship, and institutions serving low-income consumers.

EEI generally agreed with the consumer subgroups considered, but noted that how the current RECS data is structured would affect the analysis. EEI specifically questioned whether RECS broke out energy data specific to the poverty level. (EEI, Public Meeting Transcript, No. 30 at pp. 352–353) DOE notes that RECS data specifies whether consumers are at or below 100 percent of the poverty line. DOE believes this data is appropriate to conduct an LCC analysis on the low-income consumer subgroup.

In the NOPR analysis, DOE evaluated low-income consumers and institutions that serve low-income populations (*e.g.,* small nonprofits) as subgroups. However, DOE did not evaluate institutions of religious worship as a subgroup. In the 2009 Lamps Rule, DOE found that institutions of religious worship operate for fewer hours per year than any other building type in the commercial sector according to U.S. LMC: Volume I [71] data. DOE's review of the 2010 LMC data indicated that the operating hours of institutions of religious worship are comparable to other commercial building operating hours. Therefore, because they do not have inputs to the LCC that would be different from the main LCC analysis, DOE did not analyze them as subgroups. The NOPR TSD chapter 9 presents the results of the consumer subgroup analysis.

I. Shipments Analysis

DOE uses projections of product shipments to calculate the national impacts of standards on energy use, NPV, and future manufacturer cash flows. DOE develops shipment projections based on historical data and an analysis of key market drivers for each product. Historical shipments data are used to build up an equipment stock and also to calibrate the shipments model. The details of the shipments model are described in chapter 11 of the NOPR TSD.

The shipments model projects shipments of GSFLs and IRLs over a thirty-year analysis period for the base case (no standards) and for all standards cases. DOE invites comment on this choice of analysis period. Separate shipments projections are calculated for the residential sector and for the commercial and industrial sectors. The shipments model used to estimate GSFL and IRL lamp shipments for this rulemaking has four main interacting elements: (1) A lamp demand module that estimates the demand for GSFL and IRL lighting for each year of the analysis period; (2) a price-learning module, which projects future prices based on historic price trends; (3) substitution matrices, which specify the product choices available to consumers (lamps as well as lamp-and-ballast combinations for fluorescent lamps) depending on whether they are renovating lighting systems, installing lighting systems in new construction, or simply replacing lamps; and (4) a market-share module that assigns shipments to product classes, ballasts, and lamp options, based on consumer sensitivities to first costs (prices) and operation and maintenance costs.

The lamp demand module first estimates the lumen demand for GSFL and IRL lighting. The lumen demand calculation assumes that sector-specific lighting capacity (maximum lumen output of installed lamps) remains fixed per square foot of floor space over the analysis period. Floor space changes over the analysis period according to the EIA's *AEO 2013* projections of residential and commercial floor space; industrial floor space is assumed to grow at the same rate as commercial floor space. A lamp turnover calculation estimates shipments of lamps in each year given the initial stock, the expected lifetimes of the lamps (and ballasts for GSFLs), and sector-specific assumptions on operating hours. The turnover model attempts to meet the lumen demand as closely as possible, subject to the constraint that the areal density of lighting fixtures is fixed for existing buildings that are not renovated.

The lamp demand module accounts for the penetration of LED lighting into the GSFL and IRL markets. The reference assumption for LED market penetration is based on projections developed for DOE's Solid-State Lighting (SSL) Program.[72] The SSL Program projections extend only to 2030; DOE extrapolated to the end of the shipments forecast period. In the preliminary analysis, DOE assumed an upper limit on market penetration of 80

[71] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Energy Conservation Program for Consumer Products: Final Report: U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate. 2002. Washington, DC <*http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lmc_vol1_final.pdf*>.

[72] Navigant Consulting, Inc. *Energy Savings Potential of Solid-State Lighting in General Illumination Applications.* U.S. DOE Solid State Lighting Program, January 2012. Available at *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_energy-savings-report_jan-2012.pdf.*

percent for IRLs, 70 percent for commercial GSFLs, and 60 percent for residential GSFLs.

Philips questioned why DOE did not expect LEDs to take over the entire market. (Philips, Public Meeting Transcript, No. 30 at p. 270) Given that LED technology has been progressing faster than expected, DOE has revised its analysis and is now fitting the technology adoption curve, allowing an entire market takeover by LEDs. Given the best fit to the SSL forecast, DOE estimates that LEDs will achieve close to 100 percent penetration in both the GSFL and IRL markets by 2046.

The shipments model accounts for the use of lighting controls, including dimming and on-off controls, because controls affect ballast and lamp requirements and therefore lifetimes and shipments. The reference assumption for lighting system controls for the commercial sector is that state building energy code requirements for lighting controls remain constant at current levels, as does the ratio of voluntary to code-driven demand. Because code provisions are implemented only in new construction and building renovations that meet certain threshold requirements, code-driven implementation of lighting controls grows in slowly over time.

GE noted that, in the future, an increasing number of fluorescent systems will be controlled and dimmed in the commercial sector. GE pointed to an increase of controls requirements in commercial building codes and suggested that the initial five percent dimming population assumed in the analysis increase over the analysis period. (GE, Public Meeting Transcript, No. 30 at p. 217) EEI stated that, given the amount of dimmers in office spaces, they expected the percentage of lamps in the commercial sector that are on controls to be higher. (EEI, Public Meeting Transcript, No. 30 at pp. 216–217) EEI noted that the next edition of ASHRAE 90.1–2013, contains more control systems requirements for more lighting fixtures. (EEI, Public Meeting Transcript, No. 30 at p. 218)

DOE is aware that current building codes will lead to an increase in the fraction of lamps coupled to lighting control systems. Accordingly, DOE included a projection of growth in the fraction of commercial floor space subject to such building codes. The result is that the fraction of floor space utilizing various types of controls grows from 30 percent today to a projected value of 80 percent in 2046.

The CA IOUs stated that dimming ballasts will become more common with time. Specifically, the CA IOUs noted that California's Title 24 will require all new commercial buildings, and most lighting renovations in existing commercial buildings, to install dimming ballasts beginning January 2014. (CA IOUs, No. 32 at pp. 13–14) Lutron asked if DOE took California's Title 24 into account. (Lutron, Public Meeting Transcript, No. 30 at p. 218) The CA IOUs noted that Title 24 would not have been included in the 2010 LMC because the provision was passed after the 2010 LMC was published. (CA IOUs, Public Meeting Transcript, No. 30 at pp. 218–219)

DOE is aware that current building energy codes will lead to an increase in the fraction of lamps coupled to lighting control systems and dimming ballasts. Accordingly, in the shipments analysis and NIA, DOE included a projection of growth in the fraction of commercial floor space subject to such state codes, including California's Title 24 requirements, as renovations and new construction trigger compliance requirements. As mentioned previously, the result is that the fraction of floor space utilizing controls grows from 30 percent today to a projected value of 80 percent in 2046. DOE assumed that 26 percent of control systems for GSFL applications include dimming ballasts, based on data in the 2010 LMC.[73] Based on assumptions of the fraction of each control type that relies on a dimming ballast, DOE projects that the market share of dimming ballasts grows from an estimated 8 percent at present to an estimated 20 percent in 2046. DOE seeks input on the current fraction of GSFL ballast shipments that are dimming ballasts and the likely rate of growth of dimming ballasts in the future. The details of the analysis on controls and dimming are presented in chapter 11 and appendix 11A of the NOPR TSD.

The price-learning module estimates lamp and ballast prices in each year of the analysis period using a standard price-learning model.[74] The model is calibrated using three decades of historic data on the volume and value of fluorescent and PAR lamp shipments in the U.S. market, from which cumulative shipments and average prices are derived. Prices and cumulative shipments are fit to an experience curve. They are then augmented in each subsequent year of the analysis based on the shipments determined for the prior year by the module that assigns shipments to product classes and ELs. The current year's shipments, in turn, affect the subsequent year's prices. As shown in chapter 11 of the NOPR TSD, because fluorescent and PAR lamps have been on the market for decades, cumulative shipments are changing slowly, therefore experience curve effects are relatively small—an effect that is further constrained by the expected incursion of solid-state lighting into the GSFL and IRL markets.

The market-share module apportions the lamp and ballast shipments in each year among the different product classes, ballast types, and lamp options based on consumer sensitivities to first costs and operation and maintenance costs. To determine the prices used as inputs to the market-share module, DOE uses the ballast prices, weighted average lamp prices, and installation costs developed in the engineering and LCC analyses. The operation and maintenance costs are based on the power required to operate a particular lamp-and-ballast system, the price of electricity, and the annualized cost of lamp replacements over the lifetime of that system. To enable a fair comparison between systems with different light output, the module considers the prices and operating and maintenance costs computed per kilolumen of light output. For consumers replacing lamps on existing ballasts, only the lamp-related prices and energy costs are considered by the market share module. For consumers replacing an entire lamp-and-ballast system, the full price of the system, as well as the energy and annualized relamping costs, are considered. In this case, the comparison between different ballast types and product classes is made by considering a representative lamp-and-ballast combination.

The ballast types and lamp options considered in the shipments model were determined in the engineering analysis. Whereas the earlier analyses considered only lamp-and-ballast combinations that save energy relative to the baseline system, the shipments analysis allows consumers to choose among all different lamp-and-ballast systems. These lamp-and-ballast combinations include full wattage and reduced wattage lamps coupled to ballasts with high, normal, or low ballast factors, and dimming ballasts. Programmed start and instant start ballasts are also considered separately,

[73] U.S. Department of Energy—Energy Efficiency & Renewable Energy Building Technologies Program. *2010 U.S. Lighting Market Characterization.* January 2012. Washington, DC. *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.*

[74] For discussion of approaches for incorporating learning in regulatory analysis, see Taylor, Margaret, and Sydny K. Fujita. *Accounting for Technological Change in Regulatory Impact Analyses: The Learning Curve Technique.* Berkeley: Lawrence Berkeley National Laboratory, 2013. LBNL–6195E.

where appropriate. DOE limits or excludes lamp-and-ballast combinations that DOE's research indicates would not provide acceptable performance or would only do so in limited circumstances. The remaining combinations allow for a variety of different energy-saving and non-energy-saving options relative to the baseline. Details of the selection of allowable lamp-and-ballast combinations are given in chapter 11 of the NOPR TSD.

The market-share module allows for the possibility that consumers will switch among the different product classes, ballast types, and lamp options over time. Substitution matrices were developed to specify the product choices available to consumers (lamps as well as lamp-and-ballast combinations), depending on whether they are renovating lighting systems, installing lighting systems in new construction, or simply replacing lamps, and depending on the particular lighting application. In this way, the module assigns market shares to the different product classes, ballast types, and ELs based on historical observations of consumer sensitivity to price and to operating and maintenance costs.

The market-share module incorporates a limit on the diffusion of new technology into the market using the widely accepted Bass adoption model,[75] the parameters of which are based on historic penetration rates of new lighting technologies into the market. It also accounts for other observed deviations from purely price- and cost-driven behavior using an acceptance factor, which sets an upper limit on the market share of certain product classes and lamp options that DOE research indicates are acceptable only to a subset of the market. The available options depend on the case under consideration; in each of the standards cases corresponding to the different TSLs, only those lamp options at or above the particular standard level in each product class are considered to be available.

Because DOE executes the market-share module for the base case and each of the standards cases independently, the shipments analysis allows for the possibility that setting a standard on one product class could shift market share toward a different product class. The costs and benefits accruing to consumers from such market share shifts are fully accounted for in the NIA.

When the shipments model selects lamps for replacement, renovation, or new construction, it accepts only lamps or lamp-and-ballast combinations that retain lumen capacity within acceptable bounds. DOE received a number of comments on what consumers would find acceptable in terms of changes in light levels.

NEMA stated that while, in the past, it was common practice to reduce light levels by 10 percent or more when retrofitting from a T12 to a T8 lighting system, this was because the older lighting systems were typically designed to higher light levels. NEMA commented that, over the years, light level requirements specified by IESNA have been reduced, so future 4-foot linear fluorescent systems will already be operating at the appropriate lower light levels, and further light level reductions of 6 percent to 14 percent cannot be justified against the T8 systems operating in 2018. NEMA stated that DOE should seek to match the existing light levels within a plus or minus 5 percent range. (NEMA, No. 36 at p. 8)

The CA IOUs commented that scenarios in which lighting designers would specify an increase in light output instead of a reduction in system wattage will not be common in the commercial sector because (1) commercial occupants are often very sensitive to changes in workplace lighting and react negatively to light increases; and (2) commercial building operators are very sensitive to operating costs. The CA IOUs further stated that commercial building operators will prefer a retrofit option that will result in energy cost savings (without significantly reducing the light levels) over another option that increases light and doesn't save energy (unless the space was known to be underlit). The CA IOUs stated that, where DOE has a standards-case modeling choice between a lighting retrofit that would result in an increase of light levels of between 0 percent and 10 percent with no energy cost savings, and another that would result in a decrease of light levels of between 0 percent and 10 percent with energy cost savings, DOE should model the energy-saving option as the most likely scenario for consumers. (CA IOUs, No. 32 at p. 14) NEEA and NPCC commented on the modeled lamp or lighting system replacement options in which light output levels are increased 10 percent or more instead of maintaining light levels with an appropriate reduction in system power use. They contended that it is highly unlikely that a lighting retrofit or lamp replacement project would be undertaken that would result in a light output increase without using the opportunity to save energy (which often pays for or helps pay for the retrofit). (NEEA and NPCC, No. 34 at pp. 2, 4)

As discussed previously, based on manufacturer feedback, DOE determined that consumers would not notice a change in light output that is up to 10 percent, and that some consumers will choose to reduce light levels beyond 10 percent to conserve energy. Accordingly, in the shipments analysis, DOE assumes that consumers choose between lighting systems within 10 percent of current light output by considering the trade-off between first cost and operating costs, and not the relative light output. In this approach, systems that save energy in a cost-effective way will tend to be selected over systems that increase light output without saving energy. DOE further assumes that the fraction of the market that will accept larger reductions in lumen output is fixed throughout the analysis period. The size of this market segment was estimated from the current market share of reduced wattage lamps that reduce light levels by more than 10 percent compared to the baseline lamp. The model does now allow cumulative reductions in light levels. The model retains national average light levels within 10 percent of the average level at the beginning of the analysis period. No potential standards considered in this analysis lead to average light levels outside of this range.

The CA IOUs commented that there are a number of tools available to lighting designers to reduce system wattage while maintaining acceptable light levels. These options include installing lower wattage lamps, reducing ballast factors, delamping, or installing dimming ballasts. (CA IOUs, No. 32 at pp. 13–14) NEEA and NPCC commented that, if a 32 W T8 lamp replacement is undertaken, there are options available for maintaining acceptable light output while reducing energy use, such as 30 W and 28 W T8s, ballasts with a lower ballast factor, and dimming ballasts. (NEEA and NPCC, No. 34 at pp. 2, 4) NEMA commented that the energy consumption of GSFL systems is highly dependent on ballast selection and pairing, and asserted that NES of lighting systems will not be affected significantly by this proposed rulemaking on GSFL efficacy due to the overwhelming influence of ballast selection on final performance. (NEMA, No. 36 at p. 1)

DOE is aware of the substantial impact of the ballast and lamp choice on the energy consumption of a lamp-and-ballast system. As discussed earlier in this section, the shipments analysis explicitly models the possibility that

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

consumers will choose to reduce their ballast factor during a renovation or retrofit or switch to reduced wattage lamps when relamping an existing system. In addition, this analysis models the growth of dimming ballasts in the market and allows a variety of lamps to be coupled to dimming ballasts to achieve a fixed light output. Thus, when high-efficacy lamps are coupled to dimming ballasts, the overall energy savings are greater than those that are achieved when lower-efficacy lamps are coupled to dimming ballasts. DOE assigns market share to these lamp-and-ballast pairings using a model based on historical consumer sensitivity to price and operating costs. When a particular pairing saves energy in a cost-effective manner compared to other pairings, its market share is increased compared to less cost-effective options. Given that the lamp options considered in this rulemaking represent a fairly narrow range in lumen output within each product class, DOE does not consider delamping to be a likely means of saving energy for consumers who are only replacing failed lamps (see section VI.D.2.e for more information on delamping). The shipments model, however, allows for the possibility that consumers will alter the number of lamps per square foot during renovations to maintain light levels.

NEMA commented that reduced wattage lamps have limited utility as a substitute for full wattage lamps. NEMA noted that, while standard fluorescent lamp technology dims reliably, more efficient krypton-filled fluorescent lamps do not dim reliably in many applications. (NEMA, No. 36 at p.6) The CA IOUs stated that California's Title 24 requirement for controls in new buildings will result in high efficacy, full wattage T8s capable of dimming to custom light levels, ensuring higher efficacy lamps yield greater energy savings. (CA IOUs, No. 32 at p. 14) The Northeast Energy Efficiency Partnership (NEEP) also noted that high efficacy lamps do not impede control capabilities. NEEP commented that, while manufacturers had said that adding control functionality to a fluorescent fixture was the next frontier of efficiency for GSFLs, regional program administrators have not reported concerns that high efficacy GSFLs sacrifice dimming capabilities. (NEEP, No. 33 at p. 2)

DOE's research indicates that krypton gas is generally used to reduce the wattage of lamps and that full wattage lamps can generally be dimmed reliably. DOE notes that full wattage lamp options are available for all product classes at all efficacy levelss considered in this analysis. Also, as discussed previously, DOE found that dimming ballasts for 4-foot MBP lamps are commonly marketed as compatible with reduced wattage lamps, which are presumably krypton filled. Accordingly, in the shipments analysis and the NIA, DOE allows all full wattage lamp options to be coupled to dimming ballasts. DOE also allowed reduced wattage options in the 4-foot MBP category to be coupled to dimming ballasts, but, because the range of applications for this combination is restricted, DOE limits its market share in the analysis. DOE welcomes input on the assumption that a limited fraction of reduced-wattage 4-foot MBP lamps may be coupled to dimming ballasts.

NEMA commented on the issue of lamp replacement upon ballast failure. NEMA contends that when a residential ballast fails, residential GSFL consumers tend to first try to replace the lamp, and when that fails they replace the entire fixture, discarding the lamps from the old fixture. The effect is to reduce the lamp's usage life below its potential and therefore to increase shipments. (NEMA, No. 36 at p. 16) The shipments model assumes that when a residential ballast fails, all associated lamps are assumed to be replaced.

Rare earth oxides are used in GSFL phosphors to increase their efficiency. The shipments model considers the potential impact of changes in rare earth oxide prices on fluorescent lamp prices and, thereby, on GSFL shipments. Large increases in rare earth oxide prices in 2010 and 2011 raised manufacturer concerns that future price increases could have adverse impacts on the market. DOE developed shipments scenarios in its preliminary analysis to reflect uncertainties in the prices of rare earth oxides.

In the preliminary analysis, DOE assumed that the rare earth phosphor content was the same at all considered efficacy levels for each lamp type. NEMA stated that there is a relationship between rare earth phosphor content and efficiency. Specifically, NEMA indicated that to increase the efficacy of 4-foot MBP GSFLs from 89 to 90 lm/W would require 10 percent more rare earth phosphor and to reach 93 lm/W would require a 40 percent increase in rare earth phosphor. (NEMA, No. 36 at p. 14) Based on an examination of fluorescent lamp patents, DOE agrees with NEMA's comment, and has adjusted its analysis accordingly, as described in appendix 11B of the NOPR TSD.

In the preliminary analysis, DOE's reference case assumed that rare earth phosphor prices would remain constant at the October 2012 level, but DOE acknowledged the uncertainty about prices and included a scenario with much higher prices. NEEP commented that DOE appropriately addressed the variability of rare earth phosphor prices in the preliminary analysis. (NEEP, No. 33 at pp. 2–3) NEMA commented that rare earth phosphors are likely to remain critical (*i.e.,* volatile), that prices are more likely to go up than down, and suggested that DOE consult Dr. Alex King of the Critical Materials Institute of the Ames Laboratory on the subject. (NEMA, No. 36 at p. 14)

DOE examined the rare earth market and believes that the very large reduction in rare earth prices seen since the 2011 peak may represent some stabilization of the market, but it still considers future rare earth prices significantly uncertain.[76] DOE therefore considered two price scenarios in its shipments modeling for GSFLs, as described in appendix 11B of the NOPR TSD. The reference scenario assumes that rare earth prices remain fixed at their September 2013 level. The high rare earth price scenario assumes an average rare earth price 3.4 times the reference level, representing a value that is half way between the low pre-2010 baseline price and the 2011 peak price. This scenario represents the average price of regular price fluctuations between the peak and baseline amounts. The impact of the latter scenario on the results is discussed in section 0. DOE invites comment on its assumptions about future prices of rare earth elements.

Stakeholders also commented on the possibility of future scarcity in the supply of xenon gas, which could affect future prices of IRLs. NEMA commented that xenon is becoming increasingly scarce and that its loss would result in a 5 to 7 percent reduction in IRL efficacy, making it impossible to meet CSL 1 of the preliminary analysis (20 lm/W). NEMA advised DOE to investigate xenon availability trends and future prices. (NEMA, No. 36 at p. 3)

[76] DOE conferred with Dr. King, who indicated that a good comparison can be made between rare earths and cobalt, which are comparable (within about a factor of ten) in abundance in the earth's crust. In 1978, world cobalt supplies were dominated by a single source (Zaire). In 2010, rare earth supplies were dominated by a single source (China). In 1978, the use of cobalt was growing both in existing and emerging technologies. The same is true for rare earths today. Following the 1978 crisis, new cobalt mines opened, and substitute materials were developed. Markets are pursuing the same paths for the rare earths today. DOE examined inflation-adjusted cobalt prices from 1970 through 2012 and found that cobalt prices did continue to remain volatile, although later price fluctuations were less than half of the initial price peak seen in 1978.

The CA IOUs commented that xenon is already used as the primary gas fill in most IRLs and that future efficacy standards should not be affected by potential constraints on xenon supply or xenon price fluctuations. (CA IOUs, No. 32 at p. 9) NEEA pointed out that there is no current shortage of xenon gas fill and that a new standard would not require any significant amount of increased xenon supply. Therefore, the supply and price of xenon should not be an issue for the rulemaking. (NEEA, No. 34 at p. 2)

To assess the need for further investigation, DOE conducted a sensitivity analysis on the potential impact on the rulemaking of a ten-fold increase in xenon prices. The impact of the latter scenario on the results is discussed in section 0.. DOE welcomes input on its assumptions regarding the future price of xenon gas.

J. National Impact Analysis—National Energy Savings and Net Present Value Analysis

The NIA assesses the NES and the national NPV of total consumer costs and savings expected to result from amended standards for GSFLs and IRLs at specific efficacy levels. Analyzing impacts of potential energy conservation standards for GSFLs and IRLs requires comparing projections of U.S. energy consumption with amended energy conservation standards against projections of energy consumption without the standards (the base case).

Because the shipments model allows for substitutions across product classes, to understand the impact of setting a standard at any given level for any given product class, the impact on all other product classes must be considered. Therefore, in addition to conducting the analysis for the covered products as a whole, DOE evaluated the NPV and NES by product class to determine the impact of consumer switching between product classes. The NIA was developed in a Microsoft Excel spreadsheet,[77] allowing access to a broad range of scenario assumptions for conducting sensitivity analyses on specific input values.

TABLE VI.14—INPUTS FOR THE NATIONAL IMPACT ANALYSIS

Input	Description
Shipments	Annual shipments from shipments model.
Compliance date of standard	January 1, 2017.
Base case efficiencies	Estimated by market-share module of shipments model.
Standards case efficiencies	Estimated by market-share module of shipments model.
Annual energy consumption per unit	Calculated for each efficacy level and product class based on inputs from the energy use analysis.
Total installed cost per unit	Lamp prices by efficacy level, ballast prices by ballast type, and lamp and ballast installation costs. The weighted average prices and installation costs developed in the engineering analysis and LCC analysis were used.
Electricity expense per unit	Annual energy use for each product class is multiplied by the corresponding average energy price.
Escalation of electricity prices	*AEO 2013* forecasts (to 2040) and extrapolation beyond 2040.
Electricity site-to-primary energy conversion	A time series conversion factor; includes electric generation, transmission, and distribution losses.
Discount rates	3% and 7% real.
Present year	2013.

1. National Energy Savings

The inputs for determining the NES for each product class are: (1) Lamp shipments; (2) annual energy consumption per unit; (3) installed stocks of lamps (coupled to each analyzed ballast type for GSFLs) in each year; and (4) site-to-primary energy and FFC conversion factors. The lamp stocks were calculated by the shipments model for each year of the analysis period from the prior year's stock, minus retirements, plus new shipments, accounting for lamp and ballast lifetimes. DOE calculated the national electricity consumption in each year by multiplying the number of units of each product class and EL in the stock by each unit's power consumption and operating hours. The power consumption is determined by the lamp wattage and, for each GSFL, by the ballast type to which each lamp is coupled. The operating hours are given by taking a weighted average of the distributions developed in the LCC analysis. The electricity savings are estimated from the difference in national electricity consumption by GSFL between the base case (without new standards) and each of the standards cases for lamps shipped during the 2017–2046 period.

NEMA commented that DOE appears to be using a new (arbitrary) 70-year period in its analysis and requested explanation and justification for examining such a long stretch of time. (NEMA, No. 36 at pp. 2–3) In the NIA, DOE accounts for the lifetime impacts of the products shipped during a 30-year period. In the case of GSFLs and IRLs, most of the products are retired from the stock within five years. The lifetime distribution used by DOE shows a small number of lamps shipped for use in homes at the end of the 30-year shipments analysis period survive for much longer. While the energy use of these lamps is insignificant to the overall results, the calculation period for the NIA is extended to account for them.

DOE accounted for the impact of lighting system controls on lighting energy use as well as on lamp shipments, as discussed in the previous section. NEEA noted that as many as a third of commercial building control systems do not achieve their design performance and thus yield a smaller energy savings than expected. (NEEA, No. 30 at pp. 317–318) DOE understands that many lighting control systems may not achieve the savings for which they were designed. Accordingly, the estimated average energy reduction from controls is based on a meta-analysis of studies on the performance of actual lighting controls systems in the field.[78]

NEMA pointed out that light output and input power do not scale linearly for dimming GSFL systems due to the increasing importance of cathode heat

[77] Available at *www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/24.*

[78] Williams, A., B. Atkinson, K. Garbesi, E. Page, and F. Rubinstein (2012). Lighting controls in commercial buildings. *Leukos* 8(3): 161–180. *www.ies.org/leukos/samples/1_Jan12.pdf.*

power at reduced light levels. (NEMA, No. 36 at p. 14) DOE recognizes the need for cathode heating in dimming ballast systems and has included this effect in its energy consumption calculations. In particular, the shipments analysis and NIA use power consumption assumptions identical to those used in the engineering analysis, which account for cathode heating in dimming systems.

NEMA expressed concern that the highest considered efficacy levels would lead to the loss of reliable dimming and would have a negative impact on NES. NEMA asserted that, in future years, most of the energy savings from fluorescent lighting will be achieved through the increased use of lighting controls, not through increasing the efficacy of lamps, and that an aggressive standard on lamp efficacy could make these savings unachievable. (NEMA, No. 36 at p.6) NEMA further suggested that DOE perform and report an analysis of the impacts of the loss of dimming savings for efficacy levels that they claimed will drive out dimmable lamps in favor of low wattage versions. NEMA asserted that this would show a negative impact on the market and payback. They contended that increased efficiency and dimmability are inversely proportional. (NEMA 36 at p.17)

As discussed in the previous section, DOE modeled the growth of dimming ballasts in the shipments analysis and excluded or limited, as appropriate, the coupling of reduced wattage lamps to these ballasts. Therefore, the issues discussed in the previous comment are accounted for, and the NES and NPV results include any potential loss of dimming functionality.

DOE accounts for the direct rebound effect in its NES analyses. Direct rebound reflects the idea that, as appliances become more efficient, consumers use more of their service because their operating cost is reduced. In the case of lighting, the rebound could be manifested in increased hours of use or in increased lighting density (fixtures per square foot). Based on information evaluated for the preliminary analysis, DOE assumed no rebound for the residential or commercial lighting in its reference scenario for the NOPR analysis. DOE also conducted a sensitivity analysis on the rebound rate, which is presented in chapter 12 of the NOPR TSD. DOE welcomes comment on its assumptions and methodology for estimating the rebound effect for the products covered in this NOPR, including potential magnitudes of rebound effects.

DOE converted the site electricity consumption and savings to primary energy (power sector energy consumption) using annual conversion factors derived from the *AEO 2013* version of NEMS. Cumulative energy savings are the sum of the NES for each year in which product shipped during 2017 through 2046 continue to operate.

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 Science, DOE announced its intention to use FFC measures of energy use and GHG and other emissions in the NIA and emissions analysis included in future energy conservation standards rulemakings. 76 FR 51281 (August 18, 2011). While DOE stated in that notice that it intended to use the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model to conduct the analysis, it also said it would review alternative methods, including the use of EIA's NEMS. After evaluating both models and the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in the **Federal Register** in which DOE explained its determination that NEMS is a more appropriate tool for this specific use. 77 FR 49701 (August 17, 2012). Therefore, DOE is using a NEMS-based approach to conduct FFC analyses. The approach used for today's NOPR is described in appendix 12C of the NOPR TSD.

2. Net Present Value of Consumer Benefit

The inputs for determining the NPV of the total costs and benefits experienced by consumers of the considered product are: (1) Total annual installed cost; (2) total annual savings in operating costs; and (3) a discount factor to calculate the present value of costs and savings. DOE calculated net savings each year as the difference between the base case and each standards case in terms of total savings in operating costs versus total increases in installed costs. DOE calculated savings over the lifetime of products shipped during the period starting January 1, 2017 and ending December 31, 2046. DOE calculated NPV as the difference between the present value of operating cost savings and the present value of total installed costs.

a. Total Annual Installed Cost

The total installed cost includes both the product price and the installation cost. For each product class, DOE utilized weighted average prices for each of the lamp and ballast options, as well as installation costs, as developed in the engineering and LCC analyses. DOE calculated the total installed cost for each lamp-and-ballast option and determined annual total installed costs based on the annual shipments of lamps and ballasts determined in the shipments model. As noted in section VI.I, DOE assumed that GSFL and IRL prices decline slowly over the analysis period according to a learning rate developed from historical data.

As discussed in section VI.I, DOE considered two price scenarios in its modeling for GSFLs. The reference scenario assumes that rare earth prices remain fixed at their September 2013 level. The high rare earth price scenario assumes that rare earth prices are 3.4 times higher than the reference level, representing a value at the midpoint of the low pre-2010 baseline price and the peak 2011 price. The impact of the latter scenario on the NPV results is discussed in section 0.

For IRLs, DOE conducted a sensitivity analysis on the potential impact on the rulemaking of a ten-fold increase in xenon prices. The impact of the scenario on the results is discussed in section 0.

b. Total Annual Operating Cost Savings

The per-unit energy savings were derived as described in section VI.I. To calculate future electricity prices, DOE applied the projected trend in national average commercial and residential electricity prices from the *AEO 2013* Reference case, which extends to 2040, to the energy prices derived in the LCC and payback period analysis. DOE used the trend from 2030 to 2040 to extrapolate beyond 2040. In addition, DOE analyzed scenarios that used the trends in the *AEO 2013* Low Economic Growth and High Economic Growth cases. These cases have energy price trends that are, respectively, lower and higher in the long term compared to the Reference case. These price trends, and the NPV results from the associated cases, are described in chapter 12 of the NOPR TSD.

DOE estimated that annual maintenance costs do not vary with efficiency within each product class, so they do not figure into the annual operating cost savings for a given standards case. DOE utilized the lamp disposal costs developed in the LCC analysis, along with the shipments model forecast of the lamp retirements in each year, to estimate the annual cost savings related to lamp disposal costs. In this part of the analysis, DOE assumes that 30 percent of commercial consumers are subject to disposal costs.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. DOE estimates the NPV using both a 3 percent and a 7 percent real discount rate, in accordance with guidance provided by the Office of Management and Budget (OMB) to federal agencies on the development of regulatory analysis.[79] 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.

K. Manufacturer Impact Analysis

1. Overview

DOE conducted separate MIAs for GSFLs and IRLs to estimate the financial impact of amended energy conservation standards on manufacturers of GSFLs and IRLs, respectively. The MIA has both quantitative and qualitative aspects. The quantitative part of the MIA relies on the GRIM, an industry cash-flow model customized for GSFLs and IRLs covered in this rulemaking. The key GRIM inputs are data on the industry cost structure, equipment costs, shipments, and assumptions about markups and conversion costs. The key MIA output is INPV. DOE used the GRIM to calculate cash flows using standard accounting principles and to compare changes in INPV between a base case and various TSLs (the standards case). The difference in INPV between the base and standards cases represents the financial impact of amended energy conservation standards on GSFL and IRL manufacturers. Different sets of assumptions (scenarios) produce different INPV results. The qualitative part of the MIA addresses factors such as manufacturing capacity; characteristics of, and impacts on, any particular sub-group of manufacturers; and impacts on competition.

DOE conducted the MIAs for this rulemaking in three phases. In the first phase DOE prepared an industry characterization based on the market and technology assessment, preliminary manufacturer interviews, and publicly available information. In the second phase, DOE estimated industry cash flows in the GRIMs using industry financial parameters derived in the first phase and the shipment scenarios used in the NIAs. In the third phase, DOE conducted interviews with a variety of GSFL and IRL manufacturers that account for more than 90 percent of domestic GSFL sales and more than 80 percent of domestic IRL sales covered by this rulemaking. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics specific to each company and obtained each manufacturer's view of the GSFL and IRL industries as a whole. The interviews provided information that DOE used to evaluate the impacts of amended standards on manufacturers' cash flows, manufacturing capacities, and direct domestic manufacturing employment levels. See section VII.B.2.b of this NOPR for the discussion on the estimated changes in the number of domestic employees involved in manufacturing GSFLs and IRLs covered by standards. See section VI.K.4 of this NOPR for a description of the key issues manufacturers raised during the interviews.

During the third phase, DOE also used the results of the industry characterization analysis in the first phase and feedback from manufacturer interviews to group manufacturers that exhibit similar production and cost structure characteristics. DOE identified one manufacturer sub-group for a separate impact analysis—small business manufacturers—using the small business employee threshold of 1,000 total employees published by the Small Business Administration (SBA). This threshold includes all employees in a business' parent company and any other subsidiaries. Based on this classification, DOE identified 21 GSFL manufacturers that qualify as small businesses and 15 IRL manufacturers that qualify as small businesses. The complete MIA is presented in chapter 13 of the NOPR TSD, and the analysis required by the Regulatory Flexibility Act, 5 U.S.C. 601, et seq., is presented in section VIII.B of this NOPR and chapter 13 of the NOPR TSD.

2. GRIM Analysis and Key Inputs

DOE uses the GRIM to quantify the changes in cash flows over time due to amended energy conservation standards. These changes in cash flows result in either a higher or lower INPV for the standards case compared to the base case (the case where a standard is not set). The GRIM analysis uses a standard annual cash flow analysis that incorporates manufacturer costs, markups, shipments, and industry financial information as inputs. It then models changes in costs, investments, and manufacturer margins that result from amended energy conservation standards. The GRIM uses these inputs to calculate a series of annual cash flows beginning with the base year of the analysis, 2013, and continuing to 2046. DOE computes INPV by summing the stream of annual discounted cash flows during the analysis period. DOE used a real discount rate of 9.2 percent for both GSFL and IRL manufacturers. The discount rate estimates were derived from industry corporate annual reports to the Securities and Exchange Commission (SEC 10-Ks). During manufacturer interviews GSFL and IRL manufacturers were asked to provide feedback on this discount rate. Most manufacturers agreed that a discount rate of 9.2 was appropriate to use for both GSFL and IRL manufacturers. Many inputs into the GRIM come from the engineering analysis, the NIA, manufacturer interviews, and other research conducted during the MIA. The major GRIM inputs are described in detail in the sections below.

a. Capital and Product Conversion Costs

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

Using feedback from manufacturer interviews, DOE conducted both top-down and bottom-up analyses to calculate the capital and product conversion costs for GSFL and IRL manufacturers. DOE then adjusted these conversion costs if there were any discrepancies between the two methods to arrive at a final capital and product conversion cost estimate for each GSFL and IRL product class at each EL.

To conduct the top-down analysis, DOE asked manufacturers during manufacturer interviews to estimate the total capital and product conversion costs they would need to incur to be able to produce each GSFL and IRL product class at specific ELs. DOE then summed these values provided by manufacturers to arrive at total top-

[79] OMB Circular A–4, section E (Sept. 17, 2003). Available at: *www.whitehouse.gov/omb/circulars_a004_a-4*.

down industry conversion costs for GSFLs and IRLs.

To conduct the bottom-up analysis, DOE used manufacturer input from manufacturer interviews regarding the types and dollar amounts of discrete capital and product expenditures that would be necessary to convert specific production lines for GSFLs or IRLs to each EL. GSFL manufacturers identified upgrading and recalibrating production automation systems as the primary capital cost that would be necessary to meet higher efficacy levels for GSFLs. IRL manufacturers identified several potential capital costs that could be required to meet higher efficacy levels for IRLs. These include purchasing new burner coating machines, increasing the capacity of existing burner machines, purchasing reflector coating machines, and purchasing coiling machines, as well as other retooling costs. The two main types of product conversion costs for GSFLs and IRLs that manufacturers shared with DOE during manufacturer interviews were the engineering hours necessary to redesign lamps to meet higher efficacy standards and the testing and certification costs necessary to comply with higher efficacy standards. Once DOE had compiled these capital and product conversion costs, DOE then took average values (*i.e.,* average number of hours or average dollar amounts) based on the range of responses given by manufacturers for each capital and product conversion cost at each ELs.

The bottom-up conversion costs estimates DOE created were consistent with the manufacturer top-down estimates provided, so DOE used these cost estimates as the final values for each GSFL and IRL product class at each EL in the MIA.

See chapter 13 of the NOPR TSD for a complete description of DOE's assumptions for the capital and product conversion costs.

b. Manufacturer Production Costs

Manufacturing more efficacious GSFLs or IRLs is typically more expensive than manufacturing a baseline product due to the need for more costly materials and components. One of the primary drivers behind increased material costs is the need for enhanced reflectors and/or burner coatings for IRLs or rare earth oxides (REOs) for GSFLs, as well as the need for higher volumes of these materials. The higher manufacturer production costs (MPCs) for these more efficacious products can affect the revenue, gross margin, and lifetime of the product, which will then affect total volume of future shipments, and the cash flows of GSFL and IRL manufacturers. Typically, DOE develops MPCs for the covered products and uses the prices as an input to the LCC analysis and NIA. However, because GSFLs and IRLs are difficult to reverse-engineer, DOE derived end-user prices for the lamps covered in this rulemaking. DOE observed a range of end-user prices paid for GSFLs and IRLs depending on the distribution channel through which the lamps are purchased. DOE then developed three sets of discounts from the manufacturer blue-book prices representing low (state procurement), medium (electrical distributors and big box retailers), and high (Internet retailers) lamp prices for both GSFLs and IRLs. For more information about pricing, see section VI.E of this NOPR.

To calculate the MSP, the price at which manufacturers sell lamps to their customer, DOE calculated the distribution chain markup for the GSFL and IRL industries. DOE examined the SEC 10-Ks of publicly traded big box retail stores to determine the average retail markup for the medium end-user price distribution chain. DOE found the typical retail markup for big box stores was 1.52. DOE divided the medium end-user price for all GSFLs and IRLs by this value to arrive at MSPs for all GSFLs and IRLs. DOE invites comment on its methodology of using a 1.52 distribution chain markup in combination with the medium end-user price to estimate the MSP of all GSFLs and IRLs.

DOE also examined the SEC 10-Ks of all publicly traded GSFL and IRL manufacturers to estimate the average GSFL and IRL manufacturer markup. The manufacturer markup represents the markup lamp manufacturers apply to their MPCs to arrive at the MSPs. This is different from the distribution chain markup, which is the markup retail stores apply to the MSP to arrive at the end user price. Based on SEC 10-Ks, DOE found the typical manufacturer markup for GSFL and IRL manufacturers on a corporate level was 1.58. During manufacturer interviews, DOE asked manufacturers if 1.58 was an appropriate markup to use for GSFLs and IRLs. Based on manufacturer feedback that the 1.58 manufacturer markup was too high for both GSFLs and IRLs and should be lowered, DOE revised the manufacturer markup for both GSFLs and IRLs to be 1.52. The 1.52 figure is the same manufacturer markup used for these products in the 2009 Lamps Rule.

For a complete description of the end-user prices, see the product price determination in section VI.E of this NOPR.

c. Shipment Scenarios

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

In the base case shipment analysis, DOE first established a lumen capacity demand per square foot for commercial and residential spaces serviced by GSFLs and IRLs. While this lumen capacity per square foot demand is assumed to remain unchanged over the analysis period, the total lumen demand grows proportionally with the growth of new commercial and residential floor space, as projected by *AEO 2013.* DOE also expects the lighting demand for GSFLs and IRLs to be eroded by increased penetration of LEDs into the market. This LED penetration rate for the reference shipment scenario is based on the rate forecasted in DOE's Solid-State Lighting Program. (See section VI.I of this NOPR for further information.) Overall, while demand for lighting is expected to increase for the entire economy as the amount of floor space increases, the demand for GSFL and IRL specific lighting is projected to decline in the base case due to the increased penetration of alternative lighting sources such as LEDs.

In the standards case for GSFLs, DOE used a consumer choice model the shipments analysis and NIA to analyze how consumers would shift between GSFL product classes in response to standards (*e.g.,* consumers might forgo purchases of 4-foot MBP GSFLs in favor of 4-foot T5 MiniBP SO GSFLs in response to a higher 4-foot MBP GSFL standard). GSFL consumers were not, however, assumed to increase the purchase of LEDs in response to increased GSFL energy conservation standards. As discussed in section VI.I of this NOPR, the transition from GSFLs to LEDs is accounted for in the base case shipment analysis, and additional shifting to LEDs due to GSFL standards was not modeled in the standards case shipment analysis or in the NIA.

In the standards case for IRLs, the change in the number of shipments from the base case is mainly due to the increase in IRL lifetime at TSL 1 compared to the base case shipment lifetime. IRLs that meet the efficacy level specified at TSL 1 have a longer lifetime than the baseline IRLs. As a result, there are fewer shipments of IRLs at TSL 1 than in the base case over the analysis period, because the lamps at TSL1 last longer. The NIA also modeled an alternative IRL shipment scenario where the lifetime of IRLs at TSL 1 is shorter than the base case lifetime. DOE examined the impacts of a shortened lifetime scenario on manufacturers' cash flow as a sensitivity analysis. The results of the sensitivity analysis are presented in appendix 13C of the NOPR TSD. Also, similar to GSFLs, the shipments analysis and the NIA for IRLs did not model standards induced shifts to alternative lighting technologies, such as LEDs. Therefore, the MIA did not examine the revenue from LEDs in the manufacturers' cash flows as part of the IRL MIA. While the shipments analysis and the NIA recognize that consumers are shifting to alternative lighting technologies, which are accounted for in the base case shipments projection, the shipments analysis and the NIA did not model an accelerated shift to these alternative technologies specifically due to increased standards of IRLs.

For a complete description of the shipments see the shipments analysis discussion in section VI.I of this NOPR.

d. Markup Scenarios

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

Modifying these manufacturer markups in the standards case yields a different set of impacts on GSFL and IRL manufacturers than in the base case. For the MIA, DOE modeled two standards case markup scenarios for GSFLs and IRLs to represent the uncertainty regarding the potential impacts on prices and profitability for GSFL and IRL manufacturers following the implementation of amended energy conservation standards. The two scenarios are: (1) A flat, or preservation of gross margin, markup scenario and (2) a preservation of operating profit markup scenario. Each scenario leads to different manufacturer markup values, which, when applied to the inputted MPCs, result in varying revenue and cash flow impacts on GSFL and IRL manufacturers.

The flat, or preservation of gross margin, markup scenario assumes that the COGS for each product is marked up by a flat percentage to cover SG&A expenses, R&D expenses, interest expenses, and profit. This allows manufacturers to preserve the same gross margin percentage in the standards case as in the base case. This markup scenario represents the upper bound of the GSFL and IRL industries' profitability in the standards case because GSFL and IRL manufacturers are able to fully pass through additional costs due to standards to their consumers.

To derive the flat, or preservation of gross margin, markup percentages for GSFLs and IRLs, DOE examined the SEC 10-Ks of all publicly traded GSFL and IRL manufacturers to estimate the industry average gross margin percentage. Manufacturers were then asked about the industry gross margin percentage derived from SEC 10-Ks during manufacturer interviews. GSFL and IRL manufacturers stated that this average industry gross margin was too large and needed to be reduced. In response to these comments, DOE used the manufacturer markups from the 2009 Lamps Rule for GSFLs and IRLs, which was slightly less than the average industry gross margin derived from SEC 10-Ks of GSFL and IRL manufacturers.

DOE included an alternative markup scenario, the preservation of operating profit markup, because manufacturers stated they do not expect to be able to markup the full cost of production in the standards case, given the highly competitive GSFL and IRL lighting markets. The preservation of operating profit markup scenario assumes that manufacturers are able to maintain only the base case total operating profit in absolute dollars in the standards case, despite higher product costs and investment. The base case total operating profit is derived from marking up the COGS for each product by the flat markup described above. In the standards case for the preservation of operating profit markup scenario, DOE adjusted the GSFL and IRL manufacturer markups in the GRIM at each TSL to yield approximately the same earnings before interest and taxes in the standards case in the year after the compliance date of the amended GSFL and IRL standards as in the base case. Under this scenario, while manufacturers are not able to yield additional operating profit from higher production costs and the investments that are required to comply with amended GSFL and IRL energy conservation standards, they are able to maintain the same operating profit in the standards case that was earned in the base case.

The preservation of operating profit markup scenario represents the lower bound of industry profitability in the standards case. This is because manufacturers are not able to fully pass through the additional costs necessitated by GSFL and IRL energy conservation standards, as they are able to do in the flat (preservation of gross margin) markup scenario. Therefore, manufacturers earn less revenue in the preservation of operating profit markup scenario than they do in the flat markup scenario.

3. Discussion of Comments

Interested parties commented on the assumptions and results of the preliminary analysis. Comments addressed several topics: the potential shift to other lighting technologies in response to GSFL and IRL standards, the overall cumulative regulatory burden facing lighting manufacturers, the potential decrease in competition due to IRL standards, and the potential required use of proprietary technologies to achieve higher efficacy levels for IRLs. DOE addresses these comments below.

a. Potential Shift to Other Lighting Technologies

NEMA commented that further investments in GSFL and IRL technologies due to energy conservation standards will divert resources away from LED technology development. NEMA states that continued development of LEDs could lead to much great energy savings potential than the lighting technologies included in this rulemaking. NEMA recommends that DOE include in the MIA for GSFLs and IRLs the impact that such diversion of resources will have on LED technology if the lighting industry is required by a potential GSFL and IRL standard to make additional investments in GSFL and IRL technologies that are already experiencing diminishing returns on investment and use. (NEMA, No. 36 at p. 1)

DOE recognizes the opportunity cost associated with any investment, and agrees that manufacturers would need to spend capital to meet any proposed GSFL and IRL standards that they would not have to spend in the base case. The allocation of company resources among different lighting technologies is a complex business decision that each individual manufacturer will ultimately have to make. As a result, manufacturers must determine the extent to which they will balance investment in the GSFL and IRL markets with investment in emerging technologies, such as LEDs. The companies will have to weigh tradeoffs between deferring investments and deploying additional capital. DOE includes the costs on manufacturers of meeting today's proposed standards in its analysis.

NEEP commented that the MIA should account for any potential growth in LED sales lighting manufacturers might experience if the GSFL and IRL markets are projected to shrink throughout the years of the analysis. Instead of only accounting for lost revenues associated with a decrease in GSFL and IRL sales, NEEP suggests DOE also factor in the benefits those same manufacturers are potential gaining in the growing LED markets. (NEEP, No. 33 at p. 3)

Based on the shipment analysis DOE does not believe GSFL and IRL markets will increasingly migrate from traditional GSFL and IRL technologies to alternate lighting technologies, such as LEDs, in direct response to GSFL and IRL energy conservation standards. While DOE recognizes that LEDs are continuing to capture more and more of the traditional lighting markets serviced by GSFLs and IRLs, DOE does not believe that GSFL and IRL standards will increase this shift to LEDs. Therefore, this market shift to LEDs is captured in the base case shipment scenario and is not a standards-induced market shift. DOE excludes the revenue from LEDs earned by manufacturers who produce GSFLs and IRLs in the GRIM since the revenue stream would be present in both the base case and the standards case, resulting in no net impact on the change in INPV.

b. Cumulative Regulatory Burden

NEMA, along with some individual manufacturers, commented on the cumulative regulatory burden of this rulemaking given there are several DOE energy conservation standards that affect the major lighting manufacturers of this rulemaking. NEMA stated that DOE does not adequately address or quantify the cumulative regulatory burden. NEMA urges DOE to adopt a more transparent and open decision-making process to better address their continued concerns. (NEMA, No. 30 at pp. 338–340; NEMA, No. 36 at pp. 18–19) The cumulative regulatory burden is explained in greater detail in section VII.B.2.e of this NOPR, and a complete description of the cumulative regulatory burden is included in chapter 13 of the NOPR TSD. A complete description of the proposal selection process is provided in section VII.C of this NOPR.

GE commented they are concerned about the speed of this amended GSFL and IRL energy conservation standard, given that the 2009 Lamps Rule was published in 2009 and required compliance in 2012. They believe that it is difficult for manufacturers to recover their previous investments made in new technologies in only five and a half years. This potential loss in investments has a severe and negative manufacturer impact when rulemakings covering the same products are so close together. (GE, No. 30 at p. 188)

Philips similarly commented that they had invested millions of dollars in incandescent technologies to meet EISA 2007's general service lighting requirements, which could become obsolete due to amended IRL energy conservation standards. (Philips, No. 30 at p. 187) EEI also made similar comments stating that manufacturers who made long-term investments to comply with the 2009 Lamps Rule might not have had time to recover their investments in five or six years. (EEI, No. 30 at p. 187) A member of Congress commented that the OSI facility in Kentucky recently underwent major retooling to bring the facility into compliance with EISA's incandescent lighting requirements. Bringing that facility into compliance with even more stringent IRL regulations would require an increased capital outlay that is unavailable to the company at this time. This could result in a reduction of U.S. manufacturing jobs. (Barr, No. 25 at p. 1–2) As part of the cumulative regulatory burden analysis in section VII.B.2.e of this NOPR, DOE examines the investments manufacturers have made to comply with previous rulemakings.

Philips also commented on the cumulative regulatory burden, asking DOE to specify the criteria that determines if the proposed standards constitute a cumulative regulatory burden on manufacturers. (Philips, No. 30 at pp. 339–340; 347) DOE examines the cumulative regulatory burden as one of the potential impacts of potential standard levels before ultimately selecting an appropriate proposed standard. This examination of the costs and benefits of potential proposed standards is addressed in section VII.C of this NOPR.

c. Potential Decrease in Competition

EEI commented they are concerned that there could be a reduction in competition as a result of more stringent GSFL and IRL energy conservation standards. EEI stated they are especially concerned about any amended standards for IRLs due to the fact that DOJ determined that the 2009 Lamps Rule would have anti-competitive impacts on the IRL industry. EEI contends that any increase in the efficacy of IRLs due to amended standards could potentially increase these anti-competitive impacts. (EEI, No. 30 at pp. 335–337)

NEEA stated there seems to be an increase in the number of brand names available in the marketplace for IRLs. (NEEA, No. 30 at pp. 337–338) In the 2009 Lamps Rule, DOJ had expressed concerns that the proposed TSL 4 for IRLs could adversely affect competition noting that only two of the three large manufacturers manufacture IRLs that would meet the new standard and one of these manufacturers uses proprietary technology to do so. However, DOE research showed that all three large manufacturers had products that met TSL 4 and access to alternative technology pathways to achieve this efficacy that did not require propriety technology. Further, based on market research, analysis of HIR burner production, and interviews with manufacturers and HIR burner suppliers, DOE determined that manufacturers would not face any long-term capacity constraints. Therefore, DOE concluded that the proposed level in the 2009 Lamps rule for IRLs would not result in lessening competition. 74 FR 34080, 34160 (July 14, 2009).

DOE examines the potential decrease in competition from amended energy conservation standards in section VII.B.5 of this NOPR. DOE also submits a copy of the NOPR to DOJ for review as part of the rulemaking process and considers input from DOJ in developing any final standards.

4. Manufacturer Interviews

DOE conducted additional interviews with manufacturers following the preliminary analysis in preparation for the NOPR analysis. In these interviews, DOE asked manufacturers to describe their major concerns with this GSFL and

IRL rulemaking. The following section describes the key issues identified by GSFL and IRL manufacturers during these interviews.

a. Rare Earth Oxides in General Service Fluorescent Lamps

Several manufacturers are concerned that increasing the efficacy of GSFLs in response to amended energy conservation standards will require the use of significantly more REOs in GSFLs. This could expose GSFL manufacturers to the risk of another significant increase in the price of REOs. Over the past several years the price of REOs used in GSFLs has been extremely volatile. In 2011, the price of REOs significantly increased but has slowly been coming down over the past couple of years. While the current price of many of these REOs has returned to much lower levels than the peak prices experienced between 2010 and 2012, GSFL manufacturers are concerned that the price of REOs could return to those peak prices in the future. GSFL manufacturers are also concerned an increase in the demand for REOs due to amended energy conservation standards could cause the price for these REOs to spike.

Several GSFL manufacturers also noted that amended energy conservation standards for GSFLs could have adverse impacts on the domestic production of GSFLs. China is currently the dominant miner and producer of REOs worldwide and imposes quotas on the export of raw REOs. This drives up the costs for manufacturers of products using REOs that manufacture these products outside of China. As a result, manufacturers pointed out that amended GSFL standards could make it more attractive to manufacture GSFLs in China, rather than domestically, because the price of REOs would likely be much lower in China. See section VI.D.2.i of this NOPR for further discussion of the assessments of rare earth phosphor impacts from amended standards undertake in this NOPR analysis.

b. Unknown Impacts of the 2009 Lamps Rule

Several manufacturers expressed concern that amended energy conservation standards for GSFLs and IRLs would be premature given that the last round of DOE energy conservation standards for GSFLs and IRLs required compliance in July 2012. Manufacturers are still unsure how the standards from the 2009 Lamps Rule will ultimately affect their future sales and shipments as consumer preferences shift since there are a relatively large number of alternative lighting options available on the market. Manufacturers noted that they have developed new products to meet the 2009 Lamps Rule standards and are still waiting to see which consumers purchase which types of lamps.

Furthermore, manufacturers stated they have already made significant capital investments in order to be able to produce the more efficacious GSFLs and IRLs required by the 2009 Lamps Rule standards. Manufacturers are concerned that any additional increase in the efficacy of those products due to amended energy conservation standards could potentially strand the substantial capital investments made to comply with the 2009 Lamps Rule, as manufacturers have not yet fully recouped these capital investments. Manufacturers stated that a five year time period between the compliance date of the 2009 Lamps Rule (July 2012) and the estimated compliance date of the current GSFL and IRL rulemaking (2017) is too short for most manufacturers to recoup their capital investments, since manufacturing machinery typically has a much longer useful lifetime than five years. See section VII.B.2 of this NOPR for an analysis of the investments manufacturers must make to comply with standards.

c. Technology Shift

Several manufacturers contended that regardless of amended energy conservation standards, a technological shift away from GSFLs and IRLs is already occurring. They pointed out that the market is already moving toward LEDs, especially in the commercial sector. Manufacturers are concerned that amended standards would force them to divert resources away from the R&D of more efficacious lighting products, such as LEDs, by forcing manufacturers to spend time and money on GSFLs and IRLs, which have diminishing market shares. This increase in the efficacy of GSFLs and IRLs would increase the end-user price of GSFLs and IRLs which could ultimately drive consumers to purchase other lighting technologies, like LEDs. This could result in a further stranding of any capital investments made for GSFLs and IRLs. See section VI.I of this NOPR for discussion on the LED market penetration shipment scenario.

d. Impact on Residential Sector

Several manufacturers expressed concern that amended energy conservation standards for GSFLs and IRLs would not achieve substantial energy savings in the residential sector. Residential consumers do not have long operating hours and manufacturers are concerned that they will give up longer life to get a cheaper lamp. Furthermore, manufacturers expressed concern that amended GSFL standards may be overly burdensome by forcing some residential consumers of GSFLs to switch out their entire lighting system (*i.e.,* ballast and fixture) due to replacement lamps being regulated out of production for only minimal energy savings. DOE acknowledges that residential consumers could be differentially impacted by GSFL and IRL standards compared to commercial consumers. DOE analyzed residential and commercial consumers separately in the LCC analysis for GSFLs and IRLs. These results are presented in section VII.B.1.a of this NOPR.

L. Emissions Analysis

In the emissions analysis, DOE estimated the reduction in power sector emissions of SO_2, NO_X, CO_2, and Hg from potential energy conservation standards for GSFLs and IRLs. In addition, DOE estimates emissions impacts in production activities (extracting, processing, and transporting fuels) that provide the energy inputs to power plants. These are referred to as ''upstream'' emissions. Together, these emissions account for the FFC.

DOE conducted the emissions analysis using emissions factors for CO_2 and other gases derived from data in the EIA's *AEO 2013,* supplemented by data from other sources. DOE developed separate emissions factors for power sector emissions and upstream emissions. EIA prepares the *AEO* using NEMS. Each annual version of NEMS incorporates the projected impacts of existing air quality regulations on emissions. *AEO 2013* generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of December 31, 2012. The method that DOE used to derive emissions factors is described in chapter 14 of the NOPR TSD.

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 (D.C.). SO_2 emissions from 28 eastern states and D.C. were also limited under the Clean Air Interstate Rule (CAIR; 70 FR 25162 (May 12, 2005)), which created an allowance-based trading program that operates along with the Title IV program. CAIR was remanded to the U.S. Environmental

Protection Agency (EPA) by the U.S. Court of Appeals for the District of Columbia Circuit but it remained in effect. See *North Carolina* v. *EPA,* 550 F.3d 1176 (D.C. Cir. 2008); *North Carolina* v. *EPA,* 531 F.3d 896 (D.C. Cir. 2008). On July 6, 2011 EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (August 8, 2011). On August 21, 2012, the D.C. Circuit issued a decision to vacate CSAPR. See EME Homer City *Generation, LP* v. *EPA,* No. 11–1302, 2012 WL 3570721 at *24 (D.C. Cir. Aug. 21, 2012). The court ordered EPA to continue administering CAIR. The *AEO 2013* emissions factors used for today's NOPR assumes that CAIR remains a binding regulation through 2040.

The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. Under existing EPA regulations, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the adoption of an efficacy standard could be used to permit offsetting increases in SO_2 emissions by any regulated EGU. In past rulemakings, DOE recognized that there was uncertainty about the effects of efficiency standards on SO_2 emissions covered by the existing cap-and-trade system, but it concluded that negligible reductions in power sector SO_2 emissions would occur as a result of standards.

Beginning in 2015, however, SO_2 emissions will fall as a result of the Mercury and Air Toxics Standards (MATS) for power plants, which were announced by EPA on December 21, 2011. 77 FR 9304 (Feb. 16, 2012). In the final MATS rule, EPA established a standard for hydrogen chloride as a surrogate for acid gas hazardous air pollutants (HAP), and also established a standard for SO_2 (a non-HAP acid gas) as an alternative equivalent surrogate standard for acid gas HAP. The same controls are used to reduce HAP and non-HAP acid gas; thus, SO_2 emissions will be reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. *AEO 2013* assumes that, to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed by 2015. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Under the MATS, NEMS shows a reduction in SO_2 emissions when electricity demand decreases (*e.g.,* as a result of energy efficiency standards). Emissions will be far below the cap established by CAIR, so it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by any regulated EGU. Therefore, DOE believes that efficiency standards will reduce SO_2 emissions in 2015 and beyond.

CAIR established a cap on NO_X emissions in 28 eastern states and the District of Columbia. Energy conservation standards are expected to have little effect on NO_X emissions in those states covered by CAIR because excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions. However, standards would be expected to reduce NO_X emissions in the states not affected by the caps, so DOE estimated NO_X emissions reductions from the standards considered in this NOPR for these states.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would likely reduce Hg emissions. DOE estimated Hg emissions reduction using emissions factors based on *AEO 2013,* which incorporates the MATS.

In accordance with DOE's FFC Statement of Policy (76 FR 51282 (Aug. 18, 2011)), the FFC analysis includes impacts on emissions of methane (CH_4) and nitrous oxide (N_2O), both of which are recognized as GHGs. For CH_4 and N_2O, DOE calculated emissions reductions in tons and also in terms of units of carbon dioxide equivalent (CO_2eq). Gases are converted to CO_2eq by multiplying the emissions reduction in tons by the gas' global warming potential (GWP) over a 100-year time horizon. Based on the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,[80] DOE used GWP values of 25 for CH_4 and 298 for N_2O.

M. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this proposed rule, DOE considered the estimated monetary benefits from the reduced emissions of CO_2 and NO_X expected to result from each of the TSLs considered. To make this calculation similar to the calculation of the NPV of consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of product shipped in the forecast period for each TSL. This section summarizes the basis for the monetary values used for each of these emissions and presents the values considered in this rulemaking.

For today's NOPR, DOE is relying on a set of values for the social cost of carbon (SCC) that was developed by an interagency process. A summary of the basis for these values is provided below, and a more detailed description of the methodologies used is provided in appendices to chapter 15 of the NOPR TSD.

1. Social Cost of Carbon

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. Estimates of the SCC are provided in dollars per metric ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in CO_2 emissions, while a global SCC value is meant to reflect the value of damages worldwide.

Under section 1(b)(6) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), agencies must, to the extent permitted by law, assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. The purpose of the SCC estimates presented here is to allow agencies to incorporate the monetized social benefits of reducing CO_2 emissions into cost-benefit analyses of regulatory actions that have small, or ''marginal,'' impacts on cumulative global emissions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

As part of the interagency process that developed the SCC estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss

[80] Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland. 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller, Editors. 2007. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p. 212.

key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of CO_2 emissions, the analyst faces a number of serious challenges. A recent report from the National Research Council points out that any assessment will suffer from uncertainty, speculation, and lack of information about: (1) Future emissions of GHGs; (2) the effects of past and future emissions on the climate system; (3) the impact of changes in climate on the physical and biological environment; and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

Despite the serious limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing CO_2 emissions. Most Federal regulatory actions can be expected to have marginal impacts on global emissions. For such policies, the agency can estimate the benefits from reduced emissions in any future year by multiplying the change in emissions in that year by the SCC value appropriate for that year. The NPV of the benefits can then be calculated by multiplying the future benefits by an appropriate discount factor and summing across all affected years. This approach assumes that the marginal damages from increased emissions are constant for small departures from the baseline emissions path, an approximation that is reasonable for policies that have effects on emissions that are small relative to cumulative global CO_2 emissions. For policies that have a large (non-marginal) impact on global cumulative emissions, there is a separate question of whether the SCC is an appropriate tool for calculating the benefits of reduced emissions. This concern is not applicable to this rulemaking, however.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. In the meantime, the interagency group will continue to explore the issues raised by this analysis and consider public comments as part of the ongoing interagency process.

b. Social Cost of Carbon Values Used in Past Regulatory Analyses

Economic analyses for Federal regulations have used a wide range of values to estimate the benefits associated with reducing CO_2 emissions. In the final model year 2011 CAFE rule, the U.S. Department of Transportation (DOT) used both a ''domestic'' SCC value of $2 per metric ton of CO_2 and a ''global'' SCC value of $33 per metric ton of CO_2 for 2007 emission reductions (in 2007$), increasing both values at 2.4 percent per year. DOT also included a sensitivity analysis at $80 per metric ton of CO_2.[81] A 2008 regulation proposed by DOT assumed a domestic SCC value of $7 per metric ton of CO_2 (in 2006$) for 2011 emission reductions (with a range of $0 to $14 for sensitivity analysis), also increasing at 2.4 percent per year.[82] A regulation for packaged terminal air conditioners and packaged terminal heat pumps finalized by DOE in October of 2008 used a domestic SCC range of $0 to $20 per metric ton CO_2 for 2007 emission reductions (in 2007$). 73 FR 58772, 58814 (Oct. 7, 2008). In addition, EPA's 2008 Advance Notice of Proposed Rulemaking on Regulating Greenhouse Gas Emissions Under the Clean Air Act identified what it described as ''very preliminary'' SCC estimates subject to revision. 73 FR 44354 (July 30, 2008). EPA's global mean values were $68 and $40 per metric ton CO_2 for discount rates of approximately 2 percent and 3 percent, respectively (in 2006$ for 2007 emissions).

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing CO_2 emissions. To ensure consistency in how benefits are evaluated across agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted. The outcome of the preliminary assessment by the interagency group was a set of five interim values: Global SCC estimates for 2007 (in 2006$) of $55, $33, $19, $10, and $5 per metric ton of CO_2. These interim values represented the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules.

c. Current Approach and Key Assumptions

Since the release of the interim values, the interagency group reconvened on a regular basis to generate improved SCC estimates. Specifically, the group considered public comments and further explored the technical literature in relevant fields. The interagency group relied on three integrated assessment models commonly used to estimate the SCC: The FUND, DICE, and PAGE models. These models are frequently cited in the peer-reviewed literature and were used in the last assessment of the Intergovernmental Panel on Climate Change. Each model was given equal weight in the SCC values that were developed.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. A key objective of the interagency process was to enable a consistent exploration of the three models while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: Climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments.

In 2010, the interagency group selected four sets of SCC values for use

[81] See *Average Fuel Economy Standards Passenger Cars and Light Trucks Model Year 2011,* 74 FR 14196 (March 30, 2009) (Final Rule); Final Environmental Impact Statement Corporate Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015 at 3–90 (Oct. 2008) (Available at: *www.nhtsa.gov/fuel-economy*) (Last accessed December 2012).

[82] See *Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015,* 73 FR 24352 (May 2, 2008) (Proposed Rule); Draft Environmental Impact Statement Corporate Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015 at 3–58 (June 2008) (Available at: *www.nhtsa.gov/fuel-economy*) (Last accessed December 2012).

in regulatory analyses.[83] Three sets of values are based on the average SCC from three integrated assessment models, at discount rates of 2.5 percent, 3 percent, and 5 percent. The fourth set, which represents the 95th-percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from climate change further out in the tails of the SCC distribution. The values grow in real terms over time. Additionally, the interagency group determined that a range of values from 7 percent to 23 percent should be used to adjust the global SCC to calculate domestic effects, although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table VI.15 presents the values in the 2010 interagency group report, which is reproduced in appendix 15A of the NOPR TSD.

TABLE VI.15—ANNUAL SCC VALUES FROM 2010 INTERAGENCY REPORT, 2010–2050

[In 2007 dollars per metric ton CO_2]

Year	Discount rate %			
	5	3	2.5	3
	Average	Average	Average	95th Percentile
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC values used for today's notice were generated using the most recent versions of the three integrated assessment models that have been published in the peer-reviewed literature.[84] Table VI.16 shows the updated sets of SCC estimates from the 2013 interagency update in five-year increments from 2010 to 2050. Appendix 15B of the NOPR TSD provides the full set of values. The central value that emerges is the average SCC across models at 3 percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance of including all four sets of SCC values.

TABLE VI.16—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE, 2010–2050

[In 2007 dollars per metric ton CO_2]

Year	Discount rate %			
	5	3	2.5	3
	Average	Average	Average	95th Percentile
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable since they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Research Council report mentioned previously points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. There are a number of concerns and problems that should be addressed by the research community, including research programs housed in many of the federal agencies participating in the interagency process to estimate the SCC. The interagency group intends to periodically review and reconsider those estimates to reflect increasing

[83] *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government, February 2010. *www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.*

[84] Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. Interagency Working Group on Social Cost of Carbon, United States Government. May 2013; revised November 2013. *http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf.*

knowledge of the science and economics of climate impacts, as well as improvements in modeling.

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions resulting from today's rule, DOE used the values from the 2013 interagency report, adjusted to 2012$ using the Gross Domestic Product price deflator. For each of the four SCC cases specified, the values used for emissions in 2015 were $11.8, $39.7, $61.2, and $117 per metric ton avoided (values expressed in 2012$). DOE derived values after 2050 using the relevant growth rates for the 2040–2050 period in the interagency update. DOE invites comment on the methodology used to estimate the social cost of carbon.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SCC value for that year in each of the four cases. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the four cases using the specific discount rate that had been used to obtain the SCC values in each case.

2. Valuation of Other Emissions Reductions

As noted previously, DOE has taken into account how new or amended energy conservation standards would reduce NO_X emissions in those 22 states not affected by the CAIR. DOE estimated the monetized value of NO_X emissions reductions resulting from each of the TSLs considered for today's NOPR based on estimates found in the relevant scientific literature. Estimates of monetary value for reducing NO_X from stationary sources range from $468 to $4,809 per ton in 2012$.[85] DOE calculated monetary benefits using a medium value for NO_X emissions of $2,639 per short ton (in 2012$) and real discount rates of 3 percent and 7 percent.

DOE is evaluating appropriate monetization of avoided SO_2 and Hg emissions in energy conservation standards rulemakings. It has not included monetization in the current analysis.

N. Utility Impact Analysis

The utility impact analysis estimates several effects on the power generation industry that would result from the adoption of new or amended energy conservation standards. In the utility impact analysis, DOE analyzes the changes in installed electricity capacity and generation that would result for each trial standard level. The utility impact analysis uses a variant of NEMS,[86] which is a public domain, multi-sectored, partial equilibrium model of the U.S. energy sector. DOE uses a variant of this model, referred to as NEMS–BT, to account for selected utility impacts of new or amended energy conservation standards. DOE's analysis consists of a comparison between model results for the most recent *AEO* Reference Case and for cases in which energy use is decremented to reflect the impact of potential standards. The energy savings inputs associated with each TSL come from the NIA. Chapter 16 of the NOPR TSD describes the utility impact analysis in further detail.

NEEP urged DOE to quantify the economic benefits of electricity demand reductions for this rulemaking. (NEEP, No. 51 at p. 3)

For the NOPR, DOE used NEMS–BT, along with EIA data on the capital cost of various power plant types, to estimate the reduction in national expenditures for electricity generating capacity due to potential GSFL–IRL energy efficiency standards. The method used and the results are described in chapter 16 of the NOPR TSD.

DOE is evaluating whether parts of the cost reduction are a transfer and, thus, according to guidance provided by OMB to Federal agencies, should not be included in the estimates of the benefits and costs of a regulation.[87] Transfer payments are monetary payments from one group to another that do not affect total resources available to society (*i.e.,* exchanges that neither decrease nor increase total welfare). Benefits occur when savings to consumers result from real savings to producers, which increase societal benefits. Cost savings from reduced or delayed capital expenditure on power plants are a benefit, and not a transfer, to the extent that the reduced expenditure provides savings to both producers and consumers without affecting other groups. There would be a transfer to the extent that the delayed construction caused some other group (*e.g.,* product suppliers or landowners who might have assets committed to the projects) to realize a lower return on those assets. DOE is evaluating these issues to determine the extent to which the cost savings from delayed capital expenditure on power plants are a benefit to society.[88]

O. Employment Impact Analysis

Employment impacts from new or amended energy conservation standards include direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the product subject to standards; 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 product. Indirect employment impacts from standards consist of the jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, due to: (1) Reduced spending by end users on energy; (2) reduced spending on new energy supply by the utility industry; (3) increased consumer spending on the purchase of new product; 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. 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

[85] U.S. Office of Management and Budget, Office of Information and Regulatory Affairs, *2006 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities,* Washington, DC.

[86] For more information on NEMS, refer to the U.S. Department of Energy, Energy Information Administration documentation. A useful summary is *National Energy Modeling System: An Overview 2003,* DOE/EIA–0581 (2003) (March, 2003).

[87] OMB Circular A–4 (Sept. 17, 2003), p. 38.

[88] Although delayed investment implies a savings in total cost, the savings may be less than the savings in capital cost because the delay may also cause increases in other costs. For example, if the delayed investment was the replacement of an existing facility with a larger, more efficient facility, the increased cost of operating the old facility during the period of delay might offset much of the savings from delayed investment. That the project was delayed is evidence that doing so decreased overall cost, but it does not indicate that the decrease was equal to the entire savings in capital cost.

sector (*i.e.,* the utility sector) to more labor-intensive sectors (*e.g.,* the retail and service sectors). Based on the BLS data, DOE expects that net national employment may increase because of shifts in economic activity resulting from amended standards.

For the standard levels considered in the NOPR, DOE estimated indirect national employment impacts using an input/output model of the U.S. economy called Impact of Sector Energy Technologies, Version 3.1.1 (ImSET). 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 the 187 sectors. ImSET's national economic I–O structure is based on a 2002 U.S. benchmark table, specially aggregated to the 187 sectors most relevant to industrial, commercial, and residential building energy use. DOE notes that ImSET is not a general equilibrium forecasting model, and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run. For the NOPR, DOE used ImSET only to estimate short-term employment impacts. For more details on the employment impact analysis, see chapter 17 of the NOPR TSD.

P. Other Comments

DOE received several comments that address the overall merits of adopting amended standards for GSFLs and IRLs.

NEMA stated that existing voluntary incentives are already shifting the market to higher-efficiency products and systems. (NEMA, No. 36 at p. 17) Trends in the GSFL and IRL market are accounted for in DOE's projection of the base case. The impacts estimated for potential standards are above movement toward higher efficiency in the base case.

NEMA commented that standards are not justified for IRLs. Specifically, NEMA stated that the miniscule energy savings estimated for IRLs, combined with elimination of their market share by 2025, demonstrate why this class should not be further regulated and DOE should not adopt a new standard. (NEMA, No. 36 at pp. 2, 17) DOE's analysis indicates that the market share of IRLs would decline under the proposed standards, but the product would not be eliminated. The reasons for DOE's decision to propose standards for IRLs are explained in section VII.C of this notice.

NEMA also stated that, if DOE were to proceed with a higher standard for T5 SO lamps, the projected shipments go up (compared with the base case). It noted that, as the only competitor for T5 SO is LED, increasing the demand for T5 SO takes market share away from LED, a technology that is on the rise for reasons of popularity, lifetime, and efficiency. It stated that decreasing demand for LED technology in favor of an obsoleting technology that relies on critical materials (rare earth phosphors) and mercury is not a sound decision. (NEMA, No. 36 at p. 17) As discussed in chapter 11 of the NOPR TSD, the model accounts for the progressive and large incursion of LEDs into the GSFL market. The model then apportions the remaining demand for GSFL lamps among the product classes. The projected increase in shipments of T5 SO lamps relative to the base case is at the expense of 4-foot MBP lamps, not LEDs.

VII. Analytical Results

A. Trial Standard Levels

At the NOPR stage, DOE develops trial standard levels (TSLs) for consideration. The GSFL and IRL TSLs are formed by grouping different efficacy levels, which are potential standard levels for each product class. TSL 5 is composed of the max tech efficacy levels. TSL 4 is composed of the efficacy levels that, in combination, yield the maximum NPV. TSL 3 is composed of the efficacy levels that yield the maximum energy savings without using any of the EL 2 levels. TSL 2 is composed of the efficacy levels that would bring all product classes to approximately the same level of rare earth phosphor. TSL 1 is composed of the levels that represent the least efficacious lamps currently available on the U.S. market; currently there are no products in the market at the baseline (EL 0) for 8-foot RDC HO lamps or T5 lamps. For IRLs, DOE considered one TSL because only one efficacy level was analyzed (Table VII.2).

DOE used data on the representative product classes from the engineering and pricing analyses described in section VI.D.2.b for GSFLs and section VI.D.3.b for IRLs to evaluate the benefits and burdens of each of the GSFL and IRL TSLs. DOE analyzed the benefits and burdens by conducting the analyses described in section VI for each TSL. Table VII.1 presents the GSFL TSLs analyzed and the corresponding efficacy level for each GSFL representative product class. Table VII.2 presents the IRL TSL analyzed and the corresponding efficacy level for the representative IRL product class.

TABLE VII.1—COMPOSITION OF TSLS FOR GSFLS BY EFFICACY LEVEL

Representative product class	TSL 1 Current market min	TSL 2 Same phosphor level	TSL 3 Best non-EL 2	TSL 4 Max NPV	TSL 5 Max tech
1. 4-foot medium bipin, CCT ≤4,500 K	0	0	1	2	2
2. 8-foot single pin slimline, CCT ≤4,500 K	0	1	0	0	2
3. 8-foot RDC high output, CCT ≤4,500 K	1	2	1	1	2
4. 4-foot T5, Mini bipin standard output, CCT ≤4,500 K	1	1	1	1	2
5. 4-foot T5, Mini bipin high output, CCT ≤4,500 K	1	1	1	1	1

TABLE VII.2—COMPOSITION OF TSLS FOR IRLS BY EFFICACY LEVEL

Representative product class	TSL 1
Standard spectrum; >2.5 inch diameter; <125 V	1

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on GSFL and IRL consumers by looking at the effects standards would have on the LCC and PBP. DOE also examined the impacts of potential standards on consumer subgroups. These analyses are discussed below.

a. Life-Cycle Cost and Payback Period

Consumers affected by new or amended standards usually experience higher purchase prices and lower operating costs. Generally, these impacts on individual consumers are best captured by changes in LCCs and by the payback period. DOE's LCC and PBP analyses provide key outputs for each TSL, which are reported by product class in Table VII.3–Table VII.15. DOE designed the LCC analysis around lamp purchasing events and calculated the LCC savings relative to the baseline for each lamp replacement event separately in each lamp product class. Each table includes the average total LCC and the average LCC savings, as well as the fraction of product consumers for which the LCC will either decrease (net benefit), or increase (net cost) relative to the base-case forecast. When an EL results in ''positive LCC savings,'' the LCC of the lamp or lamp-and-ballast system is less than the LCC of the baseline lamp or lamp-and-ballast system, and the consumer benefits economically. When an EL results in ''negative LCC savings,'' the LCC of the lamp or lamp-and-ballast system is higher than the LCC of the baseline lamp or lamp-and-ballast system, and the consumer is adversely affected economically. The last outputs in the tables are the mean PBPs for the consumer that is purchasing a design compliant with the TSL. Entries of ''NER'' indicate standard levels that do not reduce operating costs, which prevents the consumer from recovering the increased purchase cost. The PBP cannot be calculated in those instances because the denominator of the PBP equation is 0. Because LCC savings and PBP are not relevant at the baseline level, results are ''N/A'' (not applicable) for the baselines. Chapter 8 of the NOPR TSD provides a detailed description of the LCC and PBP analysis and the results. Appendix 8B of the NOPR TSD presents Monte Carlo simulation results performed by DOE as part of the LCC analysis and also presents sensitivity results, such as LCC savings under the *AEO 2013* high-economic-growth and low-economic-growth cases.

The results for each TSL are relative to the energy use distribution in the base case (no amended standards), based on energy consumption under conditions of actual product use. The rebuttable presumption PBP is based on test values under conditions prescribed by the DOE test procedure, as required by EPCA. (42 U.S.C. 6295(o)(2)(B)(iii))

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Table VII.3 through Table VII.11 present the results for each of the five GSFL representative product classes that DOE analyzed. Specifically, these were the 4-foot MBP product class, 4-foot MiniBP SO product class, 4-foot MiniBP HO product class, 8-foot SP slimline product class, and 8-foot RDC HO product class. For GSFLs, results for the most common sector for each product class are presented. Chapter 8 of the NOPR TSD provides the LCC and PBP results for each product class in all relevant sectors.

TABLE VII.3—LCC AND PBP RESULTS FOR A 2-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN INSTANT START SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Inst.	17.19	116.96	134.33	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.88 BF Inst.	33.38	116.96	138.62	−4.29	100	0	NER
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst.	29.79	98.00	127.98	6.36	0.1	99.9	3.2
		EL 2	95.4	32.5 W T8 & 0.88 BF Inst.	26.73	116.96	143.88	−9.55	100	0	NER
		EL 2	96.0	28.4 W T8 & 0.88 BF Inst.	23.99	105.12	129.29	5.04	0	100	2.8
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Inst.	59.99	115.47	158.74	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	76.18	103.28	150.84	7.90	0	100	0.4
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst.	72.59	96.70	152.58	6.17	0.1	99.9	3.3
		EL 2	95.4	32.5 W T8 & 0.77 BF Inst.	69.53	101.06	153.88	4.87	0.1	99.9	3.2
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	66.79	101.96	152.03	6.72	0	100	2.4
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Inst.	62.78	115.47	160.44	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	78.97	103.28	152.53	7.90	0	100	0.4
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst.	75.39	96.70	154.27	6.17	0.1	99.9	3.3
		EL 2	95.4	32.5 W T8 & 0.77 BF Inst.	72.33	101.06	155.57	4.87	0.1	99.9	3.2
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	69.58	101.96	153.72	6.72	0	100	2.4

TABLE VII.4—LCC AND PBP RESULTS FOR A 2-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN PROGRAMMED START SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience: Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Prog.	17.19	178.88	196.22	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.88 BF Prog.	31.26	178.88	202.33	−6.11	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog.	29.79	150.18	180.13	16.09	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog.	26.73	178.88	205.77	−9.55	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	23.99	160.96	185.10	11.12	0.0	100.0	2.8
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Prog.	61.19	178.88	234.11	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.88 BF Prog.	75.27	178.88	240.22	−6.11	100.0	0.0	NER
		EL 1	90.0	32.5 W T8 & 0.72 BF Prog.	75.27	150.40	211.74	22.37	0.0	100.0	0.3
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog.	73.80	150.18	218.02	16.09	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog.	70.74	178.88	243.66	−9.55	100.0	0.0	NER
		EL 2	95.4	32.5 W T8 & 0.72 BF Prog.	70.74	150.40	215.18	18.93	0.0	100.0	2.5
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	67.99	160.96	222.99	11.12	0.0	100.0	2.8
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Prog.	63.98	178.88	236.52	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.88 BF Prog.	78.06	178.88	242.63	−6.11	100.0	0.0	NER
		EL 1	90.0	32.5 W T8 & 0.72 BF Prog.	78.06	150.40	214.15	22.37	0.0	100.0	0.3
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog.	76.59	150.18	220.43	16.09	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog.	73.53	178.88	246.06	−9.55	100.0	0.0	NER
		EL 2	95.4	32.5 W T8 & 0.72 BF Prog.	73.53	150.40	217.59	18.93	0.0	100.0	2.5
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	70.79	160.96	225.40	11.12	0.0	100.0	2.8

TABLE VII.5—LCC AND PBP RESULTS FOR A 4-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN INSTANT START SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-Cycle Cost Savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC Savings 2012$	Percentage of consumers that experience: Net Cost	Net Benefit	
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	27.95	225.79	254.11	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.87 BF Inst.	55.06	225.79	261.52	−7.41	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	53.17	188.99	242.52	11.58	0.2	99.8	3.3
		EL 2	95.4	32.5 W T8 & 0.87 BF Inst.	47.05	225.79	273.20	−19.10	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	41.56	202.80	244.72	9.39	0.0	100.0	2.9
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	86.30	223.94	287.56	N/A	N/A	N/A	N/A

TABLE VII.5—LCC AND PBP RESULTS FOR A 4-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN INSTANT START SYSTEM OPERATING IN THE COMMERCIAL SECTOR—Continued

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-Cycle Cost Savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC Savings 2012$	Percentage of consumers that experience: Net Cost	Percentage of consumers that experience: Net Benefit	
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	113.40	202.45	273.49	14.07	0.0	100.0	0.5
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	111.51	187.37	276.22	11.35	0.3	99.7	3.3
		EL 2	95.4	32.5 W T8 & 0.74 BF Inst.	105.39	195.81	278.53	9.03	0.2	99.8	3.3
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	99.90	201.09	278.32	9.24	0.0	100.0	2.9
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	89.09	223.94	289.26	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	116.20	202.45	275.18	14.07	0.0	100.0	0.5
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	114.31	187.37	277.91	11.35	0.3	99.7	3.3
		EL 2	95.4	32.5 W T8 & 0.74 BF Inst.	108.19	195.81	280.23	9.03	0.2	99.8	3.3
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	102.70	201.09	280.02	9.24	0.0	100.0	2.9

TABLE VII.6—LCC AND PBP RESULTS FOR A 4-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN PROGRAMMED START SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience: Net cost	Percentage of consumers that experience: Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.89 BF Prog.	27.95	354.89	383.16	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.89 BF Prog.	51.55	354.89	393.58	−10.42	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog.	53.17	297.59	351.07	32.08	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.89 BF Prog.	47.05	354.89	402.25	−19.10	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.89 BF Prog.	41.56	319.10	360.97	22.19	0.0	100.0	2.8
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.89 BF Prog.	88.14	354.89	434.98	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.87 BF Prog.	111.73	339.09	429.60	5.38	0.4	99.6	1.0
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog.	113.36	297.59	402.90	32.08	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.87 BF Prog.	107.24	339.09	438.28	−3.29	81.9	18.1	9.0
		EL 2	96.0	28.4 W T8 & 0.87 BF Prog.	101.75	304.62	398.32	36.66	0.0	100.0	2.0
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.89 BF Prog.	90.94	354.89	437.39	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.87 BF Prog.	114.53	339.09	432.01	5.38	0.4	99.6	1.0
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog.	116.15	297.59	405.30	32.08	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.87 BF Prog.	110.03	339.09	440.68	−3.29	81.9	18.1	9.0
		EL 2	96.0	28.4 W T8 & 0.87 BF Prog.	104.54	304.62	400.73	36.66	0.0	100.0	2.0

TABLE VII.7—LCC AND PBP RESULTS FOR A 2-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN INSTANT START SYSTEM OPERATING IN THE RESIDENTIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	10.48	46.85	57.34	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.87 BF Inst.	11.58	46.85	58.43	−1.09	100	0	NER
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	23.09	39.29	62.38	−5.05	94.8	5.2	17.6
		EL 2	95.4	32.5 W T8 & 0.87 BF Inst.	20.03	46.85	66.88	−9.55	100	0	NER
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	17.29	42.13	59.41	−2.08	89.8	10.2	15.2
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	52.71	46.85	99.56	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.83 BF Inst.	53.80	44.48	98.28	1.28	1.1	98.9	4.9
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	65.32	39.29	104.61	−5.05	94.8	5.2	17.6
		EL 2	95.4	32.5 W T8 & 0.83 BF Inst.	62.26	44.48	106.73	−7.17	100	0	42.5
		EL 2	96.0	28.4 W T8 & 0.83 BF Inst.	59.51	39.99	99.50	0.06	49	51	10.5
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	55.51	46.85	102.36	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.83 BF Inst.	56.60	44.48	101.08	1.28	1.1	98.9	4.9
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	68.11	39.29	107.40	−5.05	94.8	5.2	17.6
		EL 2	95.4	32.5 W T8 & 0.83 BF Inst.	65.05	44.48	109.53	−7.17	100	0	42.5
		EL 2	96.0	28.4 W T8 & 0.83 BF Inst.	62.31	39.99	102.30	0.06	49	51	10.5

TABLE VII.8—LCC AND PBP RESULTS FOR A TWO-LAMP 4-FOOT 54 W T5 MINIATURE BIPIN HIGH OUTPUT SYSTEM OPERATING IN THE INDUSTRIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	83.6	53.8 W T5 & 1 BF Prog	18.58	181.10	199.85	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	92.9	53.8 W T5 & 1 BF Prog	26.60	181.10	207.87	−8.02	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	32.52	165.38	191.12	8.73	0.0	100.0	3.9
		EL 1	102.1	47 W T5 & 1 BF Prog	35.43	158.83	190.02	9.83	0.0	100.0	3.3
Event II: Ballast Failure.	Baseline	Baseline	83.6	53.8 W T5 & 1 BF Prog	72.69	181.10	233.62	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	92.9	53.8 W T5 & 1 BF Prog	80.72	181.10	241.65	−8.02	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	86.64	165.38	224.89	8.73	0.0	100.0	3.9
		EL 1	102.1	47 W T5 & 1 BF Prog	89.55	158.83	223.79	9.83	0.0	100.0	3.3
Event III: New Construction and Renovation.	Baseline	Baseline	83.6	53.8 W T5 & 1 BF Prog	75.49	181.10	235.37	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	92.9	53.8 W T5 & 1 BF Prog	83.51	181.10	243.39	−8.02	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	89.43	165.38	226.64	8.73	0.0	100.0	3.9
		EL 1	102.1	47 W T5 & 1 BF Prog	92.35	158.83	225.54	9.83	0.0	100.0	3.3

TABLE VII.9—LCC AND PBP RESULTS FOR A TWO-LAMP 4-FOOT 28 W T5 MINIATURE BIPIN STANDARD OUTPUT SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog.	15.30	152.84	168.31	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	104.3	27.8 W T5 & 1 BF Prog.	19.17	152.84	172.18	−3.87	100.0	0.0	NER
		EL 2	109.7	27.8 W T5 & 1 BF Prog.	21.52	152.84	174.54	−6.22	100.0	0.0	NER
		EL 2	111.5	26 W T5 & 1 BF Prog.	24.67	143.23	168.07	0.25	57.9	42.1	5.7
		EL 2	116.0	25 W T5 & 1 BF Prog.	27.41	137.88	162.64	5.68	0.2	99.8	4.8
Event II: Ballast Failure.	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog.	68.19	152.84	205.74	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	104.3	27.8 W T5 & 0.85 BF Prog.	72.06	134.13	190.90	14.84	0.0	100.0	1.2
		EL 2	109.7	27.8 W T5 & 0.85 BF Prog.	74.41	134.13	193.25	12.49	0.0	100.0	2.0
		EL 2	111.5	26 W T5 & 0.85 BF Prog.	77.56	125.79	188.05	17.69	0.0	100.0	2.0
		EL 2	116.0	25 W T5 & 0.85 BF Prog.	80.30	121.15	183.32	22.42	0.0	100.0	2.2
Event III: New Construction and Renovation.	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog.	70.99	152.84	207.72	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	104.3	27.8 W T5 & 0.85 BF Prog.	74.86	134.13	192.88	14.84	0.0	100.0	1.2
		EL 2	109.7	27.8 W T5 & 0.85 BF Prog.	77.21	134.13	195.23	12.49	0.0	100.0	2.0
		EL 2	111.5	26 W T5 & 0.85 BF Prog.	80.35	125.79	190.03	17.69	0.0	100.0	2.0
		EL 2	116.0	25 W T5 & 0.85 BF Prog.	83.10	121.15	185.30	22.42	0.0	100.0	2.2

TABLE VII.10—LCC AND PBP RESULTS FOR A TWO-LAMP 8-FOOT 59 W T8 SINGLE PIN SLIMLINE SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	96.5	60.1 W T8 & 0.87 BF Inst.	26.72	219.51	246.59	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	98.2	60.1 W T8 & 0.87 BF Inst.	29.40	219.51	249.27	−2.68	100.0	0.0	NER
		EL 2	99.0	60.1 W T8 & 0.87 BF Inst.	34.52	219.51	254.39	−7.80	100.0	0.0	NER
		EL 2	105.6	54 W T8 & 0.87 BF Inst.	43.51	208.16	252.02	−5.43	96.1	3.9	7.1
		EL 2	108.0	50 W T8 & 0.87 BF Inst.	50.87	193.01	244.23	2.36	44.6	55.4	4.3
Event II: Ballast Failure.	Baseline	Baseline	96.5	60.1 W T8 & 0.87 BF Inst.	102.46	216.15	288.57	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	98.2	60.1 W T8 & 0.77 BF Inst.	105.14	193.01	268.11	20.46	0.0	100.0	0.6
		EL 2	99.0	60.1 W T8 & 0.77 BF Inst.	110.25	193.01	273.23	15.34	0.0	100.0	1.6
		EL 2	105.6	54 W T8 & 0.77 BF Inst.	119.24	183.01	272.22	16.35	0.0	100.0	2.4
		EL 2	108.0	50 W T8 & 0.87 BF Inst.	126.60	189.96	286.53	2.05	47.6	52.4	4.4

TABLE VII.10—LCC AND PBP RESULTS FOR A TWO-LAMP 8-FOOT 59 W T8 SINGLE PIN SLIMLINE SYSTEM OPERATING IN THE COMMERCIAL SECTOR—Continued

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience: Net cost	Percentage of consumers that experience: Net benefit	
Event III: New Construction and Renovation.	Baseline	Baseline	96.5	60.1 W T8 & 0.87 BF Inst.	105.25	216.15	290.24	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	98.2	60.1 W T8 & 0.77 BF Inst.	107.93	193.01	269.78	20.46	0.0	100.0	0.6
		EL 2	99.0	60.1 W T8 & 0.77 BF Inst.	113.05	193.01	274.90	15.34	0.0	100.0	1.6
		EL 2	105.6	54 W T8 & 0.77 BF Inst.	122.04	183.01	273.89	16.35	0.0	100.0	2.4
		EL 2	108.0	50 W T8 & 0.87 BF Inst.	129.40	189.96	288.20	2.05	47.6	52.4	4.4

TABLE VII.11—LCC AND PBP RESULTS FOR A TWO-LAMP 8-FOOT 86 W T8 RECESSED DOUBLE CONTACT HO SYSTEM OPERATING IN THE INDUSTRIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience: Net cost	Percentage of consumers that experience: Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	92.0	84 W T8 & 0.81 BF Inst.	24.45	171.55	196.38	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	95.2	84 W T8 & 0.81 BF Inst.	34.01	171.55	205.94	−9.56	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.81 BF Inst.	41.22	171.55	213.15	−16.77	100.0	0.0	NER
Event II: Ballast Failure.	Baseline	Baseline	92.0	84 W T8 & 0.81 BF Inst.	100.34	171.55	233.59	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	95.2	84 W T8 & 0.81 BF Inst.	109.90	171.55	243.15	−9.56	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.81 BF Inst.	117.11	171.55	250.36	−16.77	100.0	0.0	NER
Event III: New Construction and Renovation.	Baseline	Baseline	92.0	84 W T8 & 0.81 BF Inst.	103.14	171.55	234.96	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	95.2	84 W T8 & 0.81 BF Inst.	112.70	171.55	244.52	−9.56	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.81 BF Inst.	119.91	171.55	251.73	−16.77	100.0	0.0	NER

Incandescent Reflector Lamps

Table VII.12 through Table VII.15 present the commercial and residential sector LCC results for the IRL representative product class, the standard spectrum IRLs with diameters greater than 2.5 inches, input voltages less than 125 V.

TABLE VII.12—LCC AND PBP RESULTS FOR A 55 W PAR38 2,500 HOUR HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of onsumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure; or Event III: New Construction and Renovation.	Baseline	Baseline	17.8	60W, 1500hrs, Improved Halogen.	10.52	9.06	19.58	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase.	EL 1	18.5	55W, 2500hrs, HIR	13.07	8.30	16.14	3.44	0.0	100.0	3.2

TABLE VII.13—LCC AND PBP RESULTS FOR A 55 W PAR38 2,500 HOUR HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE RESIDENTIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC avings 2012$	Percentage of onsumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure; or Event III: New Construction and Renovation.	Baseline	Baseline	17.8	60W, 1500hrs, Improved Halogen.	9.40	10.36	19.75	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase.	EL 1	18.5	55W, 2500hrs, HIR	11.94	9.49	17.10	2.65	0.0	100.0	5.4

TABLE VII.14—LCC AND PBP RESULTS FOR A 55 W PAR38 4,200 HOUR IMPROVED HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure; or Event III: New Construction and Renovation.	Baseline	Baseline	17.8	60W, 1500hrs, Improved Halogen.	10.52	9.06	19.58	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase.	EL 1	18.5	55W, 4200hrs, Improved HIR.	14.94	8.30	13.64	5.94	0	100	5.6

TABLE VII.15—LCC AND PBP RESULTS FOR A 55 W PAR38 4,200 HOUR IMPROVED HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE RESIDENTIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy *lm/W*	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure; or Event III: New Construction and Renovation.	Baseline	Baseline	17.8	60W, 1500hrs, Improved Halogen.	9.40	10.36	19.75	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase.	EL 1	18.5	55W, 4200hrs, Improved HIR.	13.81	9.49	15.26	4.49	0	100	9.4

b. Consumer Subgroup Analysis

Certain consumer subgroups may be disproportionately affected by standards. Using the LCC spreadsheet model, DOE determined the impact of the TSLs on the following consumer subgroups: low-income consumers and institutions that serve low-income populations.

To reflect conditions faced by the identified subgroups, DOE adjusted particular inputs to the LCC model. For low-income consumers, DOE only used RECS data for consumers living below the poverty line. For institutions serving low-income populations, DOE assumed that the majority of these institutions are small nonprofits, and used a higher discount rate of 9.6 percent (versus 5.1 percent for the main commercial sector analysis). DOE found the differences between the LCC and PBP results for the subgroups analyzed and the primary LCC and PBP analysis to be minimal. See chapter 9 of the NOPR TSD further details of the consumer subgroup analysis.

General Service Fluorescent Lamps

Table VII.16 through Table VII.24 below show the LCC impacts and payback periods for the identified subgroups for GSFLs. Entries of ''NER'' indicate standard levels that do not reduce operating costs.

TABLE VII.16—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A 2-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN INSTANT START SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Inst.	17.19	102.28	119.60	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.88 BF Inst.	31.03	102.28	124.21	−4.61	100	0	NER
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst.	29.79	85.69	115.63	3.97	4.2	95.8	3.2
		EL 2	95.4	32.5 W T8 & 0.88 BF Inst.	26.73	102.28	129.15	−9.55	100	0	NER
		EL 2	96.0	28.4 W T8 & 0.88 BF Inst.	23.99	91.92	116.05	3.56	0	100	2.8
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Inst.	59.99	100.97	147.99	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	73.83	90.31	141.93	6.05	0	100	0.4
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst.	72.59	84.55	144.18	3.81	6.6	93.4	3.3
		EL 2	95.4	32.5 W T8 & 0.77 BF Inst.	69.53	88.37	144.93	3.06	3.6	96.4	3.2
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	66.79	89.15	142.97	5.02	0	100	2.4
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Inst.	62.78	100.97	149.93	N/A	N/A	N/A	N/A

TABLE VII.16—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A 2-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN INSTANT START SYSTEM OPERATING IN THE COMMERCIAL SECTOR—Continued

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	76.62	90.31	143.87	6.05	0	100	0.4
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst.	75.39	84.55	146.12	3.81	6.6	93.4	3.3
		EL 2	95.4	32.5 W T8 & 0.77 BF Inst.	72.33	88.37	146.87	3.06	3.6	96.4	3.2
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	69.58	89.15	144.91	5.02	0	100	2.4

TABLE VII.17—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A 2-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN PROGRAMMED START SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Prog.	17.19	146.45	163.74	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.88 BF Prog.	27.94	146.45	169.05	−5.31	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog.	29.79	122.95	152.85	10.89	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog.	26.73	146.45	173.29	−9.55	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	23.99	131.77	155.87	7.87	0.0	100.0	2.8
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Prog.	61.19	146.45	203.56	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.88 BF Prog.	71.94	146.45	208.87	−5.31	100.0	0.0	NER
		EL 1	90.0	32.5 W T8 & 0.72 BF Prog.	71.94	123.13	185.56	18.01	0.0	100.0	0.3
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog.	73.80	122.95	192.68	10.89	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog.	70.74	146.45	213.11	−9.55	100.0	0.0	NER
		EL 2	95.4	32.5 W T8 & 0.72 BF Prog.	70.74	123.13	189.80	13.77	0.0	100.0	2.5
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	67.99	131.77	195.69	7.87	0.0	100.0	2.8
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Prog.	63.98	146.45	206.09	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.88 BF Prog.	74.73	146.45	211.40	−5.31	100.0	0.0	NER
		EL 1	90.0	32.5 W T8 & 0.72 BF Prog.	74.73	123.13	188.09	18.01	0.0	100.0	0.3
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog.	76.59	122.95	195.21	10.89	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog.	73.53	146.45	215.64	−9.55	100.0	0.0	NER
		EL 2	95.4	32.5 W T8 & 0.72 BF Prog.	73.53	123.13	192.33	13.77	0.0	100.0	2.5
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	70.79	131.77	198.22	7.87	0.0	100.0	2.8

TABLE VII.18—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A 4-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN INSTANT START SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost: Installed cost 2012$	Life-cycle cost: Discounted operating cost 2012$	Life-cycle cost: LCC 2012$	Life-cycle cost savings: LCC savings 2012$	Percentage of consumers that experience: Net cost	Percentage of consumers that experience: Net benefit	Mean payback period years
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	27.95	197.44	225.67	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.87 BF Inst.	51.18	197.44	233.62	−7.95	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	53.17	165.26	218.70	6.96	8.8	91.2	3.3
		EL 3	95.4	32.5 W T8 & 0.87 BF Inst.	47.05	197.44	244.76	−19.10	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	41.56	177.33	219.17	6.50	0.1	99.9	2.9
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	86.30	195.81	264.52	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	109.52	177.03	253.68	10.84	0.0	100.0	0.5
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	111.51	163.84	257.76	6.76	9.4	90.6	3.3
		EL 2	95.4	32.5 W T8 & 0.74 BF Inst.	105.39	171.22	259.02	5.50	7.9	92.1	3.3
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	99.90	175.84	258.15	6.37	0.2	99.8	2.9
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	89.09	195.81	266.46	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	112.32	177.03	255.62	10.84	0.0	100.0	0.5
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	114.31	163.84	259.70	6.76	9.4	90.6	3.3
		EL 2	95.4	32.5 W T8 & 0.74 BF Inst.	108.19	171.22	260.96	5.50	7.9	92.1	3.3
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	102.70	175.84	260.09	6.37	0.2	99.8	2.9

TABLE VII.19—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A 4-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN PROGRAMMED START SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost: Installed cost 2012$	Life-cycle cost: Discounted operating cost 2012$	Life-cycle cost: LCC 2012$	Life-cycle cost savings: LCC savings 2012$	Percentage of consumers that experience: Net cost	Percentage of consumers that experience: Net benefit	Mean payback period years
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.89 BF Prog.	27.95	290.55	318.71	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.89 BF Prog.	46.06	290.55	327.82	−9.11	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog.	53.17	243.64	297.02	21.70	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.89 BF Prog.	47.05	290.55	337.81	−19.10	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.89 BF Prog.	41.56	261.25	303.02	15.70	0.0	100.0	2.8
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.89 BF Prog.	88.14	290.55	373.19	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.87 BF Prog.	106.25	277.61	369.36	3.83	4.6	95.4	1.0
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog.	113.36	243.64	351.49	21.70	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.87 BF Prog.	107.24	277.61	379.35	−6.16	96.0	4.0	9.0
		EL 2	96.0	28.4 W T8 & 0.87 BF Prog.	101.75	249.39	345.64	27.55	0.0	100.0	2.0
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.89 BF Prog.	90.94	290.55	375.72	N/A	N/A	N/A	N/A

TABLE VII.19—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A 4-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN PROGRAMMED START SYSTEM OPERATING IN THE COMMERCIAL SECTOR—Continued

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.87 BF Prog.	109.04	277.61	371.89	3.83	4.6	95.4	1.0
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog.	116.15	243.64	354.02	21.70	0.0	100.0	3.3
		EL 2	95.4	32.5 W T8 & 0.87 BF Prog.	110.03	277.61	381.88	−6.16	96.0	4.0	9.0
		EL 2	96.0	28.4 W T8 & 0.87 BF Prog.	104.54	249.39	348.17	27.55	0.0	100.0	2.0

TABLE VII.20—LCC AND PBP SUBGROUP RESULTS FOR LOW-INCOME CONSUMERS FOR A 2-LAMP 4-FOOT 32 W T8 MEDIUM BIPIN INSTANT START SYSTEM OPERATING IN THE RESIDENTIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	10.49	46.83	57.32	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	90.0	32.5 W T8 & 0.87 BF Inst.	11.59	46.83	58.42	−1.09	100	0	NER
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	23.11	39.27	62.38	−5.06	94.9	5.1	17.6
		EL 2	95.4	32.5 W T8 & 0.87 BF Inst.	20.05	46.83	66.88	−9.56	100	0	NER
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	17.30	42.11	59.41	−2.09	90.3	9.7	15.2
Event II: Ballast Failure.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	52.73	46.83	99.56	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.83 BF Inst.	53.82	44.45	98.28	1.28	1.1	98.9	4.9
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	65.35	39.27	104.62	−5.06	94.9	5.1	17.6
		EL 2	95.4	32.5 W T8 & 0.83 BF Inst.	62.29	44.45	106.74	−7.18	100	0	42.5
		EL 2	96.0	28.4 W T8 & 0.83 BF Inst.	59.54	39.97	99.51	0.05	49.9	50.1	10.5
Event III: New Construction and Renovation.	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst.	55.53	46.83	102.35	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.83 BF Inst.	56.62	44.45	101.07	1.28	1.1	98.9	4.9
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst.	68.14	39.27	107.41	−5.06	94.9	5.1	17.6
		EL 2	95.4	32.5 W T8 & 0.83 BF Inst.	65.08	44.45	109.54	−7.18	100	0	42.5
		EL 2	96.0	28.4 W T8 & 0.83 BF Inst.	62.33	39.97	102.30	0.05	49.9	50.1	10.5

TABLE VII.21—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A TWO-LAMP 4-FOOT 54 W T5 MINIATURE BIPIN HIGH OUTPUT SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	83.6	53.8 W T5 & 1 BF Prog.	18.57	219.84	238.55	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	92.9	53.8 W T5 & 1 BF Prog.	26.59	219.84	246.57	−8.02	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog.	32.51	200.77	227.96	10.60	0.0	100.0	3.2
		EL 1	102.1	47 W T5 & 1 BF Prog.	35.42	192.81	224.90	13.65	0.0	100.0	2.7
Event II: Ballast Failure.	Baseline	Baseline	83.6	53.8 W T5 & 1 BF Prog.	72.68	219.84	276.70	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	92.9	53.8 W T5 & 1 BF Prog.	80.70	219.84	284.72	−8.02	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog.	86.62	200.77	266.11	10.60	0.0	100.0	3.2
		EL 1	102.1	47 W T5 & 1 BF Prog.	89.53	192.81	263.05	13.65	0.0	100.0	2.7
Event III: New Construction and Renovation.	Baseline	Baseline	83.6	53.8 W T5 & 1 BF Prog.	75.47	219.84	278.68	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	92.9	53.8 W T5 & 1 BF Prog.	83.49	219.84	286.69	−8.02	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog.	89.41	200.77	268.08	10.60	0.0	100.0	3.2
		EL 1	102.1	47 W T5 & 1 BF Prog.	92.32	192.81	265.03	13.65	0.0	100.0	2.7

TABLE VII.22—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A TWO-LAMP 4-FOOT 28 W T5 MINIATURE BIPIN STANDARD OUTPUT SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog.	15.30	130.31	145.74	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	104.3	27.8 W T5 & 1 BF Prog.	19.17	130.31	149.61	−3.87	100.0	0.0	NER
		EL 2	109.7	27.8 W T5 & 1 BF Prog.	21.52	130.31	151.96	−6.22	100.0	0.0	NER
		EL 2	111.5	26 W T5 & 1 BF Prog.	24.67	122.12	146.91	−1.17	75.3	24.7	5.7
		EL 2	116.0	25 W T5 & 1 BF Prog.	27.41	117.56	142.99	2.75	11.4	88.6	4.8
Event II: Ballast Failure.	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog.	68.19	130.31	187.13	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	104.3	27.8 W T5 & 0.85 BF Prog.	72.06	114.36	175.05	12.08	0.0	100.0	1.2
		EL 2	109.7	27.8 W T5 & 0.85 BF Prog.	74.41	114.36	177.40	9.73	0.0	100.0	2.0
		EL 2	111.5	26 W T5 & 0.85 BF Prog.	77.56	107.25	173.43	13.70	0.0	100.0	2.0
		EL 2	116.0	25 W T5 & 0.85 BF Prog.	80.30	103.29	170.11	17.02	0.0	100.0	2.2
Event III: New Construction and Renovation.	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog.	70.99	130.31	189.32	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	104.3	27.8 W T5 & 0.85 BF Prog.	74.86	114.36	177.23	12.08	0.0	100.0	1.2
		EL 2	109.7	27.8 W T5 & 0.85 BF Prog.	77.21	114.36	179.59	9.73	0.0	100.0	2.0
		EL 2	111.5	26 W T5 & 0.85 BF Prog.	80.35	107.25	175.62	13.70	0.0	100.0	2.0

TABLE VII.22—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A TWO-LAMP 4-FOOT 28 W T5 MINIATURE BIPIN STANDARD OUTPUT SYSTEM OPERATING IN THE COMMERCIAL SECTOR—Continued

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
		EL 2	116.0	25 W T5 & 0.85 BF Prog.	83.10	103.29	172.30	17.02	0.0	100.0	2.2

TABLE VII.23—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A TWO-LAMP 8-FOOT 59 W T8 SINGLE PIN SLIMLINE SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	96.5	60.1 W T8 & 0.87 BF Inst.	26.72	192.30	219.30	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	98.2	60.1 W T8 & 0.87 BF Inst.	29.40	192.30	221.98	−2.68	100.0	0.0	NER
		EL 2	99.0	60.1 W T8 & 0.87 BF Inst.	34.52	192.30	227.10	−7.80	100.0	0.0	NER
		EL 2	105.6	54 W T8 & 0.87 BF Inst.	43.51	182.36	226.14	−6.84	99.6	0.4	7.1
		EL 2	108.0	50 W T8 & 0.87 BF Inst.	50.87	169.08	220.23	−0.92	67.7	32.3	4.3
Event II: Ballast Failure.	Baseline	Baseline	96.5	60.1 W T8 & 0.87 BF Inst.	102.46	189.36	268.51	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement.	EL 1	98.2	60.1 W T8 & 0.77 BF Inst.	105.14	169.09	250.92	17.59	0.0	100.0	0.6
		EL 2	99.0	60.1 W T8 & 0.77 BF Inst.	110.25	169.09	256.04	12.47	0.0	100.0	1.6
		EL 2	105.6	54 W T8 & 0.77 BF Inst.	119.24	160.33	256.27	12.24	0.0	100.0	2.4
		EL 2	108.0	50 W T8 & 0.87 BF Inst.	126.60	166.42	269.71	−1.20	68.7	31.3	4.4
Event III: New Construction and Renovation.	Baseline	Baseline	96.5	60.1 W T8 & 0.87 BF Inst.	105.25	189.36	270.44	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	98.2	60.1 W T8 & 0.77 BF Inst.	107.93	169.09	252.84	17.59	0.0	100.0	0.6
		EL 2	99.0	60.1 W T8 & 0.77 BF Inst.	113.05	169.09	257.96	12.47	0.0	100.0	1.6
		EL 2	105.6	54 W T8 & 0.77 BF Inst.	122.04	160.33	258.19	12.24	0.0	100.0	2.4
		EL 2	108.0	50 W T8 & 0.87 BF Inst.	129.40	166.42	271.64	−1.20	68.7	31.3	4.4

TABLE VII.24—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A TWO-LAMP 8-FOOT 86 W T8 RECESSED DOUBLE CONTACT HO SYSTEM OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Discounted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure.	Baseline	Baseline	92.0	84 W T8 & 0.81 BF Inst.	24.45	214.21	238.99	N/A	N/A	N/A	N/A
	Lamp Replacement.	EL 1	95.2	84 W T8 & 0.81 BF Inst.	34.00	214.21	248.54	−9.56	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.81 BF Inst.	41.21	214.21	255.75	−16.76	100.0	0.0	NER
Event II: Ballast Failure.	Baseline	Baseline	92.0	84 W T8 & 0.81 BF Inst.	100.33	214.21	280.62	N/A	N/A	N/A	N/A

TABLE VII.24—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A TWO-LAMP 8-FOOT 86 W T8 RECESSED DOUBLE CONTACT HO SYSTEM OPERATING IN THE COMMERCIAL SECTOR—Continued

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
	Lamp & Ballast Replacement.	EL 1	95.2	84 W T8 & 0.81 BF Inst.	109.89	214.21	290.18	−9.56	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.81 BF Inst.	117.09	214.21	297.38	−16.76	100.0	0.0	NER
Event III: New Construction and Renovation.	Baseline	Baseline	92.0	84 W T8 & 0.81 BF Inst.	103.13	214.21	282.16	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase.	EL 1	95.2	84 W T8 & 0.81 BF Inst.	112.68	214.21	291.71	−9.56	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.81 BF Inst.	119.89	214.21	298.92	-16.76	100.0	0.0	NER

Incandescent Reflector Lamps

Table VII.25 through Table VII.28 below show the LCC impacts and payback periods for the identified subgroups for IRLs.

TABLE VII.25—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A 55 W PAR38 2,500 HOUR HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure; or Event III: New Construction and Renovation.	Baseline	Baseline	17.8	60W, 1500hrs, Improved Halogen.	10.52	8.68	19.21	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase.	EL 1	18.5	55W, 2500hrs, HIR	13.07	7.96	15.80	3.41	0.0	100.0	3.2

TABLE VII.26—LCC AND PBP SUBGROUP RESULTS FOR LOW-INCOME CONSUMERS FOR A 55 W PAR38 2,500 HOUR HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE RESIDENTIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure; or Event III: New Construction and Renovation.	Baseline	Baseline	17.8	60W, 1500hrs, Improved Halogen.	9.40	10.21	19.62	N/A	N/A	N/A	N/A

TABLE VII.26—LCC AND PBP SUBGROUP RESULTS FOR LOW-INCOME CONSUMERS FOR A 55 W PAR38 2,500 HOUR HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE RESIDENTIAL SECTOR—Continued

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
	Lamp Replacement or New Lamp Purchase.	EL 1	18.5	55W, 2500hrs, HIR	11.95	9.36	16.98	2.64	0.0	100.0	5.5

TABLE VII.27—LCC AND PBP SUBGROUP RESULTS FOR INSTITUTIONS SERVING LOW INCOME POPULATIONS FOR A 55 W PAR38 4,200 HOUR IMPROVED HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE COMMERCIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure; or Event III: New Construction and Renovation.	Baseline	Baseline	17.8	60W, 1500hrs, Improved Halogen.	10.52	8.68	19.21	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase.	EL 1	18.5	55W, 4200hrs, Improved HIR.	14.94	7.96	13.30	5.91	0.0	100.0	5.6

TABLE VII.28—LCC AND PBP SUBGROUP RESULTS FOR LOW-INCOME CONSUMERS FOR A 55 W PAR38 4,200 HOUR IMPROVED HIR EL 1 REPRESENTATIVE LAMP OPERATING IN THE RESIDENTIAL SECTOR

Event	Response	Efficacy level	Rated lamp efficacy lm/W	Lamp option	Life-cycle cost			Life-cycle cost savings			Mean payback period years
					Installed cost 2012$	Dis-counted operating cost 2012$	LCC 2012$	LCC savings 2012$	Percentage of consumers that experience		
									Net cost	Net benefit	
Event I: Lamp Failure; or Event III: New Construction and Renovation.	Baseline	Baseline	17.8	60W, 1500hrs, Improved Halogen.	9.40	10.21	19.62	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase.	EL 1	18.5	55W, 4200hrs, Improved HIR.	13.82	9.36	15.13	4.48	0	100	9.5

c. Rebuttable Presumption Payback

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. DOE's LCC and PBP analyses generate values that calculate the payback period for consumers of potential energy conservation standards, which include, but are not limited to, the 3-year payback period contemplated under the rebuttable presumption test. However, DOE routinely conducts a full economic analysis that considers the full range of impacts—including those on 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 to evaluate the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification).

Table VII.29 shows the GSFL payback periods that are less than 3 years for the most common sector for each product class. There are no IRL payback periods less than 3 years.

TABLE VII.29—GSFL EFFICACY LEVELS WITH REBUTTABLE PAYBACK PERIOD LESS THAN THREE YEARS

Lamp description	Sector	Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Mean payback period years
2-Lamp 4-foot Medium Bipin Instant Start.	Commercial ...	Event I: Lamp Failure.	Lamp Replacement.	EL 2	96.0	28.4 W T8 & 0.88 BF Inst.	2.8
		Event II: Ballast Failure.	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	0.4
				EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	2.4
		Event III: New Construction and Renovation.	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	0.4
				EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	2.4
2-Lamp 4-foot Medium Bipin Programmed Start.	Commercial ...	Event I: Lamp Failure.	Lamp Replacement.	EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	2.8
		Event II: Ballast Failure.	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.72 BF Prog.	0.3
				EL 2	95.4	32.5 W T8 & 0.72 BF Prog.	2.5
				EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	2.8
		Event III: New Construction and Renovation.	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.72 BF Prog.	0.3
				EL 2	95.4	32.5 W T8 & 0.72 BF Prog.	2.5
				EL 2	96.0	28.4 W T8 & 0.88 BF Prog.	2.8
4-Lamp 4-foot Medium Bipin Instant Start.	Commercial ...	Event I: Lamp Failure.	Lamp Replacement.	EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	2.9
		Event II: Ballast Failure.	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	0.5
				EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	2.9
		Event III: New Construction and Renovation.	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.78 BF Inst.	0.5
				EL 2	96.0	28.4 W T8 & 0.87 BF Inst.	2.9
4-Lamp 4-foot Medium Bipin Programmed Start.	Commercial ...	Event I: Lamp Failure.	Lamp Replacement.	EL 2	96.0	28.4 W T8 & 0.89 BF Prog.	2.8
		Event II: Ballast Failure.	Lamp & Ballast Replacement.	EL 1	90.0	32.5 W T8 & 0.87 BF Prog.	1.0
				EL 2	96.0	28.4 W T8 & 0.87 BF Prog.	2.0
		Event III: New Construction and Renovation.	New Lamp & Ballast Purchase.	EL 1	90.0	32.5 W T8 & 0.87 BF Prog.	1.0
				EL 2	96.0	28.4 W T8 & 0.87 BF Prog.	2.0
T5 Miniature Bipin Standard Output.	Commercial ...	Event II: Ballast Failure.	Lamp & Ballast Replacement.	EL 1	104.3	27.8 W T5 & 0.85 BF Prog.	1.2

TABLE VII.29—GSFL EFFICACY LEVELS WITH REBUTTABLE PAYBACK PERIOD LESS THAN THREE YEARS—Continued

Lamp description	Sector	Event	Response	Efficacy level	Rated lamp efficacy lm/W	Design option	Mean payback period years
				EL 2	109.7	27.8 W T5 & 0.85 BF Prog.	2.0
				EL 2	111.5	26 W T5 & 0.85 BF Prog.	2.0
				EL 2	116.0	25 W T5 & 0.85 BF Prog.	2.2
		Event III: New Construction and Renovation.	New Lamp & Ballast Purchase.	EL 1	104.3	27.8 W T5 & 0.85 BF Prog.	1.2
				EL 2	109.7	27.8 W T5 & 0.85 BF Prog.	2.0
				EL 2	111.5	26 W T5 & 0.85 BF Prog.	2.0
				EL 2	116.0	25 W T5 & 0.85 BF Prog.	2.2
T8 Single Pin Slimline	Commercial	Event II: Ballast Failure.	Lamp & Ballast Replacement.	EL 1	98.2	60.1 W T8 & 0.77 BF Prog.	0.6
				EL 2	99.0	60.1 W T8 & 0.77 BF Prog.	1.6
				EL 2	105.6	54 W T8 & 0.77 BF Prog.	2.4
		Event III: New Construction and Renovation.	New Lamp & Ballast Purchase.	EL 1	98.2	60.1 W T8 & 0.77 BF Prog.	0.6
				EL 2	99.0	60.1 W T8 & 0.77 BF Prog.	1.6
				EL 2	105.6	54 W T8 & 0.77 BF Prog.	2.4

2. Economic Impacts on Manufacturers

DOE performed MIAs to estimate the impact of amended energy conservation standards on manufacturers of GSFLs and IRLs. The section below describes the expected impacts on GSFL and IRL manufacturers at each TSL. Chapter 13 of the NOPR TSD explains the MIA in further detail.

a. Industry Cash-Flow Analysis Results

The tables below depict the financial impacts (represented by changes in INPV) of amended energy standards on GSFL and IRL manufacturers as well as the conversion costs that DOE estimates GSFL and IRL manufacturers would incur at each TSL. DOE breaks out the impacts on GSFL and IRL manufacturers separately. To evaluate the range of cash flow impacts on the GSFL and IRL industries, DOE modeled two markup scenarios that correspond to the range of anticipated market responses to amended standards. Each scenario results in a unique set of cash flows and corresponding industry values at each TSL.

In the following discussion, the INPV results refer to the difference in industry value between the base case and the standards case that result from the sum of discounted cash flows from the base year (2013) through the end of the analysis period. The results also discuss the difference in cash flows between the base case and the standards case in the year before the compliance date for amended energy conservation standards. This figure represents the size of the required conversion costs relative to the cash flow generated by the GSFL and IRL industries in the absence of amended energy conservation standards.

Cash-Flow Analysis Results by TSL for General Service Fluorescent Lamps

To assess the upper (less severe) end of the range of potential impacts on GSFL manufacturers, DOE modeled a flat, or preservation of gross margin, markup scenario. This scenario assumes that in the standards case, manufacturers would be able to pass along all the higher production costs required for more efficacious products to their consumers. Specifically, the industry would be able to maintain its average base case gross margin (as a percentage of revenue) despite the higher product costs in the standards case. In general, the larger the product price increases, the less likely manufacturers are to achieve the cash flow from operations calculated in this scenario because it is less likely that manufacturers would be able to fully mark up these larger cost increases.

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

Table VII.30 and Table VII.31 present the projected results for GSFLs under the flat and preservation of operating profit markup scenarios. DOE examined results for all five product classes (4-foot MBP, 8-foot SP slimline, 8-foot RDC HO, 4-foot T5 MiniBP SO, and 4-foot T5 MiniBP HO) together.

TABLE VII.30—MANUFACTURER IMPACT ANALYSIS FOR GENERAL SERVICE FLUORESCENT LAMPS—FLAT MARKUP SCENARIO

	Units	Base case	Trial standard level				
			1	2	3	4	5
INPV	*(2012$ millions)*	1,542.5	1,584.4	1,580.3	1,663.1	1,901.1	1,939.7
Change in INPV	*(2012$ millions)*		41.8	37.8	120.5	358.5	397.1
	(%)		2.7%	2.5%	7.8%	23.2%	25.7%
Product Conversion Costs	*(2012$ millions)*		0.9	2.0	5.3	7.5	9.1
Capital Conversion Costs	*(2012$ millions)*		1.0	11.0	3.0	5.5	29.5
Total Conversion Costs	*(2012$ millions)*		1.9	13.0	8.3	13.0	38.6

TABLE VII.31—MANUFACTURER IMPACT ANALYSIS FOR GENERAL SERVICE FLUORESCENT LAMPS—PRESERVATION OF OPERATING PROFIT MARKUP SCENARIO

	Units	Base case	Trial standard level				
			1	2	3	4	5
INPV	*(2012$ millions)*	1,542.5	1,541.7	1,533.4	1,531.0	1,519.6	1,502.6
Change in INPV	*(2012$ millions)*		(0.9)	(9.2)	(11.5)	(22.9)	(39.9)
	(%)		−0.1%	−0.6%	−0.7%	−1.5%	−2.6%
Product Conversion Costs	*(2012$ millions)*		0.9	2.0	5.3	7.5	9.1
Capital Conversion Costs	*(2012$ millions)*		1.0	11.0	3.0	5.5	29.5
Total Conversion Costs	*(2012$ millions)*		1.9	13.0	8.3	13.0	38.6

TSL 1 sets the efficacy level at baseline for two product classes (4-foot MBP and 8-foot SP slimline) and EL 1 for three product classes (8-foot RDC HO, 4-foot T5 MiniBP SO, and 4-foot T5 MiniBP HO). EL 1 for the 4-foot T5 MiniBP HO product class represents the max tech efficacy level. At TSL 1, DOE estimates impacts on INPV range from $41.8 million to −$0.9 million, or a change in INPV of 2.7 percent to −0.1 percent. At TSL 1, industry free cash flow (operating cash flow minus capital expenditures) is estimated to decrease by approximately 0.5 percent to $156.9 million, compared to the base case value of $157.7 million in 2016, the year leading up to proposed energy conservation standards.

Percentage impacts on INPV are slightly positive to slightly negative at TSL 1. DOE does not anticipate that manufacturers would lose a significant portion of their INPV at this TSL. This is because the vast majority of shipments already meets or exceeds the efficacy levels prescribed at TSL 1. DOE projects that in the expected year of compliance (2017), 100 percent of 4-foot MBP and 8-foot SP slimline shipments would meet or exceed the efficacy levels at TSL 1. DOE estimates that these lamps account for 88 percent of GSFL shipments in 2017. Meanwhile, in 2017, 33 percent of 8-foot RDC HO shipments, 45 percent of 4-foot T5 MiniBP SO, and 37 percent of 4-foot T5 MiniBP HO shipments would meet the efficacy levels at TSL 1. Because these products comprise a very small percentage of total GSFL shipments in 2017, a very small percentage of total GSFL shipments would need to be converted at TSL 1 to meet these efficacy standards.

DOE expects conversion costs to be small compared to the industry value because most of the GSFL shipments, on a total volume basis, already meet or exceed the efficacy levels analyzed at this TSL. DOE expects GSFL manufacturers to incur $0.9 million in product conversion costs for lamp redesign and testing. DOE estimates manufacturers will have minimal capital conversion costs associated with TSL 1, as most efficacy gains will be achieved through increasing the amount of REOs used to coat the lamps, not through any major equipment upgrades or capital investments. DOE expects $1 million in capital conversion costs for manufacturers to upgrade and recalibrate production line automation.

At TSL 1, under the flat markup scenario, the shipment-weighted average MPC increases by approximately 5 percent relative to the base case MPC. Manufacturers are able to fully pass on this cost increase to consumers by design in this markup scenario. This slight price increase would mitigate the $1.9 million in conversion costs estimated at TSL 1, resulting in slightly positive INPV impacts at TSL 1 under the flat markup scenario.

Under the preservation of operating profit markup scenario, manufacturers earn the same operating profit as would be earned in the base case, but manufacturers do not earn additional profit from their investments. The 5 percent MPC increase is slightly outweighed by a lower average markup of 1.51 (compared to the flat markup of 1.52) and $1.9 million in conversion costs, resulting in small negative impacts at TSL 1.

TSL 2 sets the efficacy level at baseline for one product class (4-foot MBP), EL 1 for three product classes (8-foot SP slimline, 4-foot T5 MiniBP SO, and 4-foot T5 MiniBP HO), and EL 2 for one product class (8-foot RDC HO). EL 1 for the 4-foot T5 MiniBP HO product class and EL 2 for the 8-foot RDC HO product class represent the max tech efficacy levels. At TSL 2, DOE estimates impacts on INPV to range from $37.8 million to −$9.2 million, or a change in INPV of 2.5 percent to −0.6 percent. At this proposed level, industry free cash flow is estimated to decrease by approximately 4 percent to $152.1 million, compared to the base case value of $157.7 million in 2016.

Percentage impacts on INPV are slightly positive to slightly negative at TSL 2. DOE does not anticipate that manufacturers would lose a significant portion of their INPV at this TSL because the vast majority of shipments already meets or exceeds the efficacy levels prescribed at TSL 2. DOE projects that in 2017, 100 percent of 4-foot MBP shipments would meet or exceed the efficacy levels at TSL 2. DOE estimates that shipments of this product classes will comprise 86 percent of GSFL shipments in 2017. Meanwhile, in 2017, 57 percent of 8-foot SP slimline lamps shipments, 10 percent of 8-foot RDC HO shipments, 45 percent of 4-foot T5 MiniBP SO, and 37 percent of 4-foot T5 MiniBP HO shipments would meet or exceed the efficacy levels at TSL 2.

DOE expects conversion costs to be small compared to the industry value because most of the GSFL shipments, on a total volume basis, already meet or exceed the efficacy levels analyzed at this TSL. DOE expects that product conversion costs will rise from $0.9 million at TSL 1 to $2.0 million at TSL 2 for lamp redesign and testing. Capital conversion costs will increase from $1.0 million at TSL 1 to $11.0 million at TSL 2. This is driven by the fact that both 8-foot product classes would have to meet higher efficacy levels at this TSL. DOE believes this will result in higher capital conversion costs related to upgrading and recalibrating production line automation.

At TSL 2, under the flat markup scenario, the shipment-weighted average MPC increases by 5 percent relative to the base case MPC. In this scenario, INPV impacts are slightly positive because of manufacturers' ability to pass the higher production costs to consumers outweighs the $13.0 million in conversion costs. Under the preservation of operating profit markup scenario, the 5 percent MPC increase is slightly outweighed by a lower average markup of 1.51 (compared to the flat markup of 1.52) and $13.0 million in conversion costs, resulting in slightly negative impacts at TSL 2.

TSL 3 sets the efficacy level at baseline for one product class (8-foot SP slimline) and EL 1 for four product classes (4-foot MBP, 8-foot RDC HO, 4-foot T5 MiniBP SO, and 4-foot T5 MiniBP HO). EL 1 for the 4-foot T5 MiniBP HO product class represents the max tech efficacy level. At TSL 3, DOE estimates impacts on INPV to range from $120.5 million to −$11.5 million, or a change in INPV of 7.8 percent to −0.7 percent. At this proposed level, industry free cash flow is estimated to decrease by approximately 2 percent to $154.7 million, compared to the base case value of $157.7 million in 2016.

While more significant than the impacts at TSL 2, the impacts on INPV at TSL 3 are still relatively minor compared to the total industry value. Percentage impacts on INPV are slightly positive to slightly negative at TSL 3. DOE does not anticipate that manufacturers would lose a significant portion of their INPV TSL 3. While less than the previous TSLs, a large percentage of total shipments still already meet or exceed the efficacy levels prescribed at TSL 3. DOE projects that in 2016, 56 percent of the 4-foot MBP, 100 percent of 8-foot SP slimline, 33 percent of 8-foot RDC HO shipments, 45 percent of 4-foot T5 MiniBP SO, and 37 percent of 4-foot T5 MiniBP HO shipments would meet or exceed the efficacy levels at TSL 3.

DOE expects conversion costs to remain small at TSL 3 compared to the industry value because a significant percentage of the GSFL shipments, on a total volume basis, already meet or exceed the efficacy levels proposed at this TSL. TSL 3 is the first TSL that increases the efficacy requirement for 4-foot MBP, which as previously noted, comprise a large majority of GSFL shipments. Efficacy gains for these products, however, would likely be achieved with additional REOs, which would not require any significant capital investments. At TSL 3, DOE expects product conversion costs to increase from TSL 2 to $5.3 million. DOE, however, estimates that capital conversion costs will decrease from TSL 2 to $3.0 million at TSL 3 since no amended efficacy standards would be set at TSL 3 for 8-foot SP slimline products and the 8-foot RDC HO product class has a lower EL at TSL 3 than at TSL 2. The lower ELs for these two product classes outweigh the increase in EL of the 4-ft MBP product class and would cause manufacturers to invest less in capital conversion costs at TSL 3 than at TSL 2.

At TSL 3, under the flat markup scenario, the shipment-weighted average MPC increases by 16 percent relative to the base case MPC. In this scenario, INPV impacts are slightly positive because manufacturers' ability to pass the higher production costs to consumers outweighs the $8.3 million in conversion costs. Under the preservation of operating profit markup scenario, the 16 percent MPC increase is slightly outweighed by a lower average markup of 1.51 (compared to the flat markup scenario markup of 1.52) and $8.3 million in conversion costs, resulting in negative impacts at TSL 3.

TSL 4 sets the efficacy level at baseline for one product class (8-foot SP slimline), EL 1 for three product classes (8-foot RDC HO, 4-foot T5 MiniBP SO, and 4-foot T5 MiniBP HO), and EL 2 for one product class (4-foot MBP). EL 1 for the 4-foot T5 MiniBP HO product class and EL 2 for the 4-foot MBP product class represent the max tech efficacy levels. At TSL 4, DOE estimates impacts on INPV to range from $358.5 million to −$22.9 million, or a change in INPV of 23.2 percent to −1.5 percent. At this proposed level, industry free cash flow is estimated to decrease by approximately 3 percent to $152.9 million, compared to the base case value of $157.7 million in the year leading up to energy conservation standards.

Percentage impacts on INPV are moderately positive to slightly negative at TSL 4. DOE projects that in 2017, 21 percent of 4-foot MBP, 100 percent of 8-foot SP slimline, 33 percent of 8-foot RDC HO shipments, 45 percent of 4-foot T5 MiniBP SO, and 37 percent of 4-foot T5 MiniBP HO shipments would meet or exceed the efficacy levels at TSL 4.

While DOE expects conversion costs to increase from TSL 3 to TSL 4, DOE estimates the costs will still be small compared to the total industry value. DOE expects product conversion costs for GSFL manufacturers to increase from $5.3 million at TSL 3 to $7.5 million at TSL 4. DOE expects capital conversion costs to increase from $3.0 million at TSL 3 to $5.5 million at TSL 4. While a higher percentage of shipments would need to be converted to meet the efficacy requirements at TSL 4, increasing the efficacy of GSFLs will not likely be a very capital-intensive process. Instead, increasing GSFL efficacy will likely be more focused around increasing the amount of REOs in the lamps.

At TSL 4, under the flat markup scenario the shipment-weighted average MPC increases by 52 percent relative to the base case MPC. In this scenario, INPV impacts are slightly positive because of manufacturers' ability to pass the higher production costs to consumers outweighs the $13.0 million in conversion costs. Under the preservation of operating profit markup scenario, the 52 percent MPC increase is slightly outweighed by a lower average markup of 1.51 (compared to the flat markup scenario markup of 1.52) and $13.0 million in conversion costs, resulting in negative impacts at TSL 4.

TSL 5 sets the efficacy level at max tech for all product classes. This represents EL 1 for one product class (4-foot T5 MiniBP HO) and EL 2 for five product classes (4-foot MBP, 8-foot SP slimline, 8-foot RDC HO, and 4-foot T5 MiniBP SO). At TSL 5, DOE estimates impacts on INPV to range from $397.1 million to −$39.9 million, or a change in INPV of 25.7 percent to −2.6 percent. At this proposed level, industry free cash flow is estimated to decrease by approximately 10 percent to $143.4 million, compared to the base case value of $157.7 million in 2016.

Percentage impacts on INPV are significantly positive to slightly negative at TSL 5. DOE projects that in 2017, 21 percent of the 4-foot MBP, 25 percent of 8-foot SP slimline, 10 percent of 8-foot RDC HO shipments, 14 percent of 4-foot T5 MiniBP SO, and 37 percent of 4-foot T5 MiniBP HO shipments would meet the efficacy levels at TSL 5.

DOE expects conversion costs to increase from TSL 4 to TSL 5 due to the 8-foot slimline, 8-foot RDC HO, and 4-foot T5 MiniBP HO product classes moving to max tech ELs at TSL 5. DOE estimates that capital conversion costs will be $29.5 million at TSL 5 as a result of manufacturers having to upgrade all of their production lines to manufacture max tech products. DOE expects GSFL manufacturers to incur $9.1 million in product conversion costs for lamp redesigns and testing. However, these larger total conversion costs at TSL 5, $38.6 million remain relatively small compared to the almost $2 billion total GSFL industry value at TSL 5.

At TSL 5, under the flat markup scenario, the shipment-weighted average MPC increases by 57 percent relative to the base case MPC. In this scenario, INPV impacts are slightly positive because of manufacturers' ability to pass the higher production costs to consumers outweighs the $38.6 million in conversion costs. Under the preservation of operating profit markup scenario, the 57 percent MPC increase is slightly outweighed by a lower average markup of 1.51 (compared to the flat markup scenario markup of 1.52) and $38.6 million in conversion costs, resulting in negative impacts at TSL 5.

Cash Flow Analysis Results by TSL for Incandescent Reflector Lamps

DOE incorporated the same markup scenarios to represent the upper and lower bounds of industry impacts for IRLs as was done for GSFLs: the flat, or preservation of gross margin, markup scenario and the preservation of operating profit markup scenario. DOE, however, analyzed one TSL for IRLs in addition to the baseline levels. DOE also analyzed an alternative shipment scenario for IRLs, the shortened lifetime scenario, in addition to the reference case. DOE acknowledges that to meet the proposed IRL energy conservation standards, IRL manufacturers may choose to shorten the lifetime of some of their IRLs, rather than make the investments to increase the efficacy of the lamps. DOE presents the results of this analysis in appendix 13C of the NOPR TSD.

Table VII.32 and Table VII.33 present the projected results for IRLs under the flat and preservation of operating profit scenarios. DOE examined results for one representative product class for IRLs.

TABLE VII.32—MANUFACTURER IMPACT ANALYSIS FOR INCANDESCENT REFLECTOR LAMPS—FLAT MARKUP SCENARIO

	Units	Base case	Trial standard level 1
INPV	*(2012$ millions)*	176.0	128.6
Change in INPV	*(2012$ millions)*		(47.5)
	(%)		−27.0%
Product Conversion Costs	*(2012$ millions)*		6.1
Capital Conversion Costs	*(2012$ millions)*		65.4
Total Conversion Costs	*(2012$ millions)*		71.5

TABLE VII.33—MANUFACTURER IMPACT ANALYSIS FOR INCANDESCENT REFLECTOR LAMPS—PRESERVATION OF OPERATING PROFIT MARKUP SCENARIO

	Units	Base case	Trial standard level 1
INPV	*(2012$ millions)*	176.0	124.2
Change in INPV	*(2012$ millions)*		(51.8)
	(%)		−29.5%
Product Conversion Costs	*(2012$ millions)*		6.1
Capital Conversion Costs	*(2012$ millions)*		65.4
Total Conversion Costs	*(2012$ millions)*		71.5

TSL 1 sets the efficacy level at EL 1, max tech, for the IRL representative unit. At TSL 1, DOE estimates impacts on INPV to range from −$47.5 million to −$51.8 million, or a change in INPV of −27.0 percent to −29.5 percent. At TSL 1, industry free cash flow is estimated to decrease by approximately 131 percent to −7.5 million, compared to the base case value of $23.8 million in 2016.

INPV impacts are negative at TSL 1 regardless of the markup scenario chosen. DOE estimates that in 2017, 41 percent of IRL shipments would meet the efficacy requirements proposed at TSL 1. The majority of shipments would need to be converted to meet the standards proposed at this TSL.

DOE expects substantial conversion costs for IRL manufacturers at TSL 1 associated with increasing the efficacy of IRLs. Manufacturers would have to invest in retooling burner machines, increasing coating capacity, and upgrading their production lines to allow for enhanced reflector coating. Some manufacturers expressed concern that they do not currently possess the technology required at the analyzed standard level and could exit the market entirely. Overall, DOE expects these capital conversion costs to total $65.4 million for the industry. DOE estimates that IRL manufacturers will also incur

$6.1 million in product conversion costs for lamp and production line redesign, as well as testing and certification.

At TSL 1, under the flat markup scenario, the shipment-weighted average MPC increases by 13 percent relative to the base case MPC. In this scenario, INPV impacts are negative because the manufacturers' ability to pass the higher production costs to consumers does not outweigh $71.5 million in conversion costs. Under the preservation of operating profit markup scenario, the 13 percent MPC increase is outweighed by a lower average markup of 1.50 (compared to the flat markup scenario markup of 1.52) and $71.5 million in conversion costs, resulting in negative impacts at TSL 1. The significant capital and product conversion costs that IRL manufacturers must make at TSL 1 cause INPV to be negative regardless of the markup chosen.

DOE also analyzed a shortened lifetime sensitivity scenario where manufacturers shorten the lifetime of IRLs to mitigate the costs of complying with the proposed standard. By shortening the lifetime of IRLs manufacturers reduce the capital conversion costs they must make to comply with the proposed standard. DOE presents the INPV results of this analysis in appendix 13C of this NOPR TSD. DOE requests comment on the $6.1 product conversion costs and $65.4 capital conversion costs necessary for manufacturers to comply with the proposed standards.

b. Impacts on Employment

DOE quantitatively assessed the impacts of potential amended energy conservation standards on direct employment. DOE used the GRIM to estimate the domestic labor expenditures and number of domestic production workers in the base case and at each TSL from 2013 to 2046. DOE used statistical data from the U.S. Census Bureau's 2011 Annual Survey of Manufacturers (ASM), the results of the engineering analysis, and interviews with manufacturers to determine the inputs necessary to calculate industry-wide labor expenditures and domestic employment levels. Labor expenditures involved with the manufacture of the product are a function of the labor intensity of the product, the sales volume, and an assumption that wages remain fixed in real terms over time.

In the GRIM, DOE used the labor content of each product and the manufacturing production costs to estimate the annual labor expenditures in the industry. DOE used census data and interviews with manufacturers to estimate the portion of the total labor expenditures that is attributable to domestic labor.

The production worker estimates in this section cover only workers up to the line-supervisor level directly involved in fabricating and assembling a product within a manufacturing facility. Workers performing services that are closely associated with production operations, such as material handing with a forklift, are also included as production labor. DOE's estimates account for production workers who manufacture only the specific products covered of this rulemaking. For example, a worker on a fluorescent lamp ballast production line would not be included with the estimate of the number of GSFL or IRL workers.

The employment impacts shown in Table VII.34 and Table VII.35 below represent the potential production employment that could result following amended energy conservation standards. The upper bound of the results estimates the maximum change in the number of production workers that could occur after compliance with amended energy conservation standards when assuming that manufacturers continue to produce the same scope of covered products in the same production facilities. It also assumes that domestic production does not shift to lower labor-cost countries. Because there is a real risk of manufacturers evaluating sourcing decisions in response to amended energy conservation standards, the lower bound of the employment results includes the estimated total number of U.S. production workers in the industry who could lose their jobs if some or all existing production were moved outside of the United States. While the results present a range of employment impacts following 2017, the sections below also include qualitative discussions of the likelihood of negative employment impacts at the various TSLs. Finally, the employment impacts shown are independent of the employment impacts from the broader U.S. economy, documented in chapter 17 of the NOPR TSD. DOE seeks comment on the potential domestic employment impacts to GSFL and IRL manufacturers at the proposed efficacy levels.

Employment Impacts for General Service Fluorescent Lamps

Using 2011 ASM data and interviews with manufacturers, DOE estimates that approximately three quarters of the GSFLs sold in the United States are manufactured domestically. With this assumption, DOE estimates that in the absence of amended energy conservation standards, there would be approximately 1,800 domestic production workers involved in manufacturing GSFLs in 2017. The table below shows the range of the impacts of potential amended energy conservation standards on U.S. production workers in the GSFL industry.

TABLE VII.34—POTENTIAL CHANGES IN THE TOTAL NUMBER OF DOMESTIC GENERAL SERVICE FLUORESCENT LAMP PRODUCTION WORKERS IN 2017

Base case		Trial standard level				
		1	2	3	4	5
Total Number of Domestic Production Workers in 2017 (without changes in production locations)	1,848	1,848	1,847	1,844	1,814	1,817
Potential Changes in Domestic Production Workers in 2017 *	....	0	(1)	(4)–(1,848)	(34)–(1,848)	(31)–(1,848)

* DOE presents a range of potential employment impacts. Numbers in parentheses indicate negative numbers.

At the upper end of the range, all examined TSLs show slight negative impacts on domestic employment levels. DOE believes that manufacturers could face slight negative impacts on domestic employment levels because there would be an increase in the shipments of products typically not manufactured domestically, such as 4-foot T5 MiniBP lamps, and a decrease of products typically manufactured domestically, such as 4-foot MBP lamps.

Several manufacturers emphasized that it is difficult to predict employment impacts of energy conservation standards. One potential uncertainty is the future price of REOs and these employment decisions become more complex when more REOs are required for higher efficacious products.

DOE does not expect any significant changes in domestic employment at TSLs 1 or 2 because standards would not be amended for 4-foot MBP lamps, which comprise approximately 86 percent of GSFL shipments in 2017. While DOE does not anticipate the entire, or even a large portion of, domestic employment to move abroad at TSLs 3, 4 or 5, DOE acknowledges that there could be a loss of domestic employment at these TSLs due to the required increase in efficacy of 4-foot MBP lamps. The potential loss of domestic employment would most likely be a result of a possible increase in the price of REOs. Based on the REO prices modeled in the reference case, DOE does not estimate a significant loss of domestic employment at TSLs 3, 4, or 5. Overall, manufacturers were uncertain about how amended energy conservation standards would affect domestic employment and sourcing decisions. Ultimately, both employment and sourcing decisions could be determined by the stability and predictability of REO prices.

Employment Impacts for Incandescent Reflector Lamps

Using 2011 ASM data and interviews with manufacturers, DOE estimates that approximately half of the IRLs sold in the United States are manufactured domestically. With this assumption, DOE estimates that in the absence of amended energy conservation standards, there would be approximately 300 domestic production workers involved in manufacturing IRLs in 2017. The table below shows the range of the impacts of potential amended energy conservation standards on U.S. production workers in the IRL industry.

TABLE VII.35—POTENTIAL CHANGES IN THE TOTAL NUMBER OF DOMESTIC INCANDESCENT REFLECTOR LAMP PRODUCTION WORKERS IN 2017

Base case		Trial standard level
		1
Total Number of Domestic Production Workers in 2017 (without changes in production locations)	308	335
Potential Changes in Domestic Production Workers in 2017 *		27–(308)

* DOE presents a range of potential employment impacts. Numbers in parentheses indicate negative numbers.

At the upper end of the range TSL 1 shows a slight positive impact on domestic employment levels. The increasing product cost at TSL 1 would result in higher labor expenditures per-unit, which could cause manufacturers to hire more domestic workers to meet this added labor demand, assuming IRL production remains in domestic facilities.

Manufacturers are concerned that higher prices for IRLs will drive consumers to alternate technologies and it may not make economic sense for them to continue to produce IRLs. Increasing the efficacy of IRLs would cost manufacturers millions in capital conversion costs. Some stated that they do not have the technology to meet the proposed energy conservation standards and said it is possible they would not spend their limited resources to convert all IRL production to meet efficacy levels at TSL 1. Ultimately, the high costs associated with increasing the efficacy of IRLs could cause some IRL manufacturers to exit the market.

c. Impacts on Manufacturing Capacity

GSFL manufacturers stated that they did not anticipate any capacity constraints outside of the availability of REOs. One manufacturer pointed out that moving the industry to max tech efficacy levels could triple the amount of REOs demanded by GSFL manufacturers. Tripling the demand for REOs that are already difficult to come by could trigger some capacity concerns by creating extra volatility in the market. The sharp increase in demand for REOs could cause wide variations in the price and availability of REOs, making production costs more unpredictable.

A few IRL manufacturers expressed concern about the capacity of their IR coating machines and that the companies that manufacture those machines might not be able to respond to the demand for IR coating machines necessary to manufacture higher efficacious IRLs. DOE, however, received a comment from ADLT, a company that manufactures IR coating machines, that they estimate the current global capacity of IR coatings for IRLs to be over 50 million units annually. ADLT claims this IR coating capacity is supported by three different coating processes and provided by at least five different companies. ADLT stated they are in a position to increase their IR coating capacity by 20 million units annually using existing equipment within a two-year time period. ADLT believes that additional coating capacity can be generated from one or more of at least five IR coating facilities owned and operated by other companies worldwide. Given a three-year period between the ruling and its effective date, ADLT believes there is ample time available for various companies to react to the potential increase in IR coating demand. Given that DOE estimated approximately 65 million IRLs may be sold in 2017 in the preliminary analysis, ADLT believes that IR coating capacity in excess of 70 million units in total can readily be made available. (ADLT, No. 31 at p. 3) While this exceeds DOE's NOPR IRL shipment estimate of approximately 32 million units to be sold in 2017, ADLT did not provide a source for their claim that the current IR coating capacity is 50 million units annually or for the potential to increase this IR coating capacity to 70 million units annually in 2017. Therefore, it is unclear if this additional IR coating capacity or current IR coating capacity is sufficient to meet the potential U.S. demand for IRLs at the higher EL.

d. Impacts on Sub-Groups of Manufacturers

Using average cost assumptions to develop an industry cash-flow estimate may not be adequate for assessing differential impacts among manufacturer subgroups. Small manufacturers, niche product manufacturers, and manufacturers exhibiting cost structures substantially different from the industry average could be affected disproportionately. DOE analyzed the impacts to small businesses in section VIII.B and did not identify any other adversely impacted subgroups for GSFLs or IRLs for this rulemaking based on the results of the industry characterization.

e. Cumulative Regulatory Burden

While any one regulation may not impose a significant burden on manufacturers, the combined effects of recent or impending regulations may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Assessing the impact of a single regulation may overlook this cumulative regulatory burden. In addition to energy conservation standards, other regulations can significantly affect manufacturers' financial operations. Multiple regulations affecting the same manufacturer can strain profits and lead companies to abandon product lines or markets with lower expected future returns than competing products. For these reasons, DOE conducts a cumulative regulatory burden analysis as part of its rulemakings pertaining to lighting efficacy.

During previous stages of this rulemaking, DOE identified a number of requirements, in addition to amended energy conservation standards for GSFLs and IRLs, that manufacturers will face for products they manufacture three years prior to and three years after the compliance date of the amended standards. The following section briefly addresses comments DOE received with respect to cumulative regulatory burden and summarizes other key related concerns that manufacturers raised during interviews.

Several manufacturers expressed concern that GSFLs and IRLs face several regulations and that they have not had time to fully assess the effects of the 2009 Lamps Rule, compliance with which was required in 2012. Several manufacturers also expressed concern about the overall volume of DOE's energy conservation standards with which they must comply. Most GSFL and IRL manufacturers also make a full range of lighting products and share engineering and other resources with these other internal manufacturing divisions for different products (including certification testing for regulatory compliance). Manufacturers cited current DOE rulemakings for high intensity discharge (HID) lamps, metal halide fixtures, LEDs, and CFLs. Some manufacturers also raised concerns about other existing regulations separate from DOE's energy conservation standards that manufacturers of GSFLs and IRLs must meet. These include: the Restriction of Hazardous Substances (RoHS) Directive, California Title 20, FTC labeling requirements, Interstate Mercury Education and Reduction Clearinghouse (IMERC) labeling requirements, the Minamata Convention on Mercury, and disclosure of procurement methods of conflict minerals mandated by the Wall Street Reform and Consumer Protection Act, among others. DOE seeks comment on GSFL manufacturers potentially increasing the amount of mercury in GSFLs in order to comply with the proposed GSFL standards.

DOE discusses these and other requirements in chapter 13 of the NOPR TSD, which lists the estimated compliance costs of those requirements when available. In considering the cumulative regulatory burden, DOE evaluates the timing of regulations that impact the same product because the coincident requirements could strain financial resources in the same profit center and consequently impact capacity. DOE also identified several ongoing rulemakings that could potentially impact other business units of GSFL and IRL manufacturers in general, but the impacts of those ongoing rulemakings remain speculative and are therefore not included in the analysis for today's proposed rule. DOE did not receive any data on other regulatory costs that affect the industry modeled in the cash-flow analysis. To the extent DOE receives specific costs associated with other regulations affecting those profit centers (GSFL and IRL) modeled in the GRIM, DOE can incorporate that information into its cash-flow analysis. The cash-flow scenarios analyzed for today's proposed rule include the impacts of the 2009 Lamps Rule, as the levels established in that rule have become the baseline for the proposed standards and the lamp prices estimated in the engineering analysis reflect the investments that manufacturers made to comply with the 2009 Lamps Rule. DOE seeks comment on the compliance costs of any other regulations GSFL or IRL manufacturers must make, especially if compliance with those regulations is required three years before or after the estimated compliance date of these proposed standards (2017).

3. Shipments Analysis and National Impact Analysis

Projections of shipments are an important input to the NIA. As discussed in section VI.I, DOE developed a shipments model that incorporated substitution matrixes, which specify the product choices available to consumers (lamps as well as lamp-and-ballast combinations for fluorescent lamps) depending on whether they are renovating lighting systems, installing lighting systems in new construction, or simply replacing lamps; and a module that assigns shipments to product classes and efficacy levels based on consumer sensitivities to first costs and operation and maintenance costs. The model estimates the shipments of each lamp type in the base case and under the conditions set by each TSL. Table VII.36 and Table VII.37 present the estimated cumulative shipments in the base case and the relative change under each TSL.

TABLE VII.36—EFFECT OF STANDARD CASES ON CUMULATIVE SHIPMENTS OF GSFL IN 2017–2046

Lamp type	Base case	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
	Cumulative shipments millions	Change in shipments relative to base case (percent)	Change in shipments relative to base case (percent)	Change in shipments relative to base case (percent)	Change in shipments relative to base case (percent)	Change in shipments relative to base case (percent)
4-foot MBP	5,700	0.0	0.34	−2.7	−24	−18
8-foot SP slimline	110	0.0	−13	8.6	71	24
8-foot RDC HO	21	0.0	−8.5	0.0	0.0	−8.5
4-foot T5, MiniBP SO	410	0.0	0.83	28	250	210
4-foot T5, MiniBP HO	660	0.0	0.27	−0.01	−0.12	0.17
2-foot U-shaped	230	0.0	0.0	−0.0	−0.0	−0.0
Total GSFL*	7,100	0.0	0.13	−0.39	−3.4	−2.4

* May not sum due to rounding.

As shown in the preceding Table, depending on TSL, the consumer choice model projects significant shifts across product classes, in particular, it projects significant shifts to 4-foot T5 standard output lamps in the TSL 4 and TSL 5 standards cases. DOE requests comment on the reasonableness of its assumption that first cost is a significant driver of consumers' choice of product class, which results in the shipments analysis projecting a rapid shift from 4-foot MBP T8s to standard output T5s in the TSL 5 standards case. The TSL5 standards case substantially increases first cost for 4-foot MBP T8s.

Noting that DOE projects a sharp decrease in total GSFL shipments both with and without standards during the rulemaking period because of the projected sharp incursion of LEDs into the GSFL market, DOE also seeks comment on the reasonableness of the shipments model projection for TSL 5. Specifically, DOE seeks comment on whether standard output T5 lamps could increase from 3 to 4 percent of the standard output GSFL market presently, to approximately 13 percent of the same market by 2020, and to approximately 30 percent of the much attenuated standard output GSFL market by 2046.

TABLE VII.37—EFFECT OF STANDARD CASES ON CUMULATIVE SHIPMENTS OF IRL IN 2017–2046

Lamp Type	Base case	TSL 1
	Cumulative shipments millions	Change in shipments relative to base case (percent)
Standard spectrum; >2.5 inch diameter; <125 V	230	−20

a. Significance of Energy Savings

For each TSL, DOE projected energy savings for GSFLs and IRLs purchased in the 30-year period that begins in the year of anticipated compliance with amended standards (2017–2046). The savings are measured over the entire lifetime of product purchased in the 30-year period. DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the base case, accounting for the effects of the standards on product switching and shipments. Table VII.38 presents the estimated energy savings for each considered GSFL TSL, and Table VII.39 presents the estimated energy savings for each IRL TSL. The approach for estimating shipments and NES is further described in sections V.I and V.J and is detailed in chapter 11 and 12 of the TSD of the NOPR TSD.

TABLE VII.38—CUMULATIVE ENERGY SAVINGS FOR GSFL TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046

	Trial standard level				
	1	2	3	4	5
	Quads				
Primary Energy (Power Sector Consumption)	0.20	0.20	0.86	2.9	3.3
FFC Energy	0.21	0.21	0.89	3.0	3.5

TABLE VII.39—CUMULATIVE ENERGY SAVINGS FOR IRL TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046

	Trial standard level
	1
	Quads
Primary Energy (Power Sector Consumption)	0.012
FFC Energy	0.013

Circular A–4 requires agencies to present analytical results, including separate schedules of the monetized benefits and costs that show the type and timing of benefits and costs. Circular A–4 also directs agencies to consider the variability of key elements underlying the estimates of benefits and costs. For this rulemaking, DOE undertook a sensitivity analysis using nine, rather than 30, years of product shipments. The choice of a nine-year period is a proxy for the timeline in EPCA for the review of certain energy conservation standards and potential revision of and compliance with such revised standards.[89] The review timeframe established in EPCA is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to GSFLs and IRLs. Thus, this information is presented for informational purposes only and is not indicative of any change in DOE's analytical methodology. The NES results based on nine years of shipments are presented in Table VII.40 and Table VII.41. The impacts are counted over the lifetime of GSFL and IRL purchased in 2017–2025.

[89] Section 325(m) of EPCA requires DOE to review its standards at least once every 6 years, and requires, for certain products, a 3-year period after any new standard is promulgated before compliance is required, except that in no case may any new standards be required within 6 years of the compliance date of the previous standards. While adding a 6-year review to the 3-year compliance period adds up to 9 years, DOE notes that it may undertake reviews at any time within the 6 year period and that the 3-year compliance date may yield to the 6-year backstop. A 9-year analysis period may not be appropriate given the variability that occurs in the timing of standards reviews and the fact that for some consumer products, the compliance period is 5 years rather than 3 years.

TABLE VII.40—CUMULATIVE ENERGY SAVINGS FOR GSFL TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2025

	Trial standard level				
	1	2	3	4	5
	Quads				
Primary Energy (Power Sector Consumption)	0.10	0.10	0.42	1.3	1.5
FFC Energy	0.10	0.10	0.44	1.4	1.5

TABLE VII.41—CUMULATIVE ENERGY SAVINGS FOR IRL TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2025

	Trial standard level
	1
	Quads
Primary Energy (Power Sector Consumption)	0.008
FFC Energy	0.008

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 GSFLs and IRLs. DOE quantified the costs and benefits attributable to each TSL as the difference in total product costs and total operating costs between each standards case and the base case, accounting for the effects of the standards on product switching and shipments.

In accordance with OMB's guidelines on regulatory analysis,[90] DOE calculated the NPV using both a 7 percent and a 3 percent real discount rate. The 7 percent rate is an estimate of the average before-tax rate of return on private capital in the U.S. economy; it reflects the returns on real estate and small business capital as well as corporate capital. This discount rate approximates the opportunity cost of capital in the private sector. The 3 percent rate reflects the potential effects of standards on private consumption (*e.g.,* through higher prices for product and reduced purchases of energy). This rate represents the rate at which society discounts future consumption flows to their present value. It can be approximated by the real rate of return on long-term government debt (*i.e.,* yield on United States Treasury notes), which has averaged about 3 percent for the past 30 years.

Table VII.42 shows the consumer NPV results for each TSL considered for GSFLs, and Table VII.43 shows the consumer NPV results for each TSL considered for IRL. In each case, the impacts cover the lifetime of product purchased in 2017–2046.

TABLE VII.42—NET PRESENT VALUE OF CONSUMER BENEFITS FOR GSFL TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
	Billion 2012$				
7% discount rate	−0.39	−0.48	0.23	3.2	3.1
3% discount rate	−0.49	−0.63	1.0	8.1	8.1

TABLE VII.43—NET PRESENT VALUE OF CONSUMER BENEFITS FOR IRL TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046

	TSL 1
	Billion 2012$
7% discount rate	0.18
3% discount rate	0.28

[90] OMB Circular A–4, section E (Sept. 17, 2003). Available at: *www.whitehouse.gov/omb/circulars_a004_a-4.*

The NPV results based on the aforementioned nine-year shipments period are presented in Table VII.44 and Table VII.45. The impacts are counted over the lifetime of product purchased in 2017–2025. As mentioned previously, this information is presented for informational purposes only and is not indicative of any change in DOE's analytical methodology or decision criteria.

TABLE VII.44—NET PRESENT VALUE OF CONSUMER BENEFITS FOR GSFL TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2025

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
	Billion 2012$				
7% discount rate	−0.26	−0.33	0.04	1.1	1.1
3% discount rate	−0.29	−0.39	0.37	2.5	2.7

TABLE VII.45—NET PRESENT VALUE OF CONSUMER BENEFITS FOR IRL TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2025

	TSL 1
	Billion 2012$
7% discount rate	0.13
3% discount rate	0.18

c. Impact of Product Class Switching

As discussed at the beginning of section VII.B.3, consumer switching between product classes yields an increase in shipments for some GSFL product classes, with corresponding reductions in shipments in other product classes (see Table VII.36). Therefore, a portion of the energy savings for some of the TSLs is due to consumers' switching between product classes to more energy efficient products with lower operating costs. Similarly, the increase in product costs for some of the TSLs is substantially impacted by product-class switching. For the standard level proposed for GSFL's in this rulemaking, increases in the typical cost of 4-foot MBP GSFLs relative to 8-foot SP slimline or 4-foot MiniBP T5s is expected to drive some consumers to shift toward the latter two product classes, yielding a reduction in energy consumption relative to the base case, with a lower increase in purchase costs than would be obtained without the product-class switching. Conversely, as is true for TSL1, potential standard level that increases the typical purchase prices of the latter two product classes above would reduce migration to these product classes, yielding a net reduction in the energy savings relative to the base case, with a greater increment in product costs. This is true for example with TSL1 where the efficiency requirements are increased for product classes which are already relatively efficient (e.g., 4 foot T5 miniBP) while not increased for product classes which are relatively inefficient (e.g., 4 foot MBP). In this case, there is no product class switching as consumers are forecasted to continue purchasing the less costly and less efficient technology (4 foot MBP).

Because of these assumed shifts in shipments between product classes, the NES and monetized cost and benefit values computed for a single product class, considered in isolation, may yield negative energy savings and associated benefits as well as negative associated costs . For the proposed standard level, the increased shipments of MiniBP T5 lamps and 8-foot SP slimline lamps will lead to negative energy savings and costs for both of those product classes, when viewed in isolation, simply because significantly more lamps from those product classes are purchased and operated in the standards case than in the base case. Those negative values, however, do not represent an actual reduction in consumer benefit for the service being delivered to the consumer since the negative values for the particular product classes are more than offset by the large positive contributions to the aggregate energy savings and monetized benefits across all product classes partially due to the corresponding reduction in shipments of 4-ft MBP T8s. DOE requests comment on the consumer choice model that projects shifts in shipments between product classes and whether there are other factors (e.g. utility, costs to replace light fixtures, design incompatibility) that may preclude or limit that shifting that may not be considered in DOE's analysis. For informational purposes, chapter 12 of the TSD presents NES and NPV values computed for each product class individually.

d. Alternative Scenario Analyses

As discussed in section VI.I and VI.J, DOE conducted several sensitivity analyses to determine the potential impact of uncertain future prices for materials that are important to the manufacture of efficient GSFL and IRL products.

In the case of GSFLs, DOE considered the possibility that the price of rare earth oxides rises again. As mentioned in section V.I, rare earth oxides, used in GSFL phosphors to improve lamp efficiency, underwent a large price spike in 2010 and 2011, but their prices have since lowered to almost their pre-spike level. To assess the effect of higher rare earth prices on the impact of energy conservation standards for GSFLs, DOE performed an alternative analysis in which the average price of rare earth oxides was assumed to be midway between the peak of the 2011 price spike and the pre-spike level, and was assumed to remain at that elevated level throughout the analysis period. The details of the price model that DOE used for this analysis are given in appendix 11B of the NOPR TSD. The impacts of the modeled rare earth oxide price increase on the NES and NPV of this rulemaking were small to moderate and did not affect the ranking of the TSLs (see chapter 12 of the NOPR TSD).

In the case of IRLs, DOE considered the possibility of a significant increase in the price of xenon gas, which DOE believes is now used as a fill gas in all standards-compliant IRL products. Demand for xenon gas has been rising recently, which may lead to price increases in the future. To assess the effect of a significant xenon price increase on the impact of an energy conservation standard for IRL, DOE performed an alternative analysis in which the price of xenon is assumed to increase by a factor of ten in the near future and remain at these elevated levels throughout the analysis period. The details of the xenon market assessment used to inform this analysis are given in appendix 7C of the TSD for the NOPR. The impacts of the modeled xenon price increase on the NES and NPV of this rulemaking were minimal and did not affect the ranking of the TSLs (see chapter 12 of the NOPR TSD).

e. Indirect Impacts on Employment

DOE expects energy conservation standards for GSFLs and IRLs to reduce energy costs for product owners, and the resulting net savings to be redirected to other forms of economic activity. Those shifts in spending and economic activity could affect the demand for labor. As described in section VI.O, DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered in this rulemaking. DOE understands that there are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Therefore, DOE generated results for near-term time frames, where these uncertainties are reduced.

The results suggest that the proposed standards are likely to have 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 17 of the NOPR TSD presents detailed results.

4. Impact on Utility or Performance

DOE believes that the standards it is proposing today will not lessen the utility or performance of GSFLs and IRLs. DOE reached this conclusion based on the analyses conducted to develop the proposed GSFL and IRL efficacy levels. In the engineering analysis, DOE considered only technology options that would not have adverse impacts on product utility. See section VI.B and chapter 4 of this TSD for further details regarding the screening analysis. DOE also divided products in to classes based on performance-related features that justify different standard levels such as those impacting consumer utility. DOE then developed separate standard levels for each product class. See section VI.C and chapter 3 of this TSD for further details regarding product classes selected and consumer utility.

Further, DOE's evaluation shows that products meeting proposed efficacy levels are not of lesser utility or performance than products at existing standard levels. DOE considered several characteristics when evaluating utility and performance of GSFLs including physical constraints (*i.e.,* shape and size), diameter, lumen package, color quality (*i.e.,* CCT and CRI), lifetime, and ability to dim. DOE determined that these GSFL performance characteristics were not diminished for any proposed standard level. For IRLs, DOE considered lumen package, lifetime, shape, and diameter when evaluating utility and performance. DOE determined that these IRL performance characteristics were not diminished for any proposed standard level. DOE did not assess CRI or CCT for IRLs because they are intended as a measure of the light quality of non-incandescent/halogen lamps when compared with incandescent/halogen lamps. See section VI.D and chapter 5 of this TSD for further details on the selection of more efficacious substitutes for the baseline and development of proposed efficacy levels.

DOE requests comment on its assumption that there will be no lessening of utility or performance such that the performance characteristics, including physical constraints, diameter, lumen package, color quality, lifetime, and ability to dim, would be adversely affected for the GSFL efficacy levels. Similarly, DOE also requests comment on its assumption that there will be no lessening of utility or performance such that the performance characteristics, including lumen package, lifetime, shape, diameter, and light quality, would be adversely affected for the IRL efficacy levels.

5. Impact of Any Lessening of Competition

DOE considers any lessening of competition that is likely to result from amended standards. The Attorney General determines the impact, if any, of any lessening of competition likely to result from a proposed standard, and transmits such determination to the Secretary, together with an analysis of the nature and extent of such impact.

To assist the Attorney General in making such determination, DOE will provide DOJ with copies of the NOPR and the TSD for review. DOE will consider DOJ's comments on the proposed rule in preparing the final rule, and DOE will publish and respond to DOJ's comments in that document.

6. Need of the Nation To Conserve Energy

Enhanced energy efficiency, where economically justified, improves the nation's energy security, strengthens the economy, and reduces the environmental impacts or costs of energy production. Reduced electricity demand due to energy conservation standards is also likely to reduce the cost of maintaining the reliability of the electricity system, particularly during peak-load periods. As a measure of this reduced demand, chapter 16 in the NOPR TSD presents the estimated reduction in generating capacity for the TSLs that DOE considered in this rulemaking.

Energy savings from standards for GSFLs and IRLs could also produce environmental benefits in the form of reduced emissions of air pollutants and GHGs associated with electricity production. Table VII.46 and Table VII.47 provide DOE's estimate of cumulative emissions reductions projected to result from the TSLs considered in this rulemaking. DOE reports annual emissions reductions for each TSL in chapter 14 of the NOPR TSD.

TABLE VII.46—CUMULATIVE EMISSIONS REDUCTION ESTIMATED FOR GSFL TRIAL STANDARD LEVELS

	Trial standard level				
	1	2	3	4	5
Power Sector Emissions					
CO_2 (million metric tons)	9.9	9.7	42	140	160
SO_2 (thousand tons)	15	15	64	220	250
NO_X (thousand tons)	5.5	5.5	23	78	89
Hg (tons)	0.019	0.019	0.082	0.28	0.32
N_2O (thousand tons)	0.16	0.16	0.69	2.4	2.7
CH_4 (thousand tons)	1.1	1.0	4.5	15	18
Upstream Emissions					
CO_2 (million metric tons)	0.52	0.51	2.2	7.6	8.6
SO_2 (thousand tons)	0.11	0.11	0.48	1.6	1.9
NO_X (thousand tons)	7.2	7.0	31	100	120

TABLE VII.46—CUMULATIVE EMISSIONS REDUCTION ESTIMATED FOR GSFL TRIAL STANDARD LEVELS—Continued

	Trial standard level				
	1	2	3	4	5
Hg (tons)	0.00028	0.00028	0.0012	0.0041	0.0047
N_2O (thousand tons)	0.0053	0.0052	0.023	0.077	0.088
CH_4 (thousand tons)	43	42	180	630	720
Total Emissions					
CO_2 (million metric tons)	10	10	44	150	170
SO_2 (thousand tons)	15	15	65	220	250
NO_X (thousand tons)	13	12	54	180	210
Hg (tons)	0.020	0.019	0.083	0.28	0.32
N_2O (thousand tons)	0.17	0.16	0.71	2.5	2.8
N_2O (thousand tons CO_2eq)*	49	48	210	730	830
CH_4 (thousand tons)	44	43	190	640	730
CH_4 (million tons CO_2eq)*	1,100	1,100	4,700	16,000	18,000

* CO_2eq is the quantity of CO_2 that would have the same GWP.

TABLE VII.47—CUMULATIVE EMISSIONS REDUCTION ESTIMATED FOR IRL TRIAL STANDARD LEVELS

	Trial standard level
	1
Power Sector Emissions	
CO_2 (million metric tons)	0.66
SO_2 (thousand tons)	0.69
NO_X (thousand tons)	0.35
Hg (tons)	0.0012
N_2O (thousand tons)	0.0095
CH_4 (thousand tons)	0.066
Upstream Emissions	
CO_2 (million metric tons)	0.032
SO_2 (thousand tons)	0.0069
NO_X (thousand tons)	0.45
Hg (tons)	0.00002
N_2O (thousand tons)	0.00033
CH_4 (thousand tons)	2.7
Total Emissions	
CO_2 (million metric tons)	0.70
SO_2 (thousand tons)	0.69
NO_X (thousand tons)	0.79
Hg (tons)	0.0012
N_2O (thousand tons)	0.0099
N_2O (thousand tons CO_2eq)*	2.9
CH_4 (thousand tons)	2.7
CH_4 (million tons CO_2eq)*	68

* CO_2eq is the quantity of CO_2 that would have the same GWP.

As part of the analysis for this rule, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 and NO_X that DOE estimated for each of the TSLs considered. As discussed in section VI.M.1, DOE used the most recent values for the SCC developed by an interagency process. The four sets of SCC values resulting from that process (expressed in 2012$) represented by $11.8/metric ton (the average value from a distribution that uses a 5 percent discount rate), $39.7/metric ton (the average value from a distribution that uses a 3 percent discount rate), $61.2/metric ton (the average value from a distribution that uses a 2.5 percent discount rate), and $117/metric ton (the 95th-percentile value from a distribution that uses a 3 percent discount rate). These values correspond to the value of emission reductions in 2015; the values for later years are higher due to increasing damages as the projected magnitude of climate change increases.

Table VII.48 and Table VII.49 present the global value of CO_2 emissions reductions at each TSL. For each of the four cases, DOE calculated a present value of the stream of annual values using the same discount rate as was used in the studies upon which the dollar-per-ton values are based. DOE calculated domestic values as a range from 7 percent to 23 percent of the global values, and these results are presented in chapter 15 of the NOPR TSD.

TABLE VII.48—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION UNDER GSFL TRIAL STANDARD LEVELS

TSL	SCC Case*			
	5% discount rate, average*	3% discount rate, average*	2.5% discount rate, average*	3% discount rate, 95th percentile*
	Billion 2012$			
Power Sector Emissions				
1	77	330	520	1,000
2	76	330	520	1,000
3	330	1,400	2,200	4,300
4	1,100	4,700	7,300	14,000
5	1,200	5,300	8,400	16,000

TABLE VII.48—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION UNDER GSFL TRIAL STANDARD LEVELS—Continued

TSL	SCC Case*			
	5% discount rate, average*	3% discount rate, average*	2.5% discount rate, average*	3% discount rate, 95th percentile*
Upstream Emissions				
1	4.0	17	27	54
2	4.0	17	27	53
3	17	74	120	230
4	57	250	390	760
5	65	280	450	870
Total Emissions				
1	81	350	550	1,100
2	80	350	540	1,100
3	340	1,500	2,300	4,500
4	1,100	4,900	7,700	15,000
5	1,300	5,600	8,900	17,000

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $11.8, $39.7, $61.2, and $117 per metric ton (2012$).

TABLE VII.49—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION UNDER IRL TRIAL STANDARD LEVELS

TSL	SCC Case*			
	5% discount rate, average*	3% discount rate, average*	2.5% discount rate, average*	3% discount rate, 95th percentile*
	Billion 2012$			
Power Sector Emissions				
1	5.8	24	37	72
Upstream Emissions				
1	0.28	1.2	1.8	3.5
Total Emissions				
1	6.1	25	39	75

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $11.8, $39.7, $61.2, and $117 per metric ton (2012$).

DOE is well aware that scientific and economic knowledge about the contribution of CO_2 and other GHG emissions to changes in the future global climate and the potential resulting damages to the world economy continues to evolve rapidly. Thus, any value placed on reducing CO_2 emissions in this rulemaking is subject to change. DOE, together with other Federal agencies, will continue to review various methodologies for estimating the monetary value of reductions in CO_2 and other GHG emissions. This ongoing review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues. However, consistent with DOE's legal obligations, and taking into account the uncertainty involved with this particular issue, DOE has included in this proposed rule the most recent values and analyses resulting from the interagency process.

DOE also estimated the cumulative monetary value of the economic benefits associated with NO_X emissions reductions anticipated to result from amended standards for GSFLs and IRLs. The dollar-per-ton value that DOE used is discussed in section VI.L. Table VII.50 and Table VII.51 present the cumulative present values for each TSL calculated using 7 percent and 3 percent discount rates.

TABLE VII.50—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION UNDER GSFL TRIAL STANDARD LEVELS

TSL	3% discount rate	7% discount rate
	Million 2012$	
Power Sector Emissions		
1	9.6	5.8
2	9.5	5.8
3	40	24
4	130	77
5	150	89
Upstream Emissions		
1	12	6.9
2	12	6.9
3	50	29
4	170	93
5	190	110
Total Emissions		
1	21	13
2	21	13
3	90	53
4	290	170
5	340	200

TABLE VII.51—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION UNDER IRL TRIAL STANDARD LEVELS

TSL	3% discount rate	7% discount rate
	Million 2012$	
Power Sector Emissions		
1	0.71	0.52
Upstream Emissions		
1	0.87	0.61
Total Emissions		
1	1.6	1.1

7. Summary of National Economic Impacts

The NPV of the monetized benefits associated with emissions reductions can be viewed as a complement to the NPV of the consumer savings calculated for each TSL considered in this rulemaking. Table VII.52 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced CO_2 and NO_X emissions in each of four valuation scenarios to the NPV of consumer savings calculated for each TSL considered in this rulemaking, at both a 7 percent and 3 percent discount rate. The CO_2 values used in the columns of each table correspond to the four sets of SCC values discussed above.

TABLE VII.52—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS UNDER GSFL TRIAL STANDARD LEVELS

TSL	Consumer NPV at 3% discount rate added with:			
	SCC Case $11.8/metric ton CO_2*	SCC Case $39.7/metric ton CO_2*	SCC Case $61.2/metric ton CO_2*	SCC Case $117/metric ton CO_2*
	Billion 2012$			
1	−0.39	−0.12	0.08	0.60
2	−0.53	−0.27	−0.07	0.44
3	1.5	2.6	3.4	5.7
4	9.5	13	16	23
5	9.7	14	17	26
TSL	Consumer NPV at 7% discount rate added with:			
	SCC Case $11.8/metric ton CO_2*	SCC Case $39.7/metric ton CO_2*	SCC Case $61.2/metric ton CO_2*	SCC Case $117/metric ton CO_2*
	Billion 2012$			
1	−0.30	−0.03	0.17	0.70
2	−0.38	−0.12	0.08	0.59
3	0.63	1.8	2.6	4.8
4	4.5	8.3	11	18
5	4.6	9.0	12	21

*These label values represent the global SCC in 2015, in 2012$. For NO_X emissions, each case uses the medium value, which corresponds to $2,639 per ton.

TABLE VII.53—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS UNDER IRL TRIAL STANDARD LEVELS

TSL	Consumer NPV at 3% discount rate added with:			
	SCC Case $11.8/metric ton CO_2*	SCC Case $39.7/metric ton CO_2*	SCC Case $61.2/metric ton CO_2*	SCC Case $117/metric ton CO_2*
	Billion 2012$			
1	0.29	0.31	0.32	0.36
TSL	Consumer NPV at 7% discount rate added with:			
	SCC Case $11.8/metric ton CO_2*	SCC Case $39.7/metric ton CO_2*	SCC Case $61.2/metric ton CO_2*	SCC Case $117/metric ton CO_2*
	Billion 2012$			
1	0.19	0.20	0.22	0.25

* These label values represent the global SCC in 2015, in 2012$. For NO_X emissions, each case uses the medium value, which corresponds to $2,639 per ton.

Although adding the value of consumer savings to the values of emission reductions provides a valuable perspective, two issues should be considered. First, the national operating cost savings are domestic U.S. consumer monetary savings that occur as a result of market transactions, while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and the SCC are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of product shipped in 2017–2046. The SCC values, on the other hand, reflect the present value of future climate-related impacts resulting from the emission of one metric ton of CO_2 in each year. These impacts continue well beyond 2100.

8. Other Factors

The Secretary, 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)) No other factors were considered in this analysis.

C. Proposed Standards

When considering proposed standards, the new or amended energy conservation standard 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, considering to the greatest extent practicable 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))

DOE considers the impacts of standards at each TSL, beginning with the max tech level, to determine whether that level met the evaluation criteria. Where the max tech level is not justified, DOE then considers the next most efficient level and undertakes the same evaluation until it reaches the highest efficiency level that is technologically feasible, economically justified, and saves a significant amount of energy.

To aid the reader in understanding the benefits and/or burdens of each TSL, Table VII.54 and Table VII.55 in this section summarize the quantitative analytical results for each TSL, based on the assumptions and methodology discussed herein. The efficacy levels contained in each TSL are described in section VI.D. 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 (see section VI.H), and impacts on employment. DOE discusses the impacts on employment in GSFL and IRL manufacturing in section VII.B.2.b, and discusses the indirect employment impacts in section VI.O.

As discussed in previous DOE standards rulemakings and the February 2011 NODA (76 FR 9696, Feb. 22, 2011), DOE also notes that 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 economics literature attempts to explain why consumers appear to undervalue energy efficiency improvements. This undervaluation suggests that regulation promoting energy efficiency can produce significant net private gains (as well as producing social gains by, for example, reducing pollution). There is evidence that consumers undervalue future energy savings as a result of (1) a lack of information, (2) a lack of sufficient savings to warrant accelerating or altering purchases (*e.g.,* an inefficient ventilation fan in a new building or the delayed replacement of a water pump), (3) inconsistent weighting of future energy cost savings relative to available returns on other investments, (4) computational or other difficulties associated with the evaluation of relevant tradeoffs, and (5) a divergence in incentives (*e.g.,* renter versus owner; builder vs. purchaser). Other literature indicates that with less-than-perfect foresight and a high degree of uncertainty about the future, it may be rational for consumers to trade off these types of investments at a higher-than-expected rate between current consumption and uncertain future energy cost savings. Some studies suggest that this seeming undervaluation may be explained in certain circumstances by differences between tested and actual energy savings, or by uncertainty and irreversibility of energy investments. There may also be ''hidden'' welfare losses to consumers if newer energy efficient products are imperfect substitutes for the less efficient products they replace, in terms of performance or other attributes that consumers value. In the abstract, it may be difficult to say how a welfare gain from correcting potential under-investment in energy conservation compares in magnitude to the potential welfare losses associated with no longer purchasing a machine or switching to an imperfect substitute, both of which still exist in this framework.

The mix of evidence in the empirical economics literature suggests that if feasible, analysis of regulations mandating energy-efficiency improvements should explore the potential for both welfare gains and losses and move toward a fuller economic framework where all relevant changes can be quantified.[91] While DOE is not prepared at present to provide a fuller quantifiable framework for this discussion, DOE seeks comments on how to assess these possibilities.[92] In particular, DOE requests comment on whether there are features or attributes of the more energy efficient GSFLs and IRLs that manufacturers would produce to meet the standards in this proposed rule that might affect the welfare, positively or negatively, of consumers who purchase these lamps.

1. Benefits and Burdens of Trial Standard Levels Considered for General Service Fluorescent Lamps

Table VII.54 and Table VII.55 summarize the quantitative impacts estimated for each TSL for GSFL.

TABLE VII.54—SUMMARY OF ANALYTICAL RESULTS FOR GSFL: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
National FFC Energy Savings quads					
	0.21	0.21	0.89	3.0	3.5
NPV of Consumer Benefits 2012$ billion					
3% discount rate	−0.49	−0.63	1.0	8.1	8.1
7% discount rate	−0.39	−0.48	0.23	3.2	3.1
Cumulative Emissions Reduction (Total FFC Emissions)					
CO_2 (million metric tons)	10	10	44	150	170
SO_2 (thousand tons)	15	15	65	220	250
NO_X (thousand tons)	13	12	54	180	210
Hg (tons)	0.020	0.019	0.083	0.28	0.32
N_2O (thousand tons)	0.17	0.16	0.71	2.5	2.8
N_2O (thousand tons CO_2eq) *	49	48	210	730	830
CH_4 (thousand tons)	44	43	190	640	730
CH_4 (million tons CO_2eq) *	1,100	1,100	4,700	16,000	18,000
Value of Emissions Reduction (Total FFC Emissions)					
CO_2 *2012$ million***	82 to 1,100	80 to 1,100	340 to 4,500	1,100 to 15,000	1,300 to 17,000
NO_X—3% discount rate, *2012$ million*	21	21	90	290	340
NO_X—7% discount rate, *2012$ million*	13	13	53	170	200

* CO_2eq is the quantity of CO_2 that would have the same GWP.
** Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.

TABLE VII.55—SUMMARY OF ANALYTICAL RESULTS FOR GSFL: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
Manufacturer Impacts					
Change in Industry NPV (*2012$ million*)†	41.8—(0.9)	37.8—(9.2)	120.5—(11.5)	358.5—(22.9)	397.1—(39.9)
Change in Industry NPV (*%*)†	2.7—(0.1)	2.5—(0.6)	7.8—(0.7)	23.2—(1.5)	25.7—(2.6)
Consumer Mean LCC Savings 2012$					
4-foot MBP ≤4,500 K	0.00	0.00	0.54	3.14	3.14
4-foot T5 MiniBP SO ≤4,500 K	2.33	2.33	2.33	2.33	2.76
4-foot T5 MiniBP HO ≤4,500 K	2.28	2.28	2.28	2.28	2.28
8-foot SP Slimline ≤4,500 K	0.00	6.88	0.00	0.00	2.08
8-foot RDC HO ≤4,500 K	−9.56	−16.76	−9.56	−9.56	−16.76
Weighted Average*	−0.68	−1.00	−0.22	1.77	1.43
Consumer Mean PBP years**					
4-foot MBP ≤4,500 K	0.0	0.0	0.6	3.6	3.6
4-foot T5 MiniBP SO ≤4,500 K	1.2	1.2	1.2	1.2	4.3
4-foot T5 MiniBP HO ≤4,500 K	3.0	3.0	3.0	3.0	3.0
8-foot SP Slimline ≤4,500 K	0.0	0.6	0.0	0.0	4.5
8-foot RDC HO ≤4,500 K	NER	NER	NER	NER	NER
Weighted Average*	0.1	0.1	0.6	3.2	3.7
Weighted Average Customers with Net Cost (%)*	9.5	11.5	59.5	29.4	34.5

[91] A good review of the literature related to this issue can be found in Gillingham, K., R. Newell, K. Palmer. (2009). ''Energy Efficiency Economics and Policy,'' *Annual Review of Resource Economics,* 1: 597–619; and Tietenberg, T. (2009). ''Energy Efficiency Policy: Pipe Dream or Pipeline to the Future?'' *Review of Environmental Economics and Policy.* Vol. 3, No. 2: 304–320.

[92] A draft paper, ''Notes on the Economics of Household Energy Consumption and Technology Choice,'' proposes a broad theoretical framework on which an empirical model might be based and is posted on the DOE Web site along with this notice at *www.eere.energy.gov/buildings/appliance_standards.*

TABLE VII.55—SUMMARY OF ANALYTICAL RESULTS FOR GSFL: MANUFACTURER AND CONSUMER IMPACTS—Continued

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
Weighted Average Customers with Net Benefit (%)*	1.1	2.6	36.0	60.4	65.5
Weighted Average Customers with No Impact (%)*	89.4	85.8	4.5	10.2	0.0

* Weighted by shares of each product class in total projected shipments in 2017.
** Does not include weighting for "NER" scenarios. Entries of "NER" indicate standard levels that do not reduce operating costs, which prevents the consumer from recovering the increased purchase cost.
† Values in parentheses are negative values.

First, DOE considered TSL 5, the most efficient level (max tech), which would save an estimated total of 3.5 quads of energy, an amount DOE considers significant. TSL 5 has an estimated NPV of consumer benefit of $3.1 billion using a 7 percent discount rate, and $8.1 billion using a 3 percent discount rate.

The cumulative emissions reductions at TSL 5 are 170 million metric tons of CO_2, 210 thousand tons of NO_X, 250 thousand tons of SO_2, 0.32 tons of Hg, 730 thousand tons of CH_4, and 2.8 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reductions at TSL 5 ranges from $1,300 million to $17,000 million.

At TSL 5, the weighted average LCC savings is $3.14 for the 4-foot MBP lamps, $2.76 for the 4-foot T5 MiniBP SO lamps, $2.28 for the 4-foot T5 MiniBP HO lamps, $2.08 for the 8-foot SP slimline lamps, and −$16.76 for the 8-foot RDC HO lamps.

At TSL 5, the projected change in INPV ranges from a decrease of $39.9 million to an increase of $397.1 million. If the decrease is realized, TSL 5 could result in a net loss of up to 2.6 percent in INPV to manufacturers of covered GSFLs. Also at TSL 5, DOE estimates industry will need to invest approximately $38.6 million in conversion costs.

After considering the analysis and weighing the benefits and the burdens, DOE has tentatively concluded that, at TSL 5 for GSFL, the benefits of energy savings, positive NPV of total consumer benefits, positive impacts on consumers (as indicated by positive average LCC savings, favorable PBPs, and the large percentage of consumers who would experience LCC benefits), emission reductions and the estimated monetary value of the emissions reductions would outweigh the potential reduction in industry value, and increase in LCCs experienced by certain consumers at TSL 5. The Secretary has concluded that TSL 5 would save a significant amount of energy and is technologically feasible and economically justified.

Based on the above considerations, DOE today proposes to adopt the energy conservation standards for GSFL at TSL 5. Table VII.56 presents the proposed energy conservation standards for GSFL.

TABLE VII.56—PROPOSED ENERGY CONSERVATION STANDARDS FOR GSFL

Lamp type	CCT K	Proposed level lm/W
4-Foot Medium Bipin	≤4,500	92.4
	>4,500	90.6
2-Foot U-Shaped	≤4,500	86.9
	>4,500	84.3
8-Foot Slimline	≤4,500	99.0
	>4,500	94.1
8-Foot High Output	≤4,500	97.6
	>4,500	95.6
4-Foot Miniature Bipin Standard Output	≤4,500	97.1
	>4,500	91.3
4-Foot Miniature Bipin High Output	≤4,500	82.7
	>4,500	78.6

2. Summary of Benefits and Costs (Annualized) of the Proposed Standards for General Service Fluorescent Lamps

The benefits and costs of today's proposed standards, for product sold in 2017–2046, can also be expressed in terms of annualized values. The annualized monetary values are the sum of (1) the annualized national economic value of the benefits from consumer operation of product that meet the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in product purchase and installation costs, which is another way of representing consumer NPV), and (2) the annualized monetary value of the benefits of emission reductions, including CO_2 emission reductions.[93]

Estimates of annualized benefits and costs of the proposed standards for GSFL are shown in Table VII.57. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, for which DOE used a 3-percent discount rate along with the average SCC series that uses a 3-percent discount rate, the cost of the standards proposed in today's rule is $873 million per year in increased product costs; while the estimated benefits are $1,180 million per year in reduced product operating costs, $314 million per year in CO_2 reductions, and $19.3 million per year in reduced NO_X emissions. In this case, the net benefit would amount to $642 million per year. Using a 3-percent discount rate for all benefits and costs

[93] DOE used a two-step calculation process to convert the time-series of costs and benefits into annualized values. First, DOE calculated a present value in 2013, the year used for discounting the NPV of total consumer costs and savings, for the time-series of costs and benefits using discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions. For the latter, DOE used a range of discount rates. From the present value, DOE then calculated the fixed annual payment over a 30-year period (2017 through 2046) that yields the same present value. The fixed annual payment is the annualized value. Although DOE calculated annualized values, this does not imply that the time-series of cost and benefits from which the annualized values were determined is a steady stream of payments.

and the average SCC series, the estimated cost of the standards proposed in today's rule is $751 million per year in increased product costs; while the estimated benefits are $1,200 million per year in reduced operating costs, $314 million per year in CO_2 reductions, and $18.9 million per year in reduced NO_X emissions. In this case, the net benefit would amount to approximately $783 million per year.

TABLE VII.57—ANNUALIZED BENEFITS AND COSTS OF PROPOSED STANDARDS FOR GSFL (TSL 5)

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
	....	Million 2012$/year		
Benefits				
Operating Cost Savings	7%	1,180	1,160	1,220
	3%	1,200	1,170	1,250
CO_2 Reduction Monetized Value ($11.8/t case) **	5%	98	98	98
CO_2 Reduction Monetized Value ($39.7/t case) **	3%	314	314	314
CO_2 Reduction Monetized Value ($61.2/t case) **	2.5%	456	456	456
CO_2 Reduction Monetized Value ($117/t case) **	3%	968	968	968
NO_X Reduction Monetized Value (at $2,639/ton) **	7%	19.3	19.3	19.3
	3%	18.9	18.9	18.9
Total Benefits †	7% plus CO_2 range	1,300 to 2,160	1,280 to 2,140	1,340 to 2,210
	7%	1,520	1,490	1,560
	3% plus CO_2 range	1,320 to 2,180	1,290 to 2,160	1,370 to 2,230
	3%	1,530	1,510	1,580
Costs				
Incremental Product Costs	7%	873	910	873
	3%	751	785	751
Net Benefits				
Total †	7% plus CO_2 range	426 to 1,291	367 to 1,232	469 to 1,330
	7%	642	583	685
	3% plus CO_2 range	567 to 1,432	505 to 1,370	615 to 1,480
	3%	783	722	831

* This table presents the annualized costs and benefits associated with GSFLs shipped in 2017–2046. These results include benefits to consumers which accrue after 2046 from the products purchased in 2017–2046. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary Benefits Estimate assumes the central energy prices from *AEO2013* and a decreasing incremental product cost, due to price learning. The Low Benefits Estimate assumes the low estimate of energy prices from *AEO2013* and constant real product prices. The High Benefits Estimate assumes the high energy price estimates from *AEO2013* and decreasing incremental product costs, due to price learning.

** The CO_2 values represent global monetized values of the SCC, in 2012$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series used by DOE incorporate an escalation factor. The value for NO_X is the average of the low and high values used in DOE's analysis.

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

3. Benefits and Burdens of Trial Standard Levels Considered for Incandescent Reflector Lamps

Table VII.58 and Table VII.59 summarize the quantitative impacts estimated for the potential IRL standards.

TABLE VII.58—SUMMARY OF ANALYTICAL RESULTS FOR IRL: NATIONAL IMPACTS

Category	TSL 1
National FFC Energy Savings Quads	
	0.013
NPV of Consumers Benefits 2012$ Billion	
3% discount rate	0.28
7% discount rate	0.18
Cumulative Emissions Reduction (Total FFC Emissions)	
CO_2 (million metric tons)	0.70
SO_2 (thousand tons)	0.69

TABLE VII.58—SUMMARY OF ANALYTICAL RESULTS FOR IRL: NATIONAL IMPACTS—Continued

Category	TSL 1
NO_X (thousand tons)	0.79
Hg (tons)	0.0012
N_2O (thousand tons)	0.0099
N_2O (thousand tons CO_2eq) *	2.9
CH_4 (thousand tons)	2.7
CH_4 (thousand tons CO_2eq) *	68
Value of Emissions Reduction (Total FFC Emissions)	
CO_2 *2012$ million***	6.1 to 75
NO_X—3% discount rate *2012$ million*	1.6
NO_X—7% discount rate *2012$ million*	1.1

* CO_2eq is the quantity of CO_2 that would have the same GWP.
** Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.

TABLE VII.59—SUMMARY OF ANALYTICAL RESULTS FOR IRL: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1
Manufacturer Impacts	
Change in Industry NPV *2012$ million***	(47.5) – (51.8)
Change in Industry NPV *%***	(27.0) – (29.5)
Consumer Mean LCC Savings * 2012$	
Standard spectrum; >2.5 inch diameter; <125 V	2.95
Consumer Mean PBP * years	
Standard spectrum; >2.5 inch diameter; <125 V	5.4
Consumers with Net Cost *%*	0.0
Consumers with Net Benefit *%*	100.0
Consumers with No Impact *%*	0.0

* Weighted by shares of each equipment class in total projected shipments in 2017.
** Values in parentheses are negative values.

DOE considered TSL 1, which would save an estimated total of 0.013 quads of energy, an amount DOE considers significant. TSL 1 has an estimated NPV of consumer benefit of $0.18 billion using a 7 percent discount rate, and $0.28 billion using a 3 percent discount rate.

The cumulative emissions reductions at TSL 1 are 0.70 million metric tons of CO_2, 0.79 thousand tons of NO_X, 0.69 thousand tons of SO_2, 0.0012 tons of Hg, 2.7 thousand tons of CH_4, and 0.0099 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reductions at TSL 1 ranges from $6.1 million to $75 million.

At TSL 1, the weighted average LCC savings for the standard spectrum, > 2.5 inch diameter, < 125 V product class is $2.95. The LCC savings were positive for both representative lamp units in each sector.

At TSL 1, the projected change in INPV ranges from a decrease of $51.8 million to decrease of $47.5 million. If the larger decrease is realized, TSL 1 could result in a net loss of up to 29.5 percent in INPV to manufacturers of covered IRLs. Also at TSL 1, DOE estimates industry would need to invest approximately $71.5 million in conversion costs.

After considering the analysis and weighing the benefits and the burdens, DOE concludes that, at TSL 1 for IRLs, the benefits of energy savings, positive NPV of consumer benefits, positive impacts on consumers (as indicated by positive average LCC savings and the large percentage of consumers who would experience LCC benefits), emission reductions and the estimated monetary value of the emissions reductions would outweigh the potential reduction in industry value. Consequently, DOE has concluded that TSL 1 is economically justified.

Based on the above considerations, DOE today proposes to adopt the energy conservation standards for IRL at TSL 1. Table VII.60 presents the proposed energy conservation standards for IRL.

TABLE VII.60—PROPOSED ENERGY CONSERVATION STANDARDS FOR IRL

Lamp type	Diameter inches	Voltage V	Proposed level lm/W
Standard Spectrum			
40 W – 205 W	>2.5	≥125	$7.1P^{0.27}$
		<125	$6.2P^{0.27}$
	≤2.5	≥125	$6.0P^{0.27}$
		<125	$5.2P^{0.27}$

TABLE VII.60—PROPOSED ENERGY CONSERVATION STANDARDS FOR IRL—Continued

Lamp type	Diameter inches	Voltage V	Proposed level lm/W
Modified Spectrum			
40 W – 205 W	>2.5	≥125	$6.0P^{0.27}$
		<125	$5.2P^{0.27}$
	≤2.5	≥125	$5.1P^{0.27}$
		<125	$4.4P^{0.27}$

4. Summary of Benefits and Costs (Annualized) of the Proposed Standards for Incandescent Reflector Lamps

The benefits and costs of today's proposed standards for IRL, for product sold in 2017–2046, can also be expressed in terms of annualized values. The annualized monetary values are the sum of (1) the annualized national economic value of the benefits from consumer operation of product that meet the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in product purchase and installation costs, which is another way of representing consumer NPV), and (2) the annualized monetary value of the benefits of emission reductions, including CO_2 emission reductions.

Estimates of annualized benefits and costs of the proposed standards for IRL are shown in Table VII.61. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, for which DOE used a 3-percent discount rate along with the average SCC series that uses a 3-percent discount rate, the annualized incremental equipment cost of the standards proposed in today's rule is negative $10.4 million per year,[94] and the annualized benefits of the standards proposed in today's rule are $7.2 million per year in reduced product operating costs, $1.4 million per year in CO_2 reductions, and $0.11 million per year in reduced NO_X emissions. In this case, the net benefit would amount to $19 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series, the estimated annualized incremental equipment cost of the standards proposed in today's rule is negative $9.7 million per year,[94] and the annualized benefits of the standards proposed in today's rule are $5.9 million per year in reduced operating costs, $1.4 million per year in CO_2 reductions, and $0.09 million per year in reduced NO_X emissions. In this case, the net benefit would amount to approximately $17 million per year.

TABLE VII.61—ANNUALIZED BENEFITS AND COSTS OF PROPOSED STANDARDS FOR IRL (TSL 1)

	Discount rate	Primary estimate*	Low net benefits estimate*	High net benefits estimate*
		Million 2012$/year		
Benefits				
Operating Cost Savings	7%	7.2	7.1	10
	3%	5.9	5.8	5.8
CO_2 Reduction Monetized Value ($11.8/t case)**	5%	0.5	0.5	0.5
CO_2 Reduction Monetized Value ($39.7/t case)**	3%	1.4	1.4	1.4
CO_2 Reduction Monetized Value ($61.2/t case)**	2.5%	2.0	2.0	2.0
CO_2 Reduction Monetized Value ($117/t case)*	3%	4.2	4.2	4.2
NO_X Reduction Monetized Value (at $2,639/ton)**	7%	0.11	0.11	0.16
	3%	0.09	0.09	0.09
Total Benefits †	7% plus CO_2 range	7.8 to 12	7.7 to 11	7.8 to 12
	7%	8.7	8.6	8.7
	3% plus CO_2 range	6.4 to 10	6.4 to 10	6.4 to 10
	3%	7.4	7.3	7.3
Costs				
Incremental Product Costs ‡	7%	−10.4	−10.5	−10.4
	3%	−9.7	−9.8	−9.7
Net Benefits				
Total †	7% plus CO_2 range	18 to 22	18 to 22	18 to 22
	7%	19	19	19
	3% plus CO_2 range	16 to 20	16 to 20	16 to 20

[94] This represents a reduction in product costs compared to the base case, because the more efficacious products have substantially longer lifetimes than the products that would be eliminated by the proposed standard.

TABLE VII.61—ANNUALIZED BENEFITS AND COSTS OF PROPOSED STANDARDS FOR IRL (TSL 1)—Continued

	Discount rate	Primary estimate*	Low net benefits estimate*	High net benefits estimate*
	3%	17	17	17

* This table presents the annualized costs and benefits associated with IRLs shipped in 2017–2046. These results include benefits to consumers which accrue after 2046 from the products purchased in 2017–2046. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary Benefits Estimate assumes the central energy prices from *AEO2013* and a decreasing incremental product cost, due to price learning. The Low Benefits Estimate assumes the low estimate of energy prices from *AEO2013* and constant real product prices. The High Benefits Estimate assumes the high energy price estimates from *AEO2013* and decreasing incremental product costs, due to price learning.

** The CO_2 values represent global monetized values of the SCC, in 2012$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series used by DOE incorporate an escalation factor. The value for NO_X is the average of the low and high values used in DOE's analysis.

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

‡ This reduction in product costs occurs because the more efficacious products have substantially longer lifetimes than the products that would be eliminated by the proposed standard.

VIII. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Section 1(b)(1) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), requires each agency to identify the problem that it intends to address, including, where applicable, the failures of private markets or public institutions that warrant new agency action, as well as to assess the significance of that problem. The problems that today's standards address are as follows:

(1) There is a lack of consumer information and/or information processing capability about energy efficiency opportunities in the lighting market.

(2) There is asymmetric information (one party to a transaction has more and better information than the other) and/or high transactions costs (costs of gathering information and effecting exchanges of goods and services).

(3) There are external benefits resulting from improved energy efficiency of GSFLs and IRLs that are not captured by the users of such equipment. These benefits include externalities related to environmental protection and energy security that are not reflected in energy prices, such as reduced emissions of GHGs.

In addition, DOE has determined that today's regulatory action is an ''economically significant regulatory action'' under section 3(f)(1) of Executive Order 12866. Accordingly, section 6(a)(3) of the Executive Order requires that DOE prepare a regulatory impact analysis (RIA) on today's rule and that the Office of Information and Regulatory Affairs (OIRA) in OMB review this rule. DOE presented to OIRA for review the draft rule and other documents prepared for this rulemaking, including the RIA, and has included these documents in the rulemaking record. The assessments prepared pursuant to Executive Order 12866 can be found in the technical support document for this rulemaking.

DOE has also reviewed this regulation pursuant to Executive Order 13563, issued on January 18, 2011 (76 FR 3281, Jan. 21, 2011). EO 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in Executive Order 12866. To the extent permitted by law, agencies are required by Executive Order 13563 to: (1) Propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.

DOE emphasizes as well that Executive Order 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, the Office of Information and Regulatory Affairs has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. In this NOPR, DOE has taken particular note of the potential for future volatility in the price of rare earth oxides used in the manufacture of GSFLs as it affects the future costs and benefits of the proposed standard. DOE plans to pursue a retrospective review of rare earth prices as input for any future updates to GSFL standards. For the reasons stated in the preamble, DOE believes that today's NOPR is consistent with these with the principles laid out in Executive Order 13563, including the requirement that, to the extent permitted by law, benefits justify costs and that net benefits are maximized.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 et seq.) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General

Counsel's Web site (*http://energy.gov/gc/office-general-counsel*).

As a result of this review, DOE has prepared an IRFA for GSFLs and IRLs, a copy of which DOE will transmit to the Chief Counsel for Advocacy of the Small Business Administration (SBA) for review under 5 U.S.C. 605(b). As presented and discussed below, the IFRA describes potential impacts on GSFL and IRL manufacturers and discusses alternatives that could minimize these impacts.

A statement of the objectives of, and reasons and legal basis for, the proposed rule are set forth elsewhere in the preamble and not repeated here.

1. Description and Estimated Number of Small Entities Regulated

a. Methodology for Estimating the Number of Small Entities

For manufacturers of GSFLs and IRLs, 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. 65 FR 30836, 30848 (May 15, 2000), as amended at 65 FR 53533, 53544 (Sept. 5, 2000) and codified at 13 CFR part 121. The size standards are listed by North American Industry Classification System (NAICS) code and industry description available at: *http://www.sba.gov/content/table-small-business-size-standards*. GSFL and IRL manufacturing is classified under NAICS code 335110, ''Electric Lamp Bulb and Part Manufacturing.'' The SBA sets a threshold of 1,000 employees or less for an entity to be considered as a small business for this category.

To estimate the number of companies that could be small business manufacturers of GSFLs and IRLs covered by this rulemaking, DOE conducted a market survey using publicly available information. DOE's research involved industry trade association membership directories (including NEMA), information from previous rulemakings, individual company Web sites, SBA's database, and market research tools (*e.g.,* Hoover's reports). DOE also asked stakeholders and industry representatives if they were aware of any small manufacturers during manufacturer interviews and DOE public meetings. DOE used information from these sources to create a list of companies that potentially manufacture or sell GSFLs or IRLs and would be impacted by this rulemaking. As necessary, DOE contacted companies to determine whether they met the SBA's definition of a small business manufacturer of GSFLs or IRLs. DOE screened out companies that do not offer products covered by this rulemaking, do not meet the definition of a ''small business,'' or are completely foreign owned and operated.

For GSFLs, DOE initially identified a total of 47 potential companies that sell GSFLs in the United States. After reviewing publicly available information on these potential GSFL manufacturers, DOE determined that 26 were either large manufacturers, manufacturers that were completely foreign owned and operated, or did not sell GSFLs covered by this rulemaking. DOE then contacted the remaining 21 GSFL companies to determine whether they met SBA's definition of a small business and whether they manufactured or sold GSFLs that would be affected by today's proposal. Based on these efforts, DOE estimated that there are 21 small businesses that either manufacture or sell covered GSFLs in the United States.

For IRLs, DOE initially identified a total of 37 potential companies that sell IRLs in the United States. After reviewing publicly available information on these potential IRL manufacturers, DOE determined that 22 were either large manufacturers, manufacturers that were completely foreign owned and operated, or did not sell IRLs covered by this rulemaking. DOE then contacted the remaining 15 IRL companies to determine whether they met SBA's definition of a small business and whether they manufactured or sold IRLs that would be affected by today's proposal. Based on these efforts, DOE estimated that there are 15 small businesses that either manufacture or sell covered IRLs in the United States.

b. Manufacturer Participation

DOE contacted all 21 identified GSFL small businesses to invite them to take part in a small business MIA interview. Of the GSFL manufacturers DOE contacted, eight responded to DOE's email and phone communications and 13 did not. DOE was able to reach and discuss potential standards with two of the eight GSFL small business manufacturers that responded. The remaining six declined DOE's request to be interviewed for this rulemaking. DOE also contacted all 15 identified IRL small businesses to invite them to take part in a small business MIA interview. Of the IRL manufacturers DOE contacted, five responded to DOE's email and phone communications and 10 did not. DOE was able to reach and discuss potential standards with two of the five IRL small business manufacturers. The remaining three declined DOE's request to be interviewed for this rulemaking. DOE also obtained information about small business manufacturers and potential impacts on small businesses while interviewing large manufacturers.

c. General Service Fluorescent Lamp and Incandescent Reflector Lamp Industry Structures and Nature of Competition

Three major manufacturers supply approximately 90 percent of the GSFL market. None of these three major GSFL manufacturers are small businesses. DOE estimates that the remaining 10 percent of the GSFL market is served by either small businesses or manufacturers that are completely foreign owned and operated. No small business has more than a three percent market share in the GSFL industry. Similarly in the IRL market, the same three major GSFL manufacturers supply approximately 80 percent of the IRL market. Again, none of these three major IRL manufacturers is a small business. DOE estimates that the remaining 20 percent of the IRL market is served by either small businesses or manufacturers that are completely foreign owned and operated. No small business has more than three percent of the IRL market individually. Small businesses that sell covered GSFLs and IRLs tend to be companies that outsource the manufacturing to overseas companies who produce the lamps specified by the small businesses. These small businesses provide the specifications for these lamps as well as the testing and certification to comply with any U.S. energy conservation standards.

d. Comparison Between Large and Small Entities

For GSFLs and IRLs, small businesses differ from large manufacturers in several ways that directly affect the extent to which a company would be impacted by any potential energy conservation standards. The main differences between small and large entities for this rulemaking are that small manufacturers of GSFLs and IRLs have lower sales volumes and are frequently not the original manufacturers of GSFLs and IRLs. Therefore, these small businesses would not have any capital conversion costs to comply with amended standards, since the machinery used to produce GSFLs and IRLs is owned and operated by overseas manufacturers. The small businesses would most likely experience higher per-unit costs for the products if the conversion costs experienced by the overseas manufacturers are passed through to the small businesses, potentially reducing those small business' manufacturer markups and profits. Small businesses would also have product conversion costs associated with testing and certifying any lamps that would need to be redesigned due to standards. Typically the testing and certification costs are proportional to the number of products offered by a company and not the volume of sales. Some small businesses stated they could offer up to 75 percent of the number of covered products that large manufacturers offer; however, the volume of sales for each single product offered by a small business would be significantly smaller than that of a larger manufacturer. Consequently, the revenue associated with a single product is much smaller for small businesses than for large manufacturers. Therefore, these small businesses could have product conversion costs in the same range as large manufacturers, since product conversion costs scale to number of products offered, even though the total revenue is significantly lower for small businesses compared to large manufacturers.

Lower sales volumes are the biggest disadvantage for most small businesses. A lower-volume business' product conversion costs are spread over fewer units than a larger competitor. Thus, unless the small business can differentiate its product in some way that earns a price premium, the small business experiences a reduction in profit per-unit relative to the large manufacturer. Most small GSFL and IRL businesses operate in the same lighting markets as large manufacturers and do not operate in niche GSFL and IRL markets. Much of the same equipment would need to be purchased by both large manufacturers and small businesses to produce GSFLs and IRLs at higher efficacy levels. If the small business is not the original lamp manufacturer, the manufacturer that sells to the small business would have to purchase this equipment. Therefore, undifferentiated small businesses would face a greater per-unit cost penalty because they must spread the conversion costs over fewer units. While small businesses may not be directly paying these capital conversion costs, they are still responsible for selling certified products made by the original lamp manufacturers. The costs incurred by contracted manufacturers are passed on to small businesses that must maintain profit margins by either increasing product prices or decreasing profitability.

2. Description and Estimate of Compliance Requirements

Small GSFL and IRL businesses will be affected differently by the proposed energy conservation standards compared to large manufacturers. One of the key differences between large manufacturers and the small businesses identified by DOE for this rulemaking is that small IRL and GSFL businesses typically outsource the manufacturing of the lamps they sell to original equipment manufacturers abroad. This, in addition to the small volume of sales typical of small businesses, results in small GSFL and IRL businesses having different types and amounts of conversion costs compared to large manufacturers.

As a result of this rulemaking, small businesses will incur product conversion costs because products that no longer meet the proposed efficacy levels of amended energy conservation standards will most likely need to be redesigned, retested, and recertified. Since small businesses have significantly less revenue and annual R&D budgets than large manufacturers, the product conversion costs necessary to comply with amended standards represent a significant portion of a small business' annual revenue. However, unlike large manufacturers, small businesses will most likely not incur any capital conversion costs due to amended standards because small businesses usually do not own and operate the machinery used to manufacture the covered lamps. The capital conversion costs incurred by original equipment manufacturers will instead be passed along indirectly to the domestic small businesses.

In the GSFL market, DOE identified 21 small GSFL businesses with covered products affected by this rulemaking. It is unlikely that small GSFL businesses will incur any capital conversion costs because small businesses usually do not own and operate the machinery used to manufacture the covered lamps; however, they will likely face significant product conversion costs to cover R&D, certification, and testing of products that need to be redesigned to meet the proposed GSFL efficacy levels of today's NOPR. DOE estimates that approximately 20 percent of the covered products offered by small GSFL manufacturers meet the proposed efficacy levels at TSL 5. As a result, an average of approximately 80 percent of products would need to be redesigned to meet proposed efficacy levels, resulting in small GSFL businesses incurring more than $1.6 million on average in product conversion costs or nearly seven times as much as typical annual GSFL R&D expenses. GSFL sales account for approximately 25 percent of a typical small business' annual revenue, so redesigning up to 80 percent of those offerings could have a significant impact on their business. Redesigning a large majority of product offerings that represent a significant revenue stream will be more difficult for small businesses, compared to large businesses, as they have less R&D and revenue.

TABLE VIII.1—ESTIMATED GSFL PRODUCT CONVERSION COSTS AS A PERCENTAGE OF ANNUAL GSFL R&D EXPENSE

	Product conversion cost as a percentage of annual R&D expense (percent)	Total conversion cost as a percentage of annual revenue (percent)
Typical Large Manufacturer	1	0
Typical Small Manufacturer	692	31

In the IRL market, DOE identified 15 small IRL businesses with covered products affected by this rulemaking. DOE estimates that a typical small IRL business will not incur any direct capital conversion costs at TSL 1, the proposed standard in today's NOPR, since most IRL small businesses do not own and operate the machinery used to manufacture IRLs. The small businesses would most likely experience higher per-unit costs for the products if the conversion costs experienced by the overseas manufacturers are passed through to the small businesses, potentially reducing those small business' manufacturer markups. Small IRL businesses are expected to incur product capital conversion costs of approximately $836 thousand per manufacturer. As Table VIII.2 below illustrates, small businesses would have significant product conversion costs amounting to nearly nine times the annual amount spent on IRL R&D. Small IRL businesses have much smaller annual R&D budgets as well as smaller annual revenue streams, so incurring the product conversion costs necessary to meet the efficacy standards at TSL 1 could be problematic for those small businesses that have a large majority of their IRLs at the baseline efficacy level. Total conversion cost for a typical small business could amount to nearly a third that small business' annual IRL revenue.

TABLE VIII.2—ESTIMATED IRL PRODUCT CONVERSION COSTS AS A PERCENTAGE OF ANNUAL IRL R&D EXPENSE

	Product conversion cost as a percentage of annual R&D expense (percent)	Total conversion cost as a percentage of annual revenue (percent)
Typical Large Manufacturer	387	28
Typical Small Manufacturer	852	29

While some small businesses would have some products meet the IRL efficacy levels proposed in today's NOPR, there are a few small businesses that may not be able to meet the IRL efficacy levels proposed in today's NOPR. Not meeting TSL 1 for IRL products may also be a strategic decision for some small businesses since IRL products make up about five percent of a typical small IRL business' revenue. Therefore, some small lighting businesses may choose to not sell IRLs covered by this rulemaking and exit the market.

Small businesses in both the IRL and GSFL industries expressed concern that possible manufacturing downtime, discontinuation of product lines, and high direct and indirect conversion costs resulting from amended GSFL and IRL energy conservation standards could have a significant impact on their revenue and could affect domestic employment decisions. Domestic employment impacts would be especially prevalent in the GSFL market where GSFL revenue accounts for approximately 25 percent of a typical small business' revenue. Domestic employment impacts would be seen in small business' sales forces and warehouse staff that could be potentially downsized as a result of amended GSFL and IRL standards.

3. Duplication, Overlap, and Conflict With Other Rules and Regulations

DOE is not aware of any rules or regulations that duplicate, overlap, or conflict with the rule being considered today.

4. Significant Alternatives to the Proposed Rule

The discussion above analyzes impacts on small businesses that would result from the GSFL TSL and IRL TSL DOE is proposing in today's notice. Though TSLs lower than the proposed TSLs are expected to reduce the impacts on small entities, DOE is required by EPCA to establish standards that achieve the maximum improvement in energy efficiency that are technically feasible and economically justified, and result in a significant conservation of energy. Therefore, DOE rejected the lower TSLs.

The NOPR TSD includes a regulatory impact analysis in chapter 18. For GSFLs and IRLs, this report discusses the following policy alternatives in addition to the other TSLs being considered: (1) Consumer rebates, (2) consumer tax credits, and (3) manufacturer tax credits. DOE does not intend to consider these alternatives further because they either are not feasible to implement or are not expected to result in energy savings as large as those that would be achieved by the standard levels under consideration.

DOE continues to seek input from businesses that would be affected by this rulemaking and will consider comments received in the development of any final rule.

5. Significant Issues Raised by Public Comments

NEMA commented during the framework comment period there is an added burden of significantly more testing and reporting of a lot of small sales volume lamps which would result from the proposed increase in regulations. This increased burden would be much harder on small business manufacturers, especially if those small business manufacturers have to pay testing costs to a National Voluntary Laboratory Accreditation Program (NVLAP) source facility. (NEMA, No. 10 at p. 75) NEMA also commented during the framework comment period that there is a substantial cumulative effect of numerous concurrent lighting regulations being carried out in addition to this rulemaking and small business manufacturers are even harder hit because of this cumulative regulatory burden. NEMA believes that small business manufacturers should not have to bear an unfair burden as a result of overly aggressive policies. (NEMA, No. 10 at pp. 74–75) DOE agrees that there is potential for small manufacturers to be disproportionately burdened by additional regulations as a result of additional testing and reporting costs and from the potential of a cumulative regulatory burden, DOE outlines its conclusions on the potential impacts of amended standards on small businesses in the above section of today's NOPR.

DOE's MIA suggests that most GSFL small businesses will generally be able to maintain profitability at the TSL proposed in today's rulemaking. It is possible, however, that small IRL manufacturers could incur significant conversion costs as a result of this proposed rule, and those high costs could endanger their IRL business. However, based on the fact that IRL sales typically only account for a small but non-trivial overall portion of a small lighting business' sales, DOE does not believe that any small business will go out of business due to the IRL standard proposed in today's NOPR. DOE's MIA is based on its interviews of both small and large manufacturers, and consideration of the small business impacts explicitly enters into DOE's choice of the TSLs proposed in today's NOPR.

DOE did not receive any public comments suggesting that small businesses would not be able to achieve the efficiency levels at TSL 5 for GSFLs and at TSL 1 for IRLs. DOE seeks comment on the feasibility of small business to achieve the efficacy levels for GSFLs and IRLs proposed in today's NOPR.

C. Review Under the Paperwork Reduction Act

Manufacturers of GSFLs and IRLs 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 GSFLs and IRLs, 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 GSFLs and IRLs. 76 FR 12422 (March 7, 2011). The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910–1400. Public reporting burden for the certification is estimated to average 20 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 (NEPA) of 1969, DOE has determined that the proposed rule fits within the category of actions included in Categorical Exclusion (CX) B5.1 and otherwise meets the requirements for application of a CX. See 10 CFR Part 1021, App. B, B5.1(b); 1021.410(b) and Appendix B, B(1)–(5). The proposed rule fits within the category of actions because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, and for which none of the exceptions identified in CX B5.1(b) apply. Therefore, DOE has made a CX determination for this rulemaking, and DOE does not need to prepare an Environmental Assessment or Environmental Impact Statement for this proposed rule. DOE's CX determination for this proposed rule is available at *http://cxnepa.energy.gov.*

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism.'' 64 FR 43255 (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. EPCA governs and prescribes Federal preemption of state regulations as to energy conservation for the products that are the subject of today's proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' imposes on Federal agencies the general duty to adhere to the following requirements: (1) Eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; and (3) provide a clear legal standard for affected conduct rather than a general standard and promote simplification and burden reduction. 61 FR 4729 (Feb. 7, 1996). Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this proposed rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on state, local, and Tribal governments and the private sector. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by state, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of state, local, and Tribal governments on a proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. DOE's policy statement is also available at *http://energy.gov/gc/downloads/unfunded-mandates-reform-act-intergovernmental-consultation.*

Although today's proposed rule does not contain a Federal intergovernmental mandate, it may require expenditures of $100 million or more on the private sector. Specifically, the proposed rule will likely result in a final rule that could require expenditures of $100 million or more. Such expenditures may include: (1) Investment in research and development and in capital expenditures by GSFL and IRL 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 GSFL and IRL, starting at the compliance date for the applicable standard.

Section 202 of UMRA authorizes a Federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the proposed rule. 2 U.S.C. 1532(c). The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of the NOPR and the ''Regulatory Impact Analysis'' section of the TSD for this proposed rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. 2 U.S.C. 1535(a). DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the proposed rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6295(i)(4)–(5), today's proposed rule would establish energy conservation standards for GSFLs and IRLs that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified. A full discussion of the alternatives considered by DOE is presented in the ''Regulatory Impact Analysis'' section of the TSD for today's proposed rule.

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

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

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights'' 53 FR 8859 (Mar. 18, 1988), that this regulation 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 guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed today's NOPR under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use'' 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OIRA at OMB, a Statement of Energy Effects for any proposed significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) Is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has tentatively concluded that today's regulatory action, which sets forth energy conservation standards for GSFLs and IRLs, is not a significant energy action because the proposed standards are not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as such by the Administrator at OIRA. Accordingly, DOE has not prepared a Statement of Energy Effects on the proposed rule.

L. Review Under the Information Quality Bulletin for Peer Review

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy (OSTP), issued its Final Information Quality Bulletin for Peer Review (the Bulletin). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the Federal Government, including influential scientific information related to agency regulatory actions. The purpose of the bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are ''influential scientific information,'' which the Bulletin defines as scientific information the agency reasonably can determine will have, or does have, a clear and substantial impact on important public policies or private sector decisions. 70 FR 2667.

In response to OMB's Bulletin, DOE conducted formal in-progress peer reviews of the energy conservation standards development process and analyses and has prepared a Peer Review Report pertaining to the energy conservation standards rulemaking analyses. Generation of this report involved a rigorous, formal, and documented evaluation using objective criteria and qualified and independent reviewers to make a judgment as to the technical/scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects. The ''Energy Conservation Standards Rulemaking Peer Review Report'' dated February 2007 has been disseminated and is available at the following Web site: *www1.eere.energy.gov/buildings/appliance_standards/peer_review.html*.

IX. Public Participation

A. Attendance at the Public Meeting

The time, date, and location of the public meeting are listed in the **DATES** and **ADDRESSES** sections at the beginning of this notice. If you plan to attend the public meeting, please notify Ms. Brenda Edwards at (202) 586–2945 or *Brenda.Edwards@ee.doe.gov*. As explained in the **ADDRESSES** section, foreign nationals visiting DOE Headquarters are subject to advance security screening procedures.

In addition, you can attend the public meeting via webinar. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's Web site at: *www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/24*. Participants are responsible for ensuring their systems are compatible with the webinar software.

B. Procedure for Submitting Prepared General Statements for Distribution

Any person who has plans to present a prepared general statement may request that copies of his or her statement be made available at the public meeting. Such persons may submit requests, along with an advance electronic copy of their statement in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format, to the appropriate address shown in the **ADDRESSES** section at the beginning of this notice. The request and advance copy of statements must be received at least one week before the public meeting and may be emailed, hand-delivered, or sent by mail. DOE prefers to receive requests and advance copies via email. Please include a telephone number to enable DOE staff to make follow-up contact, if needed.

C. Conduct of the Public Meeting

DOE will designate a DOE official to preside at the public meeting and may also use a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with section 336 of EPCA (42 U.S.C. 6306). A court reporter will be present to record the proceedings and prepare a transcript. DOE reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the public meeting. After the public meeting, interested parties may submit further comments on the proceedings as well as on any aspect of the rulemaking until the end of the comment period.

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

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly and comment on statements made by others. Participants should be prepared to answer questions by DOE and by other participants concerning these issues. DOE representatives may also ask questions of participants concerning other matters relevant to this rulemaking. The official conducting the public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the public meeting.

A transcript of the public meeting will be included in the docket, which can be viewed as described in the *Docket* section at the beginning of this notice. In addition, any person may buy a copy of the transcript from the transcribing reporter.

D. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule before or after the public meeting, but no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this notice.

Submitting comments via regulations.gov. The regulations.gov Web page will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment itself or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Otherwise, persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to regulations.gov information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information (CBI)). Comments submitted through regulations.gov cannot be claimed as CBI. Comments received through the Web site will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section below.

DOE processes submissions made through regulations.gov before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that regulations.gov provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery/courier, or mail. Comments and documents submitted via email, hand delivery, or mail also will be posted to regulations.gov. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via mail or hand delivery/courier, please provide all items on a CD, if feasible. It is not necessary to submit printed copies. No facsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, that are written in English, and that are free of any defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. According to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery/courier two well-marked copies: one copy of the document marked confidential including all the information believed to be confidential, and one copy of the document marked non-confidential with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1) A description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

E. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. DOE requests comment on the overall methodology, assumptions, and results of the GSFL and IRL engineering analyses. (See section VI.D for further details.)

2. In the engineering analysis, DOE selects a baseline lamp as a reference point against which to measure changes resulting from energy conservation standards. DOE requests comments on the baseline lamps selected in this analysis for GSFLs. (See section VI.D.2.c for further details.)

3. For GSFLs, the baseline and more efficacious substitutes selected represent the most common lifetimes for each product class. DOE requests comment on the rated lifetimes of the GSFL baselines and more efficacious substitutes. (See section VI.D.2.d for further details.)

4. Because fluorescent lamps operate on a ballast in practice, DOE analyzed lamp-and-ballast systems in the engineering analysis, to more accurately capture real-world energy use and light output. DOE requests comments on its methodology for developing lamp-and-ballast systems as well as the results of these GSFL systems. (See section VI.D.2.e for further details.)

5. For GSFLs, DOE requests comment on the max tech levels identified in this analysis and more information on the accuracy of catalog and certification data which were used to identify these levels. (See section VI.D.2.f for further details.)

6. DOE develops ELs based on three factors: (1) The design options associated with the specific lamps studied; (2) the ability of lamps across wattages to comply with the standard level of a given product class; and (3) the max tech EL. DOE requests comments on the methodology used to develop ELs for GSFLs as well as on the resulting ELs. (See section VI.D.2.g for further details.)

7. DOE develops scaling factors to scale the levels developed directly for the representative product classes and determine levels for product classes not analyzed directly. DOE requests comments on the scaling factors developed to scale GSFL product classes from the less than or equal to 4,500 K CCT lamps to the greater than 4,500 K CCT lamps. DOE also requests comments on the scaling factor developed to scale from the 4-foot MBP product class to the 2-foot U-shaped product class. (See section VI.D.2.h for further details.)

8. In the engineering analysis, DOE selects a baseline lamp as a reference point against which to measure changes resulting from energy conservation standards. DOE requests comments on the baseline lamps selected in this analysis for IRLs. (See section VI.D.3.c for further details.)

9. In the engineering analysis for IRLs, DOE observed lifetime changes for different technologies. DOE requests comment on the rated lifetimes of the baseline and more efficacious substitutes. (See section VI.D.3.d for further details).

10. DOE requests comment on the max tech levels identified in this analysis and information on high efficacy IRLs including prototype lamps. (See section VI.D.3.e for further details.)

11. DOE has not found evidence that more efficacious small diameter, modified spectrum, or 130 V IRLs are not technologically feasible or practicable to manufacture, and therefore is proposing to increase efficacy levels for these lamp types. DOE requests comment on any technological barriers in manufacturing more efficacious small diameter, modified spectrum, or 130 V rated lamps for commercial production. (See section VI.D.3.i for further details.)

12. Because GSFLs and IRLs are difficult to reverse-engineer (i.e., not easily disassembled), DOE directly estimated end-user prices for lamps by establishing discounts from manufacturer suggested price lists. DOE requests feedback on the pricing methodology used in this analysis. (See section VI.E for further details.)

13. DOE used data published in the 2010 LMC in combination with CBECS, MECS, and RECS to determine an average weighted electricity price based on the probability of a GSFL or IRL in a particular building type in each census division and large state. DOE requests comment on its methodology of determining average weighted electricity prices in the LCC. (See section VI.G.6 for further details.)

14. DOE determined LCC savings and PBP results for different scenarios where consumers need to purchase a lamp (*i.e.,* lamp failure, ballast failure, and new construction and renovation for GSFLs and lamp failure and new construction and renovation for IRLs). DOE requests comments on these lamp purchasing events developed for this analysis. (See section VI.G.9 for further details.)

15. DOE conducts the LCC and PBP analyses over the lifetime of the product. DOE considered the impact of group relamping practices on GSFL lifetime in the commercial and industrial sectors. DOE requests comment on its spot and group relamping assumptions, particularly the percent of rated life at which group relamping occurs. DOE also requests comment on its general approach to determining lamp lifetime for this analysis. (See section VI.G.10.a for further details.)

16. DOE requests comment on its LCC analysis period assumptions. In particular, DOE requests comment on basing the analysis period on the baseline lamp life divided by the annual operating hours of that lamp for the IRL and the commercial and industrial sector GSFL analyses. DOE also requests comment on basing the analysis period on the useful life of the baseline lamp for a specific event for residential GSFLs. (See section VI.G.12 for further details.)

17. For this rulemaking, DOE analyzed the effects of this proposal assuming that the GSFLs and IRLs would be available to purchase for 30 years and undertook a sensitivity analysis using 9 years rather than 30 years of product shipments. The choice of a 30-year period of shipments is consistent with the DOE analysis for

other products and commercial equipment. 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. DOE is seeking input, information and data on whether there are ways to further refine the analytic timeline. (See section VI.I for further details.)

18. DOE assumes in its shipments and national impacts analyses that reduced wattage 4-foot MBP lamps can be coupled to dimming ballasts, but it assumes that no individual reduced wattage lamp option will be coupled to more than 10 percent of the dimming ballasts in the installed stock, owing to performance problems that may arise in some applications. DOE welcomes input on the reasonableness and appropriateness of these assumptions. (See section VI.I for further details.)

19. DOE assumes in its reference shipments and national impacts analyses that the future real price of rare earth oxides used in the manufacture of GSFLs will remain near current levels on average. DOE further assumes in an alternative-scenario analysis that the future price of rare earth oxides may increase owing to market forces outside of this proposed rulemaking, but DOE assumes that the future price is not likely to exceed 3.4 times the current price on average. DOE estimates that the standard proposed here would cause a maximum annual increase in demand for rare earth oxides of 296 tons in 2017, with lower demand increases in later years. DOE welcomes input on the reasonableness and appropriateness of these estimates and assumptions. (See section VI.I for further details.)

20. DOE assumes in its reference shipments and national impacts analyses that the future price of xenon gas will remain near current levels on average. DOE further assumes in an alternative-scenario analysis that the future price of xenon gas may rise but that it is not likely to exceed ten times the current price on average. DOE welcomes input on the reasonableness and appropriateness of these assumptions. (See section VI.I for further details.)

21. To improve DOE's estimates of the potential impact of lighting controls on this rulemaking, DOE seeks input on the current fraction of GSFL ballast shipments that are dimming ballasts and the likely rate of growth of dimming ballasts in the future. (See section VI.I for further details.)

22. DOE assumed zero direct rebound effect for efficiency improvements in GSFLs and IRLs. DOE conducted sensitivity analyses to evaluate alternative assumptions about rebound. DOE welcomes comment on its assumptions and methodology for estimating the rebound effect including potential magnitudes of rebound effects. (See section VI.J.1for further details.)

23. To calculate the MSP, in the MIA, DOE determined the distribution chain markup for the GSFL and IRL industries. DOE invites comment on its methodology of using a 1.52 distribution chain markup in combination with the medium end-user price to estimate the MSP of all GSFLs and IRLs. (See section VI.K.2 for further details.)

24. As part of the MIA, DOE estimates the product and capital conversion costs that all manufacturers must make to comply with potential standards. DOE requests comment on the $6.1 product conversion costs and $65.4 capital conversion costs necessary for IRL manufacturers to comply with the proposed standards. (See sections VI.K.2.a and VII.B.2.a for further details.)

25. DOE solicits comment on the application of the new SCC values used to determine the social benefits of CO_2 emissions reductions over the rulemaking analysis period. (The rulemaking analysis period covers from 2017 to 2046 plus the appropriated number of years to account for the lifetime of the equipment purchased between 2017 and 2046.) In particular, the agency solicits comment on the agency's derivation of SCC values after 2050 where the agency applied the average annual growth rate of the SCC estimates in 2040–2050 associated with each of the four sets of values. (See section VI.M.1 for further details.)

26. As part of the MIA, DOE quantitatively assessed the impacts of potential amended energy conservation standards on direct employment. DOE seeks comment on the potential domestic employment impacts to GSFL and IRL manufacturers at the proposed efficacy levels. (See section VII.B.2.b for further details.)

27. In the cumulative regulatory burden analysis, DOE assess the combined effects of recent or impending regulations on manufacturers. DOE seeks comment on the compliance costs of any other regulations GSFL or IRL manufacturers must make, especially if compliance with those regulations is required three years before or after the estimated compliance date of these proposed standards (2017). (See section VII.B.2.e for further details.)

28. As part of the cumulative regulatory burden analysis, DOE examines how the proposed standards affect manufacturers complying with other regulations. Since GSFL manufacturers must also comply with the Minimata Convention on Mercury, DOE seeks comment on GSFL manufacturers potentially increasing the amount of mercury in GSFLs in order to comply with the proposed GSFL standards. (See section VII.B.2.e for further details.)

29. For the proposed GSFL standards, DOE requests comment on the reasonableness of its assumption that first cost is a significant driver of consumers' choice of product class, which results in the shipments analysis projecting a rapid shift from 4-foot MBP T8s to standard output T5s in the TSL 5 standards case. The TSL 5 standards case substantially increases first cost for 4-foot MBP T8s. (See section VII.B.3 for further details.)

30. Noting that DOE projects a sharp decrease in total GSFL shipments both with and without standards during the rulemaking period because of the projected sharp incursion of LEDs into the GSFL market—DOE seeks comment on the reasonableness of the shipments model projection for TSL 5, specifically, that standard output T5 lamps could increase from 3 to 4 percent of the standard output GSFL market presently, to approximately 13 percent of the same market by 2020, and to approximately 30 percent of the much attenuated standard output GSFL market by 2046. (See section VII.B.3 for further details.)

31. DOE requests comment on its assumption that there will be no lessening of utility or performance such that the performance characteristics, including lumen package, color quality, lifetime, and ability to dim, would be adversely affected for the GSFL efficacy levels. (See sections VII.B.4, VI.A, VI.B, VI.C, and VI.D for further details.)

32. DOE requests comment on whether there are features or attributes, including physical constraints such as shape or diameter, of the more energy-efficient GSFL lamps that manufacturers would produce to meet the standards in this proposed rule that might affect how they would be used by consumers. DOE requests comment specifically on how any such effects should be weighed in the choice of standards for GSFLs for the final rule.

33. DOE requests comment on its assumption that there will be no lessening of utility or performance such that the performance characteristics, including lumen package and lifetime, would be adversely affected for the IRL efficacy levels. (See sections VII.B.4, VI.A, VI.B, VI.C, and VI.D for further details.)

34. DOE requests comment on whether there are features or attributes,

such as the shape or diameter, of the more energy-efficient IRL lamps that manufacturers would produce to meet the standards in this proposed rule that might affect how they would be used by consumers. DOE requests comment specifically on how any such effects should be weighed in the choice of standards for the IRLs for the final rule.

35. Due to the assumed shifts in shipments between product classes, the energy savings and monetized cost and benefit values computed for a single product class, considered in isolation, may yield negative energy savings but are more than offset by the large positive contributions to the aggregate energy savings and monetized benefits across all product classes. The expected switching between product classes also led to an aggregate negative cost estimate for the proposed standard level. In part due to the negative cost estimate for IRLs, DOE requests comment on the consumer choice model that projects shifts in shipments between product classes and whether there are other factors (e.g. utility, costs to replace light fixtures, design incompatibility) that may preclude or limit that shifting that may not be considered in DOE's analysis. (See section VII.3.c. and chapter 12 of the TSD for more details).

36. The Regulatory Flexibility Act (5 U.S.C. 601 et seq.) requires DOE to analyze the impact of its proposed standards on small entities, as well as any alternatives that accomplish the stated objectives of EPCA and minimize any significant economic impact of the proposed rule on small entities. DOE requests comment on the potential impacts to GSFL and IRL small businesses at the proposed efficacy levels. (See section VIII.B for further details.)

X. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of today's proposed rule.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, and Small businesses.

Issued in Washington, DC, on April 11, 2014.

David T. Danielson,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE proposes to amend 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. In § 430.2, add the definitions for ''700 series fluorescent lamp'', ''Designed and marketed,'' ''Fluorescent lamp designed for use in reprographic equipment,'' ''Impact-resistant fluorescent lamp,'' ''Lamps primarily designed to produce radiation in the ultra-violet region of the spectrum,'' ''Reflectorized or aperture lamp,'' in alphabetical order, and revise the definition for ''fluorescent lamp'' to read as follows:

§ 430.2 Definitions.

* * * * *

700 series fluorescent lamp means a fluorescent lamp with a color rendering index (measured according to the test procedures outlined in Appendix R to subpart B of this part) that is in the range (inclusive) of 70 to 79.

* * * * *

Designed and marketed means that the intended application of the lamp is stated in a publicly available document (e.g., product literature, catalogs, packaging labels, and labels on the product itself). This definition is applicable to terms related to the following covered lighting products: fluorescent lamp ballasts; fluorescent lamps; general service fluorescent lamps; general service incandescent lamps; incandescent lamps; incandescent reflector lamps; medium base compact fluorescent lamps; and specialty application mercury vapor lamp ballasts.

* * * * *

Fluorescent lamp means a low pressure mercury electric-discharge source in which a fluorescing coating transforms some of the ultraviolet energy generated by the mercury discharge into light, including only the following:

(1) Any straight-shaped lamp (commonly referred to as 4-foot medium bipin lamps) with medium bipin bases of nominal overall length of 48 inches and rated wattage of 25 or more;

(2) Any U-shaped lamp (commonly referred to as 2-foot U-shaped lamps) with medium bipin bases of nominal overall length between 22 and 25 inches and rated wattage of 25 or more;

(3) Any rapid start lamp (commonly referred to as 8-foot high output lamps) with recessed double contact bases of nominal overall length of 96 inches;

(4) Any instant start lamp (commonly referred to as 8-foot slimline lamps) with single pin bases of nominal overall length of 96 inches and rated wattage of 49 or more;

(5) Any straight-shaped lamp (commonly referred to as 4-foot miniature bipin standard output lamps) with miniature bipin bases of nominal overall length between 45 and 48 inches and rated wattage of 25 or more; and

(6) Any straight-shaped lamp (commonly referred to 4-foot miniature bipin high output lamps) with miniature bipin bases of nominal overall length between 45 and 48 inches and rated wattage of 44 or more.

* * * * *

Fluorescent lamp designed for use in reprographic equipment means a fluorescent lamp intended for use in equipment used to reproduce, reprint, or copy graphic material.

* * * * *

Impact-resistant fluorescent lamp means a lamp that

(1) Has a coating or equivalent technology that is compliant with NSF/ANSI 51 (incorporated by reference; see § 430.3) and is designed to contain the glass if the glass envelope of the lamp is broken; and

(2) Is designated and marketed for the intended application, with:

(i) The designation on the lamp packaging; and

(ii) Marketing materials that identify the lamp as being impact-resistant, shatter-resistant, shatter-proof, or shatter-protected.

* * * * *

Lamps primarily designed to produce radiation in the ultra-violet region of the spectrum mean fluorescent lamps that primarily emit light in the portion of the electromagnetic spectrum where light has a wavelength between 10 and 400 nanometers.

* * * * *

Reflectorized or aperture lamp means a fluorescent lamp that contains an inner reflective coating on the bulb to direct light.

* * * * *

■ 3. Section 430.32 is amended by revising paragraph (n) to read as follows:

§ 430.32 Energy and water conservation standards and their effective dates.

* * * * *

(n) *General service fluorescent lamps and incandescent reflector lamps.* (1) Except as provided in paragraphs (n)(2), (n)(3), and (n)(4) of this section, each of the following general service fluorescent lamps manufactured after the effective dates specified in the table shall meet or exceed the following lamp efficacy and CRI standards:

Lamp type	Nominal lamp wattage	Minimum CRI	Minimum average lamp efficacy lm/W	Effective date
4-foot medium bipin	>35 W	69	75.0	Nov. 1, 1995.
	≤35 W	45	75.0	Nov. 1, 1995.
2-foot U-shaped	>35 W	69	68.0	Nov. 1, 1995.
	≤35 W	45	64.0	Nov. 1, 1995.
8-foot slimline	>65 W	69	80.0	May 1, 1994.
	≤65 W	45	80.0	May 1, 1994.
8-foot high output	>100 W	69	80.0	May 1, 1994.
	≤100 W	45	80.0	May 1, 1994.

(2) The standards described in paragraph (n)(1) of this section do not apply to:

(i) Any 4-foot medium bipin lamp or 2-foot U-shaped lamp with a rated wattage less than 28 watts;

(ii) Any 8-foot high output lamp not defined in ANSI C78.81 (incorporated by reference; see § 430.3) or related supplements, or not 0.800 nominal amperes; or

(iii) Any 8-foot slimline lamp not defined in ANSI C78.3 (incorporated by reference; see § 430.3).

(3) Except as provided in paragraph (n)(4) of this section, each of the following general service fluorescent lamps manufactured after July 14, 2012, shall meet or exceed the following lamp efficacy standards shown in the table:

Lamp type	Correlated color temperature	Minimum average lamp efficacy lm/W
4-foot medium bipin	≤4,500K	89
	>4,500K and ≤7,000K	88
2-foot U-shaped	≤4,500K	84
	>4,500K and ≤7,000K	81
8-foot slimline	≤4,500K	97
	>4,500K and ≤7,000K	93
8-foot high output	≤4,500K	92
	>4,500K and ≤7,000K	88
4-foot miniature bipin standard output	≤4,500K	86
	>4,500K and ≤7,000K	81
4-foot miniature bipin high output	≤4,500K	76
	>4,500K and ≤7,000K	72

(4) Each of the following general service fluorescent lamps manufactured on or after [3 Years after Date of Publication of final rule in the **Federal Register**], shall meet or exceed the following lamp efficacy standards shown in the table:

Lamp type	Correlated color temperature	Minimum average lamp efficacy lm/W
4-foot medium bipin	≤4,500K	92.4
	>4,500K and ≤7,000K	90.6
2-foot U-shaped	≤4,500K	86.9
	>4,500K and ≤7,000K	84.3
8-foot slimline	≤4,500K	99.0
	>4,500K and ≤7,000K	94.1
8-foot high output	≤4,500K	97.6
	>4,500K and ≤7,000K	95.6
4-foot miniature bipin standard output	≤4,500K	97.1
	>4,500K and ≤7,000K	91.3
4-foot miniature bipin high output	≤4,500K	82.7
	>4,500K and ≤7,000K	78.6

(5) Except as provided in paragraphs (n)(6) and (n)(7) of this section, each of the following incandescent reflector lamps manufactured after November 1, 1995, shall meet or exceed the lamp efficacy standards shown in the table:

Nominal lamp wattage	Minimum average lamp efficacy lm/W
40–50	10.5
51–66	11.0
67–85	12.5
86–115	14.0
116–155	14.5
156–205	15.0

(6) Except as provided in paragraph (n)(7) of this section each of the following incandescent reflector lamps manufactured after July 14, 2012, shall meet or exceed the lamp efficacy standards shown in the table:

Rated lamp wattage	Lamp spectrum	Lamp diameter inches	Rated voltage	Minimum average lamp efficacy lm/W
40–205	Standard Spectrum	>2.5	≥125 V	$6.8*P^{0.27}$
			<125 V	$5.9*P^{0.27}$
		≤2.5	≥125 V	$5.7*P^{0.27}$
			<125 V	$5.0*P^{0.27}$
40–205	Modified Spectrum	>2 .5	≥125 V	$5.8*P^{0.27}$
			<125 V	$5.0*P^{0.27}$
		≤2.5	≥125 V	$4.9*P^{0.27}$
			<125 V	$4.2*P^{0.27}$

Note 1: P is equal to the rated lamp wattage, in watts.
Note 2: Standard Spectrum means any incandescent reflector lamp that does not meet the definition of modified spectrum in 430.2.

(7) Each of the following incandescent reflector lamps with the exception of BPAR, BR, and ER lamps manufactured on or after [3 Years after Date of Publication of final rule in the **Federal Register**], shall meet or exceed the following lamp efficacy standards shown in the table:

Rated lamp wattage	Lamp spectrum	Lamp diameter inches	Rated voltage	Minimum average lamp efficacy lm/W
40–205	Standard Spectrum	>2.5	≥125V	$7.1P^{0.27}$
			<125V	$6.2P^{0.27}$
		≤2.5	≥125V	$6.0P^{0.27}$
			<125V	$5.2P^{0.27}$
40–205	Modified Spectrum	>2.5	≥125V	$6.0P^{0.27}$
			<125V	$5.2P^{0.27}$
		≤2.5	≥125V	$5.1P^{0.27}$
			<125V	$4.4P^{0.27}$

Note 1: P is equal to the rated lamp wattage, in watts.
Note 2: Standard Spectrum means any incandescent reflector lamp that does not meet the definition of modified spectrum in 430.2.

(8)(i)(A) Subject to the exclusions in paragraph (n)(8)(ii) of this section, the standards specified in this section shall apply to ER incandescent reflector lamps, BR incandescent reflector lamps, BPAR incandescent reflector lamps, and similar bulb shapes on and after January 1, 2008.

(B) Subject to the exclusions in paragraph (n)(8)(ii) of this section, the standards specified in this section shall apply to incandescent reflector lamps with a diameter of more than 2.25 inches, but not more than 2.75 inches, on and after June 15, 2008.

(ii) The standards specified in this section shall not apply to the following types of incandescent reflector lamps:

(A) Lamps rated at 50 watts or less that are ER30, BR30, BR40, or ER40 lamps;

(B) Lamps rated at 65 watts that are BR30, BR40, or ER40 lamps; or

(C) R20 incandescent reflector lamps rated 45 watts or less.

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