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[6450-01-P]

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: Final rule.

SUMMARY: The Energy Policy and Conservation Act of 1975 (EPCA), as amended, prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including general service fluorescent lamps (GSFLs) and incandescent reflector lamps (IRLs). EPCA also requires the U.S. Department of Energy (DOE) to determine whether more-stringent standards would be technologically feasible and economically justified, and would save a significant amount of energy. In this final rule, DOE is adopting more-stringent energy conservation standards for GSFLs. It has determined that the amended energy conservation standards for these products would result in significant conservation of energy, and are

technologically feasible and economically justified. DOE concluded in this final rule that amending energy conservation standards for IRLs would not be economically justified.

DATES: The effective date of this rule is **[INSERT DATE 60 DAYS AFTER PUBLICATION DATE]**. Compliance with the amended standards established for GSFLs and IRLs in today's final rule is **[COMPLIANCE DATE].**

ADDRESSES: 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 webpage can be found at: www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/24 . The regulations.gov webpage will contain simple instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the docket, contact Ms. Brenda Edwards at (202) 586-2945 or by email: Brenda.Edwards@ee.doe.gov.

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SUPPLEMENTARY INFORMATION:

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I. Summary of the Final Rule and Its Benefits

Title III, Part B[1] of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Pub. L. 94-163 (42 U.S.C. 6291-6309, as codified), established the Energy Conservation Program for Consumer Products Other Than Automobiles.[2] These products include GSFLs and IRLs, the subject of this final rule.

Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Furthermore, the new or amended standard must result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)) In accordance with these and other statutory provisions discussed in this rule, DOE is adopting amended energy conservation standards for GSFLs. The amended standards, which are the minimum lumen output per watt of a lamp, are shown in Table I.1. These amended standards apply to all products listed in Table I.1, and manufactured in, or imported into, the United States on or after [INSERT DATE]. For IRLs, DOE considered an efficacy level (EL) as a means of increasing energy savings. However, based on the analyses presented in this final rule, DOE concluded that standards for IRLs are not economically justified and therefore, is not amending IRL standards. On July 14, 2009, DOE published a final rule in the Federal

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[1] For editorial reasons, upon codification in the U.S. Code, Part B was redesignated Part A.
[2] All references to EPCA in this document refer to the statute as amended through the American Energy Manufacturing Technical Corrections Act (AEMTCA), Pub. L. 112-210 (Dec. 18, 2012).

Register, which prescribed the current energy conservation standards for GSFLs and IRLs manufactured on or after July 14, 2012. 74 FR 34080.

Table I.1. Energy Conservation Standards for General Service Fluorescent Lamps (Compliance Starting [INSERT DATE])

Lamp Type	Covered Wattages W	Correlated Color Temperature Kelvin	Adopted Level lm/W*	Percent Increase Over Current Standards
4-Foot Medium Bipin	≥ 25 W	≤ 4,500 K	92.4	3.8
		> 4,500 K and ≤ 7,000 K	88.7	0.8
2-Foot U-Shaped	≥ 25 W	≤ 4,500 K	85.0	1.2
		> 4,500 K and ≤ 7,000 K	83.3	2.8
8-Foot Slimline	≥ 49 W	≤ 4,500 K	97.0	0.0
		> 4,500 K and ≤ 7,000 K	93.0	0.0
8-Foot Recessed Double Contact High Output	All	≤ 4,500 K	92.0	0.0
		> 4,500 K and ≤ 7,000 K	88.0	0.0
4-Foot Miniature Bipin Standard Output	≥ 25 W	≤ 4,500 K	95.0	10.5
		> 4,500 K and ≤ 7,000 K	89.3	10.2
4-Foot Miniature Bipin High Output	≥ 44 W	≤ 4,500 K	82.7	8.8
		> 4,500 K and ≤ 7,000 K	76.9	6.8

* A “lumen” is a measurement of the radiometric energy emission from a light source weighted by the response function of a human eye, called the photopic spectral luminous efficiency function, V(λ). Test procedures for measuring lumens are also specified at 10 CFR part 430, subpart B, appendix R.

A. Benefits and Costs to Consumers

Table I.2 presents DOE’s evaluation of the economic impacts of today’s standards on consumers of GSFLs, as measured by the average life-cycle cost (LCC) savings and the median payback period (PBP). The weighted-average LCC savings are positive for all product classes with amended standards.

Table I.2 Impacts of Energy Conservation Standards on Consumers of General Service Fluorescent Lamps

Product Class	Weighted-Average LCC Savings 2013$	Weighted-Average Mean Payback Period* years
4-foot medium bipin ≤ 4,500 K	5.98	3.1
4-foot T5 miniature bipin standard output ≤ 4,500 K	5.68	4.0
4-foot T5 miniature bipin high output ≤ 4,500 K	4.74	2.8
8-foot single pin slimline ≤ 4,500 K	0.00**	0.0**
8-foot recessed double contact HO ≤ 4,500 K	0.00**	0.0**

*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.
** Standards were not amended.

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 (2015 to 2047). Using a real discount rate of 9.2 percent, DOE estimates that the INPV for manufacturers of GSFLs is $1,551.6 million in 2013$. Under today's standards, DOE expects that manufacturers may lose up to 21.3 percent of their INPV, which is approximately $330.0 million. Additionally, based on DOE's interviews with the manufacturers of GSFLs, DOE does not expect any plant closings or significant loss of employment.

C. National Benefits[3]

DOE's analyses indicate that today's standards would save a significant amount of energy. The energy savings over the entire lifetime of GSFLs installed during the 30-

[3] All monetary values in this section are expressed in 2013 dollars and are discounted to 2014.

year period that begins in the year of compliance with amended standards (2018–2047), in comparison to the base case without amended standards, amount to 2.5 quadrillion Btu (quads)[4] for GSFLs. This represents a savings of 7.1 percent relative to the energy use of this product in the base case without amended standards. No savings are realized for IRLs, as DOE is not amending the standards for IRLs.

The cumulative net present value (NPV) of total consumer costs and savings of today's standards for GSFLs ranges from $2.0 billion (at a 7-percent discount rate) to $5.5 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 2018–2047.

In addition, today's standards for GSFLs would have significant environmental benefits. The energy savings from the 30-year product purchase period with today's standards, relative to the base case without amended standards, would result in cumulative greenhouse gas emission reductions of approximately 160 million metric tons (Mt)[5] of carbon dioxide (CO_2), 650 thousand tons of methane, 140 thousand tons of sulfur dioxide (SO_2), 230 thousand tons of nitrogen oxides (NO_X), 2.0 thousand tons of nitrous oxide (N_2O), and 0.43 tons of mercury (Hg).[6] The cumulative reduction in CO_2

[4] A quad is equal to 10^{15} British thermal units (Btu).
[5] A metric ton is equivalent to 1.1 short tons. Results for NO_X and Hg are presented in short tons.
[6] DOE calculated emissions reductions relative to the Annual Energy Outlook (AEO) 2014 Reference case, which generally represents current legislation and environmental regulations for which implementing regulations were available as of October 31, 2013.

emissions through 2030 amounts to 90 Mt, which is equivalent to the emissions associated with annual electricity use of approximately 12 million homes.

The value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 (otherwise known as the Social Cost of Carbon, or SCC) developed by a recent Federal interagency process.[7] The derivation of the SCC values is discussed in section VI.M.1. Using discount rates appropriate for each set of SCC values, DOE estimates that the net present monetary value of the CO_2 emissions reductions for GSFLs is between $1.36 billion and $17.6 billion, with a value of $5.72 billion using the central SCC case represented by $40.5/t in 2015.[8] DOE also estimates that the net present monetary value of the NO_X emissions reductions is $400 million at a 3-percent discount rate, and $240 million at a 7-percent discount rate.[9]

Table I.3 summarizes the national economic costs and benefits expected to result from today's standards for GSFLs.

Table I.3 Summary of National Economic Benefits and Costs of Amended Energy Conservation Standards for General Service Fluorescent Lamps*

Category	Present Value Billion 2013$	Discount Rate

[7] 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.
[8] The values only include CO_2 emissions, not CO_2 equivalent emissions; other gases with global warming potential are not included.
[9] DOE is currently investigating valuation of avoided Hg and SO_2 emissions for future rule makings.

Benefits		
Operating Cost Savings	11.2	7%
	18.9	3%
CO_2 Reduction Monetized Value ($12.0/t case)**	1.3	5%
CO_2 Reduction Monetized Value ($40.5/t case)**	5.72	3%
CO_2 Reduction Monetized Value ($62.4/t case)**	8.92	2.5%
CO_2 Reduction Monetized Value ($119/t case)**	17.6	3%
NO_X Reduction Monetized Value (at $2,684/ton)	0.24	7%
	0.40	3%
Total Benefits†	17.1	7%
	25.1	3%
Costs		
Incremental Installed Costs‡	9.17	7%
	13.5	3%
Including Emissions Reduction Monetized Value†	7.96	7%
	11.6	3%

* This table presents the costs and benefits associated with GSFLs shipped in 2018-2047. These results include impacts on consumers that accrue after 2047 from the products purchased in 2018-2047. 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 2013$, 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 incorporate an escalation factor.
† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to average SCC with 3-percent discount rate ($40.5/t case).

The benefits and costs of today's standards, for products sold in 2018-2047, 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 operating the product that meets the amended standard (consisting primarily of operating cost savings from using less energy, minus increases in product purchase prices 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.[10]

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, whereas the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and CO_2 savings are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of GSFLs shipped in 2018–2047. The SCC values, on the other hand, reflect the present value of all future climate-related impacts resulting from the emission of one metric ton of carbon dioxide in each year. These impacts continue well beyond 2100.

Estimates of annualized benefits and costs of today's standards for GSFLs are shown in Table I.4. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, for which DOE used a 3-percent discount rate along with the SCC series that has a value of $40.5/t in 2015, the cost of the standards in today's rule is $841 million per year in increased

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[10] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2014, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (e.g., 2020 or 2030), and then discounted the present value from each year to 2014. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates. Using the present value, DOE then calculated the fixed annual payment over a 30-year period, starting in the compliance year, that yields the same present value.

equipment costs, while the benefits are $1,030 million per year in reduced equipment operating costs, $310 million in CO_2 reductions, and $22.4 million in reduced NO_X emissions. In this case, the net benefit amounts to $516 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series that has a value of $40.5/t in 2015, the cost of the standards in today's rule is $724 million per year in increased equipment costs, while the benefits are $1,020 million per year in reduced operating costs, $310 million in CO_2 reductions, and $21.6 million in reduced NO_X emissions. In this case, the net benefit amounts to $627 million per year.[11]

[11] The annualized consumer operating cost savings, NO_X reduction monetized value, and consumer incremental product costs are higher with a 7-percent discount rate than with a 3-percent discount rate. This is in contrast to the present values in Table I.3. Under certain conditions, different present values may lead to similar annualized values when calculated with different discount rates. In this case, the combined effects of (a) projecting to 2018 the present values that DOE calculated in 2014, and (b) annualizing the projected values with 3 percent and 7 percent discount rates over the 30-year analysis period, lead to similar annualized values. For consumer incremental product costs, the effect is more pronounced because the time series covers only 30 years, instead of the longer period covered for operating cost savings and NO_X reduction monetized value.

Table I.4 Annualized Benefits and Costs of Amended Energy Conservation Standards for General Service Fluorescent Lamps*

	Discount Rate	Primary Estimate	LowNet Benefits Estimate	HighNet Benefits Estimate
		million 2013$/year		
Benefits				
Consumer Operating Cost Savings	7%	1,030	1,010	1,050
	3%	1,020	1,000	1,050
CO_2 Reduction Monetized Value ($12.0/t case) **	5%	97.5	97.1	97.5
CO_2 Reduction Monetized Value ($40.5/t case) **	3%	310	308	310
CO_2 Reduction Monetized Value ($62.4/t case) **	2.5%	448	446	448
CO_2 Reduction Monetized Value ($119/t case) **	3%	950	946	950
NO_X Reduction Monetized Value (at $2,684/ton)**	7%	22.4	22.3	22.4
	3%	21.6	21.5	21.6
Total Benefits†	7% plus CO_2 range	1,150 to 2,000	1,130 to 1,980	1,170 to 2,030
	7%	1,360	1,340	1,390
	3% plus CO_2 range	1,140 to 2,000	1,120 to 1,970	1,170 to 2,030
	3%	1,360	1,330	1,390
Costs				
Consumer Incremental Product Costs	7%	841	882	841
	3%	724	763	724
Net Benefits				
Total†	7% plus CO_2 range	300 to 1,160	241 to 1,090	328 to 1,180
	7%	516	452	540
	3% plus CO_2 range	415 to 1,270	350 to 1,200	443 to 1,300
	3%	627	561	655

* This table presents the annualized costs and benefits associated with GSFLs shipped in 2018−2047. These results include benefits to consumers that accrue after 2047 from the products purchased in 2018−2047. 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 Reference case energy prices from AEO 2014 and decreasing incremental product cost, due to price learning. The Low Benefits Estimate uses the Low Economic Growth energy prices from AEO 2014 and constant real product prices. The High Benefits Estimate assumes the Low Economic Growth energy

price estimates from AEO 2014 and the same decreasing incremental product costs as in the Primary Benefits Estimate.
** The CO_2 values represent global monetized values of the SCC, in 2013$, 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 the average SCC with 3-percent discount rate ($40.5/t case). In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

D. Conclusion

Based on the analyses culminating in this final rule, DOE found that for GSFLs the benefits to the nation of the standards (energy savings, consumer LCC savings, positive NPV of consumer benefit, and emission reductions) outweigh the burdens (loss of INPV and LCC increases for some users of these products). DOE has concluded that the standards in today's final rule represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in significant conservation of energy.

II. Introduction

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

A. Authority

Title III, Part B of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Pub. L. 94-163 (42 U.S.C. 6291-6309, as codified) established the Energy

Conservation Program for Consumer Products Other Than Automobiles, 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 further 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. (DOE notes that under 42 U.S.C. 6295(m), the agency must periodically review its already established energy conservation standards for a covered product. Under this requirement, the next review that DOE would need to conduct must occur no later than six years from the issuance of a final rule establishing or amending a standard for a covered product.)

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 amended standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)-(B)) In deciding whether an amended standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i)) DOE must make this determination after receiving comments on the proposed standard, and by considering, to the greatest extent practicable, the following seven statutory factors:

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

2. The savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered products that are likely to result from the 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 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. 6295(q)(1)) In determining whether a performance-related feature justifies a different standard for a group of products, DOE must consider such factors as the utility to the consumer of such a feature and other factors DOE deems appropriate. Id. Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 6295(q)(2))

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

Finally, pursuant to the amendments contained in section 310(3) of the Energy Independence and Security Act of 2007 (EISA 2007), any final rule for new or amended energy conservation standards promulgated after July 1, 2010, are required to address standby mode and off mode energy use. (42 U.S.C. 6295(gg) (3)) Specifically, when DOE adopts a standard for a covered product after that date, it must, if justified by the criteria for adoption of standards under EPCA (42 U.S.C. 6295(o)), incorporate standby mode and off mode energy use into 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 (EO) 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, "Regulatory Planning and Review," 58 FR 51735 (Oct. 4, 1993). 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 (OIRA) has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, DOE believes that today's final rule 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 adopted herein by DOE achieves maximum net benefits. For further discussion of how this rulemaking achieves maximum net benefits, see section VII.

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
	> 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	≥ 125 V[12]	$5.8{*}P^{0.27}$
			< 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.

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

2. Corrections to Codified Standards

In this final rule, DOE is correcting errors in the codified standards for GSFLs and IRLs. In particular, DOE is correcting 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 will 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 will read as follows:

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. 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 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.

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 website, 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[13] 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 website. The preliminary TSD included the results of the following preliminary analyses: (1) market and technology assessment; (2) screening analysis; (3) engineering analysis; (4) energy-use characterization; (5) product price determinations; (6) LCC and PBP analyses; (7) shipments analysis; and (8) national

[13] 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 in the Federal Register on September 14, 2011. 76 FR 56678. The framework document and public meeting information are available at regulations.gov under docket number EERE-2011-BT-STD-0006.

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. 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.

In April 2014, DOE published a notice of proposed rulemaking (NOPR) in the Federal Register proposing new and amended energy conservation standards for GSFLs and IRLs. 79 FR 24068 (April 29, 2014). In conjunction with the NOPR, DOE also published on its website the complete TSD for the proposed rule.[14] The NOPR TSD included updated results of the analyses conducted in the preliminary analysis stage as well as the following additional analyses: 1) LCC subgroup analysis, 2) manufacturer impact analysis (MIA), 3) employment impact analysis, 4) utility impact analysis, 5) emissions analysis, 6) monetization of emission reduction benefits, and 7) regulatory impact analysis (RIA). The NOPR TSD was accompanied by the LCC spreadsheet, the NIA spreadsheet, and the MIA spreadsheet—all of which are available on

[14] The NOPR TSD is available at regulations.gov under docket number EERE-2011-BT-STD-0006.

regulations.gov.[15] In the NOPR DOE invited comment on these analyses and related issues. DOE held a NOPR public meeting on May 1, 2014, to hear oral comments on and solicit information relevant to the proposed rule (hereafter the NOPR public meeting). DOE considered the comments received in response to the NOPR after its publication and at the NOPR public meeting when developing this final rule, and responds to these comments in this rule.

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).

[15] Supporting spreadsheets for the NOPR TSD are available at regulations.gov under docket number EERE-2011-BT-STD-0006.

a. 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 final rule TSD.

B. Technological Feasibility

1. General

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

After DOE has determined that particular technology options are technologically feasible, it further evaluates each technology option in light of the following additional screening criteria: (1) practicability to manufacture, install, and service; (2) adverse impacts on product utility or availability; and (3) adverse impacts on health or safety. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(ii)-(iv). 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 trial standard levels (TSLs) in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the final rule 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 efficacy 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 final rule TSD.) The max-tech levels that

DOE determined for this rulemaking are described in section VI.D.2.f and VI.D.3.d, respectively for GSFLs and IRLs, of this final 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 amended standards (2018–2047).[16] The savings are measured over the entire lifetime of products purchased in the 30-year analysis period.[17] 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 the standards case represents a projection of energy consumption if amended standards take effect. As described in section VI.I of this notice, the projections start from the current efficiency distribution on the market and consider various market forces, in addition to amended standards, that may affect future 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

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

[17] In the past DOE presented energy savings results for only 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 chosen to modify its presentation of national energy savings to be consistent with the approach used for its national economic analysis.

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 national energy savings in terms of the savings in the energy that is used to generate and transmit the site electricity. For electricity and natural gas and oil, DOE also calculates full-fuel-cycle (FFC) energy savings. As discussed in DOE's statement of policy and notice of policy amendment, 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. 76 FR 51281 (August 18, 2011), as amended at 77 FR 49701 (August 17, 2012).

To calculate this quantity, DOE derives annual conversion factors from the model used to prepare the Energy Information Administration's (EIA) most recent Annual Energy Outlook (AEO). For FFC energy savings, DOE's approach is based on the calculation of an FFC multiplier for the electricityused by covered products or equipment. For more information, see section VI.L.

2. Significance of Savings

To adopt standards for a covered product, DOE must determine that such action would result in "significant" energy savings. 42 U.S.C. 6295(o)(3)(B). Although the term "significant" is not defined in the Act, the U.S. Court of Appeals, in Natural Resources Defense Council v. Herrington, 768 F.2d 1355, 1373 (D.C. Cir. 1985), indicated that Congress intended "significant" energy savings in the context of EPCA to be savings that were not "genuinely trivial." The energy savings for today's adopted standards of 2.5 quads over a 30-year product purchase period (presented in section VII.B.3) 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 a potential amended standard on manufacturers, DOE conducts a MIA, as discussed in section VI.K. 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 based on 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 individual consumers, measures of economic impact include the changes in LCC and payback period (PBP) associated with new or amended standards. These measures are discussed further in the following section. For consumers in the aggregate, DOE also calculates the national net present value of the 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 are 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 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 are calculated relative to the baseline. DOE's LCC and PBP analysis is discussed in further detail in section VI.G.

c. Energy Savings

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

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)) Based on data available to DOE, the standards adopted in today's final rule would not reduce the utility or performance of the products under consideration in this rulemaking.

e. Impact of Any Lessening of Competition

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

f. Need for National Energy Conservation

In evaluating the need for national energy conservation, DOE expects that the energy savings from amended 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 amended standards also are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases primarily associated with fossil-fuel based energy production. DOE reports the emissions impacts from today's standards, and from each TSL it considered, in section VII.B.6 of this notice. DOE also reports estimates of the economic value of emissions reductions resulting from the considered TSLs, as discussed in section VII.B.7.

g. Other Factors

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

2. Rebuttable Presumption

As set forth in 42 U.S.C. 6295(o)(2)(B)(iii), EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effect potential amended energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the nation, and the environment, as required under 42 U.S.C. 6295(o)(2)(B)(i). The results of this analysis serve as the basis for DOE's evaluation of the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). The rebuttable-presumption payback calculation is discussed in section VII.B.1.a of this final rule.

IV. Issues Affecting Rulemaking Schedule

DOE received several comments on the rulemaking schedule. Appliance Standards Awareness Project (ASAP) and the Energy Efficiency Organizations (EEOs) supported the rulemaking schedule as presented in the NOPR. However, ASAP noted that DOE missed the legally required legislative deadline and urged DOE not to push the rulemaking any later than planned. (ASAP, Public Meeting Transcript, No. 49 at p. 29[18]; EEOs, No. 55 at p. 2)

Sofie E. Miller commented that the 2009 Lamps Rule required compliance on July 14, 2012 and for certain GSFL product classes, many manufacturers were granted a stay of enforcement, which is still in effect. Therefore, the full impact of the 2009 Lamps Rule on the lighting market is unknown. Further, Miller noted that manufacturers have expressed concern that the short period between the rulemakings will have a severe and negative impact on manufacturers, who may not be able to recover investments in new technologies or to develop products meeting even higher standards than those in the 2009

[18] A notation in this form provides a reference for information that is in the docket of DOE's rulemaking to develop energy conservation standards for GSFLs and IRLs (Docket No. EERE–2011–BT–STD–0006), which is maintained at www.regulations.gov. This notation indicates that the statement preceding the reference is document number 49 in the docket for the GSFL and IRL energy conservation standards rulemaking, and appears at page 29 of that document.

Lamps Rule. While DOE is statutorily required to make a determination about whether to update these standards, it may make the most sense for DOE to delay proposing new standards until the full effect of its previous standards is known, and DOE should initiate that process by conducting a retrospective review of the 2009 Lamps Rule. (Miller, No. 50 at p. 10)

DOE is conducting this rulemaking to satisfy the EPCA requirement for a second review of the GSFL and IRL standards that were finalized in the 2009 Lamps Rule and required compliance July 2012. DOE understands that Office of Hearing and Appeals (OHA) has granted 16 manufacturers 2-year waivers from standards for their 700 series T8 products that expire in 2014. Because standards from this rulemaking would become effective after these waivers granted to individual manfacturers have expired and the products granted waivers would be subject to standards, DOE has conducted its analysis assuming that the waivers will not be in place. Further, at the time of the analysis of the final rule, most of the waivers had expired and not been renewed.

Regarding this rulemaking assessing the full impact of the 2009 Lamps Rule, the analysis in this final rule was updated and finalized almost two years after the July 2012 standards required compliance, reflecting the most recent data available. DOE conducted a survey of product offerings for this final rule and identified a few new covered products since the NOPR analysis which were included in this final rule analysis. Therefore, DOE finds that the analysis in this final rule adequately assesses and captures the impacts of the July 2012 standards for these products and sees no reason to delay in adopting the appropriate standards resulting from it and requiring compliance three years after the publication of the 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, 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 ultraviolet 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. Using product literature and industry reference sources, DOE proposed clarifications of these exemptions in the NOPR. DOE did not receive any comments on the proposed clarifications. However, the National Electrical Manufacturers Association (NEMA) did state that they support all existing exemptions for fluorescent products. (NEMA, No. 54 at p. 11) DOE therefore is maintaining the clarifications to the exemption definitions.

Additionally, DOE proposed 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). In the NOPR DOE had specified the lamp types to which the proposed definition should apply as follows: 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. In this final rule, in addition to these lamp types, the definition will also apply to "general service lamps" which are also a lamp type covered by DOE.

The term "designed and marketed" is also used in the general service fluorescent lamp definition which specifies that all lamp types exempted must be "designed and marketed" for the nongeneral application they are intended to serve. One of these exemptions is lamps with a CRI of 87 or greater (hereafter "high CRI lamps").

The California Investor Owned Utilities (CA IOUs) commented that the definition of 'designed and marketed' should relate to the way products are represented in the marketplace and might be utilized. (CA IOUs, Public Meeting Transcript, No. 49 at p. 28) EEOs predicted that DOE's method of adding a definition of "designed and marketed," as proposed in the NOPR, would do nothing to prevent or dissuade manufacturers from continuing to sell high CRI lamps as inexpensive, extremely inefficient alternatives to GSFLs subject to federal standards. (EEOs, No. 55 at pp. 2-4) EEOs and the National Energy Efficiency Partnership (NEEP) commented that the exemption for high CRI GSFLs is a loophole that is undercutting the current federal standards and, if not addressed, would undercut the standards ultimately adopted by this rulemaking. EEOs, NEEP, and Earthjustice reported that they have encountered numerous examples of high CRI lamps that are being marketed as suitable general service lamps. NEEP noted that the market responded to the 2009 Lamps Rule by increased offerings of high CRI T12 lamps. These products offer no energy savings and in the case of full-wattage 40 W lamps, actually increase energy usage. EEOs found that almost all of the 4ft T12 bipin GSFLs sold online were high CRI, costing as little as $1.50 per lamp when sold in multi-packs and having efficacy ratings as low as 54 lm/W. Compared to the 92.4 lm/W proposed in the NOPR for lamps at or below a correlated color temperature (CCT) of 4,500 K, EEOs calculated that a single high CRI 2600 lumen lamp, with an average rated life of 36,000 hours, could use 720 kWh more than a regulated lamp over the course of its life. (EEOs, No. 55 at pp. 2-4; NEEP, No. 57 at pp. 2-3; Earthjustice, Public Meeting Transcript, No. 49 at p. 27; Earthjustice, No. 52 at pp. 1-3)

ASAP commented that DOE consider what modifications to the high CRI definition could be made to address the use of high CRI lamps in general service applications. (ASAP, Public Meeting Transcript, No. 49 at pp. 28-29) Earthjustice also noted that a high CRI lamp marketed for general lighting applications but fails to meet federal minimum efficacy levels would be violating energy conservation standards and the marketing claims may constitute an unfair or deceptive act or practice in violation of section 5(a)(1) of the Federal Trade Commission Act, 15 U.S.C. § 45(a)(1). Earthjustice stated that DOE should work with the Federal Trade Commission to develop guidance on the appropriate marketing of high CRI fluorescent lamps. Earthjustice suggested that DOE should also investigate whether high CRI lamps meet EPCA's thresholds for coverage and energy conservation standards. (Earthjustice, No. 52 at pp. 3-4)

The definition of "designed and marketed" adopted in today's rule refers to how the lamp is represented in the market and should be utilized by consumers. DOE believes that within the scope of this rulemaking it is implementing the appropriate changes in the CFR to clarify the exemption of high CRI products. It is not within the scope of DOE's authority in this rulemaking to modify the thresholds set by the current CRI exemptions for GSFLs.

Earthjustice commented the proposed definition of "designed and marketed" states that the intended application must be specified in a public document rather than all public documents. Earthjustice noted this as a problem specifically for high CRI lamps as it would allow manufacturers to explain the high CRI application in one document while still marketing the product as for general lighting applications in other documents. Earthjustice suggested, and EEOs concurred, that DOE should revise the definition of "designed and marketed" to provide that "the intended application of the lamp is clearly and conspicuously stated in all publicly available documents (e.g., product literature, catalogs, packaging labels, and labels on the product itself)." (Earthjustice, No. 52 at pp. 3-4; EEOs, No. 55 at pp. 2-4)

DOE agrees that the definition proposed in the NOPR for "designed and marketed" can be strengthened and therefore, in this final rule will add the word "clearly," and specify "all publicly available documents" so it reads "means that the intended application of the lamp is clearly stated in all publicly available documents (e.g., product literature, catalogs, and packaging labels)." DOE believes that it is important that all public disclsures be consistent about the intended use or application of the lamp. In addition, DOE notes that the Federal Trade Commision prescribes certain energy-related labels for lighting products, such as general service fluorescent lamps and DOE will also consider those labels along with any other voluntary marking the manufacturers currently put on their lamps when determining whether a particular lamp is "designed" and "marketed" for a specific application. DOE reiterates that it is not adopting any new labeling requirements for lamps covered by this rulemaking.

A. General Service Fluorescent Lamp Scope of Coverage

1. Additional General Service Fluorescent Lamp Types

In this rulemaking, DOE evaluated 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 GSFL that meets these criteria, DOE then assessed 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. Using the miscellaneous category of fluorescent lamps reported by the 2010 U.S. Lighting Market Characterization[19] (2010 LMC), DOE determined that the market share and energy consumption for these lamps was not substantive. The 2010 LMC's miscellaneous category composed 2.1 percent of lighting and consumed 4 terrawatt-hours (TWh) of electricity in 2010. Circline lamps are only a portion of the miscellaneous category, which also includes all fluorescents other than T5 linear and T8 and T12 linear and U-shaped lamps, as well as fluorescent lamps with unknown characteristics. Interviews with manufacturers also confirmed the low market share of these lamp types. Therefore, DOE 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 MBP lamps with lengths less than 4 feet, according to the 2010 LMC, these

[19] 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.

lamps comprised about 0.7 percent of the linear fluorescent lamp market and 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.

NEMA supported DOE’s decision not to include additional lamp types, such as 2-foot linear lamps, in the scope of the regulation agreeing that such lamps have low sales volume and low energy use. (NEMA, No. 54 at p. 11) ASAP stated it understood DOE’s reasoning for not covering 2-foot linear fluorescent lamps based on the 2010 LMC. However, ASAP noted and CA IOUs concurred that 2-foot lamps is a growing market and that DOE should address this in the final rule. (ASAP, Public Meeting Transcript, No. 49 at pp. 19-20; CA IOUs, Public Meeting Transcript, No. 49 at p. 20)

EEOs and CA IOUs commented that DOE should include and set efficacy standards for 2-foot linear lamps as part of the rulemaking, finding DOE’s assertion that linear fluorescent lamps shorter than 4 feet do not comprise a sufficiently large share of annual lamp sales and energy use to warrant coverage unconvincing. EEOs argued that DOE used outdated shipment data from the 2010 LMC, which was not specific to 2-foot linear GSFLs, to estimate sales and energy savings potential. EEOs and CA IOUS stated as this data was gathered prior to the effective date of the last round of GSFL standards it does not include the market impact from these standards. Further, EEOs and CA IOUs voiced concern over DOE’s continued use of the 2010 LMC data instead of the newer shipment data from Vermont and California. CA IOUs noted that in Vermont study (2011

Vermont Market Characterization and Assessment Study[20]), 2-foot lamps were by far the most common lamp length behind 4-foot lamps, and more common than many of the other product classes currently being covered by standards. While EEOs recognized that this data only represents a small portion of the overall lighting market, EEOs stated that using the field survey is better than relying on unreliable and outdated information from the 2010 LMC. (EEOs, No. 55 at pp.5-6; CA IOUs, No. 56 at p. 4)

DOE found using the 2010 LMC data to determine whether the 2-foot linear fluorescent lamps have a substantial market share and could result in significant energy savings is more accurate than relying on data from the Vermont study. The Vermont study is specific to a region and states that it was intended to develop the baseline data that characterizes the existing building and equipment stock in the Vermont business sector and covers the period of July 2011 to July 2012.[21] The study uses on-site surveys of 120 existing buildings for its primary data.[22] The 2010 LMC study captures all lighting installed in the U.S. in stationary applications during 2010.[23] The 2010 LMC groups linear fluorescent lamps by shape and length, and DOE used the T8 lamps with lengths less than 4 feet category to assess the 2-foot linear fluorescent market. Therefore, because this category includes more than just the 2-feet lengths, DOE's market estimates for the

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[20] 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

[21] 2011 Vermont Study, 1

[22] 2011 Vermont Study, 3

[23] 2010 LMC Study, 2

2-foot linear fluorescent lamps are likely conservative. Further, the 2009 Lamps Rule became effective September 14, 2009 and required compliance July 14, 2012. Therefore, the Vermont study that was executed before compliance was required does not offer any added benefit.

CA IOUs noted that when using the 2010 LMC data, DOE excluded 2-foot T12 lamps from its total on the premise that the market will likely shift away from T12s due to strengthened ballast standards. CA IOUs agreed that the market will shift away from T12s, however, they predicted that all of these lamp sales would likely become 2-foot T8 sales. DOE therefore should have counted 2-foot T12 shipments towards the total 2-foot lamp estimates. (CA IOUs, No. 56 at p. 4)

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.[24] 76 FR 70548 (Nov. 14, 2011). Due to these standards and because historical shipments of most T12 lamps have been decreasing steadily, a trend confirmed in manufacturer feedback from interviews, DOE determined the market will likely shift away from T12 lamps. However, even if there were a shift from 2-foot linear T12 to 2-foot linear T8 lamps it would not be significant,

[24] 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.

as the T12 lamps with lengths less than 4 feet comprise only 0.6 percent of the linear fluorescent market and 0.2 percent of all installed lighting.

EEOs reflected further on DOE's argument that 2-foot linear GSFLs are uncommon and not a large percentage of the lighting market. While EEOs agreed it is undoubtedly true that 2-foot linear GSFLs sell in much smaller volumes than 4-foot GSFLs, EEOs contended and CA IOUs agreed that regulating 2-foot linear GSFLs sales that are a small fraction of the volume of the 4-foot GSFLs lamps could still yield significant energy savings, especially as the baseline 2-foot linear lamps are extremely inefficient. Specifically, for 2-foot linear fluorescent lamps, EEOs found efficacies of 58 lm/W for T12 lamps, 77 lm/W for standard T8 lamps, and 88 lm/W for more efficient T8 lamps. By comparison, 2-foot U-shaped GSFLs which are subject to current standards have efficacies that range from 85 to 94 lm/W. (EEOs, No. 55 at pp.5-6; CA IOUs, No. 56 at p. 4) EEOs noted that in interviews, manufacturers told DOE that 2-foot linear GSFLs are used in kitchens, bathrooms, vanity lighting, hospitality applications, cabinets, and to round out edges of ceilings in commercial spaces, and the Edison Electric Institute had noted that these lamps are used in task lighting. EEOs and CA IOUs additionally argued that many 2x2 fixtures are retrofitted to 2-foot linear lamps, replacing existing U-bend lamps. EEOs also cautioned that following the exemption of certain ER and BR IRLs from standards, the sales of ER, BR lamps increased. EEOs suggested that DOE may be making the same mistake by not covering 2-foot linear GSFLs. (EEOs, No. 55 at pp.5-6)

In order to extend the scope to an additional lamp type, DOE must consider the potential energy savings that would result from regulating the lamp type under consideration. (42 U.S.C. 6295(o)) Based on its assessment of market share, trends, and product offerings, DOE does not find that significant energy savings will result from a standard for 2-foot linear fluorescent lamps.

DOE's review of 2-foot fluorescent lamp product offerings indicated that the majority of T8 products are offered in 17 W with minimal reduced wattage options and the T12 products are offered in 20 W. Therefore, any likely savings from standards would come from more efficacious T8 systems replacing T12 systems. However, as noted previously, the 2011 Ballast Rule enacts standards that will be difficult for T12 ballasts to meet and likely result in a shift away from T12 products.

As mentioned, using the relevant data in the 2010 LMC and observing the limited product offerings, DOE determined that the market share for 2-foot linear fluorescents is very low. Additionally, DOE compared the market share reported for the less than 4 feet T8 lamps in 2000 LMC compared to the 2010 LMC. From 2000 to 2010 the market of less than 4 feet T8 lamps declined from 1.5 to 0.7 percent of the linear fluorescent market and 0.5 to 0.2 percent of the entire lighting market. Further, the inventory of less than 4 feet T8 lamps declined by about 52 percent from 2000 to 2010 based on the LMC reports for those years. Therefore, DOE finds that the 2-foot linear lamps not only currently comprise a low market share but will likely not experience growth and therefore, will not result in significant energy savings.

Regarding a potential shift to the 2-foot linear lamps, while manufacturer feedback noted the applications in which 2-foot linear lamps can be utilized, it also indicated that the market share of the 2-foot linear fluorescent lamps was not likely to increase. Further, the noted applications such as cabinets or hospitality lighting indicate that this lamp type is used in specific spaces and therefore would likely have limited growth in market share.

Therefore, DOE maintains its conclusion not to include the 2-foot linear fluorescent lamp type in the scope of this rulemaking.

2. Additional General Service Fluorescent Lamp Wattages

DOE specifies a certain minimum wattage for lamp types 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. In the NOPR, DOE proposed extending coverage to the following reduced wattage lamps: 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. 79 FR at 24085 (April 29, 2014) 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. These reduced wattage lamps are generally more efficacious than their full-wattage counterparts are and offer the potential for increased energy savings. DOE did not receive any comments regarding the proposed additional wattages for inclusion in GSFL scope in response to the NOPR.

Therefore, DOE is extending coverage to the following GSFLs in the final rule:

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

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 referred to collectively as certain R, ER, and BR 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 322 of Public Law (Pub. L.) 113-76 (January 17, 2014) (hereafter, "Consolidated Appropriations Act, 2014"), which prohibits DOE from using appropriated funds to implement or enforce standards for ER, BR, and BPAR IRLs. DOE received several comments on the exclusion of the certain R, ER, BR lamps from this rulemaking and DOE's interpretation of the Consolidated Appropriations Act, 2014.

NEMA stated its support for all existing exemptions for IRL products and agreed with DOE's approach to address exempted BR lamps in a separate rulemaking when funding is available. (NEMA, No. 54 at p. 10-11) Earthjustice, however, commented DOE is obligated to include the certain R, ER, and BR IRLs in this rulemaking. Earthjustice remarked that DOE's determination that these IRLs are covered by the directive in 42 U.S.C. 6295(i)(3) to amend EPCA's standards should extend to 42 U.S.C. 6295(i)(4) under which this rulemaking is being concluded. Therefore, the exempt lamps should be a part of this rulemaking. (Earthjustice, No. 52 at p. 4) Earthjustice further commented that because the Consolidated Appropriations Act, 2014 is clearly inapplicable to R20 IRLs rated 45 W or less, DOE should adopt standards for those lamps. (Earthjustice, No. 52 at p. 5)

DOE is not including the certain R, ER, and BR IRLs in this rulemaking as it has commenced another rulemaking to address standards for these lamps. At the time DOE determined that it has the authority under EPCA to adopt standards for these R, ER, and BR IRLs, as they are covered by the directive in 42 U.S.C. 6295(i)(3), the first cycle of rulemaking to amend standards for IRLs per 42 U.S.C. 6295(i)(3) was already underway. Therefore, DOE initiated a separate rulemaking for the R, ER, and BR IRLs which included publishing a framework document and holding a public meeting, prior to the initiation of this rulemaking. Additionally, the Consolidated Appropriations Act, 2014 precludes DOE from engaging in a rulemaking involving certain ER, and BR IRLs. While DOE agrees that implementation or enforcement of standards for R IRLs are not prohibited by the Consolidated Appropriations Act, 2014, the R20 IRLs rated 45 W or less are already the subject of a separate rulemaking. Due to the progress of that rulemaking, DOE did not find it appropriate to remove the R20 IRLs rated 45 W or less from the scope of that rulemaking.

CA IOUs, NEEP, Earthjustice and EEOs noted that they do not agree with DOE's interpretation of the Consolidated Appropriations Act, 2014 and urged DOE to include all covered IRLs in this rulemaking, including the ER, BR, and BPAR lamps noted in the Act. (CA IOUs, No. 56 at p. 5; NEEP, No. 57 at p. 1; EEOs, No. 55 at p.7; Earthjustice, No. 52 at p. 5) Earthjustice commented that nothing in the text of the Act prevents DOE from using appropriated funds to adopt standards that are different from those shown in the tables in section 325(i)(1)(B). Earthjustice stated that even if DOE believes that adopting standards stronger than those in the tables would implicitly also apply standard levels blocked by the Act (in that DOE would be applying standards to remove from the market lamps that Congress allegedly sought to protect), DOE could certainly adopt standards weaker than those applied in EPAct 1992. Such standards would still represent a significant improvement in efficacy, and under the current funding constraints, may represent the maximum improvement in energy efficiency that is feasible. (Earthjustice, No. 52 at p. 5)

EEOs stated that the Consolidated Appropriations Act, 2014 only prevents DOE from using funds to implement or enforce standards contained in the tables in section 325(i)(1)(B) and not from implementing or enforcing standards developed in response to a separate congressionally required rulemaking. (EEOs, No. 55 at p.7) CA IOUs stated that EISA 2007 requires DOE to consider revising standards for these products. (CA IOUs, No. 56 at p. 5)

CA IOUs also noted that by omitting these products, the total savings potential from IRL standards is greatly minimized as standards for covered IRLs may result in more expensive, higher performing covered products and low cost, low efficacy unregulated products. CA IOUs and NEEP commented that these unregulated lamps would result in major loopholes as consumers could be incented to utilize less efficient IRLs, ultimately sacrificing significant energy savings to the country. (CA IOUs, No. 56 at p. 5; NEEP, No. 57 at p. 1) ASAP stated and was supported by CA IOUs that consumers currently have a choice between a very efficient light-emitting diode (LED), a very efficient incandescent covered lamp or a very inefficient 65 W BR or equivalent lamp. Therefore, addressing this loophole could lead to annual savings of half a billion dollars. (ASAP, Public Meeting Transcript, No. 49 at pp. 16-17)

The Consolidated Appropriations Act, 2014 prohibits expenditure of funds appropriated by that law to implement or enforce standards for BPAR, BR, and ER IRLs. Thus, DOE is not considering these specific lamps in this rulemaking.

2. Incandescent Reflector Wattages

In this rulemaking, DOE also did 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)) Additionally, while the definition of IRLs does not provide an upper wattage limit, DOE did not assess covered IRLs higher than 205 W in the NOPR. 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. DOE did not receive any comments on this assessment in response to the NOPR and therefore, analyzes the same wattage range for IRLs in this final rule.

D. Summary of Scope of Coverage

In conclusion, in this rulemaking DOE is extending the scope of coverage for GSFLs to certain wattages including 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 but not to additional GSFL types. Further, DOE is 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. DOE is also adopting a definition for "designed and marketed" as it applies to all covered lighting products.

VI. Methodology and Discussion

In the NOPR phase of this rulemaking, DOE conducted the following analyses: a market and technology assessment, screening analysis, engineering analysis, product price determination, energy-use characterization, LCC and PBP analyses, an LCC subgroup analysis, shipments analysis and NIA, 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. These analyses were then updated and revised as appropriate based on feedback received for this final rule.

DOE used four spreadsheet tools to estimate the impact of standards analyzed in the NOPR. The first tool ("Life-Cycle Cost [LCC] Analytical Tool") calculates LCCs and payback periods of potential new energy conservation standards. The second tool ("National Impact Analysis [NIA] Analytical Tool") is a spreadsheet that provides shipments forecasts and a framework that calculates national energy savings and net present value resulting from potential amended energy conservation standards. DOE assessed manufacturer impacts, largely through use of the "Government Regulatory Impact Model (GRIM)", the third tool. Additionally, DOE used output from the latest version of EIA's National Energy Modeling System (NEMS) for the emissions and utility impact analyses. NEMS is a public domain, multi-sector, partial equilibrium model of the U.S. energy sector. EIA uses NEMS to prepare its <u>Annual Energy Outlook</u> (<u>AEO)</u>, a widely known energy forecast for the United States.

NEMA voiced concerns about the number of assumptions that DOE uses in the NOPR that are not being tested by retrospectively evaluating predictions made in the 2009 Lamps Rule in order to improve DOE's predictive analysis and to tune DOE's models. (NEMA, No. 54 at p. 17)

As needed, DOE makes assumptions based on the current relevant data and research available, feedback from manufacturer interviews, and stakeholder comments, information that is informed by the impacts of the 2009 Lamps Rule. Further, in the NOPR analysis and in this final rule analysis DOE has taken appropriate steps to ensure that its models provide the most accurate assessment of standards and their impacts. In the following sections, DOE discusses its methodology and responds to comments specific to each analysis. DOE further provides details regarding its analysis including assumptions in the final rule TSD.

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 NOPR analysis. 79 FR at 24087-24090 (April 29, 2014). For further details on the technology options and the screening process, see, respectively, chapters 3 and 4 of the NOPR TSD.

Osram Sylvania (OSI) commented that many of the GSFL and IRL technology options are already being used by manufacturers, so they should not be considered technology options. (OSI, Public Meeting Transcript, No. 49 at pp. 46-47) Based on DOE research, the technology options put forth in this rulemaking for GSFLs and IRLs all remain tools manufacturers can use to increase the efficacy of the lamp. Because lamps are present on the market at different efficacy levels, it is evident that not all the technology options are being used by all manufacturers and/or are not being used to their optimal performance. Therefore, with the exception of the IRL technology options of efficient filament orientation and efficient filament coiling, which are discussed in greater detail in section VI.A.2, DOE continues to consider the technology options put forth in the NOPR as means to improve the efficacy of GSFLs and IRLs.

1. General Service Fluorescent Lamp Technology Options

DOE received comments specific to the GSFL technology options put forth in the NOPR analysis. Specifically, DOE received a comment on highly emissive coatings, fill gas compositions, and higher efficiency phosphors.

a. Highly Emissive Coatings

DOE identified highly emissive coatings as a technology option to increase GSFL efficacy in the NOPR. When electrons are more easily emitted from the fluorescent lamp electrodes, a lower voltage is needed to maintain the arc. Therefore, any improvement in electrode coating that would allow electrons to be more easily removed from the electrodes would reduce the lamp power and increase the overall efficacy of the lamp. See chapter 3 of the final rule TSD for further details.

General Electric (GE) commented that highly emissive coatings are already being used to meet the current requirements of the 2009 Lamps Rule, so it is not logical to cite this as a technology options again. (GE, Public Meeting Transcript, No. 49 at pp. 48-49)

DOE found that there are various coatings and combinations that can be used to increase lamp efficacy. Conventional coatings include barium oxide (BrO), calcium oxide (CaO), and strontium oxide (SrO), sometimes paired with the addition of zirconium oxide (ZrO) which is used to extend lamp lifetime, and silicon carbide (SiC) which removes more electrons from the electrode. Because lamps are present on the market at more than one level of efficacy, and highly emissive electrode coating technology can be optimized in different variations, it provides a mechanism to improve the efficacy of less efficacious products (see chapter 3 of the final rule TSD for more information). Therefore, DOE retained highly emissive electrode coating as a technology option for this final rule.

b. Higher Efficiency Lamp Fill Gas Composition

DOE also identified higher efficiency lamp fill gas composition as a technology option to increase GSFL efficacy in the NOPR. Lamp fill gases in fluorescent lamps increase mobility of mercury ions and electrons, facilitating recombination and resulting in increased ultraviolet (UV) output and higher lamp efficacy. See chapter 3 of the final rule TSD for further details.

GE commented that higher efficiency gas fill composition is already being used to meet the current requirements of the 2009 Lamps Rule, so it is not logical to cite this as a technology option again. (GE, Public Meeting Transcript, No. 49 at pp. 48-49)

Based on feedback from manufacturers in interviews, there are different types and ratios of fill gases that can be used to improve lamp efficacy. Because lamps are present on the market at more than one level of efficacy, and fill gas compositions can be optimized in different combinations, they provide a mechanism to improve the efficacy of less efficacious products. Therefore, DOE retained higher efficiency fill gas composition as a technology option for this final rule.

c. Higher Efficiency Phosphors

DOE also identified higher efficiency phosphors as a technology option to increase GSFL efficacy in the NOPR. 79 FR at 24088 (April 29, 2014). Triband phosphors which contain rare earth elements are more efficient phosphors that allow a lamp to emit light at the wavelengths to which human eyes are most sensitive which increases lamp efficacy. This effect is impacted by the relationship between the efficiency losses in the phosphor’s conversion of light, wavelengths sensitive to the human eye, and measurement of lamp efficacy. Generally, as thickness of the phosphor layer (also called phosphor weight) increases, lamp light output increases until it slightly decreases or stays flat. (See chapter 3 of the final rule TSD for further details).

NEMA stated that options to increase phosphor weight are essentially exhausted at the proposed efficacy level because it is near the peak of the coating weight/light output curve shown in figure 3.4.5 of chapter 3 of the NOPR TSD. (NEMA, No. 54 at pp. 22-23)

As noted, phosphor weight utilized in a lamp impacts the efficacy achieved. Because lamps are present on the market at more than one level of efficacy, varying weights of higher efficiency phosphor coatings is an option that can be utilized to improve the efficacy of less efficacious products. Therefore, DOE maintained higher efficiency phosphors as a technology option for this final rule.

d. Summary of GSFL Technology Options

In summary, in this final rule analysis, DOE identified technology options for GSFLs listed in Table VI.1.

Table VI.1. GSFL Technology Options in the Final Rule 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 NOPR. Id. at 24088-24090. Specifically, DOE received comments on thinner filaments, efficient filament coiling, efficient filament orientation, higher efficiency inert fill gases, higher pressure tungsten-halogen lamps, infrared glass coatings, efficient filament placement, and integrally ballasted low voltage lamps.

a. Thinner Filaments

In the NOPR analysis, DOE proposed thinner filaments as a technology option for increasing IRL efficacy. Id. at 24089. A thinner filament has an increased resistance and therefore an increased operating temperature, which increases the lamp efficacy. (See chapter 3 of the final rule TSD for further details.) NEMA commented that thinner filaments mean longer filaments, which reduce efficacy by defocusing the light source inside the reflector. (NEMA, No. 54 at p. 20)

DOE's research did not find any information indicating that the loss in efficacy due to the potentially defocused light with a longer filament outweighs the gain obtained by running a thinner filament at a higher temperature. Additionally, a longer filament would increase lumen output. DOE acknowledges that when utilizing a thinner filament as a technology option, other factors must be considered, such as the length of the filament required to implement the technology in its most optimal form. However, this does not preclude it as a technology option as use of it in the appropriate manner can increase IRL efficacy. Therefore, DOE maintained the use of thinner filaments as a technology option that can be manipulated to increase lamp efficacy for this final rule.

b. Efficient Filament Coiling

DOE proposed efficient filament coiling in the NOPR analysis as a technology option to increase lamp efficacy. Id. at 24089. Coiling of the incandescent lamp filament can increase luminous efficacy. The light output of an incandescent lamp is directly proportional to the light-emitting surface area of the light source. By coiling the filament, a longer filament can be used, increasing luminous output and therefore lamp efficacy. (See chapter 3 of the final rule TSD for further details.) NEMA stated that efficient filament coiling, which is necessary for efficient optics and beam patterns, is already common practice in the majority of halogen IRLs. Thus, no further efficacy increase is possible with this technology option. (NEMA, No. 54 at p. 20)

DOE research indicates that specifications of commercially available IRLs covered in this rulemaking state that the optimal coiling configuration, the CC (coiled coil) is being used. Therefore, DOE removed efficient filament coiling as a technology option that can be used to improve the efficacy of lamps on the market for this final rule.

c. Efficient Filament Orientation

DOE proposed efficient filament orientation in the NOPR analysis as a technology option to increase lamp efficacy. Id. Tungsten filaments in incandescent lamps can be positioned horizontally or vertically with respect to the base of the bulb. By positioning the filament in vertical alignment, only a small portion of the light is emitted towards the base, allowing more light to escape the bulb and be used for illumination, thereby increasing lamp efficacy. (See chapter 3 of the final rule TSD for further details.) NEMA commented that efficient filament orientation, which is necessary for efficient optics and beam patterns, is already common practice in the majority of halogen IRLs, noting that manufacturers already strive to accomplish this and thus, no further efficacy increase is possible with this technology option. (NEMA, No. 54 at p. 20)

DOE recognizes that filaments are placed in the vertical position which is optimal for commercially available IRLs covered in this rulemaking. Therefore, DOE removed efficient filament orientation as a technology option that can be used to improve the efficacy of lamps on the market for this final rule.

d. Higher Efficiency Inert Fill Gas

DOE proposed high-efficiency inert fill gas as another technology option to increase IRL efficacy in the NOPR analysis. Id. 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. (See chapter 3 of the final rule TSD for further details.) NEMA commented that higher efficiency inert fill gas is already common practice in the majority of halogen IRLs and therefore, no further efficacy increase is possible with this technology option. (NEMA, No. 54 at p. 20)

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 a 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 maintained high-efficiency inert fill gas as a technology option for this final rule.

e. Higher Pressure Tungsten-Halogen Lamps

DOE proposed the use of higher pressure tungsten-halogen as a technology option in the NOPR analysis. Id. Increasing the pressure of the halogen burner by increasing the density of halogen elements can indirectly raise the efficacy of the tungsten-halogen lamp. The increased density of halogen elements raises the probability that an evaporated tungsten element combines with a halogen element in a gaseous compound. Adding more of this gaseous compound in the burner effectively increases the amount of tungsten re-deposited on the tungsten filament. The lamp efficacy can be increased by using higher pressure to maintain the evaporation rate while increasing the filament temperature. (See chapter 3 of the final rule TSD for further details.) NEMA stated that the higher pressures in higher pressure tungsten-halogen lamps increase life but reduce efficacy due to the faster convective cooling of the filament. (NEMA, No. 54 at p. 21)

DOE understands that maintaining the filament temperature and increasing the pressure, thereby decreasing the evaporation rate of tungsten result in a gain in lifetime. However, a combination of higher pressure and increased temperature can be used to achieve both an increase in efficacy and lifetime. Therefore, DOE maintains high-efficiency inert fill gas as a technology option in this final rule.

f. Infrared Glass Coatings

DOE proposed infrared glass coatings as a technology option in the NOPR analysis. Id. at 24090. Infrared coatings on incandescent lamps are used to reflect some of the radiant energy emitted back onto the filament. This infrared radiation then supplies heat to the filament and the operating temperature increases. An increase in operating temperature results in higher light output and therefore an increase in efficacy. (See chapter 3 of the final rule TSD for further details.) NEMA commented that infrared glass coatings on burners and reflectors have been in use since the mid-1980s and have been developed to the maximum technologically feasible level. More efficient coatings with 80 or more layers have been tested, but these coatings fail due to cracking under repeated thermal expansion and contraction. Therefore, no further efficacy increase is possible with this technology option. (NEMA, No. 54 at p. 21)

Based on feedback from manufacturer interviews, DOE determined that different IR coating formulas are used on different halogen burners. Because lamps are present on the market at more than one level of efficacy, and infrared glass coating technology can be optimized in different variations, it provides a mechanism to improve the efficacy of less efficacious products. Therefore, DOE maintained infrared glass coatings as a technology option for the final rule.

g. Efficient Filament Placement

Efficient filament placement was one of the technology options presented in the preliminary analysis (see chapter 3 of the preliminary analysis TSD), but DOE did not propose it in the NOPR phase. 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. In the NOPR phase, NEMA commented that manufacturers already use efficient filament placement and that no further efficacy gains due to this technology option are possible. (NEMA, No. 54 at p. 20)

DOE had received similar comments regarding efficient filament placement in the preliminary analysis. Based on these comments and further research as well as manufacturer interviews, DOE determined that the optimal filament placement design is theoretically well understood and is being applied in commercially available IRLs covered under the scope of this rulemaking. Therefore, DOE did not propose efficient filament placement as a technology option in the NOPR analysis and maintained this decision for the final rule.

h. Integrally Ballasted Low Voltage Lamps

DOE also presented integrally ballasted low voltage lamps as a technology option in the preliminary analysis but did not propose it in the NOPR phase. 79 FR at 24089 (April 29, 2014) 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. In the NOPR phase, NEMA commented that integrally ballasted low voltage lamps use electronics that are thermally limited to 30 W or less due to American National Standards Institute/ International Electrotechnical Commission (ANSI/IEC) form constraints. Further, most IRLs are burned base-up. Therefore, this is not viable for higher power PAR lamps. (NEMA, No. 54 at p. 21)

DOE received similar comments in the preliminary analysis and reviewed feedback from manufacturer interviews and conducted further research regarding issues with this technology option. 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 is 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 did not propose integrally ballasted low voltage lamps as a technology option in the NOPR analysis and maintained this decision for the final rule.

i. Summary of IRL Technology Options

In summary, in this final rule analysis, DOE identified technology options for IRLs listed in Table VI.2.

Table VI.2. IRL Technology Options in the Final Rule 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.

Name of Technology Option	Description
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.
Crystallite Filament Coatings	Layers of micron or submicron crystallites deposited on the filament surface that increases emissivity of the filament.
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 burner pressurization, allowing higher temperature operation.
Non-Tungsten-Halogen Regenerative Cycles	Novel filament materials that regenerate.
Infrared Glass Coatings	When used with a halogen burner, this is referred to as an 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 burner, where it does not interfere with the reflectance of energy from the burner wall back to the burner 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 NOPR analysis for GSFLs and IRLs.

1. General Service Fluorescent Lamp Design Options

DOE received a general comment on the screening methodology as it relates to GSFLs. Philips commented that the screening analysis is not comprehensive enough because it is only looking at efficacy and does not consider other market requirements such as lifetime, dimmability, and CRI. (Philips, Public Meeting Transcript, No. 49 at p. 49)

One of the screening criteria is determining if a technology option would result in adverse impacts on the utility or availability of the product. DOE determined that of the design options considered for GSFLs, none would have a negative impact on the utility of the lamp (since lumen output is improved or maintained) nor would they eliminate the common lifetimes and CRI currently being offered. DOE acknowledges that krypton, a high-efficiency fill gas, seems to affect dimmability of reduced wattage lamps (i.e., energy saver lamp model). Because of the issues related to dimming associated with reduced wattage lamps, DOE's analysis requires that full-wattage lamps, which do not experience these problems, meet any proposed level. Therefore, because the use of high-efficiency fill gas would only impact the dimmability of certain product options available at a standard level (i.e., reduced wattage lamps), this design option is retained.

In summary, in this final rule analysis DOE identified 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 final rule TSD for further details on the GSFL screening analysis.

2. Incandescent Reflector Lamp Design Options

DOE received feedback on several IRL design options put forth in the NOPR analysis, including higher temperature operation, thinner filaments, and higher efficiency reflector coatings.

a. Higher Temperature Operation

In the NOPR, DOE proposed higher temperature operation as a design option. 79 FR at 24091(April 29, 2014). By operating the filament at higher temperatures, the spectral output shifts to shorter wavelengths, increasing its overlap with the photopic spectral eye sensitivity. This, in effect, increases the luminous output for a given power input and consequently increases the lamp efficacy. NEMA stated that higher temperature operation leads to a drastic and disproportionate loss in lifetime (e.g., 6-7 percent efficacy gain results in about 50 percent reduction in lifetime). (NEMA, No. 54 at p. 20)

DOE understands that there may be a tradeoff between operation at higher temperature and a decrease in lifetime. However, DOE believes the use of higher temperature operation can be tuned to achieve a gain in efficacy while maintaining a reasonable lifetime. Therefore, DOE maintained higher temperature operation as a design option for this final rule.

b. Thinner Filaments

DOE proposed thinner filaments as a design option in the NOPR analysis. A thinner filament has an increased resistance and therefore an increased operating temperature, which increases the lamp efficacy. NEMA commented that thinner filaments lead to a drastic loss in lifetime. (NEMA, No. 54 at p. 20)

DOE is aware that an incandescent lamp with a thinner filament cannot withstand as much tungsten evaporation as a thicker filament before failing, resulting in a shorter lifetime. However, a thinner filament design can be implemented to achieve a gain in efficacy while preserving a reasonable lifetime. Therefore, DOE maintained the use of thinner filaments as a design option for this final rule.

c. Higher Efficiency Reflector Coatings

DOE proposed higher efficiency reflector coatings with the exception of gold reflector coatings, as a design option in the NOPR analysis. 79 FR at 24091 (April 29, 2014). IRLs are incandescent lamps with a reflective coating, most commonly composed of aluminum or silver applied directly to the reflector surface. The reflector coating allows these lamps to place the same illuminance on a specific area with reduced watts, thereby increasing efficacy. (Note: In the NOPR and in this final rule, DOE screened out gold reflector coating due to impact on product utility as gold reflectivity diminishes at and below blue-green wavelengths, which may decrease the color quality of light. See chapter 4 of the final rule TSD for further details.)

NEMA stated that silver, the best higher efficiency reflector coating, is already in use and cannot be used in glue-sealed lamps (such as PAR20, PAR30, PAR30LN) due to extreme oxidation issues. (NEMA, No. 54 at p. 21)

DOE research indicates that it is possible to use silver reflector coatings with an epoxy (glue-based) seal. For example, DOE identified a patent that uses aluminum as an inner reflective coating extending from the rim to the base of the lamp and then a second coating consisting of silver spaced from the rim. The silver layer is heat-treated in an oven with a controlled environment prior to fusing the lens to the reflector body, which allows a seal to form without further diminishing the reflective characteristic of the silver.[25] Because there are methods to apply higher efficiency reflector coatings to all products covered by this rulemaking, DOE maintained the use of higher efficiency reflector coatings as a design option for this final rule.

d. Higher Pressure Tungsten-Halogen Lamps

DOE proposed the use of high pressure tungsten-halogen as a technology option in the NOPR analysis. 79 FR at 24091 (April 29, 2014). Increasing the pressure of the halogen burner by increasing the density of halogen elements can indirectly raise the efficacy of the tungsten-halogen lamp. NEMA stated that there are practical manufacturing process limitations and key consumer safety concerns with higher pressure tungsten-halogen lamps. (NEMA, No. 54 at p. 21)

DOE notes that this design option is being used in commercially available lamps. Further, DOE did not find information indicating any manufacturing or safety concerns

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[25] Woodward, David R. and Walter A. Boyce, Jack R. Sheppard. High efficiency sealed beam reflector lamp with reflective surface of heat treated silver. U.S. Patent No. 5789847A, filed October 24, 1995, and issued August 4, 1998.

with the use of higher pressure tungsten-halogen lamps. Therefore, DOE maintained the use of higher pressure tungsten-halogen lamps as a design option for this final rule.

In summary, in this final rule analysis DOE identified as design options the following IRL technologies that have met the screening criteria:

- Higher Temperature Operation
- Thinner Filaments
- 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 Burners

See chapter 4 of the final rule 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)) DOE received several comments regarding product classes proposed for GSFLs and IRLs in the NOPR analysis.

1. General Service Fluorescent Lamp Product Classes

In the NOPR analysis DOE considered product classes for GSFLs based on the following three factors: (1) correlated color temperature; (2) physical constraints of lamps (i.e., lamp shape and length); and (3) lumen package. 79 FR at 24091 (April 29, 2014). DOE received comments regarding establishing additional product classes based on the different spacing of 2-foot U-shaped lamps and lamp lifetime.

a. Two-Foot U-Shaped Lamps

DOE received several comments that separate product classes based on the spacing of the 2-foot U-shaped lamps may be needed. Spacing refers to the length between the two legs of the U-shaped lamp. The 2-foot U-shaped GSFLs come in 1 5/8-inch spacing and 6-inch spacing. OSI commented that the 2-foot U-shaped lamps with 1 5/8-inch spacing and 6-inch spacing should be in different product classes based on DOE's analysis in the NOPR. (OSI, Public Meeting Transcript, No. 49 at pp. 33-34) OSI stated that the reduced wattage 2-foot U-shaped lamps with 1 5/8-inch spacing are typically used in retail applications and would be eliminated by the rulemaking, resulting in an increase in energy use. OSI added that full-wattage 6-inch lamps would be eliminated by the rulemaking, removing dimming utility. (OSI, Public Meeting Transcript, No. 49 at pp. 60-61) GE noted that this issue could partially be due to the scaling of the 2-foot U-shaped product class from the 4-foot MBP product class and could be an issue specific to the scaling factor or the 4-foot MBP product class efficacy levels. (GE, Public Meeting Transcript, No. 49 at p. 61) NEMA explained that consumers have switched to reduced wattage 1 5/8-inch 2-foot U-shaped lamps, which serve retail applications and full-wattage 6-inch 2-foot U-shaped lamps are mainly used in offices for dimming purposes. (NEMA, No. 54 at p. 15)

EEOs recommended that DOE only create separate product classes for 6-inch and 1 5/8-inch spacing of 2-foot U-shaped if a technical barrier impacting efficacy potential is identified. (EEOs, No. 55 at p. 6) CA IOUs commented that DOE should not create separate product classes for U-shaped lamps with different spacing. CA IOUs supported this statement by identifying commercially available full and reduced wattage U-shaped lamps with 6-inch spacing that would meet the proposed standard in the NOPR for these products. CA IOUs also noted that of the 2-foot U-shaped offerings with 1 5/8-inch spacing, the majority of products were 31 W lamps, many of which met the standard level proposed in the NOPR analysis. Further, CA IOUs stated that there has to be a clear technical reason for design limitations for U-bend lamps of specific spacing to create separate product classes. They also noted that the 2-foot U-shaped lamps comprise a low market share that is shrinking as 2x2 fixtures are being converted to straight linear 2-foot lamps and therefore, manufacturers may not have developed an array of lamp offerings of varying efficacies. (CA IOU, No. 56 at p. 3)

DOE determines efficacy levels for 2-foot U-shaped lamps by reducing the efficacy levels of comparable 4-foot MBP lamps by an appropriate scaling factor. DOE updated this scaling factor for the final rule analysis, see section VI.D.2.h for addition detail. In response to stakeholder comments, DOE reviewed the ability of 2-foot U-shaped lamps to comply with the highest efficacy level analyzed in this final rule, paying particular attention to the ability of both lamp spacings to comply. DOE determined that full wattage and reduced wattage versions of both lamp spacings are able to meet the highest efficacy level analyzed in the 2-foot U-shaped product class. Therefore, in this final rule, DOE did not establish separate product classes for the 1 5/8-inch 2-foot U-shaped and 6-inch 2-foot U-shaped lamps.

b. Long-Life Lamps

DOE received comments that a separate product class for GSFLs with longer lifetimes than the standard lifetime may be needed. The longer life products are new on the market and mainly prevalent among the 4-foot MBP lamp types. NEMA commented that DOE should ensure that long-life lamps could meet the proposed standards or create a new product class for long-life lamps and report the associated analysis. (NEMA, No. 54 at p. 18) NEMA emphasized that the issue is that consumers are willing to pay a premium for long life (e.g., 80,000 hour) fluorescent lamps to avoid frequent lamp replacement. NEMA added that for many consumers long-life LEDs might not be an option due to first cost. (NEMA, Public Meeting Transcript, No. 49 at pp. 72-73) NEMA stated that long-life products offer utility for areas that are difficult to relamp, such as areas over assembly lines, or bridges and tunnels. Further, NEMA contended that design changes that permit much longer lifetimes have a net reduction in lumens/watt. When lumens per watt are increased lifetime is reduced and that increases the frequency of replacement, which in turn increases labor costs for replacement, increases the use of rare earth oxides in manufacturing, and increases mercury release. (NEMA, No. 54 at pp. 13-14)

GE noted that more lamps would be required to support lifetimes that may be half as long as common lifetimes for fluorescent lamps and this would also increase waste and costs to the manufacturer. GE also noted that elimination of long-life GSFLs would not result in energy savings as fluorescent lamps consume a steady amount of power from initial to mean to end life. (GE, Public Meeting Transcript, No. 49 at pp. 68-69, 73-74) Regarding a question on the market share of long-life GSFLs, OSI responded that because these products have only been recently introduced in the market it is difficult to determine and NEMA noted that it would try to obtain this data for DOE. (OSI, Public Meeting Transcript, No. 49 at p. 74; NEMA, Public Meeting Transcript, No. 49 at pp. 75-76)

EEOs remarked that although industry members proposed a separate product class for extra-long-life GSFLs with lifetimes of around 80,000 hours, these products are new on the market and it is unclear if a technical barrier exists preventing these lamps from meeting proposed standards. EEOs added that CA IOUs provided examples of reduced wattage extra-long-life 4-foot MBP lamps that would meet proposed levels. Further, EEOs agreed that extra-long-life lamps are cost effective, however, the negative impacts of a proposed level on life could be captured in DOE's economic analysis. (EEOs, No. 55 at pp. 6-7) The Northwest Energy Efficiency Alliance (NEEA) stated that it had not observed consumer concern for lifetime, noting more sales of less efficacious, long-life products. NEEA also noted that it was not possible to have both an efficacious and a good long lifetime product and expected this rulemaking to address the lifetime in the life-cycle cost analysis of the product. (NEEA, Public Meeting Transcript, No. 49 at pp. 77-79)

CA IOUs commented that a separate product class might be warranted for extra-long-life GSFLs if DOE finds a technical justification for reduced efficacy among these products. CA IOUs identified a variety of commercially available reduced wattage extra-long-life products with catalog efficacies that would pass DOE's proposed standard for 4-foot MBP lamps. Noting that these were reduced wattage lamps, CA IOUs added that if DOE is not able to identify full-wattage extra-long-life lamps that meet the proposed standards, and stakeholders present a technical justification with respect to design limitations preventing such products from being developed, a separate product class might be appropriate for this product type. However, CA IOUs noted that a standard for such a product class should be sufficiently stringent to avoid becoming a loophole. (CA IOU, No. 56 at pp. 3-4)

In response to stakeholder comments, DOE reviewed information about long life GSFLs from manufacturer interviews, product catalogs, and DOE's certification database. Manufacturer interviews indicated that it may be possible to increase the lifetime of fluorescent lamps by increasing the gas pressure, but that this may also decrease efficacy. DOE reviewed manufacturer catalog offerings and found that several manufacturers offered lamps that were marketed as "standard life" and also offered lamps that were marketed as "long life." Catalog information generally indicated that the marketed long life lamps were less efficacious than comparable standard life lamps.

Where available, certification data supported this trend. However, DOE notes that there is inconsistency in the industry regarding what actually constitutes a “long life” lamp. When comparing lamps offered by different manufacturers, one manufacturer’s “long life” product may be offered with a lifetime very similar to that of another manufacturer’s “standard life” product. Further, while DOE is aware that lifetime is a feature valued by consumers, DOE’s analysis ensures that the lifetimes typically available at the baseline level are also available at higher efficacy levels (see section VI.D.2.g for more details). In this way, DOE’s higher efficacy levels do not impact consumer utility and DOE accounts for any differences in lifetime as economic impacts in the LCC and NIA. Therefore, DOE did not establish separate product classes for long life GSFLs in this final rule analysis.

c. Summary of GSFL Product Classes

In this final rule analysis, DOE established product classes for GSFLs as summarized in Table VI.3. See chapter 3 of the final rule TSD for further details on each GSFL product class.

Table VI.3 GSFL Product Classes in Final Rule 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 NOPR analysis, DOE proposed 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. 79 FR at 24092 (April 29, 2014). DOE received comments on the rated voltage and modified spectrum product class setting factors. DOE did not receive feedback on the other product class divisions proposed for IRLs in the NOPR analysis.

a. Rated Voltage

In the NOPR analysis, DOE proposed 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. NEMA stated that DOE's reasoning for a separate 130 V product class was out of concern that consumers would shift to 130 V options that are less efficient than 120 V lamps resulting in increased energy consumption. However, NEMA noted that when operated at 120 V, a 60 W 130 V PAR38 uses less energy, approximately 54-55 W. Further, NEMA stated that since this decreases light output, consumers would not choose 130 V IRLs to ‘cheat’ on energy conservation standards. (NEMA, No. 54 at p. 30)

DOE agrees that the 130 V lamp described by NEMA would use less energy when operated at 120 V. However, in the NOPR analysis and in this final rule DOE concludes that the corresponding decrease in light output would result in consumers purchasing additional lamps to maintain sufficient light. 79 FR at 24093 (April 29, 2014). Therefore, setting higher standards for IRLs without accounting for voltage differences could result in increased energy consumption.

Westinghouse remarked that the absence of 130 V IRLs on the market has resulted in a loss in utility as 130 V IRLs were used to maintain product lifetimes in areas with transients, voltage spikes, and other power issues, and that consumers in those markets will have to buy more light bulbs due to voltage issues. Citing the 130 V lamps as an example, Westinghouse noted that in this rulemaking DOE has to be careful when setting new IRL standards that such unintended consequences do not happen as they cannot be fixed in the future due to the backsliding provision. (Westinghouse, Public Meeting Transcript, No. 49 at pp. 43-44)

DOE is aware that the 130 V lamps can provide a certain utility by lasting longer than 120 V lamps in certain areas that are susceptible to voltage spikes. However, based on its assessment that most consumers operate 130 V IRLs at 120 V and differences in efficacy when they are operated at 120 V versus tested at 130 V, DOE determined that there would be a potential migration to 130 V IRLs if they were subject to the same standards as 120 V IRLs and further that there would be additional purchases of 130 V IRLs by the consumer. Hence, in order to preserve energy savings, DOE maintained the rated voltage class division that separates covered IRLs less than 125 V from those that are greater than or equal to 125 V in this rulemaking. (See chapter 3 of the final rule TSD for further information.)

b. Modified Spectrum

Modified spectrum IRLs provide unique utility to consumers by providing a different type of light than standard spectrum lamps, much like fluorescent lamps with different CCT values. However, the same technologies (i.e., coatings) that modify the spectral emission of a lamp also decrease lamp efficacy. Therefore, in the NOPR DOE proposed a product class division separating standard spectrum IRLs from modified spectrum IRLs. 79 FR at 24093 (April 29, 2014).

EEOs added that a separate product class for modified spectrum lamps may not be needed as more efficient technologies, such as CFLs and LEDs, are able to achieve the same utility and also due to the lack of commercially available modified spectrum lamps covered by the rulemaking. (EEOs, No. 55 at pp. 7-8) CA IOUs agreed that due to the limited number of modified spectrum IRLs on the market, the category should be eliminated. (CA IOUs, Public Meeting Transcript, No. 49 at p. 20) ASAP and CA IOUs concluded that there is no need to make an exemption or have a less efficacious standard for modified spectrum lamps. (ASAP, Public Meeting Transcript, No. 49 at pp. 17-18; CA IOUs, Public Meeting Transcript, No. 49 at p. 20) NEMA commented that modified spectrum lamps, like 130 V lamps, cannot remain both cost effective and compliant and referred DOE to manufacturer interviews for additional details. (NEMA, No. 54 at p. 31)

As in the NOPR, DOE continues to believe that modified spectrum lamps offer unique utility by providing a different spectrum of light. 79 FR at 24093 (April 29, 2014). Although more efficient technologies, such as CFLs and LEDs, may offer similar spectrums, DOE must maintain consumer utility for the products that are within the scope of this rulemaking. Modified spectrum IRLs modify the spectral emission of a lamp in such a way that lamp efficacy decreases. DOE acknowledges that there are currently no modified spectrum products on the market. However, DOE maintains that there are no technological barriers to creating these products. DOE does not consider cost when establishing product classes. Because modified spectrum lamps offer unique utility but at lower efficacy compared to standard spectrum products, DOE maintained the class division for lamp spectrum in this final rule.

c. Summary of IRL Product Classes

In this final rule analysis, DOE established product classes for IRLs as summarized in Table VI.4. See chapter 3 of the final rule TSD for further details on each IRL product class.

Table VI.4 IRL Product Classes in Final Rule 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 final rule 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 final rule 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 final rule 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;[26] and (3) the max tech EL. DOE then scales the ELs of representative product classes to those classes not directly analyzed.

DOE received a comment regarding the general methodology of the IRL engineering. GE recommended that DOE conduct two separate analyses for the commercial sector and residential sector. GE noted that lamps in the residential sector have shorter lifetimes, such as 1,500 hours, as they are used less frequently and therefore need to be replaced less often, especially if the lamps are on a dimmer. GE continued that the commercial sector requires longer lifetimes of 3,000 to 4,000 hours because lamps in commercial applications can be used up to 16 hours a day. GE stated that the analyses would be skewed between the two markets and that it would have a negative effect on the residential market as residential consumers with their shorter hours of operation are less likely to see the cost savings and payback that commercial consumers would be able to accrue. GE proposed the idea that the commercial and residential lamps could be differentiated by the typical applications, wattages, and technical aspects for each sector. For example, the PAR30 lamps could be treated as residential and PAR38 lamps as commercial. GE further commented that they understood that separating the lamps by

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

sector could be difficult, but that the separation is necessary, as the proposed max tech levels applied across sectors would have the unintended consequences of removing certain utility and entire products from the market. (GE, Public Meeting Transcript, No. 49 at pp. 105-106, 116-117) NEEA agreed that separate analyses could be done for the commercial sector and for the residential sector. Alternatively, NEEA also suggested segregating the large commercial sector from the residential and small commercial sectors, such as independent, family-owned businesses and other consumers that purchase lighting similarly to homeowners. (NEEA, Public Meeting Transcript, No. 49 at p. 131)

DOE acknowledges that lamps have varying levels of penetration in different market sectors. However, there is nothing that would limit the use of a covered IRL in a specific sector. Therefore, DOE does not conduct sector-based assessments in the engineering analysis. Rather, the LCC analysis and NIA consider lamp use in different market sectors. The LCC analysis provides results for each analyzed lamp in each relevant sector. See section VII.B.1 for results of the IRL LCC analysis. 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. See section VII.B.3 for results of the NIA. Further, as part of the engineering analysis, when selecting more efficacious substitutes and establishing efficacy levels, DOE ensures that products at higher efficacy levels meet baseline consumer needs. DOE’s analysis of IRLs addresses the concerns regarding lifetime and product availability. See section VI.D.3 for further details. Therefore, DOE did not conduct separate engineering analyses by sector for IRLs.

Stakeholders had several comments specific to the GSFL and IRL engineering analyses presented in the NOPR. The following sections discuss and address feedback received from stakeholders for each product.

2. General Service Fluorescent Lamp Engineering

For GSFLs, DOE received several comments on the engineering analysis presented in the NOPR. The following sections summarize the comments and responses received on these topics, and present the GSFL engineering methodology for this final rule analysis.

a. Data Approach

Usability of Certification Data and Catalog Data

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 Compliance Certification Management System (CCMS) database[27] only contained data for 68 percent of the covered commercially available lamps. Therefore, in the NOPR analysis, DOE continued to utilize catalog data to identify baseline products and develop initial efficacy levels. DOE then used available certification data to adjust the initial efficacy levels so that the proposed levels could be met with efficacies submitted for certification.

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

NEMA commented that while catalog data is reviewed on a regular basis, due to publication delays it may not reflect all products being manufactured and, therefore, certification data would provide a more realistic representation of products than catalogs. For example, NEMA commented on DOE's assessment that only 68 percent of the commercially available fluorescent lamps in the scope of this rulemaking have certification data. NEMA stated that this percentage suggests that products identified by DOE in catalogs are not really made or sold as all manufacturers are required to submit certification data to DOE on their products on an annual basis. (NEMA, No. 54 at p. 19)

DOE understands that catalog data is subject to publication delays and may not be updated on a continuous basis. DOE frequently reviews both the available catalog data and certification data. At the time of the final rule analysis, DOE's certification database contained data for 79 percent of the covered commercially available lamps. While this percentage was an increase from the NOPR analysis, it still did not represent a comprehensive dataset on which to base an engineering analysis. Therefore, in this final rule analysis, DOE again utilized both catalog data and certification data in order to assess all available data. Specifically, DOE 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 adopted levels can be met based on the certification values submitted by manufacturers to demonstrate compliance with standards.

Regarding the certification data, NEMA stated that they had determined that erroneous conclusions could be drawn from the data in DOE's certification database. NEMA commented on an exchange with DOE regarding the application of cathode heat during testing for T8 lamps in the 4-foot MBP and 2-foot U-shaped product classes. NEMA stated that the application of cathode heat for full wattage lamps and U-shaped lamps is clear as they do not have high frequency specifications. However, NEMA asserted that while ANSI C78.81-2010 specifies that the reduced wattage (30 W, 28 W and 25 W) 4-foot MBP T8 lamps have normative high frequency (HF) reference ballast circuits, DOE requires they be tested at low frequency and permits exclusion of cathode heat, which makes them appear more efficacious than full wattage lamps. NEMA asserted that DOE certification database has erroneous values for reduced wattage lamps for the following reasons: 1) there was a lack of awareness of the exchange between DOE and NEMA on the subject of cathode heat and high frequency circuits for reduced wattage lamps; 2) the current DOE test procedure incorporates ANSI C78.81-2010, which made high frequency reference photometry normative for reduced wattage T8 lamps but requires that these lamps be tested at low frequency and permits the removal of cathode heat, which makes them seem more efficacious; and 3) DOE certification data is not required to be resubmitted if there are no changes affecting efficacy of the basic model. (NEMA, No. 54 at pp. 23-24)

DOE acknowledges that there may be confusion in the industry regarding how to test certain lamp types. Per the DOE test procedure, GSFLs are to be tested at low frequency unless only high frequency reference ballast specifications are available. (See section 4.1.1 in 10 CFR 430, subpart B, appendix R.) Because low frequency settings exist, 4-foot MBP lamps and 2-foot U-shaped lamps must be tested at low frequency. For lamps tested at high frequency, the industry standard referenced by the DOE test procedure, LM-9-09,[28] specifies that cathode heat is not utilized for high frequency circuits. Manufacturers are encouraged to contact general_service_fluorescent_lamps@ee.doe.gov with questions regarding DOE's test procedure.

Calculation of Efficacy

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. For example, because reduced wattage 4-foot T5 MiniBP HO lamps do not have a defined ANSI rated wattage, DOE used their nominal wattages, either 49 W or 47 W, to calculate efficacy.

NEMA commented on DOE's use of catalog lumens and ANSI wattage to determine catalog efficacy, stating that lamp wattage may vary when measuring catalog lumens for rating purposes. Further, NEMA noted that the ANSI-typical electrical characteristics are given for informational use only and that any determination of lamp

[28] "IES Approved Method for the Electrical and Photometric Measurement of Fluorescent Lamps" (approved Jan. 31, 2009).

power or efficacy from these values would be considered as rough estimates. (NEMA, No. 54 at p. 23)

ANSI rated wattage is the result of standardized ANSI testing and represents an industry agreed upon wattage. As noted by NEMA in response to the preliminary analysis, the rated wattage is based on the average of a very large number of samples 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. 79 FR at 24095 (April 29, 2014). Lamp wattage is also reported by manufacturers in the CCMS database. However, DOE identified inconsistencies with the reported wattage. For example, some manufacturers appeared to report nominal wattage rather than measured wattage. DOE notes that using the ANSI rated wattage provides a conservative rating for the efficacy for several lamp types, specifically those lamp types tested at low frequency (i.e., 4-foot MBP, 2-foot U-shaped, and 8-foot SP slimline). Therefore, DOE continued to use the ANSI defined rated wattage in this final rule.

For lamp types that do not have a defined ANSI rated wattage, DOE utilized the lamp's nominal wattage to calculate catalog efficacy. NEMA commented that the assumption that the rated wattage and nominal wattage of reduced wattage 4-foot T5 MiniBP HO lamps are the same is not valid. NEMA noted that until an industry standard is completed, these values are speculative in nature. (NEMA, No. 54 at p. 26)

DOE acknowledges that reduced wattage 4-foot T5 MiniBP HO lamps do not have a defined rated wattage. However, DOE believes that the nominal wattage is a reasonable approximation of rated wattage for these lamps, based on the guidelines for defining nominal wattage in ANSI C78.81. After developing initial levels based on efficacies calculated using catalog data and ANSI wattages, DOE reviewed certification data. The reported values for efficacy 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.

Rounding

NEMA disagreed with DOE's current GSFL test procedure that requires efficacies be reported to the nearest tenth. 10 CFR 430.23(r)(2) NEMA stated that due to the uncertainty of measurement, reporting lumen values to the nearest tenth was statistically incorrect and could result in enforcement issues; and further recommended that DOE require efficacies to be rounded to the nearest lumen per watt. Specifically, NEMA quoted that the National Institute of Standards and Technology (NIST) TL standards measurement of expanded uncertainty is 1.6 percent (coverage factor k=2). NEMA provided the example that a highly stable 3,000-lumen F32T8 fluorescent lamp based on NIST standards would result in an uncertainty for the reported mean of +/- 33 lumens for 21 samples. Further, NEMA stated that in addition to being contrary to the

NIST “Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results” (GUM) rounding to the nearest tenth also did not align with International Laboratory Accreditation Cooperation (ILAC) Policy for Uncertainty in Calibration (ILAC-P14:01/2013). The policy states that the expanded uncertainty should be at most two significant figures and the final result rounded to the least significant figure in the value of the expanded uncertainty assigned to the measurement result. NEMA noted that an accredited laboratory with measurements traceable to SI units through a National Metrology Institute cannot have a measurement uncertainty less than the artifact samples utilized to calibrate their systems and random lamp production samples would add further uncertainty. (NEMA, No. 54 at pp. 15-16)

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 analyzed 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.

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. In the NOPR, 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. 79 FR at 24096 (April 29, 2014). DOE received no comments on this subject and therefore maintained the same representative product classes for the final rule.

c. Baseline Lamps

Once DOE identifies representative product classes for analysis, it selects baseline lamps to analyze in each class. Typically, a baseline lamp is the most common, least efficacious lamp that just meets existing energy conservation standards. In the NOPR, DOE proposed baselines at the existing standard levels for all product classes. Id. at 24097-98. For the 4-foot MBP and 8-foot slimline product classes, DOE determined the baseline to be the least efficient product on the market at the existing standard level. For representative product classes in which there were no commercially available lamps at the existing standard level, DOE modeled baseline lamps. Feedback from stakeholders and manufacturer interviews 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 believed this trend could continue and additional lamps may be offered that just meet the existing standard level for the remaining product classes. In the NOPR, DOE modeled baseline lamps for the 8-foot RDC HO, T5 MiniBP SO, and T5 MiniBP HO product classes. Id.

NEMA agreed with the baselines selected for GSFLs based on the data in DOE's certification database, but noted its concern that product performance may be overstated due to data entry errors in the certification database or the use of catalog data that shows higher than actual performance of products. (NEMA, No. 54 at p. 17)

Because DOE received no comments to the contrary, DOE analyzed the same baselines in the final rule analysis as analyzed in the NOPR. DOE selected commercially available lamps as baselines for the 4-foot MBP and 8-foot slimline product classes and modeled baseline lamps for the 8-foot RDC HO, T5 MiniBP SO, and T5 MiniBP HO product classes. Regarding overstated product performance, DOE addresses discrepancies within the available data sets in section VI.D.2.a and discusses its methodology for developing efficacy levels in section VI.D.2.g.

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 NOPR, 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. 79 FR at 24098 (April 29, 2014). 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 several comments regarding its choices for more efficacious substitutes in the NOPR.

Four-Foot MBP Lamps

In the NOPR analysis, DOE analyzed two levels for 4-foot MBP lamps above the baseline, with the highest level represented by a more efficacious full wattage 4-foot MBP lamp and two reduced wattage lamps (28 W and 25 W) that are commercially available.

CA IOUs questioned why DOE did not consider 30 W lamps in its analysis, which would be another opportunity to save energy and stay within 10 percent of lumen output. (CA IOUs, Public Meeting Transcript, No. 49 at pp. 94-95)

DOE analyzed a database of commercially available lamps to identify the most common characteristics of lamps in each product class including wattage. DOE found the 30 W 4-foot MBP lamp to be significantly less common than the 28 W and 25 W wattages. Manufacturer feedback confirmed the most popular reduced wattage lamps in the 4-foot MBP product class to be 28 W and 25 W. Further, for consumers who choose to purchase a reduced wattage product, DOE believes the 28 W and 25 W products capture both options available: one that saves energy while maintaining lumen output within 10 percent of the lumen output of typical 32 W products and one that saves more energy but offers slightly lower lumen output. Because 28 W lamps are more efficacious than 30 W lamps and save more energy, DOE believes that consumers opting to purchase reduced wattage lamps will choose 28 W lamps rather than 30 W lamps. Therefore, DOE continued to analyze only 28 W and 25 W reduced wattage 4-foot MBP lamps in the final rule.

T5 MiniBP HO Lamps

In the NOPR analysis, DOE modeled a baseline lamp for the T5 HO product class because a commercially available lamp was not offered at the existing standard level. DOE analyzed one level above the baseline, represented by a more efficacious full wattage T5 HO lamp and two reduced wattage T5HO lamps that are commercially available.

NEMA noted that DOE should not use modeled lamps to determine more efficacious substitutes for T5 MiniBP HO lamps. (NEMA, No. 54 at p. 18) NEMA stated that if a more efficacious design was possible it would already be commercially available. Because of the high bulb wall temperatures in T5 MiniBP HO lamps, there are many characteristics to consider such as phosphor loading, cold spot control, cathode design, gas fill for reduced wattage products, and overall design for optimal performance at 35 °C. Further, NEMA was skeptical that DOE could produce measured data that demonstrates manufacturability of the more efficacious modeled T5 MiniBP HO lamp. (NEMA, No. 54 at p. 26)

As noted in section VI.D.3.b in response to stakeholder comments 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. For the final rule, DOE continues to analyze the same baseline and higher efficacy replacements, including the commercially available full wattage T5 HO lamp.

e. General Service Fluorescent Lamp Systems

Because fluorescent lamps operate on ballasts in practice, 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, DOE analyzed more efficacious systems that maintain mean lumen output[29] within 10 percent of the baseline system, when possible. Further, DOE selected

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

replacement systems that do not have higher energy consumption than the baseline system.

DOE considered two different scenarios: 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 luminous efficiency[31] (BLE). In 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. 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

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[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 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.

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.

NEMA disputed the energy savings demonstrated by the lamp-and-ballast systems. NEMA commented that re-ballasting is not common and thus spaces will more likely be overlit and consume the same amount of system energy. NEMA asserted that a 32 W fluorescent lamp, even if it's more efficacious, will consume the same amount of energy.[33] If ballasts were replaced, NEMA disagreed with DOE's assessment that, in new construction and retrofit scenarios, lamps will be paired with low ballast factor ballasts to result in lower system energy use. Further, NEMA noted that DOE's analysis shows a 2-3 percent change in system lumen output which does not align with the existing 10 percent steps in ballast factors. (NEMA, No. 54 at p. 18)

DOE agrees that a ballast is not always replaced when a lamp fails. DOE analyzes a lamp replacement scenario in which the existing ballast is not replaced and a consumer saves energy by choosing a reduced wattage lamp. For the instances in which the consumer replaces both a lamp and ballast, DOE analyzes a lamp-and-ballast replacement scenario in which a consumer can achieve energy savings by pairing a new lamp with an improved ballast. DOE selected commercially available ballasts to pair with

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[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.

[33] If paired with a dimming ballast, energy savings may be possible if the system is adjusted to maintain the same light output of the replaced system.

representative lamps and found ballasts with ballast factors available in increments smaller than 10 percent.

DOE received several comments regarding the light level that must be maintained when analyzing replacement lamp-and-ballast systems. CA IOUs stated that they were aware that lumens depreciate over time, decreasing to about 30 percent of initial lumen output. Further, they added that in a lighting retrofit the replacement of a new lamp-and-ballast system can result in up to a 15-17 percent increase in light output, and consumers actually respond negatively to this increase. Therefore, CA IOUs suggested that when examining different scenarios of sacrificing increased light over energy savings or vice versa, DOE prioritize energy savings and maintaining reasonable light levels. (CA IOUs, Public Meeting Transcript, No. 49 at pp. 93-94) NEMA disagreed with the comment made by the CA IOU's during the NOPR public meeting that consumers would not like increased light levels and a decrease of up to 10 percent of lumens would still be too much light for consumers. NEMA stated that recent studies show that the aging population requires higher light levels and regardless, does not agree that decreasing light by 10 percent in place of energy savings for all applications is acceptable due to lumen depreciation resulting in light that does not meet the required needs, creates safety issue, or violates building codes. (NEMA, No. 54 at pp. 18-19)

DOE notes that, while it may be possible to decrease light output by more than 10 percent in certain situations to maximize energy savings, it is likely not acceptable in all applications. DOE tried to select lamp-and-ballast systems that maintained mean lumen output within 10 percent of the baseline system, when possible. For the lamp-and-ballast replacement 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.

DOE also received comments regarding the pairing of GSFLs with dimming ballasts. CA IOUs noted that California's new building codes will potentially require almost all lighting to use dimming ballasts and therefore the ballasts may become common in other states as well. CA IOUs noted that this presents another opportunity for saving energy without increasing light. (CA IOUs, Public Meeting Transcript, No. 49 at pp. 94-96) CA IOUs requested clarification on compatibility issues when dimming fluorescent lamps because of the expected increase in the use of dimming products in California. (CA IOUs, Public Meeting Transcript, No. 49 at p. 63) ASAP noted that there are reduced wattage lamps that are able to be dimmed and because it is an improving situation, the analysis should not be so rigid as to require that there always be full wattage lamps available. (ASAP, Public Meeting Transcript, No. 49 at p. 65) GE responded that while reduced wattage lamps can be dimmed, their use of krypton makes them more susceptible to striations which are unacceptable to the consumer. GE added that because of this issue, major companies recommend using full wattage lamps with dimming systems as actual energy savings are obtained from the wattage at which the lamps are being operated rather than their efficacy. (GE, Public Meeting Transcript, No. 49 at pp. 66-67)

DOE agrees with the CA IOUs that the market share of dimmable systems may increase in the future and therefore continued to analyze dimmable systems in the final rule. While certain dimming ballasts are listed as compatible for operation with both full and reduced wattage lamps, DOE continues to receive feedback that there can be issues with dimming reduced wattage lamps. Specifically DOE received feedback from manufacturer interviews that problems that can be encountered when dimming linear fluorescent lamps, including difficulties in lamp starting, striations, and dropout, are exacerbated by the use of krypton in reduced wattage lamps. Because of these issues, DOE has continued to ensure that full wattage lamps can meet the efficacy levels analyzed.

In the final rule, DOE continued to analyze GSFLs operating on fluorescent lamp ballasts. In situations where a consumer selects a new ballast in addition to a new lamp, DOE allows the consumer to select a new ballast with potentially different performance characteristics, such as BF[34] or BLE. [35] DOE maintained the same methodology described previously in this section to select ballasts in the final rule. However, due to certain products being discontinued and new products introduced, certain ballast

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

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

selections in the final rule for the 4-foot MBP, 8-foot SP slimline, and 8-foot RDC HO product classes were updated. See chapter 5 of the final rule TSD for additional detail.

f. Max Tech

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 efficacy for GSFLs using the design parameters for the most efficient products available on the market or in working prototypes.

NEMA advised DOE to be wary of claims of ultra-performance lamps in the certification database, particularly since there have been no technology breakthroughs since the 2009 Lamps Rule and therefore, the max tech established in that rulemaking should not change. (NEMA, No. 54 at p. 25, 29)

In reviewing available certification data, DOE considered the possibility of exorbitant claims or incorrect data. DOE identified several efficacy values that it did not consider feasible for fluorescent lamp technology and therefore did not consider in this analysis. In general, these outliers were identified based on the reported wattage, which indicated that these lamps may not have been tested correctly. However, DOE still identified several commercially available lamps performing at efficacy levels higher than the max tech levels established in the 2009 Lamps Rule based on catalog data and certification data. Thus, manufacturers appear to be utilizing more advanced technologies or to be more efficiently utilizing existing technologies.

g. Efficacy Levels

After identifying more efficacious substitutes for each of the baseline lamps, in the NOPR DOE developed ELs based on the consideration of several factors, including: (1) the design options associated with the specific lamps being studied (e.g., grades of phosphor for GSFLs); (2) the ability of lamps across wattages to comply with the standard level of a given product class; and (3) the max tech level. When evaluating ELs in the NOPR, DOE considered only ELs at which a full wattage version of the lamp type was available because reduced wattage lamps have limited utility. 79 FR at 24103 (April 29, 2014). DOE received several comments on the ELs considered in the NOPR.

Clarification of Standard Levels

ASAP commented that the rulemaking for GSFLs is a performance standard and not a design standard, thus ensuring that full wattage lamps are available should not be a constraint for DOE. (ASAP, Public Meeting Transcript, No. 49 at pp. 50-51)

DOE agrees with ASAP that the efficacy levels analyzed in this rule are performance standards rather than design standards. Thus, DOE does not dictate how manufacturers must comply with a standard (i.e., requiring that they produce full wattage lamps). However, DOE must evaluate standards that do not lessen utility or performance of a product. (42 U.S.C. 6295(o)(2)(B)(i)(IV)) As described in section VI.D.2.e, DOE has determined that reduced wattage lamps cannot be used in all of the same dimming systems as full wattage lamps due to the addition of krypton gas. Therefore, DOE has established a performance standard such that manufacturers can continue to produce full wattage lamps if required by consumers.

Methodology to Develop Efficacy Levels

EEOs agreed with DOE's approach using catalog lumens and ANSI wattages for GSFLs to establish initial efficacy levels and then adjusting the levels based on certification data to ensure that certified values could meet proposed standards. EEOs did note that DOE had not provided specifics of the adjustments based on certification data. Based on its observations of the certified efficacy levels for a significant number of lamps, from several manufacturers, EEOs determined that the proposed standard levels for the 4-foot and 8-foot T8/T12 products were reasonable. (EEOs, No. 55 at pp. 4-5)

However, manufacturers offered several comments regarding the methodology for determining efficacy levels and how it might affect manufacturers' ability to comply with an adopted standard level. NEMA stated that manufacturers design products around the midpoint of a bell distribution curve, and therefore when the required standard is below the max-tech level, manufacturers have room to make adjustments (e.g., reducing lifetime, adding costly material) to ensure that all their products can meet the standard level. However, NEMA stated that because DOE's proposed standards for GSFLs are approaching max-tech, the design mid-point is above this max-tech level which does not allow manufacturers to build in production tolerances that would ensure compliance. (NEMA, No. 54 at p. 12) GE stated that if DOE sets the level at the upper tail of the distribution of data, it will be requiring efficacies above max tech which is at the center of that distribution. GE encouraged DOE to use the information in NEMA Lighting System Division (LSD)-63 Measurement Methods and Performance Variation for Verification Testing of General Purpose Lamps and Systems paper to analyze data in the DOE certification database and assess the variation between test measurements and in production. (GE, Public Meeting Transcript, No. 49 at pp. 86-88) Further, NEMA noted that while there is no statutory definition for the term "standard," NEMA quoted specification of the term put forth by the International Standards Organization and the Office of Management and Budget. NEMA stressed that a standard must be capable of being met consistently and repeatedly by manufacturers and one that cannot be is not within DOE's authority to promulgate. (NEMA, No. 54 at p. 13)

To demonstrate compliance with standards, DOE requires manufacturers to test a minimum of 21 lamps according to the procedures described in 10 CFR 430, subpart B, Appendix R and report a value that does not exceed the lower of the sample mean or the 95 percent lower confidence limit (LCL) of the true mean divided by 0.97. The greater the variation in the tested sample, the more likely that manufacturers will report the second value (i.e., LCL). DOE notes that the statistics included in the compliance procedures are intended to ensure that manufacturers are reporting a value that approximates the population mean. Each tested lamp is not individually required to meet or exceed the standard level. Designing products such that their population mean or the performance of each individual lamp unit within the population exceeds DOE's standard level is not required and is done so at the discretion of individual manufacturers.

DOE believes the efficacy levels analyzed in this rulemaking represent expected population means rather than outlier data in the high end of a bell distribution curve. DOE received feedback from manufacturers during interviews that catalog data represents the long term average performance of products. DOE uses catalog data to establish initial efficacy levels. DOE then compares the efficacy levels to available certification data and adjusts the levels downward if necessary. DOE does not believe that the certification values represent outlier data in the high end of a bell distribution curve. Manufacturers must select a minimum of three lamps from each month of production for a minimum of 7 months out of a 12-month period.[36] It is unlikely that selecting lamps from multiple months of production over the course of a year will result in a value that is consistently in the high end of a bell distribution curve. Furthermore, if manufacturers believe their test results are artificially high, they have the opportunity to report a more conservative value as DOE allows manufacturers to rate the product within the range of the existing standard up to the lower of the LCL divided by 0.97 or the mean. See 10 CFR 430, subpart B, Appendix R.

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[36] In the instance where production occurs during fewer than 7 of such 12 months, the manufacturer shall randomly select 3 or more lamps from each month of production, where the number of lamps selected for each month shall be distributed as evenly as practicable among the months of production to attain a minimum sample of 21 lamps.

Using this methodology, DOE accounts for variation in tested samples and ensures efficacy levels are based on values determined by DOE's test procedures and reported by manufacturers themselves. In this final rule, DOE has maintained the same methodology to develop efficacy levels.

Long-Life Lamps

NEMA stated that GSFL manufacturers have recently introduced reduced wattage 4-foot T8 MPB lamps with 84,000 – 90,000 hour life and full wattage (dimmable) lamps with 67,000 -70,000 hour life. NEMA noted that these products offer more than twice the life and better lumen maintenance than standard product with the same initial lumens, attributes that provide consumer utility. However, NEMA asserted that the proposed efficacy standard levels will eliminate the 4-foot 32 W dimmable long life and 28W long life lamps leaving only the 25W long life lamps and also eliminate a patchwork of full and reduced wattage standard lamps between 42,000 and 52,000 hours. Additionally, NEMA stated the T5 MiniBP HO long-life product would also not be able to meet the proposed standard. NEMA also warned that industry would not produce new products in response to the proposed standards but instead reduce existing product offerings and re-purpose existing products, resulting in decreased consumer satisfaction. Citing T5s specifically, NEMA stated that in order to offer choices to consumers, manufacturers may have to add more rare earth phosphors increasing production costs and then also have to decrease life to lower cost to the consumer. (NEMA, No. 54 at pp. 17-18, 47-48)

DOE reviewed catalog data to identify the long life products cited by NEMA. DOE found that while some manufacturers did offer long life products, the lifetimes of these products were inconsistent across the industry. For example, some manufacturers' long life products are similar in lifetime to other manufacturers' standard life products. While catalog data indicates that some designated long life products would meet analyzed efficacy levels, certification data is noticeably lower, suggesting that these products may not meet the highest level analyzed. DOE believes that lifetime is a feature valued by consumers. However, DOE considers lifetime to be an economic issue unless a standard requires the shortening of lamp lifetime beyond that which is typically available. Because the highest standard level analyzed will still maintain the availability of 4-foot MBP GSFLs with lifetimes ranging from 30,000 to 50,000 hours,[37] DOE did not adjust the efficacy levels in this final rule due to lifetime.

Four-Foot MBP Lamps

In the NOPR, DOE analyzed a standard 800 series full wattage T8 lamp at the baseline. (See chapter 5 of the NOPR TSD.) DOE identified two levels of efficacy above the baseline. Based on catalog data, DOE determined EL 1 (90.0 lm/W) represented an improved 800 series full wattage T8 lamp and EL 2 (93.0 lm/W) represented 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 93.0 lm/W to 92.4 lm/W

[37] Based on 3-hour programmed start operation.

based on certification data. DOE received several comments on the levels analyzed for 4-foot MBP lamps.

NEMA commended DOE on taking an analytical approach rather than relying only on catalog data or DOE certification data to determine efficacy levels for the 4-foot MBP product class. However, NEMA stated that the limitations of both the catalog and DOE certification data need to be considered to understand the efficacy distribution and max tech of 4-foot MBP lamps with CCT ≤ 4,500 K. (NEMA, No. 54 at p. 22)

NEMA commented on figure 5.3.2 of chapter 5 of the NOPR TSD, which shows the certification data for the 4-foot MBP lamps with a CCT less than 4,500 K. NEMA noted that the reported reduced wattage T8 lamp data spreads up to 10-11 percent over the max tech, plausibly indicating a mixture of properly measured 60 Hz photometry without cathode heat and erroneously reported measurements made using the normative ANSI HF ballast reference circuit. (NEMA, No. 54 at p. 24)

As mentioned in section VI.D.2.f, DOE agrees that there may be outliers in certification data due to manufacturers' confusion regarding how to test certain lamp types. DOE developed initial levels based on catalog data and then adjusted the levels based on available certification data. DOE did not adjust levels upward but rather adjusted levels downward if certification data was noticeably lower than catalog data. Thus the erroneously reported measurements cited by NEMA would not have resulted in an increased standard level.

NEMA conducted a detailed review of how the efficacy levels analyzed in the NOPR compared to the available certification data. NEMA noted that the 8 percent tolerance for a 21 sample size and 99 percent confidence limit specified in NEMA's LSD 63-2012 guidance aligns with the spread of certification data for full wattage lamps. Further, NEMA noted that the high lumen full wattage lamps falling at the upper levels of 96 lm/W represents max tech measured with favorable lab measurement bias per LSD 63-2012. (NEMA, No. 54 at p. 24)

NEMA stated that the average maximum technically feasible 4-foot MBP T8 lamp efficacy measured at 60 Hz with cathode heat is close to 92 lm/W. NEMA noted that setting a standard close to the max tech level of 92 lm/W could result in sample measurement variation below the requirement approaching 50 percent and unintended consequences such as statistical production disruption of compliant designs. NEMA concluded that DOE should maintain the current standard at 89 lm/W for 4-foot MBP T8 lamps to allow for the manufacturability of consistently compliant products. (NEMA, No. 54 at p. 24)

GE offered a slightly different opinion on the average maximum technologically feasible efficacy for 4-foot MBP lamps. GE expressed concern that for the 4-foot MBP product class, EL 1 represented the central tendency of a distribution and EL 2 at 92.4 lm/W was based on a data point from DOE's certification database that happened to come out at the higher tail of a distribution. GE noted this as normal statistical variation when taking small samples of large quantities of lamps. (GE, Public Meeting Transcript, No. 49 at pp. 86-87)

NEMA noted its concern that the rulemaking is not following well-established rules for the treatment of statistical variation as applied to the production of compliant lamps. NEMA stated that for the 4-foot MBP product class, the proposed efficacy level of 92.4 lm/W is considered the midpoint of the normal distribution performance curve of compliant lamps. However, because the Certification, Compliance, and Enforcement (CCE) rule (76 FR 12422 (March 7, 2011)) requires almost all lamps to meet the proposed efficacy level, manufacturers would have to design their products above the midpoint which would result in eliminating most of the current best performing argon-based product lines. NEMA also noted that the response that lamps listed in the CCMS database meet the level is not adequate because it ignores differences due to the understanding of reporting requirements and optimistic manufacturer claims. NEMA concluded that DOE is proposing manufacturers consistently and repeatedly produce products above the max tech. (NEMA, No. 54 at p. 22)

As described previously in this section, the statistics included in the compliance procedures are intended to ensure that manufacturers are reporting a value that approximates the population mean. Each tested lamp is not individually required to meet or exceed the standard level. Designing products such that their population mean or the performance of each individual lamp unit within the population exceeds DOE's standard level is not required and is done so at the discretion of individual manufacturers.

DOE believes the efficacy levels analyzed in this rulemaking represent expected population means rather than outlier data in the high end of a bell distribution curve. DOE received feedback from manufacturers during interviews that catalog data represents the long term average performance of products. DOE uses catalog data to establish initial efficacy levels. DOE then compares the efficacy levels to available certification data and adjusts the levels downward if necessary. DOE does not believe that the certification values represent outlier data in the high end of a bell distribution curve. Manufacturers must select a minimum of three lamps from each month of production for a minimum of 7 months out of a 12-month period.[38] It is unlikely that selecting lamps from multiple months of production over the course of a year will result in a value that is consistently in the high end of a bell distribution curve. Furthermore, if manufacturers believe their test results are artificially high, they have the opportunity to report a more conservative value as DOE allows manufacturers to rate the product within the range of the existing standard up to the lower of the LCL divided by 0.97 or the mean as determined per 10 CFR 429.27(a)(2)(i).

Using this methodology, DOE accounts for variation in tested samples and ensures efficacy levels are based on values determined by DOE's test procedures and

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[38] In the instance where production occurs during fewer than 7 of such 12 months, the manufacturer shall randomly select 3 or more lamps from each month of production, where the number of lamps selected for each month shall be distributed as evenly as practicable among the months of production to attain a minimum sample of 21 lamps.

reported by manufacturers themselves. In this final rule, DOE has maintained the same methodology to develop efficacy levels.

NEMA stated that very high efficacy levels proposed and the impossibility of reliably meeting them indicates that consumers will lose the full-wattage (argon-based) lamps in some product categories. NEMA asserted that this would push consumers to reduced wattage (krypton-based) lamps which DOE has acknowledged are not suitable for dimming applications. Further, NEMA stated that control systems are expected to deliver more national energy savings than the 2 percent efficacy difference between the proposed EL 1 and EL 2 levels. NEMA asserted that the proposed EL 2 limits the dimmability and energy saving potential if argon-based lamps cannot meet the level as they can dim far more than 2 percent lower than krypton-based lamps. NEMA also noted that end users may not be aware of potential issues that can occur if reduced wattage lamps are used in the wrong application. (NEMA, No. 54 at p. 27, 48)

NEMA stated that in order to ensure that dimmable argon-based lamps are available to take advantage of energy saving controls, the proposed efficacy level must be properly adjusted downward to make the low end of the bell distribution curve the midpoint and allow industry to be compliant. Specifically, the level must be maintained at 89 lm/W to assure that the very long life high performing argon lamps survive in the marketplace. (NEMA, No. 54 at pp. 22-23)

NEEP commented that high efficacy lamps do not impede control capabilities. NEEP added that the proposed TSL 5 efficacy level allows for 4-foot MBP full-wattage “high-lumen” T8 lamps that have the same control and dimming performance as lower efficacy lamps eliminated by the standard. (NEEP, No. 57 at p. 2)

As stated previously in this section, DOE disagrees that the analyzed levels cannot be reliably met by available products. Because manufacturers demonstrate compliance with energy conservation standards by reporting values to DOE that are intended to represent the population mean, DOE develops its efficacy levels based on these values. Thus, DOE is not adjusting efficacy levels downward to reflect the low end of a bell distribution curve. Regarding lighting controls, DOE agrees with NEMA that dimmable systems can offer significant energy savings and therefore ensures that the analyzed levels maintain the availability of full wattage (argon-based) products.

NEMA stated that the proposed level for the 4-foot MBP product class will eliminate over 80 percent of the current full wattage product offering, including the long-life products, and nearly half of the reduced wattage lamps. NEMA noted that this would result in one lamp offering for each of the three common color lamps (830, 835 and 841) per manufacturer. NEMA concluded that this proved DOE’s approach to modeling does not work. (NEMA, No. 54 at p. 25)

When DOE proposes to adopt an amended standard for a type or class of covered product, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such a product. (42 U.S.C. 6295(p)(1)) After determining this level, DOE conducts subsequent analysis to determine the impact of potential standards on individuals, manufacturers, and the nation as a whole. DOE then considers these results to determine whether the benefits of potential standard levels outweigh the burdens. See section VII.C.1 for this discussion.

For the final rule, DOE updated catalog and certification data for all products. DOE continued to identify two levels of efficacy above the baseline. Based on catalog data, DOE determined EL 1 (90.0 lm/W) represented an improved 800 series full wattage T8 lamp and EL 2 (93.0 lm/W) represented an 800 series high lumen output full wattage T8 lamp. Reduced wattage lamps also meet EL 2. Based on available certification information, DOE confirmed that no adjustment to EL 1 was necessary. As stated, DOE adjusted EL 2 to 92.4 lm/W in the NOPR anlaysis. DOE analyzed available certification information and found that, given additional certification data reported, no additional downward adjustments to EL 2 were necessary. Therefore, DOE analyzed EL 1 at 90.0 lm/W and EL 2 at 92.4 lm/W in the final rule.

Eight-Foot Slimline Lamps

In the NOPR, DOE selected a baseline lamp that just complies with the existing standard level of 97 lm/W. 79 FR at 24097, 24098 (April 29, 2014). 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 in the NOPR.

NEMA stated that there is potential for erroneous high frequency reference ballast photometry testing for full wattage (59 W) and reduced wattage (54 W) 8-foot SP slimline lamps, although less likely for 59 W lamps because ANSI C78.81-2005 and C78.81-2010 versions standardized measurement on low frequency circuits for these lamps. NEMA noted that measurements with 54 W lamps tested on high frequency circuits were more likely to appear in DOE's certification database because this lamp type will be standardized for high frequency testing in the version of ANSI C 78.81 expected to be published in 2014. (NEMA, No. 54 at p. 25) NEMA commented on figure 5.3.4 of chapter 5 of the NOPR TSD, which shows all certification data reported for the 8-foot SP slimline lamps. Specifically, examining the data from 97 lm/W (current standard) to 102.4 lm/W, NEMA stated that the spread was approximately 6 percent which is in agreement with industry expectations as specified in LSD 63-2012 and does not indicate the use of high frequency photometry testing. (NEMA, No. 54 at p. 25)

For the 8-foot SP slimline product class, NEMA recommended that DOE should maintain the current standard of 97 lm/W in order to allow the manufacturability of consistently compliant products. NEMA added that if DOE intended to propose the max tech level of 99 lm/W, it should allow for efficacy compliance tolerances of approximately 8 percent and require reporting only the sample mean value. (NEMA, No. 54 at p. 25)

For the final rule, DOE updated catalog and certification data for all products. DOE continued to identify two distinct levels above the baseline. EL 1 at 98.2 lm/W represents a standard 800 series full wattage T8 lamp and EL 2 at 99.0 lm/W 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. As described previously in this section, DOE believes that catalog and certification data approximate the population mean and therefore does not believe that an efficacy level has to be lowered further in order for products reporting those values to comply.

Eight-Foot RDC HO Product Class

In the NOPR, DOE 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 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 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 remained 97.6 lm/W. 79 FR at 24103 (April 29, 2014).

NEMA stated that the DOE certification data for the 8-foot RDC HO GSFL lamps with CCT ≤ 4,500 K lamps was too sparse for analysis and recommended retaining the current standard of 92 lm/W. (NEMA, No. 54 at p. 25) Although commenting that the data was sparse, NEMA claimed that the proposed efficacy levels would eliminate T8 HO lamps and force consumers to change to another fixture or retrofit with another technology. (NEMA, No. 54 at p. 25)

For the final rule, DOE updated catalog and certification data for all products. DOE continued to model a baseline lamp that just meets the existing standard level of 92 lm/W, because feedback from stakeholders and manufacturer interviews indicated that manufacturers will likely produce lamps at the existing standard level even if no products are currently available. DOE again identified two levels of efficacy above the baseline. DOE analyzed publicly available certification data and determined that adjustment to EL 1 in the NOPR analysis was still appropriate and maintained the adjustment 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 remained 97.6 lm/W. While there are fewer product offerings for 8-foot RDC HO lamps than for other covered lamp types, DOE does not believe the data is too sparse for analysis. For the final rule, certification data was available for 71 percent of 8-foot RDC HO lamps. DOE confirmed through its assessment of catalog and certification data that 8-foot RDC HO products meet the analyzed ELs. Because manufacturer-reported data demonstrates that products can meet the analyzed levels, DOE does not believe the efficacy levels would eliminate 8-foot RDC HO lamps and force consumers to switch to another technology.

Four-Foot T5 MiniBP SO Product Class

In the NOPR, DOE 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 lower efficacy full wattage (28 W) lamp. 79 FR at 24097, 24098 (April 29, 2014). 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 T5 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 certification data.

NEMA stated that since the 2010-2011 rare earth crisis, some efficacious phosphors are no longer available and thus many of the high performance T5 lamps currently found in product catalogs that meet the proposed standard level will be removed from the catalogs. Additionally, compliant T5 lamps may also be removed because they do not sell due to high prices. (NEMA, No. 54 at p. 19)

DOE reviewed updated catalogs and certification submissions and confirmed that the 4-foot T5 MiniBP SO and HO lamps analyzed for the final rule were still commercially available. DOE found no indication in manufacturer literature that any T5 lamps were discontinued. When considering available products, DOE relied on information provided by each manufacturer and did not speculate on the future discontinuation of products.

NEMA provided several comments on how the certification data compared to the efficacy levels DOE considered in the NOPR. NEMA acknowledged that the current standard for 4-foot T5 MiniBP SO lamps of 86 lm/W is easily achievable by max tech designs. However, NEMA disagrees with eliminating the manufacturability and marketing of consistently compliant products by setting the minimum efficacy level any higher than 89 lm/W, which is only about 4 percent below the proposed max tech level. (NEMA, No. 54 at p. 26) NEMA stated that the certification data for the 28 W 4-foot MiniBP T5 SO lamps shown in figure 5.3.8 of chapter 5 of the NOPR TSD reflects about a 7 percent spread from 93 lm/W to 100 lm/W and is in agreement with their assessment. (NEMA, No. 54 at p. 26)

For the final rule, DOE updated catalog and certification data for all products. DOE continued to model a baseline lamp that just meets the existing standard level of 86 lm/W, because feedback from stakeholders and manufacturer interviews indicated that manufacturers will likely produce lamps at the existing standard level even if no products are currently available. DOE again identified two levels of efficacy above the baseline. 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 reviewed available certification data and 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 found that a further downward adjustment was necessary and adjusted EL 2 from 98.2 lm/W to 95.0 lm/W. Additional and/or revised certification data reported since the publication of the NOPR indicated that T5 SO lamps had lower efficacies than originally indicated. As described previously in this section, DOE does not believe that catalog or certification data inherently represent values at the high end of a distribution curve and that an efficacy level has to be lowered further in order for products reporting those values to comply.

Four-Foot T5 MiniBP HO

For the NOPR, DOE analyzed one level of efficacy above the baseline level. DOE 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 lower efficacy full wattage (54 W) lamp. Manufacturer-provided information in catalogs indicates that there is one distinct product line available with an 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 evaluated EL 1 at 82.7 lm/W in the NOPR. 79 FR at 24104 (April 29, 2014).

NEMA stated that efficacy levels for T5 lamps should not be based on catalog rated efficacy at 35 °C because the industry standard IEC 60081 and the DOE test procedure require measurement at 25 °C. NEMA further noted that there is no ambiguity in the measurement circuit as all T5 lamps are measured on high frequency circuits at 25 °C. (NEMA, No. 54 at pp. 25-26)

DOE agrees that T5 lamps must be tested at 25 °C per DOE's test procedure. However, not all manufacturers provide lumen output data at 25 °C for T5 lamps in their catalogs, whereas all manufacturers provide data at 35 °C. Thus, to consider the entire market DOE developed initial efficacy levels based on 35 °C catalog data for T5 lamps and then adjusted the initial efficacy levels to reflect operation at 25 °C. DOE compared the 25 °C levels to certification data which reflects tested values at the same temperature.

NEMA provided several comments on how the certification data compared to the efficacy level DOE considered in the NOPR. NEMA noted that the spread of certification data from 81 lm/W to 96 lm/W for 54 W 4-foot T5 MiniBP HO lamps indicates variability of 17 percent, which could be explained by the steeper slope of lumen output with ambient temperature at 25 °C for T5 compared to T8 lamps. NEMA stated that the certification data shown in figure 5.3.10 of chapter 5 of the NOPR TSD agreed with its assessment of DOE's certification database. NEMA noted that for the reduced wattage 4-foot T5 MiniBP HO lamps, the certification data was shown mostly to be between 85 and 87 lm/W and with a couple of values well above 90 lm/W. Stating that it is difficult to determine the max tech for this product class, NEMA recommended that DOE set the minimum efficacy level no higher than 80 lm/W. NEMA stated that 80 lm/W would require centering the practical compliant designs near 87 lm/W to avoid statistical non-compliant results. (NEMA, No. 54 at p. 26)

For the final rule, DOE updated catalog and certification data for all products. DOE continued to model a baseline lamp that just meets the existing standard level of 76 lm/W because feedback from stakeholders and manufacturer interviews indicated that manufacturers will likely produce lamps at the existing standard level even if no products are currently available. DOE again identified one level of efficacy above the baseline representing an 800 series full wattage T5 lamp with basic coating, gas composition, and phosphor mix. Reduced wattage lamps also meet this level. Based on catalog data, DOE determined EL 1 to be 82.7 lm/W. DOE reviewed available certification data and found that the reported values did not indicate that any adjustment to the level was necessary. The certification data, as noted by NEMA, is generally higher than the catalog data on which EL 1 is based. As described previously in this section, DOE does not believe that catalog or certification data inherently represent values at the high end of a distribution curve and that an efficacy level has to be lowered further in order for products reporting those values to comply.

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.

CCT Scaling

Finding substantial variation in the percent reduction in efficacy associated with increased CCT among product classes, in the NOPR DOE proposed a separate scaling factor for each product class. 79 FR at 24105 (April 29, 2014). Based on its assessment, DOE proposed a 2 percent scaling factor for the 4-foot MBP product class, 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 MiniBP SO product class, and 5 percent for the T5 MiniBP HO product class. DOE 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.

NEMA stated it is well established in industry that there is a decrease in efficacy of 4-6 percent to go from the common 4,100 K 4-foot MBP lamps to the 5,000 K tri-phosphor lamps and a decrease in efficacy of 6-8 percent to go to the 6,500 K tri-phosphor lamps. NEMA noted that the reduction in efficacy at CCTs greater than 4,500

K becomes more significant when targeting higher efficacy levels. NEMA also contended that the 2009 Lamps Rule was erroneous in allowing only a 1 percent reduction in efficacy for 4-foot MBP lamps with a CCT greater than 4,500 K. NEMA recommended that the scaling factor for high CCT lamps allow a decrease of at least 7 percent to accommodate the average performance of higher CCT lamps and at minimum be reduced by greater than 4 percent unless limited by current regulations. NEMA also noted that European regulations allow for a decrease of 10 percent for high CCT lamps, and CEE specifications allow for a decrease of 4.3 percent for high CCT 4-foot T8 MBP lamps. (NEMA, No. 54 at p. 28)

DOE revised its scaling analysis for CCT in the final rule to use the most recent values submitted to DOE for compliance purposes rather than catalog data. DOE compared certification data for each lamp type to determine the efficacy differences between low and high CCT lamps. The data still demonstrated that the difference in efficacy between low and high CCT lamps varied by lamp type. Therefore, DOE maintained a separate scaling factor for each product class. However, the additional and revised certification data indicated slightly different scaling factors were necessary. Based on its assessment, DOE calculated a 4 percent scaling factor for the 4-foot MBP product class, 2 percent scaling factor for the 2-foot U-shaped product class, 3 percent for the 8-foot SP slimline product class, 4 percent for the 8-foot RDC HO product class, 6 percent for the T5 MiniBP SO product class, and 7 percent for the T5 MiniBP HO product class. DOE applied these scaling factors to the low CCT levels to determine the appropriate levels for high CCT lamps. If applying the scaling factor resulted in an efficacy that was lower than that of the existing standard, DOE maintained the existing standard level to avoid backsliding. (See 42 U.S.C. 6295(o)(1)) DOE compared the scaled efficacy levels to available certification data and confirmed that high CCT lamps can meet the analyzed efficacy levels.

Two-Foot U-Shaped Scaling

By comparing certification data for 2-foot U-shaped lamps with equivalent 4-foot MBP lamps, in the NOPR, DOE determined an average efficacy reduction of 6 percent for the 2-foot U-shaped lamps from the 4-foot MBP lamps was appropriate. 79 FR at 24106 (April 29, 2014). 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.

NEMA stated that only the full wattage 2-foot U-shaped 1 5/8-inch lamps and reduced wattage 2-foot U-shaped 6” lamps can meet the proposed efficacy levels. NEMA explained that consumers have switched to reduced wattage 2-foot U-shaped 1 5/8-inch lamps which serve retail applications and full wattage 2-foot U-shaped 6” lamps are mainly used in offices for dimming purposes. Therefore, NEMA concluded that the energy savings for the 2-foot U-shaped 1 5/8-inch lamps would be negative and increase the energy consumption by 2 W due to the elimination of the reduced wattage versions forcing consumers back to the full wattage version. NEMA stated that DOE should update its energy savings estimates accordingly or adopt the efficacy level at TSL 3, which would allow for both full and reduced wattage 2-foot U-shaped lamps to meet.

(NEMA, No. 54 at p. 15, 27) GE also noted that the efficacies of the 2-foot U-shaped class were scaled from the 4-foot MBP class which could indicate an issue with the scaling or the proposed efficacy levels of the 4-foot MBP. (GE, Public Meeting Transcript, No. 49 at p. 61)

DOE revised its scaling analysis for 2-foot U-shaped lamps in the final rule to use the most recent values submitted to DOE for compliance purposes. DOE compared certification data for 2-foot U-shaped lamps of both spacings (i.e., 6-inch and 1 5/8-inch leg spacing) with equivalent 4-foot MBP lamps and determined an average efficacy reduction of 8 percent for the 2-foot U-shaped lamps from the 4-foot MBP lamps was appropriate. Thus, DOE applied this scaling factor to the 4-foot MBP levels to determine the appropriate levels for 2-foot U-shaped lamps. If applying the scaling factor resulted in an efficacy that was lower than that of the existing standard, DOE maintained the existing standard level to avoid backsliding. (See 42 U.S.C. 6295(o)(1)) DOE compared the scaled efficacy levels to available certification data and confirmed that both types of 2-foot U-shaped lamps can meet with the analyzed efficacy levels.

i. Rare Earth Phosphors

DOE understands a constrained supply of rare earth phosphors may have impacts on the production of higher efficacy fluorescent lamps. DOE also acknowledges that supply and demand of rare earth phosphors should be considered when evaluating amended standards for GSFLs. Thus, in the NOPR analysis, DOE considered a scenario of increased rare earth phosphor prices in the LCC and NIA.

NEMA commented that manufacturers are at risk of not being able to make compliant lamps consistently due to the availability of high efficiency phosphors for GSFLs. If manufacturers cannot consistently produce a product, they will stop making it as with the 130 V IRLs. (NEMA, No. 54 at pp. 13-14)

NEMA noted that the proposed lm/W requirements would increase the use of rare earth oxides (REOs) per lamp. (NEMA, No. 54 at p. 34) Further, NEMA commented that even though it is possible to increase GSFL efficacy with a more efficient mix of REOs, the high material cost of the REOs needed for the small increase in efficacy is still relevant. NEMA commented that DOE should analyze price elasticity and consumer behavior during previous REO shortages, as the ELs DOE proposed in the NOPR would effectively cause another shortage of REOs. (NEMA, No. 54 at p. 34)

Noting that that China appealed World Trade Organization's (WTO's) ruling demanding greater availability of REOs, NEMA stressed that DOE should expect China to raise prices on REOs through various methods; specifically quoting an article from Bloomberg News.[39] NEMA explained that during the last REO shortage, prices increased 400 to 700 percent, and stated that this is cause for DOE to revise their price estimates to raise the upper bounds of potential spiking during periods of criticality to 700 percent of current prices. NEMA further noted that while they cannot make the same supply

[39] Bloomberg News, "China Maintains Quotas for Heavy Rare Earths, Tungsten," June 19, 2014. <http://www.bloomberg.com/news/2014-06-19/china-maintains-quotas-for-heavy-rare-earths-tungsten.html>

warnings they provided for the 2009 Lamps Rule, REO availability continues to be an issue and there are significant uncertainties regarding future supplies. (NEMA, No. 54 at pp. 34-35)

NEEP noted that REO prices and availability had improved in the last few years and, according to DOE, would continue to fluctuate. NEEP commented that DOE appropriately weighed the variability of REO prices in the analysis. (NEEP, No. 57 at p. 3)

In April of 2012, several manufacturers 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. 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.[40] Because this waiver expired in 2014, and manufacturers did not reapply for exception relief, DOE does not believe that the availability of high efficiency phosphors will affect manufacturers' ability to consistently produce a product. However, DOE acknowledges that the market for rare earth phosphors is uncertain and therefore continues to analyze in this final rule a scenario of increased rare earth phosphor prices in the LCC and NIA.

3. Incandescent Reflector Lamp Engineering

For IRLs, DOE received several comments on the engineering analysis presented in the NOPR. 79 FR at 24106 (April 29, 2014). Stakeholders provided feedback on DOE's baseline lamps, selection of more efficacious substitutes, max tech level, ELs, scaling, and xenon. The following sections summarize the comments and responses received on these topics, and present the IRL engineering methodology for this final rule analysis.

a. 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 NOPR analysis DOE identified standard spectrum lamps, with diameters greater than 2.5 inches, and input voltage less than 125 V as the representative product

[40] 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.

class, shown in gray in Table VI.5. 79 FR at 24107 (April 29, 2014). NEMA commented that the only IRLs that still have any meaningful product sales are in the standard spectrum, less than 2.5 inches in diameter, less than 125 V product class. (NEMA, No. 54 at p. 21) Receiving no other comments, DOE maintained the same IRL representative product classes for the final rule.

Table VI.5. IRL Representative Product Classes

Lamp Type	Diameter	Voltage
Standard spectrum	> 2.5 inches	≥ 125
		< 125 (representative)
	≤ 2.5 inches	≥ 125
		< 125
Modified spectrum	> 2.5 inches	≥ 125
		< 125
	≤ 2.5 inches	≥ 125
		< 125

b. 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. DOE reviewed product offerings in catalogs, shipment trends, and information obtained during manufacturer interviews to identify the common characteristics of lamps that meet standards. In the NOPR, DOE identified a PAR38 lamp as the most prevalent lamp shape and diameter in the representative product class. Id. at 24109. From all PAR38 lamps with the most common characteristics, DOE selected a lamp that just met existing standards as the baseline: 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, $5.9P^{0.27}$. DOE received several comments on its selection of the baseline for IRLs.

GE stated that they agreed that the baseline lamp is representative of its product class. (GE, Public Meeting Transcript, No. 49 at p. 104) However, NEMA commented that a 60 W IRL with a lifetime of 1,000 hours should be the baseline as it is the lowest performing most common product. (NEMA, No. 54 at p. 29) As noted, the baseline is usually representative of the most common, least efficacious lamp that meets existing energy conservation standards. Based on DOE's review of product offerings in catalogs, 1,500 hours is the most common lifetime. Among the covered IRLs product offerings, 1,500-hour lamps comprise 27 percent of offerings while 1,000-hour lamps comprise 12 percent. The 1,500-hour product selected as the baseline lamp in the NOPR performs at the minimum efficacy required by existing standards. Therefore, DOE is maintaining the 1,500-hour lamp as the baseline in the final rule analysis. Table VI.6 summarizes the performance characteristics of the IRL baseline lamp. For further information, see chapter 5 of the final rule TSD.

Table VI.6 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

c. 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 NOPR, DOE considered substitute lamps that saved energy and, where possible, had a light output within 10 percent of the baseline lamp's light output. Id. at 24109. In identifying the more efficacious substitutes, DOE utilized a database of commercially available lamps. DOE identified two higher efficacy, reduced wattage lamps, referred to in this analysis as an HIR lamp with a lifetime of 2,500 hours and an improved HIR lamp with a lifetime of 4,200 hours, as more efficacious substitutes for the baseline lamp. DOE received several comments regarding its choice for the more efficacious substitutes.

NEMA insisted that 3,000-hour and longer lifetimes must be available in the commercial market for the product line to maintain viability, as long life is a consumer-demanded utility. Lamp lifetimes shorter than 3,000 hours for premium and expensive halogen PAR38 lamps would not be sustainable or acceptable in the commercial market. (NEMA, No. 54 at p. 21)

NEMA further explained that the only remaining method to increase IRL efficacy is by shortening their lifetime, and many IRLs are already rated at 1,000 hours. NEMA noted that a 1,000-hour lifetime represents a previous loss of utility from complying with efficacy requirements, and that the shortened lifetime has resulted in public backlash. NEMA warned that with the standards proposed in the NOPR, consumers would lose the utility of lifetime. Using a calculation from The Science of Incandescence,[41] NEMA stated that the higher efficacy of EL 1 would result in a 30 percent reduction in lifetime for these lamps, causing a total loss of financial feasibility. (NEMA, No. 54 at pp. 21, 29, 49) Westinghouse remarked that IRLs are already at max tech, and that unlike with GSFLs, there is no opportunity for tradeoffs between efficacy and utility. (Westinghouse, Public Meeting Transcript, No. 49 at pp. 54-56)

DOE recognizes that there is an inverse relationship between efficacy and lifetime for IRLs. DOE believes typical lifetimes of IRLs regulated by this rulemaking are between 1,500 and 4,400 hours. In the engineering analysis, DOE only considered lamps with lifetimes greater than or equal to the baseline when selecting representative lamp units. DOE found evidence that improved technology lamps (i.e., HIR lamps) with lifetimes higher than the baseline lifetime are prevalent on the market. Both

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[41] Vukcevich, Milan R., Science of Incandescence, NELA Press, 1992.

representative lamp units that DOE selected in the engineering analysis have lifetimes longer than the baseline. 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. One of the representative units at EL 1 has a lifetime of 4,200 hours. Thus, DOE ensured that products with lifetimes greater than 3,000 hours would be available for consumers desiring longer life products.

NEMA commented that the PAR38 lamp is not an adequately representative lamp and inappropriately skews DOE's analysis because it is the only lamp type in the class that can physically incorporate the largest number of technology options, overstating the possible energy savings. NEMA encouraged DOE to examine smaller diameter lamps to better understand what technology options are feasible. (NEMA, No. 54 at p. 29) As an example, NEMA commented that the lifetime of the PAR30 lamp would have to be shortened to the point of being economically infeasible and unmarketable to consumers to meet standards. (NEMA, No. 54 at pp. 29-30) NEMA could not identify a lamp that met the EL proposed in the NOPR while still providing adequate lifetime in all sizes. Specifically, NEMA stated that the rule proposed in the NOPR would allow only certain PAR38 lamps to meet the regulations and most other types and classes of covered IRLs would be eliminated. NEMA argued, therefore, that the EL proposed in the NOPR is invalid for most lamps. (NEMA, No. 54 at p. 29)

DOE recognizes that in addition to PAR38 lamps, the representative product class also includes PAR30 lamps. Because it is a more common lamp size among the covered

IRLs, DOE selected PAR38 as the diameter for the baseline lamp and more efficacious substitutes of the baseline. DOE's research indicates that the design options identified for PAR38 lamps are also applicable to PAR30 lamps. DOE assessed the availability of PAR30 lamps as more efficacious substitutes. DOE found that there are PAR30 lamps with lifetimes of 3,500 and 4,400 hours that are able to achieve the same efficacies as PAR38 lamps. See chapter 5 of the final rule TSD for additional details.

CA IOUs expressed disappointment that there were not multiple efficacy levels representing higher performance products. CA IOUs stated that DOE had restricted itself to a small subset of IRLs by focusing on PAR38 lamps and requiring lumens to be within 10 percent of the baseline lamp, limiting the lumen range to about 963 to 1,170. CA IOUs mentioned that any design strategies used in other lamp types, (e.g., 800-lumen lamp, 1,200-lumen lamp, PAR30 lamp) that improved efficacy would be fairly transferable among lamp types. CA IOUs questioned why DOE did not consider potential efficacy improvements from these lamp types. (CA IOUs, Public Meeting Transcript, No. 49 at pp. 107-109) Specifically, CA IOUs noted four lamps that have better performance than the proposed efficacy level: the GE 60 W PAR HIR Plus operating at 21 lm/W, the Philips PAR38 Energy Halogen DiOptic operating at 20 lm/W, the OSRAM SYLVANIA PAR38 medium-base warm white outdoor halogen flood operating at 20 lm/W, and the OSRAM SYLVANIA PAR38 warm white outdoor halogen flood operating at 21 lm/W. (CA IOUs, Public Meeting Transcript, No. 49 at pp. 107-109, 118)

ASAP also disagreed with DOE's criteria of restricting lumen output to be within 10 percent of the baseline lamp, noting that the NOPR analysis seemed to suggest that DOE understood that technologies used in one lamp to achieve a certain lumen package can be used in another. Therefore, ASAP questioned why DOE rejected a more efficacious technology used in another lamp due to the lumen output of that lamp having a greater than 10 percent difference from the baseline lamp. ASAP stated that DOE should have analyzed the more efficacious technology and used scaling to maintain the baseline lumen output. (ASAP, Public Meeting Transcript, No. 49 at p. 113)

GE, on the other hand, commented that the analysis presented in the NOPR was fairly accurate in terms of addressing and looking at the other potential more efficacious products. GE argued that not all of the lamps proposed by commenters to be more efficacious were within the scope of this rulemaking and not all of the proposed technologies were transferable to covered lamps. (GE, Public Meeting Transcript, No. 49 at p. 112)

DOE used certain criteria when selecting more efficacious substitutes. Specifically, DOE only considered lamps with the same reflector shape as the baseline lamp, wattages less than the baseline wattage, lumens within 10 percent of the baseline lumens, lifetimes equal to or greater than the baseline lifetime, and that were commercially available in the United States or available as prototypes. These criteria ensured that higher efficacy lamps with similar characteristics to the baseline were available to consumers at each efficacy level analyzed.

When establishing efficacy levels, DOE considered all lamps available. DOE reviewed the design options incorporated into each lamp, the ability of lamps across lumen packages to meet the level, and the max tech level. Regarding the four lamps that CA IOUs noted as having better performance than the proposed efficacy level, one of them was part of a product line for which certification data indicated that the product line performed below or much closer to EL 1 than indicated by its catalog data. Another of the lamps was part of a product family for which certification data indicated that product performance was at the existing standard level, or baseline, rather than EL 1. A third lamp in the group of four did not have certification data available for DOE to substantiate its performance claims in catalogs. The fourth lamp did have both catalog and certification data available and that data indicated that it performed above EL 1. However, this lamp was not part of a full product line that would indicate that the technology incorporated in the lamps could be used across all lumen packages. While DOE is aware that it is generally the case that technology can be shared among various lamps, modeling a product allows DOE to estimate lamp performance but not confirm performance via certification data or independent testing, a significant concern in this rulemaking. Furthermore, costs for such a product would be uncertain as it would not be commercially available at the time of the analysis. Therefore, DOE chose not to model a higher efficacy lamp that met its criteria for selecting representative units in the NOPR as well as the final rule analysis.

NEEA commented that, unless the market shares of the 60 W PAR38 and 55 W PAR38 lamps are close to 90 percent of the market, DOE's analysis was incomplete and the more efficacious lamps suggested by CA IOUs need to be analyzed. (NEEA, Public Meeting Transcript, No. 49 at pp. 111-112)

Through a review of product offerings in catalogs, DOE determined that PAR38 is the most common lamp diameter and 60 W is at least twice as common as any other wattage. Further, DOE did not restrain the representative lamp units to 55 W but rather required that the wattage be less than the baseline. DOE found that the majority of product offerings on the market have wattages at or below 60 W. Thus, DOE finds that the baseline and more efficacious lamp units analyzed represent the most widely offered products on the market. Table VI.7 summarizes the performance characteristics of the more efficacious substitutes for IRLs. For further information see chapter 5 of the final rule TSD.

Table VI.7 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	1,120	4,200

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

d. Max Tech

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 IRLs using the design parameters for the most efficient products available on the market or in working prototypes.

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

ASAP and CA IOUs commented that DOE made a mistake in not considering higher ELs for IRLs. ASAP stated that CA IOUs provided reasons for considering higher levels in response to the preliminary analysis and DOE dismissed the suggestions with a "grab bag" of unsubstantiated arguments for not considering the higher levels. (ASAP, Public Meeting Transcript, No. 49 at p. 17; CA IOUs, Public Meeting Transcript, No. 49 at p. 20) Further, CA IOUs commented that they do not think that DOE adequately considered alternative technology options they gave in response to the preliminary analysis for a more efficacious max tech. (CA IOUs, Public Meeting Transcript, No. 49 at p. 114) CA IOUs stated that they suggested more efficacious lamps and in not considering them, DOE has not complied with their statutory requirement to investigate max tech. (CA IOUs, Public Meeting Transcript, No. 49 at p. 110) CA IOUs continued that commercially available products were available in different lumen bins or that there were different lamp shapes from PAR38. CA IOUs noted that some of the data they had for support were compliance certification values and some were prototype products from the past or developed recently. (CA IOUs, Public Meeting Transcript, No. 49 at p. 110)

DOE evaluated the more efficacious lamps proposed by stakeholders in response to the preliminary analysis. As discussed in the NOPR, DOE did not consider some of these lamps when evaluating the max tech level because they were not available with the same reflector shapes or input voltage as the IRLs covered by this rulemaking. 79 FR at 24111(April 29, 2014). In addition, as described in section VI.D.3.c, certification data indicates that some lamps are not performing at the high efficacies advertised in catalogs. Absent certification or independent test data, DOE is unable to verify high efficacy claims. Finally, although certain higher efficacy products have certification data confirming their performance above EL 1, they are not part of a full product line that would indicate that the technology incorporated in the lamps could be used across all lumen packages.

Regarding prototype lamps, 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.[42] DOE notes that the lamps tested were prototype lamps and were not manufactured during commercial scale production runs. The measured efficacy of the prototype lamps greatly exceeded the efficacy of commercially available lamps with similar lumen packages. DOE did 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. Therefore, in the NOPR phase DOE requested information on the incremental manufacturer production cost of a lamp that could achieve the efficacy of the prototype lamps compared to a lamp that complies with EL 1. DOE also sought information on the manufacturing costs including equipment and product conversion costs necessary to produce lamps at the efficacy of the prototype lamps. However, DOE did not receive any information to conduct a cost assessment of the higher efficacy prototypes and therefore, did not include them in this final rule analysis.

CA IOUs stated that the efficacy standards proposed in the NOPR would not be a challenge and an efficacy standard of more than three times higher, as shown in appendix 5A of the NOPR TSD, would be possible and likely be cost effective. Most manufacturers already have the capability to meet the levels proposed in the NOPR, and the achievement of higher efficacies was proven through the testing of prototype lamps. CA IOUs commended DOE on its tests of prototyped products, but expressed confusion over why DOE did not develop pricing estimates for these products and create a corresponding EL. They also questioned why DOE had not used the comments on

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[42] DOE independently verified efficacy values provided by the manufacturer. At the time of NOPR analysis, the manufacturer was still conducting lifetime testing. DOE did not receive any updates on lifetime testing of the prototype lamps at the time of the final rule analysis.

projected sale prices given during manufacturer interviews in their analysis. CA IOUs noted that a pricing estimate could also have been achieved by a teardown analysis of the prototype lamps compared with similar, commercially available components. Specifically, CA IOUs gave the example that lamps using high performance HIR burner are already commercially available in A-line and MR16 bulb shapes, selling for $3.49 and $6.90, respectively. Supported by these analyses, CA IOUs urged DOE to conduct a complete review of the higher efficacy prototype EL. (CA IOUs, No. 56 at p. 5)

As noted in the NOPR, while DOE was able to test the efficacies of the prototype lamps, it had insufficient information to perform a cost analysis. 79 FR at 24111 (April 29, 2014). DOE did not find that a teardown analysis of the prototype lamps would be a feasible method to estimate costs. DOE would be unable to determine through teardowns whether the halogen burners used in various product offerings were the same because of the difficulty in analyzing the IR coating, specifically identifying the combinations of coatings applied. Without this knowledge, DOE could not distinguish the specific technology differences between one halogen burner and another and estimate costs accordingly. Expected retail prices of the prototype lamp were provided through comments and manufacturer interviews, but the information indicated that the prices of the higher efficacy products would be less than those of the lamps that comply with EL 1 and even the baseline. As these lamps utilize a more advanced IR coating than lamps currently available on the market, the manufacturer-provided cost was inconsistent with the available market information. Further, this manufacturer does not distribute covered IRLs in the U.S. market. Therefore, DOE was unable to estimate the price of the prototype lamp by comparing it to a similar lamp offered by the same manufacturer, which would have allowed DOE to isolate the change in price due to the more efficient coating. For these reasons, DOE concluded that it did not have the information needed to conduct a cost assessment of the higher efficacy prototype lamps and therefore, did not include them in this final rule analysis.

e. Efficacy Levels

After identifying more efficacious substitutes for each of the baseline lamps, in the NOPR, DOE developed ELs based on the consideration of several factors, including: (1) the design options associated with the specific lamps being studied; (2) the ability of lamps across wattages to comply with the standard level of a given product class; and (3) the max tech level. 79 FR at 24093 (April 29, 2014).

For IRLs, DOE developed a continuous equation that specifies a minimum efficacy requirement across wattages and represents the potential efficacy a lamp can achieve 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 EL in the NOPR analysis. Id. at 24113. DOE received a comment from NEMA regarding the EL presented for IRLs in the NOPR analysis.

NEMA stated that energy conservation standards above the current IRL standards could not be economically justified. NEMA further stated that the $6.2P^{0.27}$ level proposed in the NOPR is inappropriately set at the higher end of the normal distribution curve for performance. Following the CCE rules, if the average performance of the more efficacious lamps is $6.2P^{0.27}$, the standard should be set at $6.0P^{0.27}$. NEMA did note, however, for standard spectrum IRLs under 125 V, it would be possible to consistently produce lamps at a higher efficacy, up to $6.0P^{0.27}$ from $5.9P^{0.27}$, for lamps between 60 W and 205 W. NEMA expressed their belief that only this subset of IRLs could reliably increase their efficacy, and only by that increment. NEMA doubted that this increase would generate significant energy savings on its own. (NEMA, No. 54 at pp. 21-22)

DOE conducted an updated engineering analysis for the final rule and determined that EL 1 corresponded to an efficacy requirement of $6.2P^{0.27}$ based on certification data. DOE notes that the statistics included in the compliance procedures are intended to ensure that manufacturers are reporting a value that approximates the population mean. Each tested lamp is not individually required to meet or exceed the standard level. Designing products such that their population mean or the performance of each individual lamp unit within the population exceeds DOE's standard level is not required and is done so at the discretion of individual manufacturers. Regarding an assessment of national energy savings for IRLs see section VII.B.3. Regarding DOE's conclusion as to whether a standard is economically justified, DOE weighs the benefits and burdens in section VII.C.3.

For the final rule analysis, DOE again reviewed the most updated catalog and certification data available for covered IRLs. As in the NOPR analysis, DOE used the catalog data to identify all products on the market and ensure consideration of all available products in the analysis and assessed both catalog and certification efficacy values to identify efficacy levels. In the NOPR analysis, DOE had found there to be certification data for 51 percent of covered IRL products compliant with the July 2012 standards. For the final rule analysis, DOE found that updates to DOE's certification database resulted in certification data for 61 percent of covered IRL products. While this was an increase from the NOPR analysis, it still did not represent a comprehensive dataset on which to base an engineering analysis. Therefore, in this final rule analysis, DOE again used catalog data to identify all products on the market and ensure consideration of all available products in the analysis. DOE assessed both catalog and certification efficacy values to identify efficacy levels. 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 EL that DOE determined based on the representative lamps is a curve that represents a standard across all wattages.

Table VI.8 presents the efficacy level for IRLs. See chapter 5 of the final rule TSD for additional information on how the engineering analysis was conducted.

Table VI.8 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

f. 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 smaller diameter lamps, lamps with higher input voltages, and modified spectrum lamps. 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 NOPR analysis, DOE scaled from the EL developed for 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 without extending the reflector lens. Therefore, in the NOPR 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.

CA IOUs noted that small diameter lamps are less efficacious than larger lamps and agreed with DOE's scaling factor as appropriate, except for the 3.5 percent to account for double-ended burners, as CA IOUs believed that small diameter lamps are capable of utilizing these burners. CA IOUs stated that DOE had not provided enough analysis on the potential issue that fitting double-ended burners in a small diameter lamp would change the physical shape of the lamp and thereby impact whether these lamps can fit in fixtures in which they are currently used. CA IOUs questioned if DOE had collected data on the various lengths of small diameter lamps on the market. CA IOUs noted that they have found R20 lamps with single-ended burners that range in length from 3.1 to 4.2 inches. They stated that the R20 lamp with a double-ended burner they submitted to DOE was 3.5 inches long, and therefore still in the typical R20 range. (CA IOUs, Public Meeting Transcript, No. 49 at pp. 124-126, 128-129)

OSI commented that, in general, technologies used in PAR30 lamps cannot be used in PAR20 lamps. (OSI, Public Meeting Transcript, No. 49 at p. 127) OSI noted that luminaire manufacturers construct luminaires for the actual lamp length on the market, not to the ANSI specifications for the bulb shape. OSI clarified, therefore, that a lamp longer than what is otherwise on the market would not fit in luminaires, regardless of whether it still met the ANSI requirements for the bulb shape. (OSI, Public Meeting

Transcript, No. 49 at pp. 128-129) GE agreed and added that a small increase in lamp length would not matter for certain luminaires, such as a track lighting fixture, but that DOE could not assume the new design would fit in all existing fixtures. (GE, Public Meeting Transcript, No. 49 at p. 125) OSI explained that fitting the lamp with the double-ended burner into the luminaire would not be the only problem, DOE should also consider the temperature limits that the double-ended burner might force the lamp to exceed. (OSI, Public Meeting Transcript, No. 49 at p. 127) NEMA commented that lamps need to be designed to match the physical shape of the luminaires in the market. (NEMA, No. 54 at p. 49)

DOE must consider how the use of a design option affects product utility and whether a more efficacious product is an appropriate substitute for an existing less efficacious product. (42 U.S.C. 6295(o)(2)(B)(i)) DOE confirmed that a double-ended burner was present in the small diameter (PAR20) prototype lamp mentioned previously and also in a commercially available PAR20 lamp that is outside the scope of this rulemaking. However, manufacturers noted that fitting a double-ended burner into a small diameter lamp requires changes to the physical shape of the lamp, specifically requiring an extension of the reflector lens. (NEMA, no. 36 at p. 12; GE, Public Meeting Transcript, No. 49 at p. 125) While the modified lamp may still meet ANSI standards for a small diameter lamp such as a PAR20, it would be larger than 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. DOE conducted an analysis by comparing lengths of small diameter lamps to existing fixtures. The lengths of lamps with double-ended burners varied and DOE cannot state with certainty that these lengths will fit in all fixtures. Further, within the wattage range of lamps covered by this rulemaking (40 W or higher), heat dissipation in lamps with a smaller envelope using a double-ended burner could also become an issue. Additionally, manufacturer feedback indicated 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 such that the benefits in efficacy could be realized.

Therefore, in this final rule DOE continued to apply an additional 3.5 percent reduction factor when scaling efficacies of large diameter to small diameter lamps to account for the ability of small diameter lamps to utilize only single-ended burners.

Operating Voltages Greater Than or Equal to 125 Volts

In the NOPR 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 operating at 120 V[43] to use the same technology and possess the same general performance characteristics as 120 V lamps operating 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 Illuminating Engineering Society of North America (IESNA) Lighting Handbook

[43] While a 130 V lamp is typically operated at 120 V, DOE test procedures require that lamps rated at 130 V be tested at 130 V.

equations that relate lifetime, lumens, and wattage to voltage of incandescent lamps, DOE determined that a 15 percent scaling factor was necessary.

NEMA commented that in the 2009 Lamps Rule, DOE set a level for 130 V lamps which was approximately 15 percent higher than achievable with the maximum available technology. NEMA argued that, as the efficacy of 130 V lamps is actually slightly lower than 120 V lamps, the only way to achieve such efficacy levels is to greatly shorten lamp life to less than 500 hours even if a 130 V lamp was operated on 120 V. If the consumer had a high voltage problem and was operating near 130 V, the lamp life would be shortened to a few hundred hours. In both scenarios, very short life products are unmarketable to the consumer, especially for 130 V consumers who were primarily buying the lamp due to its long life on 120 V operation during voltage fluctuations. Giving the example of the 130 V IRL, NEMA commented that DOE is incorrect in its assumptions that no utility would be lost with higher IRL standards. Specifically, NEMA explained that 130 V IRLs were able to operate under elevated voltage spike and transient conditions, and are now eliminated from the market due to the 2009 Lamps Rule standards. (NEMA, no. 54 at p. 48)

Philips commented that the scaling factor used for any new 130 V lamp standards would not matter as the lamp is already out of the market. (Philips, Public Meeting Transcript, No. 49 at p. 123) GE commented that the max tech for 120 V and 130 V lamps are almost identical, so the 15 percent scaling factor used to scale between the two lamps in the 2009 Lamps Rule is responsible for eliminating 130 V lamps from the marketplace, along with its utility. (GE, Public Meeting Transcript, No. 49 at p. 123)

DOE has not found evidence that more efficacious 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 EL 1. Therefore, in this final rule analysis, DOE continued to determine a higher efficacy level for these lamp types.

Further, DOE remains concerned, 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 on 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.

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 final rule analysis, DOE is using 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 NOPR analysis, DOE established ELs for modified spectrum IRLs by scaling from the ELs developed for the standard spectrum product class. DOE determined that a reduction of 15 percent from the standard spectrum ELs would be appropriate for modified spectrum IRLs.

EEOs cited a 2009 study by Ecos Consulting which found a 9-11 percent light loss associated with IRL modified spectrum lenses, and recommended either eliminating the allowance altogether or reducing it to 10 percent. (EEOs, No. 55 at p. 7)

Regarding the use of a 15 percent scaling factor from standard spectrum to modified spectrum IRLs, DOE based this determination on both its understanding of the differences in characteristics and performance of these two lamp types. 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. 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, DOE maintained a 15 percent efficacy reduction from a standard spectrum IRL to a modified spectrum IRL for this final rule.

g. 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 scarcity of xenon makes it questionable that IRL products will be able to comply with the proposed standards just by adding more xenon to the lamp burners. NEMA stated that due to a xenon shortage last year manufacturers had to reduce the use of xenon. NEMA explained that the remaining efficacy margin under current standards allows continued production of IRLs during xenon shortages. Further, NEMA noted that the big xenon producing companies have not expanded their production capacity as much and there is high demand and limited production capacity for this gas. (NEMA, No. 54 at p. 35) NEMA remarked that DOE’s xenon price analysis ignores xenon shortages. (NEMA, No. 54 at p. 11) Further, NEMA stated the current high cost of xenon is at 13 Euros per liter compared to its previously low price in early 2013. NEMA predicted that xenon prices would not drop again and instead continue to increase with the increased number of incandescent A-line replacement lamps (which also utilize xenon). (NEMA, No. 54 at p.35)

NEMA warned that manufacturers are at risk of not being able to make compliant lamps consistently due to the availability of xenon for IRLs, and if are unable to do so, they will stop making them, as they did with the 130 V IRLs. (NEMA, No. 54 at pp. 13-14) NEMA reported that a member's global buyer for noble gases had reported that xenon availability is at a minimum. NEMA concluded that the EL should be reduced due to the unavailability of xenon and noted that lighting legislation hugely affects the supply and demand of xenon. (NEMA, No. 54 at p.35)

DOE acknowledges that xenon supply and prices are important factors for IRLs. Therefore, in the NOPR analysis DOE conducted a market assessment of xenon supply, demand, and prices as well as LCC and NIA sensitivities to determine the impact of increased end user lamp prices due to increases in the price of xenon. DOE updated this market and price assessment as well as the sensitivities for the final rule analysis.

Based on this research, DOE determined that even if there are short term shortages of xenon, the long term supply of xenon is stable due to its availability in the air. Thus, supply could be increased to meet a continued increase in demand. DOE acknowledges that the supply of xenon cannot be quickly altered in the short term, and therefore conducted a sensitivity analysis to determine the impact of an increased price of xenon. In the final rule analysis, using NEMA's estimation of the current price of xenon, DOE updated the xenon price utilized in the LCC sensitivity analysis from $10 per liter to $18 per liter. Based on the results of this analysis, DOE determined that positive LCC savings could still be achieved at EL 1 with higher xenon prices. Additionally, in the NIA, 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 impacts of the modeled xenon price increase on the NES and NPV of this rulemaking were minimal. See appendix 7C of the final rule TSD for complete details on the xenon price sensitivity conducted in the LCC, and chapter 12 of this final rule TSD for details on the xenon price sensitivity conducted in the NIA.

h. Proprietary Technology

In response to the EL (and max tech) proposed for IRLs in the NOPR, DOE received several comments regarding proprietary technology. 79 FR at 24111 (April 29, 2014). NEMA stated that processes for silver, the best higher efficiency reflector coating, are patent-protected intellectual property (IP). (NEMA, No. 54 at p. 21)

While DOE had determined in the 2009 Lamps Rule 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). For this rulemaking, in interviews conducted in the preliminary analysis, manufacturers indicated that there were no specific patent or intellectual property barriers to obtaining commercially available

IRL technologies. Further, for the NOPR analysis, DOE confirmed during interviews that proprietary technology is not a barrier to achieving the proposed max tech level. Therefore, DOE has concluded that 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. Hence, the EL for IRLs in this final rule is based on a commercially available improved HIR lamp that does not require proprietary technology to achieve its efficacy. Therefore, DOE has determined that this level can be achieved without the use of proprietary technology.

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 NOPR analysis, DOE gathered publicly available lamp pricing data after the compliance date of the July 2012 standards. 79 FR at 24116 (April 29, 2014). Based on feedback from manufacturer interviews, DOE determined that GSFLs and IRLs are sold through three main channels (state procurement; large distributors, including do-it-yourself (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. DOE then 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. DOE received several comments on the pricing analysis.

GE remarked that the pricing methodology presented in the NOPR is a reasonable approach. (GE, Public Meeting Transcript, No. 49 at pp. 130-131) CA IOUs agreed that the pricing methodology is appropriate for GSFLs but not for IRLs, as the latter is predominantly purchased through retail channels for homes and small businesses instead of through distributors or state procurements. (CA IOUs, Public Meeting Transcript, No. 49 at p. 131; NEEA, Public Meeting Transcript, No. 49 at pp. 131-132)

DOE’s assessment of the GSFL and IRL markets indicated that there are three main distribution channels. Of these three, DOE determined that the majority of volume goes through the large distributors and DIY stores and assigned it an 80 percent weighting. Because this channel includes stores such as Home Depot and Lowes in addition to distributors, it encompasses channels through which residential and small business consumers are more likely to make their purchases. Additionally, DOE determined that while the volume may be low, IRLs are included in state procurement contracts; therefore, DOE included them as a distribution channel and assigned them a low weighting.

In the final rule analysis, DOE used the same methodology as described for the NOPR analysis. For the final rule, DOE scaled the prices from 2012$ to 2013$ in the LCC analysis and NIA, using the ratio of the 2013 consumer price index (CPI) and 2012 CPI multiplied by the 2012$ price. See chapter 7 of the final rule TSD for further information on the pricing 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

In the NOPR, 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. Id. at 24117. DOE characterized representative lamp or lamp-and-ballast systems in the engineering analysis (see section VI.D). 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),[44] the Commercial Building Energy Consumption Survey (CBECS),[45] the Manufacturer Energy Consumption Survey (MECS),[46] and the Residential Energy Consumption Survey (RECS).[47] Id. at 24118. DOE did not receive any comments on this subject and maintained this approach for determining operating hours for this final rule. DOE updated the MECS data to 2010 data.[48]

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[44] 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, D.C. <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>

[45] 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, D.C. <www.eia.gov/consumption/commercial/data/2003/index.cfm?view=microdata>

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

[47] U.S. Department of Energy, Energy Information Administration. RECS Public Use Microdata files. 2009. Washington, D.C. <www.eia.gov/consumption/residential/data/2009/>

[48] U.S. Department of Energy, Energy Information Administration. Manufacturing Energy Consumption Survey, Table 9.1: Enclosed Floorspace and Number of Establishment Buildings. 2010. Washington, D.C. <http://www.eia.gov/consumption/manufacturing/data/2010/>

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 NOPR 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 final rule TSD for further information.

DOE received an overall comment regarding its approach to lighting controls for GSFLs and IRLs. Westinghouse suggested that DOE separate dimming percentages between IRLs and GSFLs because in the commercial sector, GSFLs are generally dimmed more often and IRLs are on simple switch circuits, and in the residential sector, IRLs are frequently dimmed and GSFLs are almost never dimmed. (Westinghouse, Public Meeting Transcript, No. 49 at p. 142)

DOE agrees with Westinghouse that GSFLs and IRLs are used differently and that usage varies depending on the market sector. DOE calculated separate dimming percentages for GSFL and IRL and for each market sector in which they are present. The following sections discuss these percentages in more detail.

a. General Service Fluorescent Lamp Lighting Controls

In the NOPR, 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. Id. 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 did not analyze dimmable GSFL systems in the residential sector because DOE believes these systems are rarely dimmed. DOE determined that the average reduction of system lumen output for GSFLs was 33 percent, based on research and manufacturer input. DOE did not receive any comments on this approach to analyzing GSFL dimming and therefore maintained this approach in the final rule.

b. Incandescent Reflector Lamp Lighting Controls

In the NOPR 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. Id. at 24119. 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 approach to analyzing IRL dimming.

Philips disagreed with only 5 percent dimming in the commercial sector, stating that given the 30-year analysis period, this percentage is understated. Philips specifically referenced California's new requirements for dimming in all renovations and new buildings and American Society of Heating, Refrigerating and Air Conditioning Engineers' (ASHRAE's) support of these measures driving increased dimming prevalence across the country. (Philips, Public Meeting Transcript, No. 49 at pp. 137-138) NEEA agreed with Philips that 5 percent dimming for the commercial sector is too low and added that the 29 percent dimming DOE used for the residential sector is far too high. Westinghouse also questioned the 29 percent dimming estimate for the residential sector noting that if the percentage was for residential IRLs only, it may be representative but was too high for GSFLs as homeowners tend not to dim those lamps. (Westinghouse, Public Meeting Transcript, No. 49 at p. 141)

To update DOE's numbers, NEEA suggested a report they had completed on a 13-month residential metering study that studied 2,200 sensors in 103 houses by fixture type, technology, and room. NEEA explained that their data include the wattage of the lamp, the controls on the socket, the number of lamps per fixture, the number of lamps per switch, the type of fixture, and room in which it is located. NEEA suggested that the data contain enough samples to characterize residential lighting in the four states included. NEEA also mentioned a census they conducted across 1,400 houses that gathered the same data, which can then be applied across the entire region. NEEA sent a summary of the data to DOE for immediate use, and stated that the rest of the data would be available for download on NEEA's and NEMA's websites. (NEEA, Public Meeting Transcript, No. 49 at pp.138, 140)

Regarding the accuracy of the percentages, the 29 percent of lamps on dimmers was applied to IRLs for the residential sector analysis and the 5 percent of lamps on dimmers was applied to IRLs for the commercial sector. As noted, these values are based on the 2010 LMC and DOE believes are an accurate representation of the percentage of IRLs on dimmers in each sector. Regarding the potential increase in percentage, while the percentage of occupancy sensors may increase, DOE assumed that the percentage of IRLs on dimmers will remain relatively constant because dimmers provide utility for consumers beyond energy savings. DOE also reviewed NEEA's data, but ultimately maintained the methodology described above because NEEA's data is limited to the Northwest region while the 2010 LMC lighting controls data is based several building audit studies, spanning several geographic regions and years of data collection, which was then scaled based an inventory of lighting at the national level. Therefore, for this final rule, DOE maintained its methodology for analyzing dimming for IRLs.

G. Life-Cycle Cost Analysis and Payback Period Analysis

In the NOPR analysis, DOE conducted LCC and PBP analyses to evaluate the economic impacts of proposed energy conservation standards for GSFLs and IRLs on individual consumers. 79 FR at 24119 (April 29, 2014). 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 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 higher efficiency 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.[49]

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 (2018, 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

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[49] 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.

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[50] 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.

DOE did not receive any comments on the general methodology regarding the LCC and PBP assessment. In the final rule analysis, DOE generally maintained the methodology from the NOPR analysis, with a few changes. Table VI.9 summarizes the approach and data DOE used to derive inputs to the LCC and PBP calculations for the NOPR, as well as the changes made for this final rule. The final rule TSD chapter 8 and its appendices provide details on the spreadsheet model and of all the inputs to the LCC and PBP analyses. The final rule 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 final rule analysis.

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

Table VI.9 Summary of Inputs and Key Assumptions in the LCC and PBP Analyses*

Inputs	NOPR TSD	Changes for the Final 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 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.	No change
Sales Tax	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.	No change
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 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.	Updated MECS data to 2010 data.
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

Inputs	NOPR TSD	Changes for the Final Rule
Electricity Prices	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 and lamp type calculated from the probability of a GSFL or IRL purchased in each census division or large state.	Electricity: Based on EIA's Form 861 data for 2012 scaled to 2013 (the dollar year of the analysis) using AEO 2014 and the consumer price index. Variability: No change
Electricity Price Projections	Forecasted using AEO 2013.	Forecasted using AEO 2014.
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

Inputs	NOPR TSD	Changes for the Final Rule
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, [51] Office of Management and Budget (OMB) Circular No. A-94,[52] and state and local bond interest rates.[53] 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[54] 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. Residential GSFLs lamp failure: Based on the lifetime of the ballast. Residential GSFLs ballast failure and new construction/renovation: Based on the lifetime of the ballast.	No change
Compliance Date of Standards	2017	2018
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 final rule TSD.

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[51] Damodaran Online, The Data Page: Historical Returns on Stocks, Bonds, and Bills – United States (2014). Available at: http://pages.stern.nyu.edu/~adamodar.

[52] U.S. Office of Management and Budget, Circular No. A-94 Appendix C (2013). Available at: www.whitehouse.gov/omb/circulars_a094/a94_appx-c.

[53] Federal Reserve Board, Statistics: Releases and Historical Data - Selected Interest Rates – State and Local Bonds (2014). Available at: www.federalreserve.gov/datadownload/Build.aspx?rel=H15.

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

1. Consumer Product Price

In the NOPR, 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. 79 FR at 24122 (April 29, 2014). DOE then developed low, medium, and high prices based on its findings. DOE 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. In the final analysis, DOE maintained the same methodology, but converted the prices to 2013$ instead of 2012$. For further discussion regarding end-user prices, see section VI.E.

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 NOPR analysis, DOE obtained state and local sales tax data from the Sales Tax Clearinghouse. Id. The data represented weighted averages that included county and city rates. DOE used the data to calculate 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 (New York, California, Texas, and Florida). 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. DOE did not receive any feedback on its approach to determining sales tax. In this final rule analysis, DOE used the same methodology with updated sales tax data from the Sales Tax Clearinghouse.[55]

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 NOPR analysis, DOE considered the

[55] Sales Tax Clearinghouse. Aggregate State Tax Rates. (2014). Available at: http://thestc.com/STrates.stm.

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. Id.

DOE did not receive any comments on the installation cost. DOE retained this methodology for determining installation costs in this final rule 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. For further discussion regarding annual energy-use calculations, see section VI.F.1. DOE maintained its methodology of determining annual energy-use inputs in this final rule analysis.

5. Product Energy Consumption Rate

As in the NOPR analysis, DOE determined lamp input power for IRLs based on published manufacturer literature. 79 FR at 24123 (April 29, 2014). 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 final rule analysis.

6. Electricity Prices

For the LCC and PBP in the NOPR 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. Id. 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 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 did not receive any comments on this approach. DOE retained this methodology for determining electricity prices in this final rule analysis.

7. Electricity Price Projections

To estimate the trends in energy prices for the NOPR analysis, DOE used the price forecasts in AEO 2013. Id. To arrive at prices in future years, DOE multiplied current average prices by the forecast of annual average price changes in AEO 2013. In this final rule analysis, DOE used the same approach, but updated its energy price forecasts using AEO 2014. 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 this approach and maintained this methodology for determining electricity price projections in the final rule analysis.

8. Replacement and Disposal Costs

In its NOPR analysis, DOE addressed lamp replacements occurring within the analysis period as part of installed costs for considered lamp or lamp-and-ballast system designs. Id. 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 2012$. 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.[56] 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.[57] 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 and 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 final rule 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

[56] Environmental Health and Safety Online's fluorescent lights and lighting disposal and recycling Web page—Recycling Costs. Available at www.ehso.com/fluoresc.php.

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

different set of lamp or lamp-and-ballast designs and, therefore, a different set of LCC savings for a certain efficacy level. In the NOPR analysis, DOE evaluated three types of events that would prompt a consumer to purchase a lamp. Id at 24123. These events are described in the following list. 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 several comments regarding the lamp purchasing events assessed in the NOPR analysis. OSI questioned if, in the event of ballast failure in the new construction and renovation scenario, the installed cost includes the price of controls that are required by recent building codes, especially ASHRAE 90.1. (OSI, Public Meeting Transcript, No. 49 at pp. 144-145) ASHRAE 90.1 is a standard that provides the minimum requirements for energy-efficient design of certain commercial buildings. OSI noted that any replacement of lamps and ballasts that could be considered renovation would be subject to building codes requiring the installation of lighting controls, and this cost should be added to the scenarios. (OSI, Public Meeting Transcript, No. 49 at p. 146) Westinghouse agreed, stating that having to buy a control for a lamp should be treated no differently than having to hire an electrician and is part of the installation cost for a typical end-user product. (Westinghouse, Public Meeting Transcript, No. 49 at p. 145) NEEA acknowledged that controls may be required by building codes, but pointed out that a building code would apply regardless of the EL chosen. Thus the costs of controls would be the same at each level and would be unlikely to change the incremental installed costs analyzed in the LCC analysis. (NEEA, Public Meeting Transcript, No. 49 at p. 146)

DOE agrees that in the LCC analysis, a consumer that purchases a new lamp will have to comply with the same building code in both the base case (absent amended energy conservation standards) and the standards case (with amended energy conservation standards). In instances where the building code would require lighting controls, DOE reviewed the lighting systems analyzed in the GSFL engineering analysis for this rulemaking and determined that the required controls would not differ between the baseline systems analyzed and each higher efficacy system. Because the controls would be the same at each level, the incremental costs associated with the controls (price and installation) would not be different for the different ELs, Therefore, DOE did not include the cost of controls in the final rule analysis.

Regarding more efficient replacement systems analyzed, NEMA noted switching from T12 or T8 to T5 lamps is expensive, and therefore suggested that the LCC and PBP analyses include the re-ballasting costs for lamps, luminaires, ballasts, labor, and down time. (NEMA, No. 54 at p. 48)

The LCC and PBP analyses determine the economic impacts to a consumer within an individual product class. Because only one type of lamp (i.e., T5 or T8) is specified within each product class, DOE does not account for product class switching in the LCC and PBP analyses. DOE does, however, account for product class switching in the shipments analysis and, subsequently, the NIA. See VI.I for additional details on product class switching in the shipments analysis.

DOE received no other comments on lamp purchase events and is maintaining the lamp purchase events and the associated assumptions in this final rule analysis.

10. Product Lifetime

a. Lamp Lifetime

In the NOPR 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 NOPR analysis, DOE assumed that a lamp subject to group relamping operates for 85 percent of its rated lifetime based on information from manufacturers in interviews that consumer behavior had changed due to recent economic conditions and group relamping occurred at 85-90 percent of rated life. Id. at 24124.

Westinghouse agreed that relamping would occur at 85 percent of rated life in the commercial sector, however, they noted that in the residential sector, relamping would occur when the resident cannot see or when the lamp fails. (Westinghouse, Public Meeting Transcript, No. 49 at p. 144) Philips further commented that older consumers would relamp sooner, due to impaired eyesight. (Philips, Public Meeting Transcript, No. 49 at p. 144)

DOE assumed that during group relamping, a consumer removes and replaces a collection of lamps that are near the end of their lives at once, as a way of avoiding the failure of any individual lamp in the collection. While DOE models this behavior in the commercial sector, DOE assumed that residential sector consumers replace their lamps either when they fail or when the associated fixture is removed; thus, there are no spot or group relamping lifetime impacts on the residential sector.

NEMA noted that group relamping is commonly recommended at 70-80 percent of rated life. During the 2010-2011 rare earth crises, group relamping may have been delayed, but it has since come back in line with the recommended time frame. (NEMA, No. 54 at p. 32)

DOE acknowledges that the economic conditions that impacted group relamping decisions may have been temporary and, taking into consideration NEMA's observation, changed the group relamping assumption to 75 percent of rated life for the final rule analysis. See chapter 8 of the final rule TSD for further details.

In the NOPR, DOE used 15 years as the estimated fixture and ballast lifetime in the residential sector for purposes of its analyses. NEMA commented that DOE should not assume a normal average lifetime for residential GSFLs as these lamps typically fail from frequent switching rather than deterioration of the emitter. NEMA mentioned that failure due to rapid switching is unpredictable and variable, based on the frequency of switches, and therefore it is difficult to define an average lifetime in this sector. NEMA suggested that DOE review their analysis for residential GSFL lifetime by incorporating switching and hours of use data from the NEEA residential building stock assessment metering study. (NEMA, No. 54 at pp. 31-32)

Based on a report, DOE found that the average fixture and ballast in the residential sector lasts for 15 years.[58] Therefore, in its residential sector analysis for GSFLs, DOE established 15 years as the average ballast lifetime in the residential sector, regardless of operating hours. Because the lamp lifetime exceeds the ballast lifetime under average operating hours conditions, DOE assumed that the ballast lifetime of 15 years limits the lamp lifetime. While the typical lifetime of a GSFL is about 37 years in the residential sector, by basing the analysis period on the ballast lifetime, DOE used a much shorter analysis period than the product lifetime in its analysis for residential GSFLs and, therefore, likely accounted for early failure of lamps due to frequent switching. As recommended by NEMA, DOE also reviewed NEEA's data, but found that the data did not provide the lifetime data on the GSFLs DOE analyzed in the residential sector. Therefore, DOE maintained the lamp lifetime of 15 years based on the ballast lifetime for this final rule analysis.

b. Ballast Lifetime

Chapter 8 of the NOPR TSD 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 and retained these ballast lifetimes in the final rule.

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[58] Economic Research Associates, Inc., and Quantec, LLC. Revised/Updated EULs Based On Retention And Persistence Studies Results. Southern California Edison, 2005.

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.[59]

In the NOPR analysis, for the residential sector, DOE derived discount rates from estimates of the interest or "finance cost" to purchase residential products. 79 FR at 24125 (April 29, 2014). 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."[60] 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.

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[59] 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.

[60] 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.

DOE received no comments concerning the determination of discount rates. Thus, DOE maintained this approach in the final rule analysis. For further details on discount rates, see chapter 8 and appendix 8C of the final rule TSD.

12. Analysis Period

The analysis period is the span of time over which the LCC is calculated. In the NOPR 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. Id. 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. GE and Philips commented that this approach seemed reasonable. (GE, Public Meeting Transcript, No. 49 at p. 147; Philips, Public Meeting Transcript, No. 49 at p. 148) DOE maintained this approach for determining the analysis period in the final rule analysis.

13. Compliance Date of Standards

The compliance date is the date when a covered product is required to meet a new or amended standard. Consistent with 42 U.S.C. 6295(i)(5), DOE analyzed a compliance date in 2018, three years after the publication of the final amended standards. DOE 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. Incandescent Reflector Lamp Life-Cycle Cost Results in the NOPR

DOE received several comments regarding the LCC results of IRLs in the NOPR analysis. GE commented that the LCC analysis appeared to be done mostly for commercial customers of PAR38 lamps and would have a dramatically different and negative outcome for the residential sector and other consumers. (GE, Public Meeting Transcript, No. 49 at p. 152)

DOE conducted separate LCC analyses for the commercial sector and residential sector. See chapter 8 of the final rule TSD for all results by sector.

NEMA commented that consumers were unlikely to realize the operating cost savings DOE claimed in the NOPR. (NEMA, No. 54 at p. 11) NEMA questioned how the proposed rulemaking can generate positive savings for consumers of IRLs when the increased product costs are higher than the energy savings. NEMA reasoned that an 18.75 lm/W PAR38 would need an infrared coated burner to reach an efficacy of 19.57 lm/W to comply with the standards proposed in the NOPR. The increased efficacy would save the consumer $0.36 per year while the burner would add about $1 to the cost of the lamp. NEMA further argued that the lamp is only rated at 1,100 hours, so the consumer will never see the payback from the improved lamp. NEMA commented that DOE cannot assume that technological breakthroughs yet to be discovered would improve the efficacy and lifetime of the lamp. As such, NEMA concluded that DOE cannot prove that a full range of products would comply with the standards proposed in the NOPR, and that DOE has not adequately addressed the negative cost effects on the consumer. (NEMA, No. 54 at pp. 32-33)

In its analysis, DOE considered only more efficacious replacements with lifetimes greater than or equal to the baseline lifetime. Both representative lamp units that DOE analyzed at EL 1 have lifetimes longer than the baseline. The characteristics of the representative lamp units were used as inputs to the LCC analysis. The LCC analysis assumes that the analysis period is the lifetime of the baseline lamp. Any lamps at higher efficacy levels that have longer lifetimes than that of the baseline product incorporate a residual value into the life-cycle cost, which subtracts the value of the lamp at the end of the analysis period from the total life-cycle cost. Thus, the residual values of the longer lifetime lamps increase the LCC savings.

NEMA commented that the increased efficacy of the EL 1 proposed in the NOPR would result in a 30 percent reduction in lifetime,[61] meaning a total loss of financial feasibility as the payback period would be longer than the lifetime of the more efficacious lamps. (NEMA, No. 54 at p. 29)

DOE recognizes that there is an inverse relationship between efficacy and lifetime for IRLs. The engineering analysis focuses on commercially available products and DOE does not analyze efficacy levels that require shorter lifetimes than the baseline product.

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[61] NEMA cited the following reference for this calculation: Vukcevich, Milan R. The Science of Incandescence. NELA Press, 1992.

However, DOE is aware that to meet higher efficacy levels, manufacturers can choose to produce lamps with shorter lifetimes than the baseline lamp to achieve higher efficacies. Given that manufacturers responded to the July 2012 standards by introducing IRLs with shorter lifetimes, DOE understands 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 in the final rule analysis. (See chapter 5 of the final rule 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 13B of the final rule TSD). For the shortened lifetime sensitivity, because the wattage is the same as the baseline, there are no energy savings and therefore, the LCC savings are negative and a payback period cannot be calculated.

H. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended standards on consumers, DOE evaluates the impact on identifiable subgroups of consumers (e.g., low-income households) that a national standard may disproportionately affect. In the NOPR analysis, DOE evaluated low-income consumers and institutions that serve low-income populations (e.g., small nonprofits) as subgroups. DOE did not receive any comments regarding subgroups and therefore maintained this approach for assessing consumer subgroups in the final rule analysis. Chapter 9 of the final rule TSD 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 a product stock and also to calibrate the shipments model. The details of the shipments model are described in chapter 11 of the final rule TSD.

The shipments model projects shipments of GSFLs and IRLs over a 30-year analysis period for the base case (no standards) and for all standards cases. Separate shipments projections are calculated for the residential sector and for the commercial and industrial sectors. The shipments model used to estimate 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 2014 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.[62] The SSL Program projections extend only to 2030; DOE extrapolated to the end of the shipments forecast period. DOE fitted the technology adoption curve to allow for 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.

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[62] 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.

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.

The price-learning module estimates lamp and ballast prices in each year of the analysis period using a standard price-learning model.[63] 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 final rule 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.

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[63] 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

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.

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 did not increase energy relative to the baseline system, the shipments analysis allows consumers to choose among 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, 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 final rule 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 retrofitting lighting systems, renovating the lighted space, 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.

DOE projects that some fraction of the lighting market currently being served by T8 lamps will migrate to T5 lamps in the absence of standards. At the NOPR stage, DOE projected that the standards in this rulemaking would make certain T5 systems more cost competitive relative to certain T8 systems, resulting in an increase in the rate of this T8 to T5 lamp migration. DOE received comments regarding product class switching between T8 lamps and T5 lamps. Philips, NEMA, and GE commented that consumers will not switch from T8 lamps to T5 lamps. Philips and NEMA stated that T5s have been on the market for 20 years and have not been used as substitutes for T8s. NEMA and GE mentioned that T5 lamps are shorter than T8 lamps; therefore, T5 lamps cannot be used to retrofit T8 fixtures and vice versa. Philips, NEMA, and GE also noted that T5 and T8 lamps are used in different applications. Because T5 lamps have higher luminance than T8 lamps, T5 lamps are typically used in indirect fixtures or places with high ceiling heights, whereas T8 lamps are used in direct fixtures or places with lower ceiling heights. Hence Philips, NEMA, and GE stated that these lamps cannot be used interchangeably. (Philips, Public Meeting Transcript, No. 49 at p. 163-164; GE, Public Meeting Transcript, No. 49 at p. 163, p. 167-168; NEMA, No. 54 at p. 14, p. 46)

DOE is aware that there are physical and optical differences between T8 and T5 lamps. DOE assumes in its modeling for this rulemaking that switching between T8 and T5 lamps does not occur during retrofits. The potential for substitution of 4-foot MBP and 8-foot slimline with T5 SO Lamps is only assumed at the time of new construction and renovation, when a new luminaire would be specified. DOE's analysis indicates that there exist T5 luminaires that compete directly with 4-foot MBP T8 luminaires in most applications in the largest luminaire markets (e.g., commercial offices, education, industrial). In some cases, luminaire manufacturers offer essentially identical luminaires in 4-foot T8 and T5 versions. Therefore, DOE believes that the switching from T8s to T5s estimated in the NOPR, and in the final rule, is reasonable. See appendix 11C of the final rule TSD for examples of these luminaires and a discussion of DOE's analysis of the substitution potential for 4-foot MBP and T5 SO Lamps.

NEMA noted that first cost is a significant driver of consumers' choice of product class and, as a consequence, higher initial T8 lamp costs would drive consumers to T5 products or LED products in new construction and renovation projects. (NEMA, No. 54 at p. 46) This comment is consistent with DOE's assumptions in the analysis for this rulemaking.

NEMA noted that, even if the standards required the 4-foot MBP T8 to increase phosphor use, T5 lamps would remain more expensive than T8 lamps owing to differences in manufacturing technology. (NEMA, No. 54 at p. 34) DOE determined the end-user prices of lamps by applying a shipment-weighted discount to the blue book price of the lamp. In certain cases the end-user prices for 4-foot MBP T8 lamps are higher than for T5 MiniBP SO lamps (see chapter 7 of the final rule TSD). At max tech, the full-wattage 4-foot MBP T8 lamp end-user prices are higher than the full wattage T5 MiniBP SO.

NEMA also commented that T5 lamp sales are not from T8 consumers but are mainly from consumers switching from older inefficient technology, like HID lamps. However, NEMA added that this rulemaking would slow down the transition from HID products to T5 lamps. (NEMA, No. 54 at p. 47)

In its assessment of the market, DOE did not find any T5 HO lamps at the baseline efficacy level considered here. Thus, the amended standard represents the least efficacious T5 HO lamps on the market. For this reason DOE believes that this standard will have no impact on the transition from HID to T5 technology.

NEMA noted that the inability of non-PAR38 lamps to meet the proposed standard would cause consumers to switch to either expensive LED lamps or BR lamps that consume more energy than PAR lamps. NEMA calculated that the overall energy savings could be negative. (NEMA, No. 54 at pp. 20, 29) NEMA stated that significant energy savings would be lost under the proposed standards due to forcing halogen PAR30 lamp consumers to switch to LED lamps, the reduced wattage 39W PAR30 lamps, or 65W BR30 lamps after PAR30 lamps are eliminated from the market. NEMA and GE predicted that the majority of consumers would switch to the BR30 lamps, which would cause an increase of 97 kWh per year, an inadvertent increase of 0.03 quads of energy. NEMA stated that, given the popularity of these IRLs and the alternative lamps once they are eliminated, no new standard should be set for PAR30 lamps. (NEMA, No. 54 at pp. 48-49; GE, Public Meeting Transcript, No. 49 at pp. 121-122) ASAP noted that there are substitute lamps outside of the scope of this rulemaking and that DOE needed to consider what consumer choices could be made among the unregulated product options. (ASAP, Public Meeting Transcript, No. 49 at pp. 114-115) GE disagreed and stated that consumers purchase quite a number of regulated products, such as PAR20, PAR30, and 90W PAR38 lamps. (GE, Public Meeting Transcript, No. 49 at pp. 115-116)

DOE's analysis indicates that there are PAR30 and PAR20 products on the market that meet EL 1. DOE recognizes that BR lamps are potential substitutes for non-PAR38 IRLs. However, given the large price difference between PAR and BR lamps in the current market, DOE believes that all consumers currently using PAR lamps are obtaining a unique utility from the PAR lamps for which they are willing to pay a substantial price premium. Thus, DOE believes that all potential switching from PAR to BR lamps has already taken place. DOE accounts for some consumers shifting to LED lamps with the use of an LED market adoption curve.

The market-share module incorporates a limit on the diffusion of new technology into the market using the widely accepted Bass adoption model,[64] 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.

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

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, retrofit, renovation, or new construction, it accepts only lamps or lamp-and-ballast combinations that retain lumen capacity within acceptable bounds.

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 not 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.

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 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. As in the NOPR analysis, DOE did not consider delamping in this final rule because manufacturer feedback confirmed that delamping is not common practice when retrofitting existing T8 systems as lumen output levels have already been reduced to comply with newer recommended lighting levels and building codes. 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 noted that future installations or retrofits would not adequately "tune" lamp and ballast pairings, by manipulating the ballast factor, especially during the maintenance phase of system lifetime when lamps and ballasts get replaced on a case-by-case basis. Furthermore, without this ballast tuning, consumers would have increased light density with the same energy consumption as the previous lamp-and-ballast system had. (NEMA, No. 54 at pp. 18 and 36)

DOE is aware that the ballast factor is not typically modified during the maintenance phase of a lamp-ballast system. DOE assumes in its modeling for this rulemaking that any tuning of the ballast and lamp pairing does not occur during the maintenance phase. Adequate tuning is only assumed at the time of new construction, renovation, and retrofitting.

GE and NEMA disagreed with the assumption that ballast factors can be tuned to maintain the same light output. They both stated that ballast factors are only available in 10 percent increments while the resulting increase in efficacy is only about 2-3 percent. They commented that consumers will keep the same ballast factor for retrofits, which means that the lamps will still consume the same amount of energy but will be giving 2-3 percent more lumen output. (GE, Public Meeting Transcript, No. 49 at p.196-198; NEMA, No. 54 at p. 18)

DOE is aware that ballast factors tend to cluster around modal values that are separated by roughly 10 percent. However, in analyzing the market, DOE identified ballasts with a broad range of ballast factors that were not restricted to these modal values. Moreover, DOE notes that the increase in lumen output from the baseline to the full-wattage EL 2 lamp is 7 percent for 4-ft MBP lamps, and 16 percent for T5 SO lamps. DOE believes that, for consumers undertaking renovations, lighting retrofits, and new construction, the selection of ballast factor will be informed by the lamps available on the market and that an increased fraction of consumers will choose lower ballast factors than are now typical if typical lamp lumen ratings increase.

DOE notes that full wattage lamp options are available for all product classes at all efficacy levels considered in this analysis. 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. 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.

NEMA provided their Ballast Section market survey data, indicating that dimming ballast sales decreased between 2010 and 2013. NEMA acknowledged that CA Title 24 and ASHRAE 90.1 may increase these shipments, but stated that the increase in shipments could not be properly estimated at this time due to their recent or sporadic adoption. NEMA noted that the last rulemaking constrained this decreasing market. (NEMA, No. 54 at p. 33, p. 35, p. 47)

DOE thanks NEMA for the input on dimming ballast shipments. DOE believes that, given the many recently updated commercial building codes that require lighting controls, the market share of dimming ballasts is very likely to increase in the future and that the recent decline is likely transitory. Therefore, DOE has modeled the fraction of commercial floorspace that is subject to such codes and utilizes this in its analysis to estimate the future market share of dimming ballasts, based on current usage of dimming in fluorescent lighting systems.

Rare earth oxides (REOs) are used in GSFL phosphors to increase their efficacy. 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 NOPR to reflect uncertainties in the prices of rare earth oxides.

NEMA noted that the prices during the last REO crisis increased by 400 to 700 percent. Due to decreased REO prices and subsequent slowing of REO supply expansion, NEMA mentioned the possibility of another price increase as future supplies are uncertain. Therefore, NEMA suggested that DOE revise the estimates of the high end of possible prices to 700 percent of current prices. (NEMA, No. 54 at p. 34-35)

DOE has examined the rare earth oxide market and still considers future rare earth prices significantly uncertain. DOE considered two price scenarios in its shipments modeling for GSFLs, as described in appendix 11B of the final rule TSD. The reference scenario assumes that rare earth prices remain fixed at their June 2014 level. The high rare earth price scenario assumes an average rare earth price 4.5 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. DOE notes that the high rare earth price scenario represents a high price volatility scenario where the price could fluctuate at higher or lower levels than 4.5 times the baseline rare earth price.

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 total energy consumption with amended energy conservation standards to projections of energy consumption without the standards (the base case).

As the shipments model allows for substitutions across product classes when lighting systems are selected during renovation or new construction, understanding the impact of setting a standard at any given level for any given product class requires considering the impact on all other product classes. 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,[65] allowing access to a broad range of scenario assumptions for conducting sensitivity analyses on specific input values. The major inputs for the NIA are described in Table VI.10.

Table VI.10 Inputs for the National Impact Analysis

Input	Description
Shipments	Annual shipments from shipments model.
Compliance date of standard	January 1, 2018
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 2014 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	2014

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

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

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 estimated 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 GSFLs between the base case (without new standards) and each of the standards cases for lamps shipped during the 2018-2047 period.

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. 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.[66]

NEMA requested clarification on DOE's assumption that no individual reduced wattage lamp option will be coupled to more than 10 percent of the dimming ballasts in

[66] 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

the installed stock, owing to performance problems that may arise in some applications. (NEMA, No. 54 at p. 33) NEMA further commented that DOE cannot assume energy savings from pairing 28W energy-saver lamps with dimming ballasts, as DOE cannot presume that consumers will tolerate not having full dimming functionality with these lamps. NEMA specified that DOE must remove all energy savings estimated to result from the energy-saver lamps in this scenario and instead assume full-wattage lamps would be installed. (NEMA, No. 54 at p. 36)

In its assessment of the market, DOE noted the presence of T8 dimming ballasts whose marketing materials indicated compatibility with reduced wattage lamps. Therefore, DOE believes that at least some consumers with dimming ballasts would consider coupling them to such lamps. DOE is aware, however, that in some cases significant performance degradation is possible when coupling reduced wattage lamps to dimming ballasts. Therefore, DOE assumed that only a small fraction of consumers with dimming ballasts would consider purchasing reduced wattage lamps to install on their ballasts. Specifically, DOE took this fraction to be 10 percent of consumers who have dimming ballasts. This represents the fraction of consumers who would consider such a lamp-ballast combination among the set of plausible options; not all such consumers will in fact decide to purchase reduced wattage lamps. Thus, the fraction of dimming ballasts that are coupled to reduced wattage lamps remains exceedingly small in DOE's projections throughout the analysis period.

NEMA commented that, although 4-foot T8 argon lamps can have efficacies of 89, 90, 91, or 92.4 lumens per watt, at different efficacies these lamps will still operate at the same wattages, and instead they would just provide different illumination. Therefore, NEMA stated that there is no meaningful difference in national energy use impact from choosing any of these three levels above 89 lm/W. Furthermore, NEMA added that an energy conservation standard for 4-foot MBP GSFLs at 89 lm/W will maintain consumer utility as well as increase national energy savings by increasing use of dimming systems. (NEMA, No. 54 at p. 14)

DOE does not agree that lamps at different efficacies will still operate at the same wattages. DOE considers two modes by which energy savings can be achieved with full-wattage lamps. First, when using more efficacious lamps, consumers with dimming ballasts may dim their systems to a lower input wattage to achieve the same light output. Second, consumers undertaking renovations, lighting retrofits, and new construction may select lower ballast factors on average if only high-efficacy lamps are available on the market. Regarding NEMA's claim that a standard at 89 lm/W will increase national energy savings by maintaining utility and increasing use of dimming systems, DOE has ensured that, at all ELs considered for 4-foot MBP lamps, lamp options are available that can be coupled to dimming systems. Therefore DOE does not believe that this final rule will negatively impact the energy savings that is available from dimming

DOE accounts for the direct rebound effect in its NES analysis. 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 final rule analysis.

NEMA commented that, if light levels are reduced through energy-saver lamps or lower ballast factor ballasts, end users could offset the reduction in light levels by increasing the GSFL use or through other technologies, thereby reducing the energy-saving benefit. NEMA referenced an article and a report that they believe support their point of view. (NEMA, No. 54 at p. 36) Additionally, Miller commented that DOE should evaluate whether there was a measurable rebound effect resulting from use of more energy-efficient lamps. (Miller, No. 50 at p. 12)

DOE is not aware of any methodologically sound studies that have quantified a direct rebound effect for lighting efficacy improvement in commercial buildings, where most GSFLs are used. As discussed in chapter 12 of the final rule TSD, DOE did not find evidence of systematic increases in operating hours or lighting density of GSFLs or IRLs with increased efficacy of these products. The items mentioned by NEMA refer to the potential for higher lighting demand when consumers start using LEDs. DOE believes that adoption of LEDs would not be impacted by the standards in this notice, so any rebound effect associated with this lighting technology is not germane. Based on the weight of the evidence, DOE assumed zero rebound for GSFLs or IRLs with increased efficacy. DOE also conducted a sensitivity analysis assuming a high rebound rate of 15 percent, which is presented in chapter 12 of the final rule TSD. Using a high rebound rate does not change the relative ranking of the considered TSLs.

DOE converted the site electricity consumption and savings to primary energy (power sector energy consumption) using annual conversion factors derived from the AEO 2014 version of NEMS. Cumulative energy savings are the sum of the NES for each year in which product shipped during 2018 through 2047 continue to operate.

DOE has historically presented NES in terms of primary energy savings. In 2011, 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 emissions in the NIA and emissions analysis included in future energy conservation standards rulemakings. 76 FR 51281 (August 18, 2011). After evaluating the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in the Federal Register in which DOE explained its determination that NEMS is the most appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701 (August 17, 2012). Therefore DOE is using a NEMS-based approach to conduct FFC analyses for today’s final rule.This approach is further described in appendix 12C of the final rule TSD.

GE and NEMA stated that there are no energy savings from switching from T8 lamps to T5 lamps. GE mentioned that, although the efficacies of T5 lamps are measured at high frequency and T8 lamps are measured at low frequency, the lamps have similar efficacies. (GE, Public Meeting Transcript, No. 49 at p. 163) NEMA commented that the efficiencies of T8 and T5 lamps are not directly comparable, because the efficiencies are measured differently. (NEMA, No. 54 at p. 14, p. 46) NEMA further added that the T5 lamp-ballast systems have the same power consumption as the equivalent T8 lamp-ballast systems. (GE, Public Meeting Transcript, No. 49 at p. 163; NEMA, No. 54 at p. 46)

DOE does not assume an automatic energy savings from switching from a T8 system to a T5 system. The energy use of a lamp-and-ballast system is calculated using the wattage of the installed lamps as well as the ballast factor and ballast luminous efficacy of the ballast on which the lamps are installed. DOE notes that, while it does not assume automatic energy savings of a T5 system compared to a T8 system, there are T5 lamp-and-ballast combinations (e.g., low ballast factor ballast coupled with high efficacy lamps) that can have lower power consumption compared to a T8 system of similar light output. Further, DOE agrees that testing on high frequency circuits versus low frequency circuits impacts efficacy measurements. Per DOE test procedure, GSFLs are tested at low frequency unless only high frequency reference ballast specifications are available. The T5 MiniBP SO and HO lamps and 8-foot RDC HO should be tested on high frequency circuits, as those are the only specifications provided for these lamp types. The 4-foot MBP, 2-foot U-shaped and 8-foot SP slimline lamps should be tested on low frequency circuits. Therefore, within each product class, the lamp efficacies should be comparable, however, efficacies of lamps across product classes may not be comparable.

NEMA noted that PAR38 lamps that currently meet the proposed standard are not available through consumer channels and consumers would lose all reasonable options for PAR lamps. (NEMA, No. 54 at pp. 10) DOE understands that the availability of certain PAR lamps may be concentrated in the commercial sector. However, DOE does not find that to be a barrier to such lamps becoming available and used in other sectors of the market.

NEMA noted that setting new standards for 130 V IRLs would be a waste of resources and would skew energy savings estimates, as the product is no longer available. (NEMA, No. 54 at p. 54) DOE assumes in its analysis that there are no 130 V IRLs on the market. No energy savings from such products are assumed.

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 in the 2018-2047 period. The NPV was calculated 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 June 2014 level. The high rare earth price scenario assumes that rare earth prices are 4.5 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 VII.B.3.c.

NEEP expressed support for DOE's REO pricing analysis (NEEP, No. 57 at p. 3), but NEMA stated that DOE does not include an analysis of price elasticity and consumer buying practices during previous REO shortages. NEMA also noted that the proposed standards would create an REO shortage. (NEMA, No. 54 at p. 34; Public Meeting Transcript, No. 49 at pp. 180-182)

DOE estimates that, for the amended standards, the annual increase in demand for REOs will be approximately 300 tons per year in the first 5 years, which amounts to less than 1 percent of the annual 8,000-ton global demand for REOs used in phosphors. DOE expects that demand will steadily decrease over the analysis period owing to the increasing LED market. Therefore, DOE does not believe that the amended standards will cause a significant change in the supply of REOs.

For IRLs, DOE conducted a sensitivity analysis on the potential impact on the rulemaking of a 10-fold increase in xenon prices. The impact of the scenario on the results is discussed in section VII.B.3.c.

b. Total Annual Operating Cost Savings

The per-unit energy savings were derived as described in section III.C. To calculate future electricity prices, DOE applied the projected trend in national average commercial and residential electricity prices from the AEO 2014 Reference case, which extends to 2040, to the energy prices derived in the LCC and PBP 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 2014 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 final rule TSD.

DOE estimated that annual maintenance costs do not vary with efficacy 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 from extended lamp lifetime. In the NIA, 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. In accordance with OMB's guidelines on regulatory analysis,[67] 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

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

return on long-term government debt (i.e., yield on U.S. Treasury notes), which has averaged about 3 percent for the past 30 years.

K. Manufacturer Impact Analysis

DOE conducted separate MIAs for GSFLs and IRLs to estimate the financial impact of potential 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, product 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 cases). The difference in INPV between the base and standards cases represents the financial impact of potential 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 subgroup of manufacturers; impacts on competition; and the cumulative regulatory burden placed on GSFL and IRL manufacturers.

DOE outlined its complete methodology for the MIA in the previously published NOPR. Also, the complete MIA is presented in chapter 13 of the final rule TSD.

1. Manufacturer Production Costs

Manufacturing more efficacious lamps is typically more expensive than manufacturing baseline lamps due to the need for more costly components and materials used in the lamps as well as more extensive R&D to design the more efficacious lamps. The resulting changes in the manufacturer product costs (MPCs) of the representative lamps can affect the revenues, gross margins, and cash flows of lamp manufacturers. DOE strives to accurately model the potential changes in these production costs, as they are a key input for the GRIM and DOE's overall analysis. For the final rule, DOE updated the dollar year of the MPCs from 2012$, the dollar year used in the NOPR, to 2013$.

2. Shipment Projections

Changes in sales volumes and efficacy distribution of lamps over time can significantly affect manufacturer finances. The GRIM estimates manufacturer revenues based on total unit shipment projections and the distribution of shipments by efficacy level. For the final rule, DOE slightly altered the distribution of shipments based on interested party comments. DOE also updated the shipments to reflect the potential amended standard going into effect in 2018 as opposed to 2017, the standard compliance date used in the NOPR. This had a negligible effect on the MIA results. For the MIA, the GRIM used the NIA's annual shipment projections from 2015, the base year, to 2047, the end of the analysis period. For a complete description of the shipment analysis see chapter 11 of the final rule TSD.

3. Markup Scenarios

For the GSFL and IRL NOPR MIAs, DOE modeled two standards case markup scenarios to represent the uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of potential amended energy conservation standards: (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.

During the NOPR public meeting, Philips and Westinghouse commented that DOE should consider a third markup scenario for GSFLs where manufacturers are not able to maintain the absolute dollars on their GSFLs, as they do in the preservation of operating profit, due to the increase in MPC of GSFLs as a result of amended energy conservation standards. Philips stated that amended standards could cause a total commoditization of the GSFL market, especially at max-tech, so the only way to differentiate products is by price. They also stated that since manufacturers have already established the pricing levels for these GSFLs today, it is hard to justify an increase in the price after standards go into effect, as many of the big box retail stores are not going to accept a higher price for GSFLs. Both of the factors likely will result in manufacturers reducing their manufacturer markups. (Philips, Public Meeting Transcript, No. 49 at pp. 216-217; Westinghouse, Public Meeting Transcript, No. 49 at pp. 221-222) Based on the GSFL market pricing conditions described during manufacturer interviews, DOE concluded that the markup scenario recommended by Philips and Westinghouse is a realistic markup scenario that should be incorporated into the MIA to reflect the range of possible outcomes following GSFL standards. Therefore, DOE examined the INPV impacts of a two-tiered markup scenario in the final rule for the GSFL MIA as a result of these comments. The results of this additional markup scenario are displayed in section VII.B.2.a, along with the rest of the manufacturer INPV results.

In the two-tiered markup scenario, DOE assumed that higher efficacy GSFLs command a higher manufacturer markup and baseline efficacy GSFLs subsequently have a lower manufacturer markup. DOE estimated the manufacturer markups for GSFLs under a two-tier pricing strategy in the base case based on manufacturer interviews conducted as part of the NOPR analysis. In the standards case, DOE modeled the situation in which portfolio reduction reduces the margin of higher efficacy GSFLs as they become the new baseline efficacy products due to amended standards. This new two-tiered markup scenario represents the lower bound profitability markup scenario.

4. Product and Capital Conversion Costs

Amended energy conservation standards will cause manufacturers to incur one-time conversion costs to bring their production facilities and product designs into compliance. For the MIA, DOE classified these one-time conversion costs into two major groups: (1) product conversion costs and (2) capital conversion costs. Product conversion costs are one-time investments in R&D, testing, compliance, marketing, and other non-capitalized costs necessary to make product designs comply with amended standards. Capital conversion costs are one-time investments in property, plant, and equipment necessary to adapt or change existing production facilities such that new product designs can be fabricated and assembled. For the final rule, DOE only updated the dollar year of the conversion costs from 2012$, the dollar year used in the NOPR, to 2013$.

During the NOPR public meeting GE and Philips commented that they believe that IRL manufacturers would be unwilling to make large investments to make sure IRLs comply with energy conservation standards at TSL 1, since the market is changing so rapidly to LEDs and manufacturers might not ever be able to recover any substantial investment put in upgrading their IRLs. (Philips, Public Meeting Transcript, No. 49 at p. 231 & GE, Public Meeting Transcript, No.49 a pp. 231-232) DOE understands manufacturers' concern with making significant investments in a product that is rapidly losing market share and projected to experience a significant decline in shipments over the analysis period. DOE took these manufacturers' concerns into account when selecting the standards for IRLs in this final rule.

5. Other Comments from Interested Parties

During the NOPR public meeting and comment period, interested parties commented on the assumptions, methodology, and results of the NOPR MIA. DOE received comments about the potential high cost to manufacturers versus the relatively low energy savings for the NOPR standards proposed; the potential negative impacts on competition due to standards; and the potential impact of standards on alternative lighting technologies. These comments are addressed in the following sections.

a. High Cost to Manufacturers versus Relatively Low Energy Savings

NEMA and GE commented that the pending IRL standards as proposed in the NOPR would have a significant negative impact on IRL manufacturers' INPV while only marginally contributing to the projected energy savings. (NEMA, No. 54 at pp. 3-5 & GE, Public Meeting Transcript, No. 49 at pp. 217-218) DOE agrees that as proposed in the NOPR, the IRL standards at TSL 1 could reduce IRL manufacturers' INPV by up to 29.5 percent and would save an estimated 0.013 quads. DOE carefully examines all potential burdens, such as a potential decrease in manufacturers' INPV and the cumulative regulatory burden placed on manufacturers by additional regulations, against potential benefits, such as energy savings and consumer benefits, when determining final standards. Both the benefits and burdens for this rulemaking were closely examined before making a final decision regarding the IRL standards. See section VII.C.3 of this final rule for a complete description of the potential benefits and burdens of IRL standards.

b. Impacts on Competition

A couple of interested parties commented that DOE should use the Herfindahl-Hirschman Index (HHI) to examine whether potential energy conservation standards could significantly lessen competition in an industry. (Kidwell, No. 53 at pp. 1-6 & Miller, No. 50 at pp. 10-11, 13) The HHI is used by DOJ to examine market consolidation in the case of potential mergers. In these cases there is clear market share information before and after the event being analyzed, a potential merger. However, when examining potential energy conservation standards it is more difficult to accurately predict how individual manufacturers will respond to potential standards.

The decision of an individual manufacturer to make an upfront investment in order to comply with potential standards and remain in an existing market as opposed to exit the market is a complex business. For the GSFL and IRL rulemakings there is no technical reason any of the major manufacturers could not continue to manufacture compliant products, could maintain their current market share within an industry, or would be forced to exit the market. DOE acknowledges that both the GSFL and IRL markets are moderately concentrated markets, according to the HHI. However, based on manufacturer interviews, DOE does not believe there is any technical or proprietary reason the market share of either the GSFL or IRL markets would substantially change due to the energy conservation standards established in this final rule. Therefore, an analysis using the HHI would not be able to determine if standards lessened competition, since the market share before the standards would be similar to the market share after the standards.

c. Impact of GSFL and IRL Standards on Alternative Lighting Technologies

NEEP commented that the MIA should account for the potential growth in other lighting technologies (i.e., LEDs), since alternative lighting sales are projected to take market share away from GSFLs and IRLs in the future. (NEEP, No. 57 at p.3) DOE's shipment analysis does predict that LEDs and other alternative lighting technologies will significantly take more and more market share away from GSFLs and IRLs in future years. This growing LED market share is modeled in the base case of the shipment analysis when no energy conservation standards are enacted, and is therefore independent from any GSFL or IRL standards that are being analyzed in this rulemaking.

The shipment analysis does not anticipate that consumers will shift to LEDs as a result of potential GSFL or IRL standards and therefore the total number of lighting hours fulfilled by GSFLs and IRLs is the same in the base case as in the standards cases. Since DOE is attempting to model the direct impacts of the GSFL and IRL standards independently from other external factors that are occurring in the GSFL and IRL markets, DOE does not believe it should include revenue from the sale of alternative lighting technologies in the MIA for GSFLs and IRLs. See the shipments analysis in chapter 11 of the final rule TSD for a complete description of how GSFL and IRL shipments change in response to potential GSFL and IRL standards.

6. Manufacturer Interviews

DOE interviewed manufacturers representing more than 90 percent of covered GSFL and more than 80 percent of covered IRL sales in the United States. The NOPR interviews were in addition to the preliminary interviews DOE conducted as part of the preliminary analysis. DOE outlined the key issues for the rulemaking for GSFL and IRL manufacturers in the NOPR. 79 FR at 24136-7(April 29, 2014) DOE considered the information received during these interviews in the development of the NOPR and this final rule. Comments on the NOPR regarding the impact of potential amended standards on manufacturers were discussed in the previous sections. DOE did not conduct interviews with manufacturers between the publication of the NOPR and this final rule. Also, DOE did not receive any comments on the manufacturer key issues identified in the NOPR.

L. Emissions Analysis

In the emissions analysis, DOE estimated the reduction in power sector emissions of carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and mercury (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 full-fuel-cycle (FFC). In accordance with DOE's FFC Statement of Policy (76 FR 51282 (Aug. 18, 2011)),[68] the FFC analysis also includes impacts on emissions of methane (CH_4) and nitrous oxide (N_2O), both of which are recognized as greenhouse gases.

DOE primarily conducted the emissions analysis using emissions factors for CO_2 and most of the other gases derived from data in AEO 2014. Combustion emissions of CH_4 and N_2O were estimated using emissions intensity factors published by the Environmental Protection Agency (EPA), GHG Emissions Factors Hub.[69] DOE developed separate emissions factors for power sector emissions and upstream emissions.

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[68] DOE's FFC was amended in 2012 for reasons unrelated to the inclusion of CH_4 and N_2O. 77 FR 49701 (Aug. 17, 2012).
[69] http://www.epa.gov/climateleadership/inventory/ghg-emissions.html.

The method that DOE used to derive emissions factors is described in chapter 14 of the final rule TSD.

For CH_4 and N_2O, DOE calculated emissions reduction in tons and also in terms of units of carbon dioxide equivalent (CO_2eq). Gases are converted to CO_2eq by multiplying the physical units by the gas' global warming potential (GWP) over a 100-year time horizon. Based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,[70] DOE used GWP values of 28 for CH_4 and 265 for N_2O.

EIA prepares the Annual Energy Outlook using NEMS. Each annual version of NEMS incorporates the projected impacts of existing air quality regulations on emissions. AEO 2014 generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of October 31, 2013.

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

[70] IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Chapter 8.

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.[71] In 2011, EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (Aug. 8, 2011). On August 21, 2012, the D.C. Circuit issued a decision to vacate CSAPR.[72] The court ordered EPA to continue administering CAIR. The emissions factors used for today's final rule, which are based on AEO 2014, assume that CAIR remains a binding regulation through 2040.[73]

The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. Beginning in 2016, however, SO_2 emissions will decline significantly as a result of the Mercury and Air Toxics Standards (MATS) for power plants. 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

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[71] 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).

[72] See EME Homer City Generation, LP v. EPA, 696 F.3d 7, 38 (D.C. Cir. 2012), cert. granted, 81 U.S.L.W. 3567, 81 U.S.L.W. 3696, 81 U.S.L.W. 3702 (U.S. June 24, 2013) (No. 12-1182).

[73] On April 29, 2014, the U.S. Supreme Court reversed the judgment of the D.C. Circuit and remanded the case for further proceedings consistent with the Supreme Court's opinion. The Supreme Court held in part that EPA's methodology for quantifying emissions that must be eliminated in certain states due to their impacts in other downwind states was based on a permissible, workable, and equitable interpretation of the Clean Air Act provision that provides statutory authority for CSAPR. See EPA v. EME Homer City Generation, No 12-1182, slip op. at 32 (U.S. April 29, 2014). On October 23, 2014, the D.C. Circuit lifted the stay of CSAPR and CSAPR is scheduled to go into effect (and the CAIR will sunset) as of January 1, 2015. Because DOE is using emissions factors based on AEO 2014 for today's final rule, the final rule assumes that CAIR, not CSAPR, is the regulation in force. The difference between CAIR and CSAPR is not relevant for the purpose of DOE's analysis of SO_2 emissions.

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 2014 assumes that, in order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed by 2016. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Under the MATS, emissions will be far below the cap established by CAIR, so it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by any regulated EGU. Therefore, DOE believes that energy efficiency standards will reduce SO_2 emissions in 2016 and beyond

CAIR established a cap on NO_x emissions in 28 eastern States and the District of Columbia.[74] 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 today's final rule for these States.

[74] CSAPR also applies to NO_X, and it would supersede the regulation of NO_X under CAIR. As stated previously, the current analysis assumes that CAIR, not CSAPR, is the regulation in force. The difference between CAIR and CSAPR with regard to DOE's analysis of NO_X is slight.

The MATS limit mercury emissions from power plants, but they do not include emissions caps. DOE estimated mercury emissions reduction using emissions factors based on AEO 2014, which incorporates the MATS.

M. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this rule, DOE considered the estimated monetary benefits from the reduced emissions of CO_2 and NO_X that are expected to result from each of the TSLs considered. In order 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 products shipped in the forecast period for each TSL. This section summarizes the basis for the monetary values used for each of these emissions and presents the values considered in this rulemaking.

For today's final rule, 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 in the following section, and a more detailed description of the methodologies used is provided as an appendix to chapter 15 of the final rule 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 carbon dioxide. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in carbon dioxide 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 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 carbon dioxide emissions, the analyst faces a number of challenges. A 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 greenhouse gases; (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 limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions. The agency can estimate the benefits from reduced (or costs from increased) emissions in any future year by multiplying the change in emissions in that year by the SCC values appropriate for that year. The NPV of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. In the meantime, the interagency group will continue to explore the issues raised by this analysis and consider public comments as part of the ongoing interagency process.

b. Development of Social Cost of Carbon Values

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across Federal agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted. The outcome of the preliminary assessment by the interagency group was a set of five interim values: global SCC estimates for 2007 (in 2006$) of $55, $33, $19, $10, and $5 per metric ton of CO_2. These interim values represented the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules.

c. Current Approach and Key Assumptions

After the release of the interim values, the interagency group reconvened on a regular basis to generate improved SCC estimates. 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 (IPCC). Each model was given equal weight in the SCC values that were developed.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. A key objective of the interagency process was to enable a consistent exploration of the three models while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers’ best estimates and judgments.

The interagency group selected four sets of SCC values for use in regulatory analyses.[75] 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,[76] although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table VI.11 presents the values in the 2010 interagency group report, which is reproduced in appendix 15A of the final rule TSD.

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[75] 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. http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

[76] It is recognized that this calculation for domestic values is approximate, provisional, and highly speculative. There is no a priori reason why domestic benefits should be a constant fraction of net global damages over time.

Table VI.11. Annual SCC Values from 2010 Interagency Report, 2010–2050 (in 2007 dollars per metric ton CO2)

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.[77] Table VI.12 shows the updated sets of SCC estimates from the 2013 interagency update in five-year increments from 2010 to 2050. Appendix 15B of the final rule 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.

[77] 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

Table VI.12. 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 above points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. There are a number of analytical challenges that are being addressed by the research community, including research programs housed in many of the Federal agencies participating in the interagency process to estimate the SCC. The interagency group intends to periodically review and reconsider those estimates to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling.

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions, DOE used the values from the 2013 interagency report, adjusted to 2013$ using the Gross Domestic Product price deflator. For each of the four SCC cases specified, the values used for emissions in 2015 were $12.0, $40.5, $62.4, and $119 per metric ton avoided (values expressed in 2013$). DOE derived values after 2050 using the relevant growth rates for the 2040-2050 period in the interagency update.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SCC value for that year in each of the four cases. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the four cases using the specific discount rate that had been used to obtain the SCC values in each case.

The Associations objected to DOE's continued use of the SCC in the cost-benefit analysis performed in connection with this proposed rule, and they believe the SCC should be withdrawn as a basis for the rule. They stated that the SCC calculation should not be used in any rulemaking or policymaking until it undergoes a more rigorous notice, review, and comment process. (The Associations, No. 51 at p. 4) In contrast, the Joint Commenters stated that the current SCC values are sufficiently robust and accurate to continue to be the basis for regulatory analysis going forward. They argued that, if anything, current values are significant underestimates of the SCC. They stated that the interagency working group's analytic process was science-based, open, and transparent, and the SCC is an important and accepted tool for regulatory policy-making, based on well-established law and fundamental economics. (The Joint Comment, 48 at p. 1)

NEMA presented a critique–based largely on the writing of Robert Pindyck of the Massachusetts Institute of Technology–of the integrated assessment models (IAMs) used in projecting future damages from CO_2 emissions. The critique included strong criticisms of the IAMs' climate sensitivity analysis and damage function. NEMA argued that given the enormous uncertainty in the IAMs, these models–even "averaged" as the Interagency Working Group has done–are poor tools for agency decision-making, particularly with respect to products regulated by EPCA that are not themselves a source of emissions. (NEMA, No. 54 at pp. 39-44)

DOE acknowledges the limitations of the SCC estimates, which are discussed in detail in the 2010 interagency working group's report. Specifically, uncertainties in the assumptions regarding climate sensitivity, as well as other model inputs such as economic growth and emissions trajectories, are discussed and the reasons for the specific input assumptions chosen are explained. However, the three integrated assessment models used to estimate the SCC are frequently cited in the peer-reviewed literature and were used in the last assessment of the IPCC. In addition, new versions of the models that were used in 2013 to estimate revised SCC values were published in the peer-reviewed literature (see appendix 15B of the final rule TSD for discussion). Although uncertainties remain, the revised estimates used for today's final rule are based on the best available scientific information on the impacts of climate change. The current estimates of the SCC have been developed over many years, and with input from the public. In November 2013, OMB announced a new opportunity for public comment on the interagency technical support document underlying the revised SCC estimates. 78 FR 70586. OMB is reviewing comments and considering whether further revisions to the SCC estimates are warranted. DOE stands ready to work with OMB and the other members of the interagency working group on further review and revision of the SCC estimates as appropriate.

NEMA stated that the monetized benefits of carbon emission reductions are informative at some level, but should not be considered as determinative in the Secretary's decision-making under EPCA. NEMA believes that DOE should base its net benefit determination for justifying a particular energy conservation on the traditional criteria relied upon by DOE: impacts on manufacturers, consumers, employment, energy savings, and competition. (NEMA, 54 at pp. 38 and 44) In a similar vein, the Associations believe the SCC should be withdrawn as a basis for the proposed rule. (The Associations, No. 51, p. 4)

The monetized benefits of carbon emission reductions are one factor that DOE considers in its evaluation of the economic justification of proposed standards. As shown in Table VII.58, the benefits of today's standards in terms of consumer operating cost savings exceed the incremental costs of the standards-compliant products. The benefits of CO_2 emission reductions were considered by DOE, but were not determinative in DOE's decision to adopt today's standards, nor were they a primary basis of that decision.

2. Valuation of Other Emissions Reductions

As noted previously, DOE has taken into account how amended energy conservation standards would reduce site NO_X emissions nationwide and increase power sector NO_X emissions in those 22 States not affected by the CAIR. DOE estimated the monetized value of net NO_X emissions reductions resulting from each of the TSLs considered for today's final rule based on estimates found in the relevant scientific literature. Estimates of monetary value for reducing NO_X from stationary sources range from $476 to $4,893 per ton in 2013$.[78] DOE calculated monetary benefits using a medium value for NO_X emissions of $2,684 per short ton 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 TSL. The utility impact analysis is

[78] 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 (2006) (Available at: http://www.whitehouse.gov/sites/default/files/omb/assets/omb/inforeg/2006_cb/2006_cb_final_report.pdf).

based on published output from NEMS. Each year, NEMS is updated to produce the AEO reference case as well as a number of side cases that estimate the economy-wide impacts of changes to energy supply and demand. DOE uses those published side cases that incorporate efficiency-related policies to estimate the marginal impacts of reduced energy demand on the utility sector. The output of this analysis is a set of time-dependent coefficients that capture the change in electricity generation, primary fuel consumption, installed capacity and power sector emissions due to a unit reduction in demand for a given end use. These coefficients are multiplied by the stream of energy savings calculated in the NIA to provide estimates of selected utility impacts of new or amended energy conservation standards. Chapter 16 of the final rule TSD describes the utility impact analysis in further detail.

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 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 for the final rule, 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).[79] 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. DOE used ImSET only to estimate short-term employment impacts. For more details on the employment impact analysis, see chapter 17 of the final rule TSD.

P. Proposed Standards in April 2014 NOPR

In the NOPR, DOE proposed to adopt new and amended standards for all GSFL product classes and amended standards for all IRL product classes. For GSFLs, DOE proposed adopting TSL 5, which represented the max tech and maximum NES. Specifically, TSL 5 would set energy conservation standards at EL 2 for the 4-foot MBP, 8-foot SP slimline, 8-foot RDC HO, and T5 MiniBP SO product classes. For IRLs, DOE

[79] Roop, J. M., M. J. Scott, and R. W. Schultz, ImSET: Impact of Sector Energy Technologies, 2005. Pacific Northwest National Laboratory. Richland, WA. Report No. PNNL- 15273. <http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15273.pdf>

proposed adopting TSL 1, which was EL 1 and represented max tech. DOE received general comments on the proposed standards.

Miller stated that there are three problems that DOE states it is trying to address by setting efficacy standards for GSFLs and IRLs: lack of consumer information, asymmetric information about the benefits of energy-efficient commercial appliances, and externalities related to greenhouse gas emissions. However, two of the problems cited by DOE—lack of consumer information about energy efficiency and information asymmetry—are not addressed in its proposed efficacy standards. Additionally, DOE does not explain why GSFL and IRL consumers would suffer from either informational deficits or cognitive biases that would cause them to purchase products with high lifetime costs without demanding higher price, higher efficacy products. Miller further states that this asymmetric information, if it exists, could be remedied by improved labeling or other types of consumer education campaigns rather than banning products from the marketplace, especially given the projected penetration rates of LEDs. (Miller, No. 50 at p. 11)

Section 1(b)(1) of Executive Order 12866, "Regulatory Planning and Review" requires Federal agencies 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. 58 FR 51735 (Oct. 4, 1993) Section 1(b) also states that agencies should adhere to the listed principles to the extent permitted by law. DOE's standards rulemaking process is intended to fulfill the requirements of EPCA. 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)) The proposed standards, and the standards established in this final rule, meet these criteria. By adopting standards that achieve maximum improvement in energy efficiency that is technologically feasible and economically justified, this rulemaking is indirectly addressing any potential lack of consumer information regarding energy efficiency and asymmetric information regarding these products. Alternative remedies proposed by Miller, such as labeling and consumer information, are covered by other programs established by EPCA. (42 U.S.C. 6294 and 42 U.S.C. 6307) However, the existence of such programs does not obviate DOE's legal requirement to adhere to the standards rulemaking process laid out in EPCA.

Miller stated that DOE's approach is contrary to instruction to agencies in Executive Order 13563, which requires agencies to identify and consider regulatory approaches that reduce burdens and maintain flexibility and freedom of choice for the public. Miller noted that this included warnings, appropriate default rules, and disclosure requirements, and providing clear and intelligible information to the public. (Miller, No. 50 at p. 11)

DOE identified and evaluated non-regulatory approaches to improving the efficacy of GSFLs and IRLs, as described in chapter 18 of the final rule TSD. DOE currently does not have statutory authority to implement most of these alternatives. Furthermore, DOE concluded that all of the non-regulatory alternatives would save less energy and have a lower NPV than adopted standards.

Regarding warnings, default rules, and disclosure requirements, in this final rule notice DOE clearly describes amendments to existing standards being adopted in today's final rule and explains that compliance to the new and amended standards will be required three years after the publication date of this notice. See section VI.G.13 for compliance date information. DOE has held public meetings and invited comments from stakeholders in the framework, preliminary analysis, and NOPR stages of this rulemaking and held interviews with manufacturers at the preliminary and NOPR stages. At each stage DOE has published documents, including this final notice, that clearly lay out the methodology, assumptions, analysis, and results, as well as describe in detail comments received from stakeholders and DOE's responses.

Miller also stated that DOE's proposal does not maintain flexibility and freedom of choice for purchasers of GSFLs and IRLs, and the resulting benefits do not justify the costs as required both by statute and by Executive Order. (Miller, No. 50 at p. 12)

DOE determined that the proposed levels in the NOPR and the standard being adopted today do not lessen the utility or performance of GSFLs and IRLs. DOE has ensured that the typical characteristics of lamps meeting the existing standard, such as shape, CCT, CRI, lifetime, and lumen package are represented at the higher efficacy levels proposed in the NOPR and being adopted in today's rule. Further, consumers will continue to have a range of purchasing choices under the adopted standards. For further comments and discussion on the impact of higher efficacy levels on product availability, see section VI.D.2 for GSFLs and section VI.D.3 for IRLs.

Miller stated that if DOE proceeds to issue the standards as proposed in the NOPR, DOE should commit to retrospective review to assess whether the rule meets the statutory standard of achieving the maximum improvement in energy efficiency that is both technologically feasible and economically justified, while also resulting in a significant conservation of energy. Miller outlined a number of metrics to consider in a retrospective review. These included quantifying environmental benefits and security, reliability, and costs of maintaining the nation's energy system as a result of standards; and potentialities such as a rebound effect, impedance of LED technology, adverse impacts on manufacturers, increased mercury, and loss of product utility and optionality as a result of standards. (Miller, No. 50 at p. 12) Miller also noted that DOE should commit to measuring metrics and assumptions of this final rule on a regular basis and collecting information for this purpose. (Miller, No. 50 at p. 9)

As stated in DOE's Final Plan for the Retrospective Review of Existing Rules, dated August 23, 2011,[80] DOE is committed to maintaining a consistent culture of retrospective review and analysis. In the plan, DOE sets forth a process for identifying

[80] Available at http://energy.gov/gc/services/open-government/restrospective-regulatory-review.

significant rules that are obsolete, unnecessary, unjustified, excessively burdensome, or counterproductive. Once such rules have been identified, DOE will, after considering public input on any proposed change, determine what action is necessary or appropriate. DOE will continually engage in review of its rules to determine whether there are burdens on the public that can be avoided by amending or rescinding existing requirements. DOE's consideration of appliance standards within the context of retrospective review is discussed at pages 9-10 of the final plan. Since the release of its final plan, DOE has issued a number of reports documenting its progress in the retrospective review of its regulations.[81] DOE has also issued a number of Requests for Information seeking input from the public on its retrospective review efforts, most recently on July 3, 2014. 79 FR at 37963 (April 29, 2014). DOE encourages all interested parties to provide input in DOE's retrospective review process.

CA IOUs and ASAP endorsed the NOPR analyses and stated they would support a final rule similar to the rule proposed in the NOPR. (CA IOUs, Public Meeting Transcript, No. 49 at p. 245; ASAP, Public Meeting Transcript, No. 49 at pp. 16, 244) EEOs stated the proposed standards would build on the achievements of the 2009 Lamps Rule, which had increased minimum efficacy by 19 percent for GSFLs and 62 percent for IRLs, by further increasing efficacy by 4 percent for GSFLs and 8 percent for IRLs. Specifically, EEOs highlighted the potential savings from the proposed standards for GSFLs, but noted that potential savings from proposed IRL standards are also significant.

[81] These reports are also available at http://energy.gov/gc/services/open-government/restrospective-regulatory-review.

EEOs also pointed out that the proposed standards were cost-effective for both commercial and residential consumers. (EEOs, No. 55 at p. 2) GE, however, found the standard levels proposed in the NOPR problematically high, especially with regards to the increased burden on the industry. (GE, Public Meeting Transcript, No. 49 at p. 243)

When considering establishing new or amending existing standards, DOE weighs the benefits and burdens of such standards. In the NOPR, for GSFL TSL 5 and IRL TSL 1, DOE determined that the benefits of energy savings, positive NPV of total consumer benefits, positive impacts on consumers, emission reductions and the estimated monetary value of the emissions reductions would outweigh the potential reduction in industry value. In the following sections DOE discusses comments received specifically on the proposed standards for GSFLs and IRLs.

1. GSFLs Proposed Standards

DOE also received several comments specific to the GSFL standards proposed in the NOPR. ASAP noted that the proposed GSFL standards, in combination with the GSFL standards from the 2009 Lamps Rule and the ballast standards from the 2011 Ballast Rule, would result in substantial energy savings, in particular due to their impact on the commercial sector. ASAP stated and CA IOUs agreed that this is an example of how standards can couple with utility-based and voluntary programs to shift lighting efficiency. (ASAP, Public Meeting Transcript, No. 49 at pp. 13-15; CA IOUs, Public Meeting Transcript, No. 49 at p. 20) CA IOUs further commented that the proposed GSFL standards are designed to push the fluorescent lamp market to “best-in-class” and the resulting energy savings estimate of 3.5 quads is significant. (CA IOUs, No. 56 at pp. 1-2) NEEP noted that the proposed max-tech efficacy levels for GSFL would bring over 2 TWhs of annual electricity reduction to the NEEP region in 2020 and more than 100 MWs of capacity reductions (9.8TWhs and 573 MW nationally). NEEP continued that the very aggressive energy efficiency programs administered in the region have made the proposed standards practical. (NEEP, No. 57 at p. 1)

NEMA, however, disagreed, stating that the proposed higher performance levels would result in the unavailability of extended life lamps, inability for manufacturers to repeatedly and consistently produce products for testing and enforcement problems, price increases, minimal efficiency gains, consumer diversion to full-wattage lamps with reduced energy savings, and a significant financial impact to U.S. industry without sufficient payback. (NEMA, No. 54 at p. 16)

As previously noted, in the NOPR analysis, DOE proposed TSL 5 for GSFLs, which required adopting the proposed EL 2 for the 4-foot MBP lamps, 8-foot slimline lamps, 8-foot RDC HO, 4-foot T5 MiniBP SO, and EL 1 for 4-foot T5 MiniBP HO. 79 FR 24068, 24174 Based on an assessment of catalog and certification data, DOE found that these levels are technologically feasible (see chapter 5 of the NOPR TSD for the further details on the engineering analysis) and maintained the GSFLs with typical lifetimes (see section VI.D.2.g for further discussion). Although DOE proposed TSL 5 in the NOPR, as discussed in section VII.C.1, in this final rule DOE found that the burdens of TSL 5 outweigh the benefits and is therefore adopting a lower standard level.

NEMA recommended alternative standards for the GSFL product classes than those proposed in the NOPR. For lamps with CCT ≤ 4,500 K, NEMA recommended that the current standards be maintained for the 4-foot MBP (89.0 lm/W) and 2-foot U-shaped (84.0 lm/W) product classes and standards be amended to 98.0 lm/W for the 8-foot SP slimline product class; 94.0 lm/W for the 8-foot RDC HO product class; 90.0 lm/W for the 4-foot T5 MiniBP SO product class; and 80.0 lm/W for the 4-foot T5 MiniBP HO product class. (NEMA, No. 54 at pp. 27-28) For lamps with CCT > 4,500 K, NEMA recommended that the current standards be maintained for 4-foot MBP lamps (88 lm/W); 2-foot U-shaped lamps (81 lm/W); and 8-foot SP slimline lamps (93.0 lm/W) and standards be amended to 90 lm/W for the 8-foot RDC HO product class; 84 lm/W for the 4-foot T5 MiniBP SO; and 76 lm/W for the 4-foot T5 MiniBP HO product class. (NEMA, No. 54 at p. 28)

CA IOUs noted that DOE has proposed a standard for the 4-foot MBP lamps that can be achieved by an 800 series, full-wattage, and high-lumen T8 lamp. CA IOUs mentioned that their rebate and incentive programs have encouraged the adoption of these third generation T8 lamps and have utilized them in cost-effective installations to achieve large energy savings, and also mentioned that the standards would further encourage this market transformation without adversely impacting product performance. (CA IOUs, No. 56 at pp. 1-2) NEEP commented that about two-thirds of the savings would be lost if the levels of the 4-foot MBP lamps were weakened, therefore DOE should maintain these levels as the higher performing lamps are available and cost-effective. (NEEP, No. 57 at p. 1)

Based on catalog and certification data, for the 4-foot MBP product class DOE determined that there were two higher efficacy levels than the existing standard: EL 1 representing a standard 800 series full wattage lamp and EL 2 representing an improved 800 series full wattage lamp in which the phosphor mix and/or coating is enhanced to increase efficacy. DOE developed standards for the 2-foot U-shaped product class by scaling from standards for the 4-foot MBP product class. DOE developed a scaling factor based on the efficacy difference of comparable 4-foot MBP and 2-foot U-shaped product lines, and in this final rule confirmed this scaling factor using updated certification data. For this final rule, DOE used updated catalog and certification data for all products and confirmed the higher efficacy levels above the existing standard for the 4-foot MBP and 2-foot U-shaped lamps. Therefore, DOE found that higher efficacy levels than the current standards for the 4-foot MBP, 2-foot U-shaped, and 8-foot SP slimline lamps are feasible and reflect the performance of products currently on the market. See section VI.D.2.g for the detailed engineering analysis of these lamp types.

In the NOPR for lamps with CCT ≤ 4,500 K, the proposed TSL 5 required EL 2 at 92.4 lm/W for 4-foot MBP lamps; EL 2 at 99.0 lm/W for the 8-foot SP slimline lamps; EL 2 at 97.6 lm/W for the 8-foot RDC HO lamps; EL 2 at 97.1 lm/W for the 4-foot T5 MiniBP SO lamps; and EL 1 at 82.7 lm/W for the 4-foot T5 MiniBP HO lamps. DOE determined the efficacies at these levels based on commercially available lamps using both catalog and certification data, and therefore found that these efficacies are accurate representation of higher performing products on the market. For this final rule, DOE analyzed updated catalog and certification data and confirmed these efficacy levels with the exception of T5 MiniBP SO lamps which was adjusted to be 95 lm/W based on certification data. See section VI.D.2.g for the detailed engineering analysis of these lamps.

In the NOPR, for lamps with CCT > 4,500 K, the proposed TSL 5 required EL 2 at 90.6 lm/W for 4-foot MBP lamps; EL 2 at 94.1 lm/W for the 8-foot SP slimline lamps; EL 2 at 95.6 lm/W for the 8-foot RDC HO lamps; EL 2 at 91.3 lm/W for the 4-foot T5 MiniBP SO lamps; and EL 1 at 78.6 lm/W for the T5 MiniBP HO lamps. Standards for GSFLs with CCT > 4,500 K were scaled from corresponding GSFLs with CCT ≤ 4,500 K. In the NOPR, DOE developed scaling factors based on the differences in efficacies between less than 4,500 K and greater than 4,500 K comparable products on the market. DOE verified the developed scaling factors using certification data. For this final rule, DOE adjusted certain scaling factors based on updated certification data, which resulted in the following changes for lamps with CCT > 4,500 K: EL 2 for the 4-foot MBP was adjusted to 89.3 lm/W; EL 2 for the 8-foot SP slimline was adjusted to 96.0 lm/W; EL 2 for the 8-foot RDC HO lamps was adjusted to 93.7 lm/W; EL 2 for the 4-foot T5 MiniBP SO was adjusted to 89.3 lm/W; and EL 1 for the T5 MiniBP HO was adjusted to 76.9 lm/W. See chapter 5 of this final rule TSD for the detailed engineering analysis of GSFL scaling.

DOE conducted a comprehensive analysis of all GSFL products available on the market and utilized both catalog and certification data to determine the efficacy levels for each product class. After weighing the benefits and burdens in this final rule analysis, DOE is adopting TSL 4 which will require EL 2 for the 4-foot MBP lamps and the 4-foot T5 MiniBP SO lamps; EL 1 for the 4-foot T5 MiniBP HO lamps; and maintain existing standards for the 8-foot SP slimline and 8-foot RDC HO lamps. See section VII.C.1 for a discussion on the benefits and burdens of GSFL standards.

People's Republic of China (P.R. China) commented that for the 8-foot SP slimline lamps with a CCT > 4,500 K the standard proposed in the NOPR increases existing standards by 1.2 percent, while for the 4-foot T5 MiniBP SO lamps with a CCT ≤ 4,500 K the existing standard is increased by 12.9 percent. P.R. China questioned the range of increase in efficacy in the proposed standards for these two lamp types. (P.R. China, No. 58, p. 3)

As mentioned previously, DOE considers the 8-foot SP slimline with CCT > 4,500 K and the 4-foot T5 MiniBP SO with CCT ≤ 4,500 K as two separate product classes due to their difference in utility and efficacy. See section VI.C.1 for more details on GSFL product classes. Based on its review of catalog and certification data, DOE determined that there were 4-foot T5 MiniBP SO lamps available on the market with efficacies much higher than their existing standard compared to the commercially available 8-foot SP slimline lamps.

NEMA commented that rare earth availability remains volatile; particularly the phosphor mix used in argon-based 92+ lm/W lamps. NEMA remarked that forcing all products to use specialized rare earth phosphor mixes is extremely risky for argon-based lamps as the proposed standard is at the high end of the technology limits, and DOE cannot risk having only krypton based lamps available due to their lack of dimmability. Thus, EL 2 cannot be used for 4-foot MBP lamps. (NEMA, No. 54 at p. 14)

EL 2 for the 4-foot MBP lamps was based on the performance of full wattage, argon-based lamps that are currently on the market. DOE acknowledges that supply and demand of rare earth phosphors should be considered when evaluating amended standards for GSFLs. DOE conducted LCC and NIA sensitivities for a scenario with increased rare earth phosphor prices in the NOPR. With regards to impacts on consumers, DOE found that proposed efficacy levels remained achievable even with increased phosphor prices. In the NIA, DOE found that the ranking of TSLs by NPV remained unchanged in the high rare earth phosphor price scenario. For this final rule, DOE conducted these sensitivities with an updated phosphor price and reached the same conclusions. See chapter 12 and appendix 7B of the final rule TSD for more detail on DOE's assessment of impact of rare earth phosphors.

DOE also received a comment regarding the LCC results for GSFLs and the impact on the proposed standard. For 8-foot RDC HO lamps, Westinghouse questioned the economic justification behind consumers losing 16-17 percent of the value of the product over its average lifetime. (Westinghouse, Public Meeting Transcript, No. 49 at p. 152)

The LCC analysis is one of the factors that DOE considers when weighing the benefits and burdens of TSLs. In the NOPR the 8-foot RDC HO product class showed negative LCC savings at the proposed TSL 5. In the final rule, DOE is adopting TSL 4 which does not amend the standard level for 8-foot HO lamps. As discussed below, TSL 4 includes a combination of ELs that maximizes NPV; in addition to 8-foot HO lamps, TSL 4 also does not amend the standard level for 8-foot slimline lamps.

Additionally, DOE received a comment on choosing between TSL 4 and TSL 5, as presented in the NOPR. NEMA commented that TSL 5 is very similar to TSL 4 in national energy use, but has a significantly higher conversion cost for manufacturers and the most negative INPV. NEMA commented that the NOPR shows a modest national energy savings difference between TSL 4 and TSL 5 in the proposed GSFL rule, as computed by the DOE for the NOPR (3.0 v. 3.5 quads over 30 years). NEMA claimed that the reason for this is because, considering all the assumptions and estimates used to calculate the savings, the energy savings estimate of both levels is within +/- 5 percent or well within the uncertainty of both projections. (NEMA, No. 54 at p. 27) NEMA further claimed that there is more manufacturing investment required to go from TSL 4 ($13M) to TSL 5 ($38.6M) (79 FR at 24160, Table VII.30 [April 29, 2014]), and DOE has a legislative and executive mandated obligation to reduce or eliminate the regulatory burden of TSL 5. NEMA claimed that TSL 5 would require an additional investment in production lines that are projected to decline in future years without generating meaningful incremental national energy savings and that this is not an acceptable or reasonable decision for the U.S. government to make. NEMA commented that the money would be better invested into research in new technologies with a larger energy savings impact. (NEMA, No. 54 at p. 27)

NEMA noted that that primary difference between TSL 4 and TSL 5 is that the 8-foot slimline and 8-foot RDC HO categories jump from EL 0 to EL 2, but NEMA added that they should not be moved any higher than EL 1, as they would not increase national energy savings and will be costly to the manufacturer. NEMA further commented that it is unreasonable to assume that manufacturers or consumers would make the investment to switch from a T8 to T5 system, nor from 8-foot fluorescent systems to T5 systems, due to the cost involved with their lack of interchangeability. NEMA stated that DOE must remove these false assumptions and restructure the energy savings projections. (NEMA, No. 54 at p. 15)

In the NOPR, TSL 4 represented the maximum NPV that was achievable in the analysis from any combination of ELs. DOE determined that the increase in energy savings at TSL 5 compared to TSL 4, as well as generally positive impact on consumers, emission reductions and the estimated monetary value would outweigh the potential reduction in industry value experienced at TSL 5 compared to TSL 4. Therefore, DOE proposed TSL 5 as it represented maximum national energy savings. Further, the uncertainty in key variables, such as energy price forecast or product price trends would generally affect TSL 4 and TSL 5 in the same way, so DOE would expect the relative ranking to remain.

The switching from 4-foot MBP or 8-foot SP slimline systems was allowed only in new construction and renovation and based on DOE research that indicated there are comparable luminaires. DOE is aware that there are physical and optical differences between T8 and T5 lamps and the potential for substitution of 4-foot MBP T8 or 8-foot SP slimline T8 with T5 MiniBP SO lamps is only assumed at the time of new construction and renovation, when a new luminaire would be specified. DOE's analysis indicates that there exist T5 luminaires that compete directly with 4-foot MBP T8 luminaires in most applications in the largest luminaire markets (e.g., commercial offices, education, industrial) and in some cases, luminaire manufacturers offer essentially identical luminaires in 4-foot MBP T8 and T5 MiniBP versions. For these same reasons, DOE also assumed switching between 8-foot SP slimline with T5 MiniBP SO is possible. See appendix 11C of the final rule TSD for examples of these luminaires and a discussion of DOE's analysis of the substitution potential for 4-foot MBP and T5 MiniBP SO Lamps.

Further, in this final rule, DOE modified TSL 4 slightly so that maximum NPV is achieved from a combination of ELs that minimizes the net burden on a consumer for a product class that may have negative NPV in the absence of product class switching (e.g., consumers substituting a T8 system with T5 system). This modification resulted in only one EL change between the TSL 4 proposed in the NOPR and the TSL 4 presented in today's final rule: for the 8-foot RDC HO product class the efficacy level in the TSL 4 presented for this final rule is at the baseline rather than EL 1. DOE is adopting TSL 4 in this final rule for GSFLs. See section VII.C.1 for a discussion on the benefits and burdens of GSFL standards.

2. IRL Proposed Standards

DOE received several comments regarding the proposed TSL 1 for IRLs in the NOPR. NEMA commented that 130 V lamps are no longer available, so there is no reason to establish a new standard for them since there will be no energy savings. (NEMA, Public Meeting Transcript, No. 49 at pp. 37-38) Philips added that 130 V lamps cannot be produced. (Philips, Public Meeting Transcript, No. 49 at p. 37) GE stated that the proposed 130 V lamp standard exceeds the capability of making a practical lamp as the proposed efficacy level of the 130 V lamps is 15 percent higher than that for the 120 V lamps. GE added that the only way to reach this efficacy is to decrease lifetime by two thirds if operated at 120 V and even lower if operated at 130 V, making it impractical to sell. GE stated that the proposed regulations raise the efficacy level 5 percent higher and that this is just as impossible as the last standard. (GE, Public Meeting Transcript, No. 49 at pp. 40-42)

CA IOUs disagreed, stating that not setting a standard for 130 V lamps leaves the door open to potential loopholes. CA IOUs cited the example that DOE exempted certain BR and ER lamps and these lamps have grown in market share. Therefore, the CA IOUs stated that products that are not on the market now but might be in the future should be regulated. (CA IOUs, Public Meeting Transcript, No. 49 at p. 39)

DOE is aware that at the time of this final rule there are no 130 V IRLs covered by this rulemaking on the market. However, DOE did not find any evidence that permanently precludes these lamps from becoming commercially available. DOE's research also does not indicate that the lamps are not being manufactured solely due to technological barriers. DOE remains concerned that if 130 V lamps do become available and standards for 120 V lamps are raised and not for the 130 V lamps, there may be a potential migration to the 130 V lamps that would result in increased energy consumption. See section VI.C.2 and VI.D.3.f for further discussion. Therefore, when considering higher efficacy standards for the less than 125 V product class in TSL 1, DOE also considered higher efficacy standards for the greater than or equal to 125 V product class.

DOE also received overall comments on the merit of proposing TSL 1, which represented max tech (EL 1) for IRLs. CA IOUs and NEEP commented that they support the DOE's proposal to increase the stringency of IRL standards, but stated that the standards proposed in the NOPR could be higher. (NEEP, No. 57 at p. 3; CA IOU, No. 56 at p. 4) NEEP stated that additional ELs should be established that represent the maximum technologically feasible level and typically evaluates the maximum commercially available level. NEEP noted that there were products in DOE's certification database with higher efficacies than the proposed standard, which should have been considered in the analysis. (NEEP, No. 57 at p. 3) CA IOUs agreed with DOE's proposal to adopt a standard that can be met with HIR design strategy. CA IOUs continued that they have incentive programs that promote a shift towards higher efficiency technology, such as LEDs, but are not able to promote and incentivize the highest efficacy incandescent products. CA IOUs mentioned that DOE would be the biggest driver in promoting this shift to high-efficacy IRLs, and noted that the HIR technology is a proven and cost-effective design. (CA IOUs, No. 56 at p. 4) ASAP stated that the proposed IRL standard will help ensure that buyers have a choice of efficient options in that market place, including LEDs or very efficacious incandescent lamps. (ASAP, Public Meeting Transcript, No. 49 at pp. 15-16)

NEMA, however, disagreed, stating that the limited benefits to the nation from amended standards for IRLs do not justify the burden on the manufacturers and consumers of IRLs. With regards to negative impacts on manufacturers, NEMA presented a graph that plotted the percentage INPV and the estimated energy savings from DOE's appliance efficiency rulemakings since 2008. NEMA also calculated and plotted the midpoint average percentage INPV as -10.95 percent and average projected energy savings at 2.156 of these rulemakings. NEMA noted on this graph that with the exception of the proposed GSFL standards, all lighting rulemakings have resulted in INPV more negative than the midpoint INPV, and the proposed IRL standards are the second most severe in negative impacts to manufacturers. Further, on NEMA's graph, the proposed IRLs standards result in the lowest energy savings compared to the average projected energy savings of 2.156 quads. NEMA stated that on this basis alone, the proposed IRL standards deviate from the norms and should not be deemed economically justified. NEMA also provided a summary of the negative INPV from various product rulemakings that result in a cumulative regulatory burden on IRL manufacturers. NEMA noted that the imposition of the burden of the proposed IRL standards in addition to this cumulative regulatory burden called for “alternatives to direct regulation” per Executive Order 12866, which in this case would be to not amend the existing IRL standards as only one TSL is proposed. NEMA also stated that the IRL standards proposed in the NOPR would result in an increase in prices that would drive consumers to alternate technologies and manufacturers to exit the IRL market and result in the loss of all or most domestic employment in IRL manufacturing. (NEMA, No. 54 at pp. 2-4)

With regards to impact on consumers, NEMA emphasized that the proposed IRL standards would require IRL consumers to accept a 30-50 percent increase in price. Further, NEMA predicted that due to initial costs, consumers would choose to purchase the less efficacious, unregulated higher wattage IRLs. (NEMA, No. 54 at pp. 2, 10) NEMA suggested that regulations allowing lower priced lamps at 60 W or below as substitutes for 90 W IRLs would move consumers to more energy efficient options. In contrast, the proposed IRL standards would limit consumer options to higher-end commercial products that utilize HIR. NEMA explained that halogen PAR lamps would not meet the proposed standards unless life was reduced by at least 20 percent, which would be a loss to consumer utility. Therefore, NEMA concluded that for these reasons the IRL standards proposed in the NOPR would increase rather than decrease national energy use. (NEMA, No. 54 at pp. 2, 10) GE noted the positive LCC saving results for

IRLs were likely based mainly on commercial customers that use PAR38 lamps and would be very different for the residential consumers. GE questioned how a standard that has no economic benefits could be adopted. (GE, Public Meeting Transcript, No. 49 at p. 152)

DOE is aware that TSL 1 for IRLs resulted in negative impacts on industry and would increase end-user prices. Regarding the LCC assessment, DOE analyzed both the IRL commercial and residential sectors at TSL 1 and found them to be positive for both representative lamp units. As noted previously, in addition to the impact on manufacturers and consumers, DOE weighed other factors when determining whether or not TSL 1 was economically justified. In the NOPR, DOE found 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. In this final rule analysis,after reevaluating the factors considered in weighing the benefits and burdens of a potential standard, DOE is not amending standards for IRLs in today’s final rule. See section VII.C.3 for a discussion on the benefits and burdens of IRL standards.

VII. Analytical Results

A. Trial Standard Levels

For the final rule, DOE develops 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 combination of efficacy levels that yield the maximum NPV. TSL 3 is composed of efficacy levels that yield the maximum energy savings without using any of the EL 2 levels. For both TSL 4 and TSL 3 efficacy level combinations, to ensure that max NES and NPV were based on consumer options to save energy for each lamp type, DOE did not consider an efficacy level for a product class that did not result in energy savings from options within the product class. 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 commercially available 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.a 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 VII.C 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	0	0	2
4. 4-foot T5, Mini bipin standard output, CCT ≤ 4,500 K	1	1	1	2	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 in the following subsections.

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 through 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 economically benefits. 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 final rule 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 the appendix also presents sensitivity results, such as LCC savings under the AEO 2014 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))

General Service Fluorescent Lamps

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 final rule 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[82]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	17.38	126.22	143.80	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.88 BF Inst	34.60	126.22	147.97	-4.17	100.0	0	NER
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst	30.12	105.71	136.03	7.77	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.88 BF Inst	27.03	126.22	153.45	-9.65	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.88 BF Inst	24.25	113.41	137.86	5.94	0.0	100.0	2.6
Event II: Ballast Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.88 BF Inst	60.77	126.00	167.94	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	77.99	112.69	158.80	9.14	0.0	100.0	0.4
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst	73.51	105.51	160.20	7.74	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.77 BF Inst	70.42	109.77	161.36	6.58	0.0	100.0	2.9
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	67.64	108.63	157.45	10.49	0.0	100.0	1.9

[82] The lifetimes of the representative lamps units range from 4.8 to 5.5 years.

Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option[82]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience: Net Cost	Percentage of Consumers that Experience: Net Benefit	
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.88 BF Inst	63.61	126.00	169.54	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	80.84	112.69	160.40	9.14	0.0	100.0	0.4
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst	76.35	105.51	161.79	7.74	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.77 BF Inst	73.26	109.77	162.96	6.58	0.0	100.0	2.9
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	70.49	108.63	159.04	10.49	0.0	100.0	1.9

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[83]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	17.38	200.67	218.22	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.88 BF Prog	33.47	200.67	225.18	-6.96	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog	30.12	168.52	198.82	19.41	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog	27.03	200.67	227.87	-9.65	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog	24.25	180.59	205.02	13.20	0.0	100.0	2.6
Event II: Ballast Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.88 BF Prog	61.98	200.67	255.15	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.88 BF Prog	78.07	200.67	262.11	-6.96	100.0	0.0	NER
		EL 1	90.0	32.5 W T8 & 0.72 BF Prog	78.07	168.05	229.49	25.66	0.0	100.0	0.3
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog	74.72	168.52	235.74	19.41	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog	71.63	200.67	264.80	-9.65	100.0	0.0	NER
		EL 2	95.4	32.5 W T8 & 0.72 BF Prog	71.63	168.05	232.18	22.97	0.0	100.0	2.3

[83] The lifetimes of the representative lamps units range from 6.9 to 9.2 years.

Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option[83]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog	68.85	180.59	241.95	13.20	0.0	100.0	2.6
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.88 BF Prog	64.82	200.67	257.51	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.88 BF Prog	80.91	200.67	264.46	-6.96	100.0	0.0	NER
		EL 1	90.0	32.5 W T8 & 0.72 BF Prog	80.91	168.05	231.84	25.66	0.0	100.0	0.3
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog	77.56	168.52	238.10	19.41	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog	74.47	200.67	267.15	-9.65	100.0	0.0	NER
		EL 2	95.4	32.5 W T8 & 0.72 BF Prog	74.47	168.05	234.53	22.97	0.0	100.0	2.3
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog	71.70	180.59	244.30	13.20	0.0	100.0	2.6

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[84]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	28.26	248.52	277.17	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.87 BF Inst	57.07	248.52	284.37	-7.21	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	53.75	208.09	262.22	14.94	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.87 BF Inst	47.56	248.52	296.46	-19.30	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	42.01	223.26	265.66	11.51	0.0	100.0	2.7
Event II: Ballast Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.87 BF Inst	87.41	242.00	303.87	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	116.22	220.90	289.98	13.89	0.0	100.0	0.5
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	112.90	202.40	289.76	14.12	0.0	100.0	3.2
		EL 2	95.4	32.5 W T8 & 0.74 BF Inst	106.71	213.66	294.83	9.05	0.4	99.6	3.4
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	101.16	217.26	292.88	10.99	0.0	100.0	2.7
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.87 BF Inst	90.25	242.00	305.47	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	119.06	220.90	291.58	13.89	0.0	100.0	0.5
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	115.74	202.40	291.35	14.12	0.0	100.0	3.2

[84] The lifetimes of the representative lamps units range from 4.8 to 5.5 years.

Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option[84]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
		EL 2	95.4	32.5 W T8 & 0.74 BF Inst	109.55	213.66	296.42	9.05	0.4	99.6	3.4
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	104.00	217.26	294.47	10.99	0.0	100.0	2.7

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[85]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
Event I: Lamp Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.89 BF Prog	28.26	396.53	425.14	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.89 BF Prog	55.17	396.53	436.96	-11.82	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog	53.75	332.51	386.60	38.54	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.89 BF Prog	47.56	396.53	444.44	-19.30	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.89 BF Prog	42.01	356.54	398.90	26.24	0.0	100.0	2.7
Event II: Ballast Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.89 BF Prog	89.27	396.53	475.65	N/A	N/A	N/A	N/A
	Lamp &	EL 1	90.0	32.5 W T8 & 0.87	116.18	378.87	469.82	5.83	0.3	99.7	1.0

[85] The lifetimes of the representative lamps units range from 6.9 to 9.2 years.

Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option[85]	Life-Cycle Cost: Installed Cost 2013$	Life-Cycle Cost: Discounted Operating Cost 2013$	Life-Cycle Cost: LCC 2013$	Life-Cycle Cost Savings: LCC Savings 2013$	Life-Cycle Cost Savings: Percentage of Consumers that Experience Net Cost	Life-Cycle Cost Savings: Percentage of Consumers that Experience Net Benefit	Mean Payback Period years
	Ballast Replacement			BF Prog							
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog	114.75	332.51	437.11	38.54	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.87 BF Prog	108.57	378.87	477.30	-1.64	74.2	25.8	8.4
		EL 2	96.0	28.4 W T8 & 0.87 BF Prog	103.02	340.36	433.24	42.42	0.0	100.0	1.9
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.89 BF Prog	92.11	396.53	478.01	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.87 BF Prog	119.02	378.87	472.17	5.83	0.3	99.7	1.0
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog	117.59	332.51	439.47	38.54	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.87 BF Prog	111.41	378.87	479.65	-1.64	74.2	25.8	8.4
		EL 2	96.0	28.4 W T8 & 0.87 BF Prog	105.86	340.36	435.59	42.42	0.0	100.0	1.9

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[86]	Life-Cycle Cost: Installed Cost 2013$	Life-Cycle Cost: Discounted Operating Cost 2013$	Life-Cycle Cost: LCC 2013$	Life-Cycle Cost Savings: LCC Savings 2013$	Life-Cycle Cost Savings: Percentage of Consumers that Experience Net Cost	Life-Cycle Cost Savings: Percentage of Consumers that Experience Net Benefit	Mean Payback Period years

[86] The lifetimes of the representative lamps units are 15 years.

Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option[86]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	10.59	49.49	60.09	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.87 BF Inst	11.70	49.49	61.19	-1.10	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	23.33	41.51	64.84	-4.75	94.0	6.0	16.9
		EL 2	95.4	32.5 W T8 & 0.87 BF Inst	20.24	49.49	69.74	-9.65	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	17.47	44.51	61.97	-1.88	86.3	13.7	14.6
Event II: Ballast Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.87 BF Inst	53.44	49.49	102.93	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.83 BF Inst	54.54	46.98	101.53	1.41	0.8	99.2	4.7
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	66.18	41.51	107.69	-4.75	94.0	6.0	16.9
		EL 2	95.4	32.5 W T8 & 0.83 BF Inst	63.09	46.98	110.07	-7.14	100.0	0.0	40.8
		EL 2	96.0	28.4 W T8 & 0.83 BF Inst	60.31	42.24	102.56	0.38	43.8	56.2	10.1
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.87 BF Inst	56.28	49.49	105.77	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.83 BF Inst	57.38	46.98	104.37	1.41	0.8	99.2	4.7
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	69.02	41.51	110.53	-4.75	94.0	6.0	16.9
		EL 2	95.4	32.5 W T8 & 0.83 BF Inst	65.93	46.98	112.91	-7.14	100.0	0.0	40.8
		EL 2	96.0	28.4 W T8 & 0.83 BF Inst	63.15	42.24	105.40	0.38	43.8	56.2	10.1

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[87]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
Event I: Lamp Failure	**Baseline**	Baseline	83.6	53.8 W T5 & 1 BF Prog	18.79	198.89	217.86	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	92.9	53.8 W T5 & 1 BF Prog	26.89	198.89	225.96	-8.11	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	32.88	181.63	207.42	10.44	0.0	100.0	3.6
		EL 1	102.1	47 W T5 & 1 BF Prog	35.82	174.43	205.82	12.04	0.0	100.0	3.0
Event II: Ballast Failure	**Baseline**	Baseline	83.6	53.8 W T5 & 1 BF Prog	73.59	198.89	250.82	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	92.9	53.8 W T5 & 1 BF Prog	81.69	198.89	258.93	-8.11	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	87.68	181.63	240.38	10.44	0.0	100.0	3.6
		EL 1	102.1	47 W T5 & 1 BF Prog	90.62	174.43	238.78	12.04	0.0	100.0	3.0
Event III: New Construction and Renovation	**Baseline**	Baseline	83.6	53.8 W T5 & 1 BF Prog	76.43	198.89	252.53	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	92.9	53.8 W T5 & 1 BF Prog	84.54	198.89	260.63	-8.11	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	90.52	181.63	242.09	10.44	0.0	100.0	3.6
		EL 1	102.1	47 W T5 & 1 BF Prog	93.46	174.43	240.49	12.04	0.0	100.0	3.0

[87] The lifetimes of the representative lamps units range from 5.1 to 7.2 years.

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[88]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
Event I: Lamp Failure	**Baseline**	Baseline	94.6	27.8 W T5 & 1 BF Prog	15.48	168.05	183.71	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	104.3	27.8 W T5 & 1 BF Prog	19.38	168.05	187.62	-3.91	100.0	0.0	NER
		EL 2	109.7	27.8 W T5 & 1 BF Prog	21.76	168.05	190.00	-6.29	100.0	0.0	NER
		EL 2	111.5	26 W T5 & 1 BF Prog	24.94	157.48	182.61	1.10	35.6	64.4	5.4
		EL 2	116.0	25 W T5 & 1 BF Prog	27.72	151.60	176.35	7.36	0.0	100.0	4.5
Event II: Ballast Failure	**Baseline**	Baseline	94.6	27.8 W T5 & 1 BF Prog	69.04	168.05	219.39	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	104.3	27.8 W T5 & 0.85 BF Prog	72.94	147.48	202.73	16.66	0.0	100.0	1.1
		EL 2	109.7	27.8 W T5 & 0.85 BF Prog	75.32	147.48	205.11	14.28	0.0	100.0	1.8
		EL 2	111.5	26 W T5 & 0.85 BF Prog	78.50	138.30	199.12	20.28	0.0	100.0	1.9
		EL 2	116.0	25 W T5 & 0.85 BF Prog	81.28	133.20	193.64	25.76	0.0	100.0	2.1
Event III: New Construction and Renovation	**Baseline**	Baseline	94.6	27.8 W T5 & 1 BF Prog	71.88	168.05	221.29	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	104.3	27.8 W T5 & 0.85 BF Prog	75.79	147.48	204.63	16.66	0.0	100.0	1.1
		EL 2	109.7	27.8 W T5 & 0.85 BF Prog	78.17	147.48	207.01	14.28	0.0	100.0	1.8

[88] The lifetimes of the representative lamps units range from 6.9 to 8.1 years.

Event	**Response**	**Efficacy Level**	**Rated Lamp Efficacy** lm/W	**Design Option**[88]	**Life-Cycle Cost**			**Life-Cycle Cost Savings**			**Mean Payback Period** years
					Installed Cost 2013$	**Discounted Operating Cost** 2013$	**LCC** 2013$	**LCC Savings** 2013$	**Percentage of Consumers that Experience**		
									Net Cost	Net Benefit	
		EL 2	111.5	26 W T5 & 0.85 BF Prog	81.34	138.30	201.01	20.28	0.0	100.0	1.9
		EL 2	116.0	25 W T5 & 0.85 BF Prog	84.12	133.20	195.53	25.76	0.0	100.0	2.1

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[89]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	27.02	235.88	263.29	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	98.2	60.1 W T8 & 0.87 BF Inst	29.72	235.88	266.00	-2.70	100.0	0.0	NER
		EL 2	99.0	60.1 W T8 & 0.87 BF Inst	34.89	235.88	271.17	-7.88	100.0	0.0	NER
		EL 2	105.6	54 W T8 & 0.87 BF Inst	43.98	223.67	268.05	-4.75	93.5	6.5	6.6
		EL 2	108.0	50 W T8 & 0.87 BF Inst	51.41	207.38	259.19	4.10	18.4	81.6	4.1
Event II: Ballast Failure	Baseline	Baseline	96.5	60.1 W T8 & 0.87 BF Inst	103.85	232.93	301.36	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	98.2	60.1 W T8 & 0.77 BF Inst	106.55	207.99	279.13	22.23	0.0	100.0	0.5
		EL 2	99.0	60.1 W T8 & 0.77 BF Inst	111.72	207.99	284.31	17.06	0.0	100.0	1.5
		EL 2	105.6	54 W T8 & 0.77 BF Inst	120.81	197.22	282.62	18.75	0.0	100.0	2.3
		EL 2	108.0	50 W T8 & 0.87 BF Inst	128.24	204.71	297.54	3.83	21.5	78.5	4.1
Event III: New Construction and Renovation	Baseline	Baseline	96.5	60.1 W T8 & 0.87 BF Inst	106.69	232.93	302.88	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	98.2	60.1 W T8 & 0.77 BF Inst	109.39	207.99	280.65	22.23	0.0	100.0	0.5
		EL 2	99.0	60.1 W T8 & 0.77 BF Inst	114.57	207.99	285.82	17.06	0.0	100.0	1.5

[89] The lifetimes of the representative lamps units are 5.4 years.

Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option[89]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
		EL 2	105.6	54 W T8 & 0.77 BF Inst	123.65	197.22	284.13	18.75	0.0	100.0	2.3
		EL 2	108.0	50 W T8 & 0.87 BF Inst	131.08	204.71	299.06	3.83	21.5	78.5	4.1

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[90]	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
Event I: Lamp Failure	Baseline	Baseline	92.0	84 W T8 & 0.95 BF Prog	24.73	225.36	250.47	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	95.2	84 W T8 & 0.95 BF Prog	34.39	225.36	260.13	-9.67	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.95 BF Prog	41.67	225.36	267.42	-16.95	100.0	0.0	NER
Event II: Ballast Failure	Baseline	Baseline	92.0	84 W T8 & 0.95 BF Prog	103.98	225.36	287.49	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	95.2	84 W T8 & 0.95 BF Prog	113.65	225.36	297.16	-9.67	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.95 BF Prog	120.93	225.36	304.44	-16.95	100.0	0.0	NER
Event III: New Construction and Renovation	Baseline	Baseline	92.0	84 W T8 & 0.95 BF Prog	106.82	225.36	288.82	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	95.2	84 W T8 & 0.95 BF Prog	116.49	225.36	298.49	-9.67	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.95 BF Prog	123.77	225.36	305.77	-16.95	100.0	0.0	NER

[90] The lifetimes of the representative lamp units are 3.6 years.

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	10.67	9.88	20.54	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase	EL 1	17.8	55W, 2500hrs, HIR	13.25	9.05	17.00	3.54	0.0	100.0	3.0

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	9.52	10.92	20.45	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase	EL 1	17.8	55W, 2500hrs, HIR	12.10	10.01	17.74	2.71	0.0	100.0	5.2

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	10.67	9.88	20.54	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase	EL 1	20.4	55W, 4200hrs, Improved HIR	15.15	9.05	14.46	6.08	0.0	100.0	5.2

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	9.52	10.92	20.45	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase	EL 1	20.4	55W, 4200hrs, Improved HIR	14.00	10.01	15.87	4.58	0.0	100.0	9.0

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 8.2 percent (versus 3.6 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 final rule TSD further details of the consumer subgroup analysis.

<u>General Service Fluorescent Lamps</u>

Table VII.16 through Table VII.24 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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	17.38	110.26	127.79	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.88 BF Inst	32.05	110.26	132.38	-4.59	100	0	NER
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst	30.12	92.34	122.61	5.18	1.3	98.7	3.1
		EL 2	95.4	32.5 W T8 & 0.88 BF Inst	27.03	110.26	137.44	-9.65	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.88 BF Inst	24.25	99.07	123.47	4.32	0.0	100.0	2.6
Event II: Ballast Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.88 BF Inst	60.77	110.06	156.30	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	75.44	98.44	149.27	7.03	0.0	100.0	0.4
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst	73.51	92.17	151.15	5.15	1.4	98.6	3.1
		EL 2	95.4	32.5 W T8 & 0.77 BF Inst	70.42	95.89	151.78	4.53	0.3	99.7	2.9
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	67.64	94.89	148.01	8.30	0.0	100.0	1.9
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.88 BF Inst	63.61	110.06	158.18	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	78.28	98.44	151.15	7.03	0.0	100.0	0.4
		EL 2	93.0	26.6 W T8 & 0.88 BF Inst	76.35	92.17	153.03	5.15	1.4	98.6	3.1
		EL 2	95.4	32.5 W T8 & 0.77 BF Inst	73.26	95.89	153.66	4.53	0.3	99.7	2.9
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	70.49	94.89	149.89	8.30	0.0	100.0	1.9

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	17.38	163.71	181.21	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.88 BF Prog	30.05	163.71	187.69	-6.48	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog	30.12	137.48	167.73	13.49	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog	27.03	163.71	190.86	-9.65	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog	24.25	147.33	171.71	9.51	0.0	100.0	2.6
Event II: Ballast Failure	Baseline	Baseline	89.2	32.5 W T8 & 0.88 BF Prog	61.98	163.71	220.61	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.88 BF Prog	74.65	163.71	227.09	-6.48	100.0	0.0	NER
		EL 1	90.0	32.5 W T8 & 0.72 BF Prog	74.65	137.10	200.48	20.13	0.0	100.0	0.3
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog	74.72	137.48	207.12	13.49	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog	71.63	163.71	230.26	-9.65	100.0	0.0	NER
		EL 2	95.4	32.5 W T8 & 0.72 BF Prog	71.63	137.10	203.65	16.97	0.0	100.0	2.3
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog	68.85	147.33	211.11	9.51	0.0	100.0	2.6

Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option	Life-Cycle Cost			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.88 BF Prog	64.82	163.71	223.12	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.88 BF Prog	77.49	163.71	229.60	-6.48	100.0	0.0	NER
		EL 1	90.0	32.5 W T8 & 0.72 BF Prog	77.49	137.10	202.99	20.13	0.0	100.0	0.3
		EL 2	93.0	26.6 W T8 & 0.88 BF Prog	77.56	137.48	209.64	13.49	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.88 BF Prog	74.47	163.71	232.77	-9.65	100.0	0.0	NER
		EL 2	95.4	32.5 W T8 & 0.72 BF Prog	74.47	137.10	206.16	16.97	0.0	100.0	2.3
		EL 2	96.0	28.4 W T8 & 0.88 BF Prog	71.70	147.33	213.62	9.51	0.0	100.0	2.6

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			Life-Cycle Cost Savings			Mean Payback Period years
					Installed Cost 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	28.26	217.09	245.65	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.87 BF Inst	52.85	217.09	253.57	-7.92	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	53.75	181.77	235.82	9.83	1.9	98.1	3.1
		EL 2	95.4	32.5 W T8 & 0.87 BF Inst	47.56	217.09	264.95	-19.30	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	42.01	195.03	237.33	8.31	0.0	100.0	2.7
Event II: Ballast Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.87 BF Inst	87.41	211.39	279.10	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	112.00	192.97	268.59	10.51	0.0	100.0	0.5
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	112.90	176.80	269.99	9.11	2.2	97.8	3.2
		EL 2	95.4	32.5 W T8 & 0.74 BF Inst	106.71	186.63	273.63	5.46	5.1	94.9	3.4
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	101.16	189.78	271.23	7.86	0.0	100.0	2.7
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.87 BF Inst	90.25	211.39	280.98	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	114.84	192.97	270.47	10.51	0.0	100.0	0.5
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	115.74	176.80	271.87	9.11	2.2	97.8	3.2
		EL 2	95.4	32.5 W T8 & 0.74 BF Inst	109.55	186.63	275.51	5.46	5.1	94.9	3.4
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	104.00	189.78	273.11	7.86	0.0	100.0	2.7

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 2013$	Life-Cycle Cost: Discounted Operating Cost 2013$	Life-Cycle Cost: LCC 2013$	Life-Cycle Cost Savings: LCC Savings 2013$	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	28.26	323.51	352.00	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.89 BF Prog	49.53	323.51	363.05	-11.04	100.0	0.0	NER
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog	53.75	271.27	325.26	26.75	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.89 BF Prog	47.56	323.51	371.30	-19.30	100.0	0.0	NER
		EL 2	96.0	28.4 W T8 & 0.89 BF Prog	42.01	290.88	333.13	18.88	0.0	100.0	2.7
Event II: Ballast Failure	**Baseline**	Baseline	89.2	32.5 W T8 & 0.89 BF Prog	89.27	323.51	405.90	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.87 BF Prog	110.54	309.10	402.54	3.36	4.0	96.0	1.0
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog	114.75	271.27	379.15	26.75	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.87 BF Prog	108.57	309.10	410.79	-4.89	88.8	11.2	8.4
		EL 2	96.0	28.4 W T8 & 0.87 BF Prog	103.02	277.68	373.82	32.07	0.0	100.0	1.9
Event III: New Construction and Renovation	**Baseline**	Baseline	89.2	32.5 W T8 & 0.89 BF Prog	92.11	323.51	408.41	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.87 BF Prog	113.38	309.10	405.05	3.36	4.0	96.0	1.0
		EL 2	93.0	26.6 W T8 & 0.89 BF Prog	117.59	271.27	381.66	26.75	0.0	100.0	3.1
		EL 2	95.4	32.5 W T8 & 0.87 BF Prog	111.41	309.10	413.30	-4.89	88.8	11.2	8.4
		EL 2	96.0	28.4 W T8 & 0.87 BF Prog	105.86	277.68	376.33	32.07	0.0	100.0	1.9

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	10.60	49.49	60.09	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	90.0	32.5 W T8 & 0.87 BF Inst	11.71	49.49	61.20	-1.10	100	0	NER
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	23.36	41.50	64.86	-4.77	93.3	6.7	16.9
		EL 2	95.4	32.5 W T8 & 0.87 BF Inst	20.26	49.49	69.75	-9.66	100	0	NER
		EL 2	96.0	28.4 W T8 & 0.87 BF Inst	17.48	44.50	61.98	-1.89	86.4	13.6	14.6
Event II: Ballast Failure	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst	53.46	49.49	102.94	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.83 BF Inst	54.56	46.98	101.54	1.40	0.8	99.2	4.7
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	66.21	41.50	107.71	-4.77	93.3	6.7	16.9
		EL 2	95.4	32.5 W T8 & 0.83 BF Inst	63.11	46.98	110.09	-7.15	100.0	0.0	40.8
		EL 2	96.0	28.4 W T8 & 0.83 BF Inst	60.34	42.24	102.57	0.37	43.8	56.2	10.1
Event III: New Construction and Renovation	Baseline	Baseline	89.2	32.5 W T8 & 0.87 BF Inst	56.30	49.49	105.79	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	90.0	32.5 W T8 & 0.83 BF Inst	57.40	46.98	104.38	1.40	0.8	99.2	4.7
		EL 2	93.0	26.6 W T8 & 0.87 BF Inst	69.05	41.50	110.55	-4.77	93.3	6.7	16.9
		EL 2	95.4	32.5 W T8 & 0.83 BF Inst	65.96	46.98	112.93	-7.15	100.0	0.0	40.8
		EL 2	96.0	28.4 W T8 & 0.83 BF Inst	63.18	42.24	105.42	0.37	43.8	56.2	10.1

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
Event I: Lamp Failure	**Baseline**	Baseline	83.6	53.8 W T5 & 1 BF Prog	18.78	239.73	258.66	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	92.9	53.8 W T5 & 1 BF Prog	26.88	239.73	266.76	-8.10	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	32.86	218.93	245.99	12.67	0.0	100.0	3.0
		EL 1	102.1	47 W T5 & 1 BF Prog	35.81	210.25	242.43	16.23	0.0	100.0	2.6
Event II: Ballast Failure	**Baseline**	Baseline	83.6	53.8 W T5 & 1 BF Prog	73.57	239.73	295.57	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	92.9	53.8 W T5 & 1 BF Prog	81.67	239.73	303.67	-8.10	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	87.65	218.93	282.90	12.67	0.0	100.0	3.0
		EL 1	102.1	47 W T5 & 1 BF Prog	90.60	210.25	279.34	16.23	0.0	100.0	2.6
Event III: New Construction and Renovation	**Baseline**	Baseline	83.6	53.8 W T5 & 1 BF Prog	76.41	239.73	297.48	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	92.9	53.8 W T5 & 1 BF Prog	84.51	239.73	305.59	-8.10	100.0	0.0	NER
		EL 1	102.0	49 W T5 & 1 BF Prog	90.49	218.93	284.81	12.67	0.0	100.0	3.0
		EL 1	102.1	47 W T5 & 1 BF Prog	93.44	210.25	281.25	16.23	0.0	100.0	2.6

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
Event I: Lamp Failure	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog	15.48	143.06	158.67	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	104.3	27.8 W T5 & 1 BF Prog	19.38	143.06	162.58	-3.91	100.0	0.0	NER
		EL 2	109.7	27.8 W T5 & 1 BF Prog	21.76	143.06	164.96	-6.29	100.0	0.0	NER
		EL 2	111.5	26 W T5 & 1 BF Prog	24.94	134.06	159.14	-0.47	71.2	28.8	5.4
		EL 2	116.0	25 W T5 & 1 BF Prog	27.72	129.06	154.58	4.09	2.5	97.5	4.5
Event II: Ballast Failure	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog	69.04	143.06	199.02	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	104.3	27.8 W T5 & 0.85 BF Prog	72.94	125.55	185.42	13.60	0.0	100.0	1.1
		EL 2	109.7	27.8 W T5 & 0.85 BF Prog	75.32	125.55	187.80	11.22	0.0	100.0	1.8
		EL 2	111.5	26 W T5 & 0.85 BF Prog	78.50	117.74	183.17	15.86	0.0	100.0	1.9
		EL 2	116.0	25 W T5 & 0.85 BF Prog	81.28	113.39	179.27	19.75	0.0	100.0	2.1
Event III: New Construction and Renovation	Baseline	Baseline	94.6	27.8 W T5 & 1 BF Prog	71.88	143.06	201.16	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	104.3	27.8 W T5 & 0.85 BF Prog	75.79	125.55	187.56	13.60	0.0	100.0	1.1
		EL 2	109.7	27.8 W T5 & 0.85 BF Prog	78.17	125.55	189.94	11.22	0.0	100.0	1.8
		EL 2	111.5	26 W T5 & 0.85 BF Prog	81.34	117.74	185.31	15.86	0.0	100.0	1.9
		EL 2	116.0	25 W T5 & 0.85 BF Prog	84.12	113.39	181.41	19.75	0.0	100.0	2.1

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	27.02	206.75	234.09	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	98.2	60.1 W T8 & 0.87 BF Inst	29.72	206.75	236.79	-2.70	100.0	0.0	NER
		EL 2	99.0	60.1 W T8 & 0.87 BF Inst	34.89	206.75	241.97	-7.88	100.0	0.0	NER
		EL 2	105.6	54 W T8 & 0.87 BF Inst	43.98	196.05	240.35	-6.26	99.8	0.2	6.6
		EL 2	108.0	50 W T8 & 0.87 BF Inst	51.41	181.77	233.51	0.58	59.9	40.1	4.1
Event II: Ballast Failure	**Baseline**	Baseline	96.5	60.1 W T8 & 0.87 BF Inst	103.85	204.17	279.48	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	98.2	60.1 W T8 & 0.77 BF Inst	106.55	182.31	260.33	19.15	0.0	100.0	0.5
		EL 2	99.0	60.1 W T8 & 0.77 BF Inst	111.72	182.31	265.50	13.98	0.0	100.0	1.5
		EL 2	105.6	54 W T8 & 0.77 BF Inst	120.81	172.87	265.14	14.34	0.0	100.0	2.3
		EL 2	108.0	50 W T8 & 0.87 BF Inst	128.24	179.43	279.14	0.34	63.2	36.8	4.1
Event III: New Construction and Renovation	**Baseline**	Baseline	96.5	60.1 W T8 & 0.87 BF Inst	106.69	204.17	281.25	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	98.2	60.1 W T8 & 0.77 BF Inst	109.39	182.31	262.10	19.15	0.0	100.0	0.5
		EL 2	99.0	60.1 W T8 & 0.77 BF Inst	114.57	182.31	267.27	13.98	0.0	100.0	1.5
		EL 2	105.6	54 W T8 & 0.77 BF Inst	123.65	172.87	266.91	14.34	0.0	100.0	2.3
		EL 2	108.0	50 W T8 & 0.87 BF Inst	131.08	179.43	280.91	0.34	63.2	36.8	4.1

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	Percentage of Consumers that Experience		
									Net Cost	Net Benefit	
Event I: Lamp Failure	**Baseline**	Baseline	92.0	84 W T8 & 0.95 BF Prog	24.72	279.36	304.43	N/A	N/A	N/A	N/A
	Lamp Replacement	EL 1	95.2	84 W T8 & 0.95 BF Prog	34.38	279.36	314.09	-9.66	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.95 BF Prog	41.66	279.36	321.37	-16.94	100.0	0.0	NER
Event II: Ballast Failure	**Baseline**	Baseline	92.0	84 W T8 & 0.95 BF Prog	103.96	279.36	345.38	N/A	N/A	N/A	N/A
	Lamp & Ballast Replacement	EL 1	95.2	84 W T8 & 0.95 BF Prog	113.62	279.36	355.04	-9.66	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.95 BF Prog	120.90	279.36	362.32	-16.94	100.0	0.0	NER
Event III: New Construction and Renovation	**Baseline**	Baseline	92.0	84 W T8 & 0.95 BF Prog	106.80	279.36	346.85	N/A	N/A	N/A	N/A
	New Lamp & Ballast Purchase	EL 1	95.2	84 W T8 & 0.95 BF Prog	116.47	279.36	356.51	-9.66	100.0	0.0	NER
		EL 2	97.6	84 W T8 & 0.95 BF Prog	123.74	279.36	363.79	-16.94	100.0	0.0	NER

Incandescent Reflector Lamps

Table VII.25 through Table VII.28 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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	10.67	9.46	20.13	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase	EL 1	17.8	55W, 2500hrs, HIR	13.25	8.67	16.62	3.51	0.0	100.0	3.0

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	9.53	10.77	20.31	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase	EL 1	17.8	55W, 2500hrs, HIR	12.11	9.88	17.61	2.70	0.0	100.0	5.3

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	10.67	9.46	20.13	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase	EL 1	20.4	55W, 4200hrs, Improved HIR	15.15	8.67	14.08	6.05	0.0	100.0	5.2

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 2013$	Discounted Operating Cost 2013$	LCC 2013$	LCC Savings 2013$	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	9.53	10.77	20.31	N/A	N/A	N/A	N/A
	Lamp Replacement or New Lamp Purchase	EL 1	20.4	55W, 4200hrs, Improved HIR	14.01	9.88	15.74	4.57	0.0	100.0	9.2

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	2.6
		Event II: Ballast Failure	Lamp & Ballast Replacement	EL 1	90.0	32.5 W T8 & 0.78 BF Inst	0.4
				EL 2	95.4	32.5 W T8 & 0.77 BF Inst	2.9
				EL 2	96.0	28.4 W T8 & 0.87 BF Inst	1.9
		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	95.4	32.5 W T8 & 0.77 BF Inst	2.9
				EL 2	96.0	28.4 W T8 & 0.87 BF Inst	1.9
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	2.6
		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	2.3
				EL 2	96.0	28.4 W T8 & 0.88 BF Prog	2.6
		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	2.3
				EL 2	96.0	28.4 W T8 & 0.88 BF Prog	2.6

Lamp Description	Sector	Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option	Mean Payback Period years
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	2.7
		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	2.7
		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	2.7
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	2.7
		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	1.9
		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	1.9

Lamp Description	Sector	Event	Response	Efficacy Level	Rated Lamp Efficacy lm/W	Design Option	Mean Payback Period years
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	1.1
				EL 2	109.7	27.8 W T5 & 0.85 BF Prog	1.8
				EL 2	111.5	26 W T5 & 0.85 BF Prog	1.9
				EL 2	116.0	25 W T5 & 0.85 BF Prog	2.1
		Event III: New Construction and Renovation	New Lamp & Ballast Purchase	EL 1	104.3	27.8 W T5 & 0.85 BF Prog	1.1
				EL 2	109.7	27.8 W T5 & 0.85 BF Prog	1.8
				EL 2	111.5	26 W T5 & 0.85 BF Prog	1.9
				EL 2	116.0	25 W T5 & 0.85 BF Prog	2.1
T8 Single Pin Slimline	Commercial	Event II: Ballast Failure	Lamp & Ballast Replacement	EL 1	98.2	60.1 W T8 & 0.77 BF Prog	0.5
				EL 2	99.0	60.1 W T8 & 0.77 BF Prog	1.5
				EL 2	105.6	54 W T8 & 0.77 BF Prog	2.3
		Event III: New Construction and Renovation	New Lamp & Ballast Purchase	EL 1	98.2	60.1 W T8 & 0.77 BF Prog	0.5
				EL 2	99.0	60.1 W T8 & 0.77 BF Prog	1.5
				EL 2	105.6	54 W T8 & 0.77 BF Prog	2.3

2. Economic Impacts on Manufacturers

DOE performed MIAs to estimate the impact of amended energy conservation standards on manufacturers of GSFLs and IRLs. The following section describes the expected impacts on GSFL and IRL manufacturers at each TSL. Chapter 13 of the final rule TSD explains the MIA in further detail.

a. Industry Cash-Flow Analysis Results

The tables in this section depict the financial impacts (represented by changes in INPV) of potential 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 separately breaks out the impacts on GSFL and IRL manufacturers. To evaluate the range of cash-flow impacts on the GSFL and IRL industries, DOE modeled three markup scenarios for GSFLs and two markup scenarios for IRLs that correspond to the range of anticipated market responses to potential 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 (2015) 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 potential 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 potential amended energy conservation standards.

Cash-Flow Analysis Results by TSL for General Service Fluorescent Lamps

To assess the upper (less severe) bound 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) bound of the range of potential impacts on the GSFL manufacturers, DOE modeled a two-tier markup scenario. The two-tiered markup scenario assumes manufacturers offer two different tiers of markups, one for lower efficacy levels and one for higher efficacy levels. This scenario models a situation where a reduction in premium markups reduces the profitability of higher efficacy products. During manufacturer interviews, manufacturers provided information on the range of typical efficacy levels in these two tiers and the change in profitability at each level. DOE used this information to estimate markups for GSFLs under a two-tier pricing strategy. In the standards case, DOE modeled the situation in which GSFL standards result in less product differentiation, compression of the higher markup tier, and an overall reduction in profitability.

In addition to an upper and lower bound markup scenario, DOE also modeled the preservation of operating profit markup scenario. This scenario models the situation where manufacturers earn the same nominal operating profit in the standards case as they would earn in the base case, despite the higher production costs resulting from standards. While this scenario does not represent an upper or lower bound for this analysis, it displays the INPV results if manufacturers are able to implement a common pricing strategy following abrupt changes to MPCs, as is the case with energy conservation standards.

Table VII.30 through Table VII.32 present the projected results for GSFLs under the flat, preservation of operating profit, and two-tier 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	(2013$ millions)	1,551.6	1,601.1	1,599.8	1,682.0	1,978.4	1,996.2
Change in INPV	(2013$ millions)	-	49.5	48.2	130.4	426.8	444.6
	(%)	-	3.2	3.1	8.4	27.5	28.7
Product Conversion Costs	(2013$ millions)	-	0.9	2.0	5.1	7.8	9.2
Capital Conversion Costs	(2013$ millions)	-	1.0	11.2	2.0	18.8	29.9
Total Conversion Costs	(2013$ millions)	-	1.9	13.2	7.2	26.6	39.1

Table VII.31 Manufacturer Impact Analysis for General Service Fluorescent Lamps – Preservation of Operating Profit

	Units	Base Case	Trial Standard Level				
			1	2	3	4	5
INPV	(2013$ millions)	1,551.6	1,551.0	1,542.0	1,542.9	1,525.4	1,516.4
Change in INPV	(2013$ millions)	-	(0.6)	(9.6)	(8.7)	(26.2)	(35.2)
	(%)	-	0.0	-0.6	-0.6	-1.7	-2.3
Product Conversion Costs	(2013$ millions)	-	0.9	2.0	5.1	7.8	9.2
Capital Conversion Costs	(2013$ millions)	-	1.0	11.2	2.0	18.8	29.9
Total Conversion Costs	(2013$ millions)	-	1.9	13.2	7.2	26.6	39.1

Table VII.32 Manufacturer Impact Analysis for General Service Fluorescent Lamps – Two Tier Markup Scenario

	Units	Base Case	Trial Standard Level				
			1	**2**	**3**	**4**	**5**
INPV	(2013$ millions)	1,551.6	1,508.7	1,495.1	1,477.4	1,221.6	1,183.9
Change in INPV	(2013$ millions)	-	(42.9)	(56.5)	(74.2)	(330.0)	(367.7)
	(%)	-	-2.8	-3.6	-4.8	-21.3	-23.7
Product Conversion Costs	(2013$ millions)	-	0.9	2.0	5.1	7.8	9.2
Capital Conversion Costs	(2013$ millions)	-	1.0	11.2	2.0	18.8	29.9
Total Conversion Costs	(2013$ millions)	-	1.9	13.2	7.2	26.6	39.1

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 max tech. At TSL 1, DOE estimates impacts on INPV range from $49.5 million to -$42.9 million, or a change in INPV of 3.2 percent to -2.8 percent. At TSL 1, industry free cash flow (operating cash flow minus capital expenditures) is estimated to decrease by less than 1 percent to $164.2 million, compared to the base-case value of $164.5 million in 2017, the year leading up to the energy conservation standards.

Percentage impacts on INPV range from 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 (2018), 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

86 percent of GSFL shipments in 2018. Meanwhile, in 2018, 32 percent of 8-foot RDC HO shipments, 46 percent of 4-foot T5 MiniBP SO, and 39 percent of 4-foot T5 MiniBP HO shipments would meet the efficacy levels at TSL 1. Because these products comprise only a small percentage of total GSFL shipments in 2018, 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 prescribed 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 $1.0 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 6 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 nominal operating profit as would be earned in the base case, but manufacturers do not earn additional profit from their investments. The 6 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 slightly negative impacts at TSL 1.

Under the two-tier markup scenario, manufacturers lose differentiation in their product offerings and premium markups erode as high-efficacy products become baseline offerings due to standards. The 6 percent MPC increase does not mitigate the lower average markup of 1.50 and $1.9 million in conversion costs, resulting in slightly 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 max tech. At TSL 2, DOE estimates impacts on INPV to range from $48.2 million to -$56.5 million, or a change in INPV of 3.1 percent to -3.6 percent. At this standard level, industry free cash flow is estimated to decrease by approximately 3.4 percent to $159.3 million, compared to the base case value of $164.5 million in 2017.

Percentage impacts on INPV range from 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 meet or exceed the efficacy levels prescribed at TSL 2. DOE projects that in 2018, 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 83 percent of GSFL shipments in 2018. Meanwhile, in 2018, 60 percent of 8-foot SP slimline lamps shipments, 10 percent of 8-foot RDC HO shipments, 46 percent of 4-foot T5 MiniBP SO, and 39 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 $11.2 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 7 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 $13.2 million in conversion costs. Under the preservation of operating profit markup scenario, the 7 percent MPC increase is slightly outweighed by a lower average markup of 1.51 (compared to the flat markup of 1.52) and $13.2 million in conversion costs, resulting in slightly negative impacts at TSL 2. Under the two-tier markup scenario, the 7 percent MPC increase is also slightly outweighed by a lower average markup of 1.50 and $13.2 million in conversion costs, resulting in slightly negative impacts at TSL 2.

TSL 3 sets the efficacy level at baseline for two product classes (8-foot SP slimline and 8-foot RDC HO) and EL 1 for three product classes (4-foot MBP, 4-foot T5 MiniBP SO, and 4-foot T5 MiniBP HO). EL 1 for the 4-foot T5 MiniBP HO product class represents max tech. At TSL 3, DOE estimates impacts on INPV to range from $130.4 million to -$74.2 million, or a change in INPV of 8.4 percent to -4.8 percent. At this standard level, industry free cash flow is estimated to decrease by approximately 1.5 percent to $154.1 million, compared to the base-case value of $164.5 million in 2017.

While more significant than the impacts at TSL 2, the lower bound markup scenario impacts on INPV at TSL 3 are still relatively minor compared to the total industry value. Percentage impacts on INPV range from moderately positive to slightly negative at TSL 3. DOE does not anticipate that manufacturers would lose a significant portion of their INPV at 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 2018, 57 percent of the 4-foot MBP, 100 percent of 8-foot SP slimline, 100 percent of 8-foot RDC HO shipments, 46 percent of 4-foot T5 MiniBP SO, and 39 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 at this TSL. TSL 3 is the first TSL that increases the efficacy requirement for 4-foot MBP lamps, 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 a significant capital investment. At TSL 3, DOE expects product conversion costs to increase from TSL 2 to $5.1 million. DOE, however, estimates that capital conversion costs will decrease from TSL 2 to $2.0 million at TSL 3 as no amended efficacy standards would be set at TSL 3 for 8-foot SP slimline products or the 8-foot RDC HO product class. 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 $7.2 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 1.49 (compared to the flat markup scenario markup of 1.52) and $7.2 million in conversion costs, resulting in slightly negative impacts at TSL 3. Under the two-tier markup scenario, the 16 percent MPC increase is outweighed by a lower average markup of 1.48 and $7.2 million in conversion costs, resulting in negative impacts at TSL 3.

TSL 4 sets the efficacy level at baseline for two product classes (8-foot SP slimline and 8-foot RDC HO), EL 1 for one product class (4-foot T5 MiniBP HO), and EL 2 for two product classes (4-foot MBP and T5 MiniBP SO). EL 1 for the 4-foot T5 MiniBP HO product class and EL 2 for the 4-foot MBP and T5 MiniBP SO product classes represent max tech. At TSL 4, DOE estimates impacts on INPV to range from $426.8 million to -$330.0 million, or a change in INPV of 27.5 percent to -21.3 percent. At this standard level, industry free cash flow is estimated to decrease by approximately 7 percent to $154.1 million, compared to the base-case value of $164.5 million in the year leading up to energy conservation standards.

Percentage impacts on INPV range from significantly positive to moderately negative at TSL 4. DOE projects that in 2018, 23 percent of 4-foot MBP, 100 percent of 8-foot SP slimline, 100 percent of 8-foot RDC HO shipments, 14 percent of 4-foot T5 MiniBP SO, and 39 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 $5.1 million at TSL 3 to $7.8 million at TSL 4. DOE expects capital conversion costs to increase from $2.0 million at TSL 3 to $18.8 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, compared to the base case INPV. 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 significantly positive because of manufacturers' ability to pass the higher production costs to consumers outweighs the $26.6 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 1.44 (compared to the flat markup scenario markup of 1.52) and $26.6 million in conversion costs, resulting in slightly negative impacts at TSL 4. Under the two-tier markup scenario, the 52 percent MPC increase is moderately outweighed by a lower average markup of 1.39 and $26.6 million in conversion costs, resulting in moderately 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 four 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 $444.5 million to -$367.7 million, or a change in INPV of 28.7 percent to -23.7 percent. At this standard level, industry free cash flow is estimated to decrease by 10 percent to $148.7 million, compared to the base-case value of $164.5 million in 2017.

Percentage impacts on INPV range from significantly positive to significantly negative at TSL 5. DOE projects that in 2018, 23 percent of the 4-foot MBP, 26 percent of 8-foot SP slimline, 10 percent of 8-foot RDC HO, 14 percent of 4-foot T5 MiniBP SO, and 39 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 and 8-foot RDC HO product classes moving to max tech at TSL 5. DOE estimates that capital conversion costs will be $29.9 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 $9.2 million in product conversion costs for lamp redesigns and testing. However, these larger total conversion costs at TSL 5, $39.1 million, remain relatively small compared to the approximately $1.5 billion base-case GSFL INPV.

At TSL 5, under the flat markup scenario, the shipment-weighted-average MPC increases by 55 percent relative to the base-case MPC. In this scenario, INPV impacts are significantly positive because of manufacturers' ability to pass the higher production costs to consumers outweighs the $39.1 million in conversion costs. Under the preservation of operating profit markup scenario, the 55 percent MPC increase is slightly outweighed by a lower average markup of 1.44 (compared to the flat markup scenario markup of 1.52) and $39.1 million in conversion costs, resulting in slightly negative impacts at TSL 5. Under the two-tier markup scenario, the 55 percent MPC increase is significantly outweighed by the lower average markup of 1.38 and $39.1 million in conversion costs, resulting in significantly negative impacts at TSL 5.

Cash-Flow Analysis Results by TSL for Incandescent Reflector Lamps

DOE incorporated two markup scenarios to represent the upper and lower bounds of the IRL industry: the flat, or preservation of gross margin, markup scenario to represent the upper bound (least severe) and the preservation of operating profit markup scenario to represent the lower bound (most severe). DOE, however, analyzed one TSL for IRLs in addition to the baseline level. DOE also analyzed an alternative shipment scenario for IRLs, the shortened lifetime scenario, in addition to the reference case. DOE acknowledges that to meet TSL 1, 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 13B of this final rule TSD.

Table VII.33 and Table VII.34 present the projected results for IRLs under the flat markup and preservation of operating profit markup scenarios. DOE examined results for one representative product class for IRLs.

Table VII.33 Manufacturer Impact Analysis for Incandescent Reflector Lamps - Flat Markup Scenario

	Units	Base Case	Trial Standard Level
			1
INPV	(2013$ millions)	145.4	93.0
Change in INPV	(2013$ millions)	-	(52.5)
	(%)	-	-36.1
Product Conversion Costs	(2013$ millions)	-	6.2
Capital Conversion Costs	(2013$ millions)	-	66.4
Total Conversion Costs	(2013$ millions)	-	72.6

Table VII.34 Manufacturer Impact Analysis for Incandescent Reflector Lamps - Preservation of Operating Profit Markup Scenario

	Units	Base Case	Trial Standard Level
			1
INPV	(2013$ millions)	145.4	89.2
Change in INPV	(2013$ millions)	-	(56.2)
	(%)	-	-38.6
Product Conversion Costs	(2013$ millions)	-	6.2
Capital Conversion Costs	(2013$ millions)	-	66.4
Total Conversion Costs	(2013$ millions)	-	72.6

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 -$52.5 million to -$56.2 million, or a change in INPV of -36.1 percent to -38.6 percent. At TSL 1, industry free cash flow is estimated to decrease by approximately 142 percent to -$9.3 million, compared to the base-case value of $22.64million in 2017.

INPV impacts are significantly negative at TSL 1, regardless of the markup scenario chosen. DOE estimates that in 2018, approximately half of the IRL shipments would meet the efficacy requirements at TSL 1. The other half of the shipments would need to be converted to meet the standards 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 $66.4 million for the industry. DOE estimates that IRL manufacturers will also incur $6.2 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 12 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 is outweighed by the substantial $72.6 million conversion costs. Under the preservation of operating profit markup scenario, the 12 percent MPC increase is again outweighed by a lower average markup of 1.50 (compared to the flat markup scenario markup of 1.52) and $72.6 million in conversion costs, resulting in significantly negative impacts at TSL 1. The significant capital and product conversion costs that IRL manufacturers must make at TSL 1 cause INPV to be significantly negative, regardless of the markup scenario analyzed.

DOE also analyzed a shortened lifetime sensitivity scenario where manufacturers shorten the lifetime of IRLs to mitigate the investments they must make to comply with the standards at TSL 1. By shortening the lifetime of IRLs, manufacturers reduce the capital conversion costs they must make to comply with the standards at TSL 1. DOE presents the INPV results of this analysis in appendix 13B of this final rule TSD.

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 2015 to 2047. 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 manufacturing 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 MPCs 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 only cover workers up to the line-supervisor level 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.35 and Table VII.36 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 potential amended 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 potential amended 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 2018, the following sections 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 this final rule TSD.

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 1,937 domestic production workers involved in manufacturing GSFLs in 2018. Table VII.35 shows the range of the impacts of amended energy conservation standards on U.S. production workers in the GSFL industry.

Table VII.35 Potential Changes in the Total Number of Domestic General Service Fluorescent Lamp Production Workers in 2018

	Base Case	Trial Standard Level				
		1	2	3	4	5
Total Number of Domestic Production Workers in 2018 (without changes in production locations)	1,937	1,937	1,937	1,934	1,918	1,916
Potential Changes in Domestic Production Workers in 2018*	-	-	-	(3) - (1,937)	(19) - (1,937)	(21) - (1,937)

*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 83 percent of GSFL shipments in 2018. 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 potential amended energy conservation standards, there would be approximately 281 domestic production workers involved in manufacturing IRLs in 2018. Table VII.36 shows the range of the impacts of potential amended energy conservation standards on U.S. production workers in the IRL industry.

Table VII.36 Potential Changes in the Total Number of Domestic Incandescent Reflector Lamp Production Workers in 2018

	Base Case	Trial Standard Level
		1
Total Number of Domestic Production Workers in 2018 (without changes in production locations)	281	303
Potential Changes in Domestic Production Workers in 2018*	-	22 - (281)

*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 potential 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 investment costs associated with increasing the efficacy of IRLs could cause some IRL manufacturers to exit the market or move production abroad.

As part of the MIA for the NOPR, DOE presented a range of potential impacts on domestic IRL employment at the proposed standard level, TSL 1 for the NOPR. In the NOPR analysis for IRLs, the impact at TSL 1 ranged from an additional hiring of approximately 30 employees, due to the increase in production costs of IRLs at TSL 1, to a potential decrease of approximately 300 employees, if all domestic IRL manufacturing moved overseas. NEMA stated that the lower bound scenario, where up to 300 domestic employees would lose their job, would be the most likely scenario if DOE adopted IRL standards at TSL 1. (NEMA, No. 54 at p. 9) GE similarly expressed concern at the NOPR public meeting, stating that if IRL manufacturers are required to make significant investments to keep IRL production in the United States, it will put any domestic IRL production employment at risk. (GE, Public Meeting Transcript, No. 49 at p. 232)

DOE presents a range of possible domestic employment impacts due to the uncertainty regarding the future production location of IRLs (i.e., domestic versus foreign) as manufacturers could move current domestic production overseas as a result of IRL standards. DOE understands there is a real risk that IRL manufacturers could either move domestic production to a lower labor-cost country in an effort to reduce labor expenditures or they could exit the IRL market altogether due to declining market share of IRLs. DOE took into consideration any potential negative domestic employment impact on U.S. manufacturing caused by either manufacturers moving IRL production overseas in response to potential standards or IRL manufacturers potentially exiting the market before selecting the standards for IRLs in this final rule.

NEMA also commented that the increase in the price of IRLs caused by potential standards could cause consumers to forgo purchasing IRLs in favor of LEDs. Therefore, NEMA believes that there could be a significant reduction in the number of IRLs purchased by consumers, as a result of IRL standards, which will cause domestic IRL manufacturing to be severely impacted. (NEMA, No. 54 at p. 10) While DOE recognizes that LEDs are increasingly taking more and more market share from IRLs over time, DOE's shipment analysis does not model consumers switching from IRLs to LEDs as a result of higher energy conservation standards of IRLs. Therefore, DOE does not anticipate a reduction in the number of domestic employees caused by consumers forgoing the purchases of IRLs in favor of LEDs as a result of potential IRL standards. See chapter 11 of this final rule TSD for a complete description of the shipments analysis.

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 during manufacturer interviews that moving the industry to max tech could triple the amount of REOs demanded by GSFL manufacturers. Tripling the demand for REOs that are already difficult to obtain 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 during manufacturer interviews that their IR coating machines would not have a large enough capacity and that the companies that manufacture those machines might not be able to respond to the demand for IR coating machines necessary to manufacture more efficacious IRLs. Meeting the high level of coating capacity as a result of higher efficacy standards for IRLs this rule may be more difficult for smaller manufacturers than larger manufacturers. Some manufactures suggested that large manufacturers may already have the coating capacity necessary and that the smaller manufacturers may need to incur capital expenditures to add coating capacity at higher standards.

d. Impacts on Subgroups of Manufacturers

Using average cost assumptions to develop an industry cash-flow estimate may not be adequate for assessing differential impacts among manufacturer subgroups. Small manufacturers, niche product manufacturers, and manufacturers exhibiting cost structures substantially different from the industry average could be 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 an analysis of cumulative regulatory burden as part of its rulemakings pertaining to product efficacy.

For the cumulative regulatory burden analysis, DOE looks at other regulations that could affect GSFL manufacturers that will take effect approximately 3 years before or after the compliance date of amended energy conservation standards for these products. In written comments, manufacturers cited Federal regulations on products other than GSFLs that contribute to their cumulative regulatory burden. The compliance years and expected industry conversion costs of relevant amended energy conservation standards are indicated in Table VII.37.

Table VII.37 Compliance Dates and Expected Conversion Expenses of Federal Energy Conservation Standards Affecting General Service Fluorescent Lamp Manufacturers

Federal Energy Conservation Standards	Approximate Compliance Date	Estimated Total Industy Conversion Expense
General Service Incandescent Lamps 74 FR 12058 (March 23, 2009)	2012; 2013; & 2014	N/A†
Fluorescent Lamp Ballasts 76 FR 70548 (November 14, 2011)	2014	$82 million (2010$)
Metal Halide Lamp Fixtures 79 FR 7746 (February 10, 2014)	2017	$3.0 million (2012$)
General Service Lamps	2019*	N/A††
Ceiling Fan Light Kits	2019*	N/A††
HID Lamps 79 FR 62910 (October 21, 2014)	N/A**	N/A††
Candelabra Base Incandescent Lamps and Intermediate Base Incandescent Lamps	N/A[β]	N/A††
Other Incandescent Reflector Lamps	N/A[β]	N/A††

† For minimum performance requirements prescribed by the Energy Independence and Security Act of 2007 (EISA 2007), DOE did not estimate total industry conversion costs because an MIA was not completed as part of a rulemaking. Pub. L. 110-140. EISA 2007 made numerous amendments to the Energy Policy and Conservation Act (EPCA) of 1975, Pub. L. 94-163, (42 U.S.C. 6291–6309), which established an energy conservation program for major household appliances and industrial and commercial equipment.

†† For energy conservation standards for rulemakings awaiting DOE final action, DOE does not have a finalized estimated total industry conversion cost.

* The dates listed are an approximation. The exact dates are pending final DOE action.

** DOE has published a notice of proposed determination that did not establish energy conservation standards for any HID lamps.

[β] These rulemakings are placed on hold due to the Consolidated Appropriations Act, 2012 (Public Law 112-74).

NEMA commented that energy conservation standards have become increasingly burdensome on lighting manufacturers as the lighting sector has experienced more rulemakings since EISA 2007 than any other covered product sector. NEMA also commented that several of these standards have required significant investment from lighting manufacturers and resulted in a negative financial impact to these lighting manufacturers (NEMA, No. 54 at pp. 2-3) NEMA further stated, that given the large negative impacts to manufacturers based on the proposed IRL standards in the NOPR and the large negative impacts to IRL manufacturers from the previous 2009 Lamps Rule, as well as the other DOE prescribed energy conservation standards on lighting manufacturers, Executive Order 12866 directs DOE to consider “alternatives to direct regulation” so that its regulations “impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the cost of cumulative regulations.” (NEMA, No. 54 at p. 8)

DOE agrees with NEMA that at least four major energy conservation standards have been enacted on lighting products since EISA 2007. These previous standards covered GSFLs and IRLs (74 FR 34080 [July 14, 2009]), which went into effect in July 2012, fluorescent lamp ballasts (76 FR 70548 [November 14, 2011]), which went into effect in November 2014, and metal halide lamp fixtures (79 FR 7746 [February 10, 2014]), which will go into effect in February 2017. DOE also agrees that the INPV impacts to manufacturers for these rulemakings ranged from moderate to significant, depending on the markup scenario analyzed. The cumulative regulatory burden seeks to mitigate the overlapping effects on manufacturers of new or revised DOE standards and other regulatory actions affecting those same manufacturers. DOE considered the cumulative regulatory burden on lighting manufacturers as one of the burdens of complying with potential GSFL and IRL standards when selecting the final standards for these products in today’s final rule.

3. 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. The model includes 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.37 and Table VII.38 present the estimated cumulative shipments in the base case and the relative change under each TSL.

Table VII.38 Effect of Standard Cases on Cumulative Shipments of GSFL in 2018–2047

Lamp Type	Base Case	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
	Cumulative Shipments millions	Change in Shipments Relative to Base Case	Change in Shipments Relative to Base Case	Change in Shipments Relative to Base Case	Change in Shipments Relative to Base Case	Change in Shipments Relative to Base Case
4-foot MBP	5,800	0.00%	0.24%	-1.8%	-12%	-12%
8-foot SP slimline	190	0.00%	-5.2%	3.6%	35%	9.6%
8-foot RDC HO	43	0.00%	-0.28%	0.00%	-0.01%	-0.29%
4-foot T5, MiniBP SO	330	0.00%	0.77%	23%	160%	170%
4-foot T5, MiniBP HO	760	0.00%	0.02%	-0.01%	-0.07%	-0.05%
2-foot U-shaped	240	0.00%	0.00%	0.00%	0.00%	0.00%
Total GSFL*	7,300	0.00%	0.09%	-0.24%	-1.8%	-1.4%

* May not sum due to rounding.

Table VII.39 Effect of Standard Cases on Cumulative Shipments of IRL in 2018–2047

Lamp Type	Base Case	TSL 1
	Cumulative Shipments millions	Change in Shipments Relative to Base Case
Standard spectrum; > 2.5 inch diameter; < 125 V	230	-16%

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 (2018–2047). The savings are measured over the entire lifetime of products 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.39 presents the estimated energy savings for each considered GSFL TSL, and Table VII.40 presents the estimated energy savings for each IRL TSL. The approach for estimating shipments and NES is further described in sections VI.I and VI.J and is detailed in chapter 11 and 12 of the final rule TSD.

Table VII.40 Cumulative Energy Savings for GSFL Trial Standard Levels for Units Sold in 2018–2047

	Trial Standard Level				
	1	**2**	**3**	**4**	**5**
	quads				
Primary Energy (Power Sector Consumption)	0.18	0.19	0.71	2.4	2.4
FFC Energy	0.19	0.20	0.74	2.5	2.6

Table VII.41 Cumulative Energy Savings for IRL Trial Standard Level for Units Sold in 2018–2047

	Trial Standard Level
	1
	quads
Primary Energy (Power Sector Consumption)	0.011
FFC Energy	0.011

OMB Circular A-4[91] 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

[91] U.S. Office of Management and Budget, "Circular A-4: Regulatory Analysis" (Sept. 17, 2003) (Available at: http://www.whitehouse.gov/omb/circulars_a004_a-4/)

undertook a sensitivity analysis using nine, rather than 30, years of product shipments. The choice of a 9-year period is a proxy for the timeline in EPCA for the review of certain energy conservation standards and potential revision of and compliance with such revised standards.[92] 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.41 and Table VII.42. The impacts are counted over the lifetime of GSFLs and IRLs purchased in 2018–2026.

Table VII.42 Cumulative Energy Savings for GSFL Trial Standard Levels for Units Sold in 2018 –2026

	Trial Standard Level				
	1	**2**	**3**	**4**	**5**
	quads				
Primary Energy (Power Sector Consumption)	0.098	0.10	0.38	1.2	1.2
FFC Energy	0.10	0.11	0.39	1.2	1.2

[92] 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.43 Cumulative Energy Savings for IRL Trial Standard Level for Units Sold in 2018 –2026

	Trial Standard Level
	1
	quads
Primary Energy (Power Sector Consumption)	0.0089
FFC Energy	0.0093

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.

A portion of the savings in operating costs in some of the TSLs is due to switching to products with lower operating costs. In particular, the adopted standard in the rulemaking is projected to increase the typical cost of 4-foot MBP lamps relative to 8-foot SP slimline or 4-foot MiniBP T5s, therefore driving some consumers to shift toward the latter two product classes, yielding a reduction in operating costs relative to the base case.

Table VII.43 shows the consumer NPV results for each TSL considered for GSFLs, and Table VII.44 shows the consumer NPV results for each TSL considered for IRLs. In each case, the impacts cover the lifetime of product purchased in 2018–2047.

Table VII.44 Net Present Value of Consumer Benefits for GSFL Trial Standard Levels for Units Sold in 2018 –2047

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
	billion 2013$				
7% discount rate	-0.37	-0.51	0.35	2.0	1.6
3% discount rate	-0.42	-0.61	1.1	5.5	4.9

Table VII.45 Net Present Value of Consumer Benefits for IRL Trial Standard Level for Units Sold in 2018 –2047

	TSL 1
	billion 2013$
7% discount rate	0.17
3% discount rate	0.25

The NPV results based on the aforementioned 9-year shipments period are presented in Table VII.45 and Table VII.46. The impacts are counted over the lifetime of product purchased in 2018–2026. 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.46 Net Present Value of Consumer Benefits for GSFL Trial Standard Levels for Units Sold in 2018–2026

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
	billion 2013$				
7% discount rate	-0.26	-0.37	0.16	0.65	0.33
3% discount rate	-0.25	-0.4	0.52	1.9	1.5

Table VII.47 Net Present Value of Consumer Benefits for IRL Trial Standard Level for Units Sold in 2018–2026

	TSL 1
	billion 2013$
7% discount rate	0.14
3% discount rate	0.19

c. 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 would rise again. As mentioned in section VI.I, rare earth oxides, used in GSFL phosphors to improve lamp efficacy, 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 final rule 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 final rule 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 IRLs, 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 final rule TSD. 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 final rule TSD).

d. 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 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 final rule TSD presents detailed results.

4. Impact on Utility or Performance of Equipment

DOE concluded that the standards it proposed in the NOPR 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 the final rule 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 the final rule 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. As discussed in section VI.B.1, DOE ensured full wattage lamps were able to meet the proposed efficacy levels to preserve reliable dimming. 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 the final rule TSD for further details on the selection of more efficacious substitutes for the baseline and development of proposed efficacy levels.

5. Impact of Any Lessening of Competition

Per EPCA, DOE is required to establish energy conservation standards that ‘‘shall be designed to achieve the maximum improvement in energy efficiency * * * which the Secretary determines is technologically feasible and economically justified.’’ (42 U.S.C. 6295(o)(2)(A)) To determine economic justification, DOE considers (among other factors) ‘‘the economic impact of the standard on the manufacturers’’ and ‘‘the impact of any lessening of competition * * * that is likely to result.” (42 U.S.C. 6295(o)(2)(B)(i))

NEMA noted that the efficacy levels proposed for IRLs in the NOPR were dependent on the use of a single-ended IR burner which is limited to a single company due to patent, and that DOE legally cannot favor a single company over all others. (NEMA, No. 54 at p. 10) NEMA commented that only one US manufacturer has an industrial setup to produce single-ended IR burners which are used in smaller diameter lamps. NEMA remarked that the 3.5 percent discount in efficacy would grant a competitive advantage to this manufacturer. (NEMA, No. 54 at pp. 30-31)

In the engineering analysis, DOE scaled the efficacy levels of large diameter IRLs (i.e., greater than 2.5 inches) to determine the efficacy levels of small diameter IRLs (i.e., equal to or less than 2.5 inches). In addition to a reduction in efficacy due to a small diameter, DOE also applied an additional 3.5 percent reduction to account for the need to use single-ended burners in small diameter lamps to maintain the same shape. DOE did not find a patent specific to single-ended burners used in small diameter IRLs and therefore, believes single-ended technology is accessible. Also, based on interviews with manufacturers DOE does not believe there are any technical impediments to setting up the production of single-ended small diameter IRLs. DOE acknowledges that manufacturers who do not currently have the industrial setup to produce single-ended IR burners, could face additional conversion costs to implement this production setup than manufacturers that already have this production setup. DOE did not include these additional conversion costs for those manufacturers without single-ended burner production capabilities in the MIA since there are no manufacturers currently producing small diameter IRLs that are within the scope of this rulemaking and the MIA typically only analyzes the costs associated with maintaining the total base case production volume at the standards efficacy levels for each product class.

While DOE acknowledges that there could be additional costs for manufacturers without single-ended burner production capabilities, based on manufacturer interviews and an assessment of the technology, DOE does not believe there is a technical or legal (i.e., patent) barrier to implementing a single-ended burner manufacturing process. Therefore, DOE concluded that the efficacy level determined for IRLs in this final rule would not result in competitive disadvantage to manufacturers.

DOJ also reviewed the standards proposed in the NOPR analysis for GSFLs and IRLs and similarly concluded that they are unlikely to have a significant adverse impact on competition.

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, the Utility Impact Analysis show reductions in electricity generation and installed capacity across the analysis period, with the magnitude and peak of these reductions varying by electricity source fuel type, such as coal, natural gas, nuclear, oil, and renewables. Chapter 16 in the final rule TSD presents the estimated reduction in generation and installed 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.47 and Table VII.48 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 final rule TSD.

Table VII.48 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)	12	12	45	150	150
SO_2 (thousand tons)	11	11	41	140	140
NO_X (thousand tons)	9.4	9.8	36	120	120
Hg (tons)	0.033	0.034	0.13	0.42	0.43
CH_4 (thousand tons)	1.0	1.1	4.0	14	14
N_2O (thousand tons)	0.15	0.15	0.58	2.0	2.0
Upstream Emissions					
CO_2 (million metric tons)	0.58	0.60	2.3	7.7	7.9
SO_2 (thousand tons)	0.11	0.11	0.41	1.4	1.4
NO_X (thousand tons)	8.2	8.5	32	110	110
Hg (tons)	0.00024	0.00025	0.00093	0.0031	0.0032
CH_4 (thousand tons)	48	50	190	640	650
N_2O (thousand tons)	0.0052	0.0054	0.020	0.069	0.070
Total Emissions					
CO_2 (million metric tons)	12	13	48	160	160
SO_2 (thousand tons)	11	11	42	140	140
NO_X (thousand tons)	18	18	69	230	240
Hg (tons)	0.033	0.035	0.13	0.43	0.44
CH_4 (thousand tons)	49	51	190	650	660
CH_4 (million tons CO_2eq)*	1,400	1,400	5,400	18,000	19,000
N_2O (thousand tons)	0.15	0.16	0.60	2.0	2.1
N_2O (thousand tons CO_2eq)*	41	42	160	540	550

* CO_2eq is the quantity of CO_2 that would have the same GWP.

Table VII.49 Cumulative Emissions Reduction Estimated for IRL Trial Standard Level

	Trial Standard Level
	1
Power Sector Emissions	
CO_2 (million metric tons)	0.74
SO_2 (thousand tons)	0.75
NO_X (thousand tons)	0.62
Hg (tons)	0.0023
CH_4 (thousand tons)	0.06
N_2O (thousand tons)	0.0085
Upstream Emissions	
CO_2 (million metric tons)	0.032
SO_2 (thousand tons)	0.006
NO_X (thousand tons)	0.45
Hg (tons)	0.000014
CH_4 (thousand tons)	0.0003
N_2O (thousand tons)	2.6
Total Emissions	
CO_2 (million metric tons)	0.77
SO_2 (thousand tons)	0.76
NO_X (thousand tons)	1.1
Hg (tons)	0.0023
CH_4 (thousand tons)	2.7
CH_4 (thousand tons CO_2eq)*	76
N_2O (thousand tons)	0.0088
N_2O (thousand tons CO_2eq)*	2.3

* 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 2013$) represented by $12.0/metric ton (the average value from a distribution that uses a 5-percent discount rate), $40.5/metric ton (the average value from a distribution that uses a 3-percent discount rate), $62.4/metric ton (the average value from a distribution that uses a 2.5-percent discount rate), and $119/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.49 and Table VII.50 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 final rule TSD.

Table VII.50 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*
	Million 2013$			
Power Sector Emissions				
1	100	430	660	1,300
2	110	440	690	1,400
3	390	1,600	2,600	5,000
4	1,300	5,400	8,500	17,000
5	1,300	5,600	8,700	17,000
Upstream Emissions				
1	5.0	21	33	65
2	5.2	22	34	67
3	19	82	130	250
4	65	270	430	840
5	66	280	440	860
Total Emissions				
1	110	450	690	1,400
2	110	470	720	1,400
3	410	1,700	2,700	5,300
4	1,400	5,700	8,900	18,000
5	1,400	5,800	9,100	18,000

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $12.0, $40.5, $62.4, and $119 per metric ton (2013$).

Table VII.51 Estimates of Global Present Value of CO_2 Emissions Reduction Under IRL Trial Standard Level

TSL	SCC Case*			
	5% discount rate, average*	3% discount rate, average*	2.5% discount rate, average*	3% discount rate, 95th percentile*
	Million 2013$			
Power Sector Emissions				
1	7.1	28	44	86
Upstream Emissions				
1	0.31	1.2	1.9	3.7
Total Emissions				
1	7.4	30	46	90

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $12.0, $40.5, $62.4, and $119 per metric ton (2013$).

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 amended 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.51 and Table VII.52 present the cumulative present values for each TSL calculated using 7-percent and 3-percent discount rates.

Table VII.52 Estimates of Present Value of NO_X Emissions Reduction Under GSFL Trial Standard Levels

TSL	3% discount rate	7% discount rate
	Million 2013$	
Power Sector Emissions		
1	17	11
2	18	12
3	66	42
4	210	130
5	220	140
Upstream Emissions		
1	14	8.8
2	15	9.3
3	56	34
4	190	110
5	190	110
Total Emissions		
1	32	20
2	33	21
3	120	75
4	400	240
5	410	250

Table VII.53 Estimates of Present Value of NO_X Emissions Reduction Under IRL Trial Standard Level

TSL	3% discount rate	7% discount rate
	Million 2013$	
Power Sector Emissions		
1	1.3	0.97
Upstream Emissions		
1	0.92	0.67
Total Emissions		
1	2.2	1.6

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.53 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 previously.

Table VII.54 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 $12.0/metric ton CO_2 plus NO_x*	**SCC Case $40.5/metric ton CO_2 plus NO_x***	**SCC Case $62.4/metric ton CO_2 plus NO_x***	**SCC Case $119/metric ton CO_2 plus NO_x***
	Billion 2013$			
1	-0.28	0.058	0.31	0.98
2	-0.47	-0.11	0.15	0.85
3	1.7	3.0	3.9	6.5
4	7.2	12	15	23
5	6.7	11	14	23
TSL	**Consumer NPV at 7% Discount Rate added with:**			
	SCC Case $12.0/metric ton CO_2 plus NO_x*	**SCC Case $40.5/metric ton CO_2 plus NO_x***	**SCC Case $62.4/metric ton CO_2 plus NO_x***	**SCC Case $119/metric ton CO_2 plus NO_x***
	Billion 2013$			
1	-0.24	0.097	0.34	1.0
2	-0.37	0.153	0.24	0.94
3	0.84	2.2	3.1	5.7
4	3.6	8.0	11	20
5	3.3	7.7	11	20

* These label values represent the global SCC in 2015, in 2013$. For NO_X emissions, each case uses the medium value, which corresponds to $2,684 per ton.

Table VII.55 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 Level

TSL	Consumer NPV at 3% Discount Rate added with:			
	SCC Case $12.0/metric ton CO_2 plus NO_x*	**SCC Case $40.5/metric ton CO_2 plus NO_x***	**SCC Case $62.4/metric ton CO_2 plus NO_x***	**SCC Case $119/metric ton CO_2 plus NO_x***
	Billion 2013$			
1	0.26	0.29	0.30	0.35
TSL	**Consumer NPV at 7% Discount Rate added with:**			
	SCC Case $12.0/metric ton CO_2 plus NO_x*	**SCC Case $40.5/metric ton CO_2 plus NO_x***	**SCC Case $62.4/metric ton CO_2 plus NO_x***	**SCC Case $119/metric ton CO_2 plus NO_x***
	Billion 2013$			
1	0.18	0.20	0.22	0.26

* These label values represent the global SCC in 2015, in 2013$. For NO_X emissions, each case uses the medium value, which corresponds to $2,684 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 2018–2047. 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.

C. Conclusions

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 meets 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 efficacy 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.55 and Table VII.56 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 VII.A. 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 VII.B.1.b) 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 VII.B.3.d.

DOE also notes that the economics literature provides a wide-ranging discussion of how consumers trade off upfront costs and energy savings in the absence of government intervention. Much of this literature attempts to explain why consumers appear to undervalue energy efficiency improvements. There is evidence that consumers undervalue future energy savings as a result of (1) a lack of information; (2) a lack of sufficient salience of the long-term or aggregate benefits; (3) a lack of sufficient savings to warrant accelerating or altering purchases; (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 (for example, renter versus owner or builder versus 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. This undervaluation suggests that regulation that promotes energy efficiency can produce significant net private gains (as well as producing social gains by, for example, reducing pollution).

In DOE's current regulatory analysis, potential changes in the benefits and costs of a regulation due to changes in consumer purchase decisions are included in two ways. First, if consumers forego a purchase of a product in the standards case, this decreases sales for product manufacturers and the cost to manufacturers is included in the MIA. Second, DOE accounts for energy savings attributable only to products actually used by consumers in the standards case; if a standard decreases the number of products purchased by consumers, this decreases the potential energy savings from an energy conservation standard. DOE provides estimates of changes in the volume of product purchases in chapter 9 of the final rule TSD. DOE's current analysis does not explicitly control for heterogeneity in consumer preferences, preferences across subcategories of products or specific features, or consumer price sensitivity variation according to household income.[93]

While DOE is not prepared at present to provide a fuller quantifiable framework for estimating the benefits and costs of changes in consumer purchase decisions due to an energy conservation standard, DOE is committed to developing a framework that can support empirical quantitative tools for improved assessment of the consumer welfare impacts of appliance standards. DOE has posted a paper that discusses the issue of consumer welfare impacts of appliance standards, and potential enhancements to the methodology by which these impacts are defined and estimated in the regulatory

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[93] P.C. Reiss and M.W. White, Household Electricity Demand, Revisited, Review of Economic Studies (2005) 72, 853–883.

process.[94] DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and how to quantify this impact in its future regulatory analysis.

1. Benefits and Burdens of Trial Standard Levels Considered for General Service Fluorescent Lamps

Table VII.55 and Table VII.56 summarize the quantitative impacts estimated for each TSL for GSFL.

[94] Alan Sanstad, Notes on the Economics of Household Energy Consumption and Technology Choice. Lawrence Berkeley National Laboratory (2010) (Available at: http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf.

Table VII.56 Summary of Analytical Results for GSFL: National Impacts

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
National FFC Energy Savings quads					
	0.19	0.20	0.74	2.5	2.6
NPV of Consumer Benefits 2013$ billion					
3% discount rate	-0.42	-0.61	1.1	5.5	4.9
7% discount rate	-0.37	-0.51	0.35	2.0	1.6
Cumulative Emissions Reduction (Total FFC Emissions)					
CO_2 (million metric tons)	12	13	48	160	160
SO_2 (thousand tons)	11	11	42	140	140
NO_X (thousand tons)	18	18	69	230	240
Hg (tons)	0.033	0.035	0.13	0.43	0.44
CH_4 (thousand tons)	49	51	190	650	660
CH_4 (million tons CO_2eq)*	1,400	1,400	5,400	18,000	19,000
N_2O (thousand tons)	0.15	0.16	0.60	2.0	2.1
N_2O (thousand tons CO_2eq)*	41	42	160	540	550
Value of Emissions Reduction (Total FFC Emissions)					
CO_2 2013$ billion**	0.11 to 1.4	0.11 to 1.4	0.41 to 5.3	1.4 to 18	1.4 to 18
NO_X – 3% discount rate 2013$ million	32	33	120	400	410
NO_X – 7% discount rate 2013$ million	20	21	75	240	250

* 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.57 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 (2013$ million)† (Base Case Industry NPV of $1,551.6)	49.5 – (42.9)	48.2 – (56.5)	130.4 – (74.2)	426.8 – (330.0)	444.6 – (367.7)
Change in Industry NPV (%)†	3.2 – (2.8)	3.1 – (3.6)	8.4 – (4.8)	27.5 – (21.3)	28.7 – (23.7)
Consumer Mean LCC Savings 2013$					
4-foot MBP ≤ 4,500 K	0.00	0.00	-0.07	5.98	5.98
4-foot T5 MiniBP SO ≤ 4,500 K	2.87	2.87	2.87	5.68	5.68
4-foot T5 MiniBP HO ≤ 4,500 K	4.74	4.74	4.74	4.74	4.74
8-foot SP Slimline ≤ 4,500 K	0.00	5.02	0.00	0.00	1.72
8-foot RDC HO ≤ 4,500 K	-9.66	-16.94	0.00	0.00	-16.94
Weighted Average*	0.49	0.56	0.54	5.55	5.47
Consumer Mean PBP years**					
4-foot MBP ≤ 4,500 K	0.0	0.0	0.5	3.1	3.1
4-foot T5 MiniBP SO ≤ 4,500 K	1.2	1.2	1.2	4.0	4.0
4-foot T5 MiniBP HO ≤ 4,500 K	2.8	2.8	2.8	2.8	2.8
8-foot SP Slimline ≤ 4,500 K	0.0	0.5	0.0	0.0	4.4
8-foot RDC HO ≤ 4,500 K	NER	NER	0.0	0.0	NER
Weighted Average*	0.3	0.3	0.8	3.0	3.2
Weighted-Average Consumers with Net Cost (%)*	8.6	10.5	61.1	22.0	24.9
Weighted-Average Consumers with Net Benefit (%)*	5.9	6.9	34.9	73.4	75.1
Weighted-Average Consumers with No Impact (%)*	85.5	82.6	4.0	4.6	0.0

* DOE calculates the LCC savings and PBP relative to the baseline for each EL for each representative product class. Each TSL corresponds to a specific EL for each representative product class. (See Table VII.1 for the TSLs analyzed and the corresponding ELs.) The weighted averages are calculated by weighting the shares of each product class in total projected shipments in 2018.

** 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 2.56 quads of energy, an amount DOE considers significant.

TSL 5 has an estimated NPV of consumer benefit of $1.6 billion using a 7-percent discount rate, and $4.9 billion using a 3 percent discount rate.

The cumulative emissions reductions at TSL 5 are 160 million metric tons of CO_2, 240 thousand tons of NO_X, 140 thousand tons of SO_2, 0.44 tons of Hg, 660 thousand tons of CH_4, and 2.1 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reductions at TSL 5 ranges from $1.4 billion to $18 billion.

At TSL 5, DOE estimates industry will need to invest approximately $39.1 million in conversion costs. At TSL 5, the projected change in INPV ranges from a decrease of $367.7 million to an increase of $444.6 million, which equates to a decrease of 23.7 percent and an increase of 28.7 percent, respectively, in INPV for manufacturers of covered GSFLs.

At TSL 5, the weighted-average LCC savings is $5.98 for the 4-foot MBP lamps, $5.68 for the 4-foot T5 MiniBP SO lamps, $4.74 for the 4-foot T5 MiniBP HO lamps, $1.72 for the 8-foot SP slimline lamps, and -$16.94 for the 8-foot RDC HO lamps.

At TSL 5, 8-foot HO lamps are required to meet EL 2, which represents an 800 series full wattage T8 lamp. Because no reduced wattage 8-foot HO lamps exist at this level, consumers who require 8-foot HO lamps must purchase a more efficient lamp that consumes the same amount of energy as lamps available at lower efficacy levels. Thus, for an increased cost, these consumers must purchase a lamp that produces more light but does not save energy. Because there are no energy-saving options for 8-foot HO consumers at TSL 5, all consumers that continue to purchase this lamp type would experience negative LCC savings.

After considering the analysis and weighing the benefits and the burdens, DOE has determined that at TSL 5 for GSFLs, the benefits of energy savings, positive NPV of total consumer benefits, the overall positive impacts on consumers, emission reductions and the estimated monetary value of the emissions reductions would be outweighed by the potential reduction in industry value and negative LCC savings experienced by consumers of 8-foot RDC HO lamps. Therefore, the Secretary has concluded that TSL 5 is not economically justified.

Next, DOE considered TSL 4, which represents the combination of ELs that achieve the maximum NPV. TSL 4 would save an estimated total of 2.5 quads of energy, an amount DOE considers significant and approaches maximum energy savings achieved at TSL 5. TSL 4 has an estimated NPV of consumer benefit of $2.0 billion using a 7-percent discount rate, and $5.5 billion using a 3 percent discount rate.

The cumulative emissions reductions at TSL 4 are 160 million metric tons of CO_2, 230 thousand tons of NO_X, 140 thousand tons of SO_2, 0.43 tons of Hg, 650 thousand tons of CH_4, and 2.0 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reductions at TSL 4 ranges from $1.4 billion to $18 billion.

At TSL 4, DOE estimates industry will need to invest approximately $26.6 million in conversion costs. At TSL 4, the projected change in INPV ranges from a decrease of $330.0 million to an increase of $426.8 million, which equates to a decrease of 21.3 percent and an increase of 27.5 percent, respectively, in INPV for manufacturers of covered GSFLs.

At TSL 4, the weighted average LCC savings is $5.98 for the 4-foot MBP lamps, $5.68 for the 4-foot T5 MiniBP SO lamps, and $4.74 for the 4-foot T5 MiniBP HO lamps. At TSL 4, no amended standard is adopted for the 8-foot SP slimline lamps or 8-foot RDC HO lamps and therefore LCC savings are not reported.

After considering the analysis and weighing the benefits and the burdens, DOE determined that at TSL 4 for GSFLs, the benefits of energy savings, positive NPV of total consumer benefits, the overall positive impacts on consumers, emission reductions and the estimated monetary value of the emissions reductions would outweigh the potential reduction in industry value. The Secretary has concluded that TSL 4 would save a significant amount of energy and is technologically feasible and economically justified.

Based on the above considerations, DOE today adopts the energy conservation standards for GSFLs at TSL 4. Table VII.57 presents the adopted energy conservation standards for GSFLs.

Table VII.58 Energy Conservation Standards for GSFL

Lamp Type	CCT K	Adopted Level lm/W
4-Foot Medium Bipin	≤ 4,500	92.4
	> 4,500	88.7
2-Foot U-Shaped	≤ 4,500	85.0
	> 4,500	83.3
8-Foot Slimline	≤ 4,500	97.0
	> 4,500	93.0
8-Foot High Output	≤ 4,500	92.0
	> 4,500	88.0
4-Foot Miniature Bipin Standard Output	≤ 4,500	95.0
	> 4,500	89.3
4-Foot Miniature Bipin High Output	≤ 4,500	82.7
	> 4,500	76.9

2. Summary of Benefits and Costs (Annualized) of the Adopted Standards for General Service Fluorescent Lamps

The benefits and costs of today's standards, for product sold in 2018-2047, 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 amended 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.[95]

Estimates of annualized benefits and costs of the standards for GSFL are shown in Table VII.58. The results under the primary estimate are as follows. Using a 7-percent

[95] See section VI.M for description of the method used for annualization.

discount rate for benefits and costs other than CO_2 reduction, for which DOE used a 3-percent discount rate along with the SCC series that has a value of $40.5/t in 2015, the cost of the standards in today's rule is $841 million per year in increased equipment costs, while the benefits are $1,030 million per year in reduced equipment operating costs, $310 million in CO_2 reductions, and $22.4 million in reduced NO_X emissions. In this case, the net benefit amounts to $516 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series that has a value of $40.5/t in 2015, the cost of the standards in today's rule is $724 million per year in increased equipment costs, while the benefits are $1,020 million per year in reduced operating costs, $310 million in CO_2 reductions, and $21.6 million in reduced NO_X emissions. In this case, the net benefit amounts to $627 million per year. [96]

[96] The annualized consumer operating cost savings, NO_X reduction monetized value, and consumer incremental product costs are higher with a 7-percent discount rate than with a 3-percent discount rate. This is in contrast to the present values in Table VII.58. Under certain conditions, different present values may lead to similar annualized values when calculated with different discount rates. In this case, the combined effects of (a) projecting to 2018 the present values that DOE calculated in 2014, and (b) annualizing the projected values with 3 percent and 7 percent discount rates over the 30-year analysis period, lead to similar annualized values. For consumer incremental product costs, the effect is more pronounced because the time series covers only 30 years, instead of the longer period covered for operating cost savings and NO_X reduction monetized value.

Table VII.59 Annualized Benefits and Costs of Amended Standards for GSFL (TSL 4)*

	Discount Rate	Primary Estimate	Low Net Benefits Estimate	High Net Benefits Estimate
		million 2013$/year		
Benefits				
Consumer Operating Cost Savings	7%	1,030	1,010	1,050
	3%	1,020	1,000	1,050
CO_2 Reduction Monetized Value ($12.0/t case) **	5%	97.5	97.1	97.5
CO_2 Reduction Monetized Value ($40.5/t case) **	3%	310	308	310
CO_2 Reduction Monetized Value ($62.4/t case) **	2.5%	448	446	448
CO_2 Reduction Monetized Value ($119/t case) **	3%	950	946	950
NO_X Reduction Monetized Value (at $2,684/ton)**	7%	22.4	22.3	22.4
	3%	21.6	21.5	21.6
Total Benefits†	7% plus CO_2 range	1,150 to 2,000	1,130 to 1,980	1,170 to 2,030
	7%	1,360	1,340	1,390
	3% plus CO_2 range	1,140 to 2,000	1,120 to 1,970	1,170 to 2,030
	3%	1,360	1,330	1,390
Costs				
Consumer Incremental Product Costs	7%	841	882	841
	3%	724	763	724
Net Benefits				
Total†	7% plus CO_2 range	300 to 1,160	241 to 1,090	328 to 1,180
	7%	516	452	540
	3% plus CO_2 range	415 to 1,270	350 to 1,200	443 to 1,300
	3%	627	561	655

* This table presents the annualized costs and benefits associated with GSFLs shipped in 2018−2047. These results include benefits to consumers that accrue after 2047 from the products purchased in 2018−2047. 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 Reference case energy prices from AEO 2014 and decreasing incremental product cost, due to price learning. The Low Benefits Estimate uses the Low Economic Growth energy prices from AEO 2014 and constant real product prices. The High Benefits Estimate assumes the Low Economic Growth energy price estimates from AEO 2014 and the same decreasing incremental product costs as in the Primary Benefits Estimate.

** The CO_2 values represent global monetized values of the SCC, in 2013$, 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 the average SCC with 3-percent discount rate ($40.5/t case). In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

3. Benefits and Burdens of Trial Standard Levels Considered for Incandescent Reflector Lamps

Table VII.59 and Table VII.60 summarize the quantitative impacts estimated for the TSL for IRL.

Table VII.60 Summary of Analytical Results for IRL: National Impacts

Category	TSL 1
National FFC Energy Savings quads	
	0.011
NPV of Consumers Benefits 2013$ billion	
3% discount rate	0.25
7% discount rate	0.17
Cumulative Emissions Reduction (Total FFC Emissions)	
CO_2 (million metric tons)	0.77
SO_2 (thousand tons)	0.76
NO_x (thousand tons)	1.1
Hg (tons)	0.0023
CH_4 (thousand tons)	2.7
CH_4 (thousand tons CO_2eq)*	76
N_2O (thousand tons)	0.0088
N_2O (thousand tons CO_2eq)*	2.3
Value of Emissions Reduction (Total FFC Emissions)	
CO_2 2013$ million**	7 to 90
NO_X – 3% discount rate 2013$ million	2.2
NO_X – 7% discount rate 2013$ million	1.6

* 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.61 Summary of Analytical Results for IRL: Manufacturer and Consumer Impacts

Category	TSL 1
Manufacturer Impacts	
Change in Industry NPV (2013$ million)** (Base Case Industry NPV of $145.4)	(52.5) – (56.2)
Change in Industry NPV (%)*	(36.1) – (38.6)
Consumer Mean LCC Savings* 2013$	
Standard spectrum; > 2.5 inch diameter; < 125 V	3.09
Consumer Mean PBP* years	
Standard spectrum; > 2.5 inch diameter; < 125 V	5.3
Consumers with Net Cost %	0.0
Consumers with Net Benefit %	100.0
Consumers with No Impact %	0.0

* Values in parentheses are negative values.

DOE considered TSL 1, which would save an estimated total of 0.0102 quads of energy, an amount DOE considers significant. TSL 1 has an estimated NPV of consumer benefit of $0.17 billion using a 7-percent discount rate, and $0.25 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 1 are 0.77 million metric tons of CO_2, 1.1 thousand tons of NO_X, 0.76 thousand tons of SO_2, 0.0023 tons of Hg, 2.7 thousand tons of CH_4, and 0.0088 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reductions at TSL 1 ranges from $7 million to $90 million.

At TSL 1, the weighted average LCC savings for the standard spectrum, > 2.5 inch diameter, < 125 V product class is $3.09. The LCC savings were positive for both representative lamp units in each sector.

At TSL 1, DOE estimates industry would need to invest approximately $72.6 million in conversion costs. At TSL 1, the projected change in INPV ranges from a decrease of $52.5 million to a decrease of $56.2 million. If the larger decrease is realized, TSL 1 could result in a net loss of up to 38.6 percent in INPV to manufacturers of covered IRLs.

At TSL 1, given the size of the investment, DOE believes there is uncertainty as to whether manufacturers would spend the capital required to produce more efficient, longer lifetime products at the volume needed to satisfy the market demand. Manufacturers could instead choose to forego the significant investment and produce exempt products or exit the market entirely. DOE is also aware that to meet higher efficacy levels, manufacturers can choose to produce lamps with a shorter lifetime and did so in response to the July 2012 standards by introducing IRLs with shorter lifetimes. DOE conducted a sensitivity analysis to assess the impacts of manufacturers shortening the lifetime of covered IRLs to meet TSL 1. DOE determined that if manufacturers shorten the lifetime of IRLs, consumers would experience negative LCC savings in both the residential and commercial sectors.

After considering the analysis and weighing the benefits and the burdens, DOE concluded 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), emission reductions and the estimated monetary value of the emissions reductions would be outweighed by the potential reduction in industry value and the potential negative costs to consumers in the scenario that manufacturers shortened the lifetime of covered IRLs. Consequently, DOE has concluded that TSL 1 is not economically justified.

Based on the above considerations, DOE today is not amending energy conservation standards for IRLs.

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 limited relevant consumer information in the lighting market, and the high costs of gathering and analyzing relevant information leads some consumers to miss opportunities to make cost-effective investments in energy efficiency.

(2) In some cases the benefits of more efficient products are not realized due to misaligned incentives between purchasers and users. An example of such a case is when the product purchase decision is made by a building contractor or building owner who does not pay the energy costs.

(3) There are external benefits resulting from improved energy efficiency of GSFLs and IRLs that are not captured by the users of such products. These benefits include externalities related to public health, environmental protection and national security that are not reflected in energy prices, such as reduced emissions of air pollutants and greenhouse gases that impact human health and global warming.

In addition, DOE has determined that today's regulatory action is a "significant regulatory action" under Executive Order 12866. DOE presented to OIRA in the OMB for review the draft rule and other documents prepared for this rulemaking, including a regulatory impact analysis (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. (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, OIRA has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For this final rule, DOE has utilized the latest market and technology assessments, product information, and prices available at the time of this analysis and developed shipment projections based on historical data and key market drivers to determine national energy savings and net present value of potential standards. Further, in anticipation of future trends DOE has also considered various alternative scenarios including increases in rare earth phosphor and xenon prices. Therefore, DOE believes that today’s final rule is consistent with these principles, including the requirement that, to the extent permitted by law, benefits justify costs and that net benefits are maximized.

For future regulatory efforts regarding this product category, DOE will utilize the latest market and technology assessments, product information, and prices available at the time of the analysis and develop shipment projections based on historical data and key market drivers. Additionally, the agency will restrospectively evaluate the consumer choice model and related shipments trends that project that consumers will switch from purchasing one type of product class to another as a result of the revised energy efficiency standards. DOE's evaluation will verify the assumptions and revise as appropriate the consumer choice model for the next rulemaking iteration.

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, and a final regulatory flexibility analysis (FRFA) for any such rule that an agency adopts as a final rule, 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 website (http://energy.gov/gc/office-general-counsel). DOE reviewed the April 2014 NOPR (79 FR 24068) and today's final rule under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003.

As a result of this review, DOE has prepared a FRFA for GSFLs, but not for IRLs since DOE is not setting amended energy conservation standards for IRLs as part of today's final rule. As presented and discussed in the following section, the GSFL FRFA describes impacts on GSFL manufacturers and discusses alternatives that could minimize these impacts. A statement of the reasons for establishing the standards in today's final rule, and the objectives of, and legal basis for these standards, are set forth elsewhere in the preamble and not repeated here. Chapter 13 of this final rule TSD contains more information about the impact of this rulemaking on manufacturers.

1. Description and Estimated Number of Small Entities Regulated

a. Methodology for Estimating the Number of Small Entities

For manufacturers of GSFLs, the Small Business Administration (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 and are available at http://www.sba.gov/content/table-small-business-size-standards. GSFL 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 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 websites, 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 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. 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 standards. Based on these efforts, DOE estimated that there are 21 small businesses that either manufacture or sell covered GSFLs 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 obtained information about small business manufacturers and potential impacts on small businesses while interviewing large manufacturers.

c. GSFL Industry Structure 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. Small businesses that sell covered GSFLs 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, small businesses differ from large manufacturers in several ways that directly affect the extent to which a company would be impacted by energy conservation standards. The main differences between small and large entities for this rulemaking are that small manufacturers of GSFLs have lower sales volumes and are frequently not the original manufacturers of GSFLs. Therefore, these small businesses would not have any capital conversion costs to comply with amended standards, since the machinery used to produce GSFLs 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 businesses operate in the same lighting markets as large manufacturers and do not operate in niche GSFL markets. Much of the same manufacturing equipment would need to be purchased by both large manufacturers and small businesses to produce GSFLs 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 manufacturing 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 businesses will be affected differently by the amended 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 GSFL businesses typically outsource the manufacturing of the lamps they sell to original product manufacturers abroad. This, in addition to the small volume of sales typical of small businesses, results in small GSFL businesses having different types and amounts of conversion costs compared to large manufacturers.

As a result of these standards, small GSFL businesses will incur product conversion costs because products that no longer meet the efficacy levels of today's 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 GSFLs. The capital conversion costs incurred by original product 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 GSFLs; 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 efficacy levels set in today's standard. DOE estimates that approximately 61 percent of the covered products offered by small GSFL manufacturers meet the efficacy levels established by today's final rule, TSL 4. As a result, an average of approximately 39 percent of products would need to be redesigned to meet these efficacy levels, resulting in small GSFL businesses incurring more than $1.08 million on average in product conversion costs or nearly five 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 39 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	**Total conversion cost as a percentage of annual revenue**
Typical Large Manufacturer	3%	1%
Typical Small Manufacturer	471%	21%

Small businesses in the GSFL industry expressed concern that possible manufacturing downtime, discontinuation of product lines, and high direct and indirect conversion costs resulting from amended GSFL energy conservation standards could have a significant impact on their revenue and could affect domestic employment decisions. Domestic employment impacts could be especially prevalent, since 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 the GSFL standards established in today's final rule.

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 final rule established today.

4. Significant Alternatives to the Rule

The discussion in the previous section analyzes impacts on GSFL small businesses that would result from DOE's final rule. In addition to the other TSLs being considered, the final rule TSD includes a RIA. For GSFLs, the RIA discusses the following policy alternatives: (1) no change in standard; (2) consumer rebates; (3) consumer tax credits; (4) manufacturer tax credits; (5) voluntary energy efficiency targets; and (6) bulk government purchases. While these alternatives may mitigate to some varying extent the economic impacts on small entities compared to the adopted standards, DOE did not consider these alternatives further because they are expected to result in energy savings that are much smaller than those that will be achieved by the adopted standard levels in this final rule (for 4-foot MBP the energy savings ranged from 51 percent to 98 percent less primary energy savings; for 4-foot T5 MiniBP SO the energy savings ranged from 84 percent to 98 percent less primary energy savings). In reviewing alternatives, DOE also examined energy conservation standards set at lower efficacy levels. DOE notes that it did not consider an alternative compliance date for the entire industry affected by this rulemaking. DOE is constrained by the three-year lead time required by statute (42 U.S.C. 6295(i)(5)). However, certain compliance date alternatives may be available to individual manufacturers, as discussed below. Accordingly, DOE is declining to adopt any of these alternatives and is adopting the standards set forth in this rulemaking. See chapter 18 of the final rule TSD for further detail on the policy alternatives that DOE considered.

Additional compliance flexibilities may be available through other means. For example, individual manufacturers may petition for a waiver of the applicable test procedure. Further, EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8,000,000 may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. Additionally, Section 504 of the Department of Energy Organization Act, 42 U.S.C. 7194, provides authority for the Secretary to adjust a rule issued under EPCA in order to prevent "special hardship, inequity, or unfair distribution of burdens" that may be imposed on that manufacturer as a result of such rule. Manufacturers should refer to 10 CFR part 430, subpart E, and part 1003 for additional details.

C. Review Under the Paperwork Reduction Act

Manufacturers of GSFLs 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, 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. 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 30 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 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 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 rule. DOE's CX determination for this 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 final rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) 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, the final 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. Pub. L. 104-4, sec. 201 (codified at 2 U.S.C. 1531). For an amended regulatory action likely to result in a rule that may cause the expenditure by state, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a federal agency to develop an effective process to permit timely input by elected officers of state, local, and Tribal governments on a "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect 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/office-general-counsel.

DOE has concluded that the final rule would likely require expenditures of $100 million or more on the private sector. Such expenditures may include: (1) investment in research and development and in capital expenditures by GSFL 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 efficacy GSFLs, starting at the compliance date for the applicable standard.

Section 202 of UMRA authorizes a federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the final rule. 2 U.S.C. 1532(c). The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The

SUPPLEMENTARY INFORMATION section of this final ruleand the "Regulatory Impact Analysis" section of the final rule TSD 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 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 final rule establishes energy conservation standards for GSFLs 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 final rule TSD for today's final rule.

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

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

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights" 53 FR 8859 (March 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 final rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

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 significant energy action. A "significant energy action" is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has concluded that today's regulatory action, which sets forth energy conservation standards for GSFLs, is not a significant energy action because the amended 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 final 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.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule prior to its effective date. The report will state that it has been determined that the rule is a "major rule" as defined by 5 U.S.C. 804(2).

IX. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of today's final 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 December 30, 2014.

Kathleen B. Hogan
Deputy Assistant Secretary for Energy Efficiency
Energy Efficiency and Renewable Energy

For the reasons set forth in the preamble, DOE amends part 430 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 430 -- ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

1. The authority citation for part 430 continues to read as follows:

   Authority: 42 U.S.C. 6291-6309; 28 U.S.C. 2461 note.

2. 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 ultraviolet 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 clearly stated in all publicly available documents (e.g., product literature, catalogs, and packaging labels). This definition is applicable to terms related to the following covered lighting products: fluorescent lamp ballasts; fluorescent lamps; general service fluorescent lamps; general service incandescent lamps; general service lamps; incandescent lamps; incandescent reflector lamps; medium base compact fluorescent lamps; and specialty application mercury vapor lamp ballasts.

*   *   *   *   *

<u>Fluorescent lamp</u> 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 ultraviolet 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), 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 [**INSERT DATE 3 YEARS AFTER DATE OF PUBLICATION 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	88.7
2-foot U-shaped	≤ 4,500K	85.0
	> 4,500K and ≤ 7,000K	83.3
8-foot slimline	≤ 4,500K	97.0
	> 4,500K and ≤ 7,000K	93.0
8-foot high output	≤ 4,500K	92.0
	> 4,500K and ≤ 7,000K	88.0
4-foot miniature bipin standard output	≤ 4,500K	95.0
	> 4,500K and ≤ 7,000K	89.3
4-foot miniature bipin high output	≤ 4,500K	82.7
	> 4,500K and ≤ 7,000K	76.9

(5) Except as provided in paragraphs (n)(6) 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) 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) (i)(A) Subject to the exclusions in paragraph (n)(7)(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)(7)(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.

*   *   *   *   *

Appendix

[The following letter from the Department of Justice will not appear in the Code of Federal Regulations.]

U.S. Department of Justice
Antitrust Division
William J. Baer
Acting Assistant Attorney General
RFK Main Justice Building
950 Pennsylvania Ave., NW
Washington, D.C. 20530-0001
(202)514-2401 / (202)616-2645 (Fax)

August 25, 2014

Eric J. Fygi
Deputy General Counsel
Department of Energy
Washington, DC 20585

Dear Deputy General Counsel Fygi:

I am responding to your June 11, 2014 letter seeking the views of the Attorney General about the potential impact on competition of proposed energy conservation standards for general service fluorescent lamps and certain incandescent reflector lamps. Your request was submitted under Section 325(o)(2)(B)(i)(V) of the Energy Policy and Conservation Act, as amended (ECPA), 42 U.S.C. 6295(o)(2)(B)(i)(V), which requires the Attorney General to make a determination of the impact of any lessening of competition that is likely to result from the imposition of proposed energy conservation standards. The Attorney General's responsibility for responding to requests from other departments about the effect of a program on competition has been delegated to the Assistant Attorney General for the Antitrust Division in 28 CFR § 0.40(g).

In conducting its analysis the Antitrust Division examines whether a proposed standard may lessen competition, for example, by substantially limiting consumer choice, by placing certain manufacturers at an unjustified competitive disadvantage, or by inducing avoidable inefficiencies in production or distribution of particular products. A lessening of competition could result in higher prices to manufacturers and consumers.

We have reviewed the proposed standards contained in the Notice of Proposed Rulemaking (79 Fed. Reg. 24068, April 29, 2014) (NOPR). We have also reviewed supplementary information submitted to the Attorney General by the Department of Energy. Based on this review, our conclusion is that the proposed energy conservation standards for general service fluorescent lamps and certain incandescent reflector lamps are unlikely to have a significant adverse impact on competition.

Sincerely,

William J. Baer

Enclosure