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10 CFR Part 431
Energy Conservation Program: Energy Conservation Standards for Metal Halide Lamp Fixtures; Final Rule

DEPARTMENT OF ENERGY

10 CFR Part 431

[Docket Number EERE–2009–BT–STD–0018]

RIN 1904–AC00

Energy Conservation Program: Energy Conservation Standards for Metal Halide Lamp Fixtures

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 metal halide lamp fixtures (MHLFs). 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 MHLFs. It has determined that the new and amended energy conservation standards for this equipment would result in significant conservation of energy, and are technologically feasible and economically justified.

DATES: The effective date of this rule is April 11, 2014. Compliance with the new and amended standards established for MHLFs in today's final rule is required by February 10, 2017.

The incorporation by reference of certain publications listed in this rule is approved by the Director of the Federal Register on April 11, 2014.

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 Web page can be found at: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/16*. The regulations.gov Web page 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), Public Law 94–163 (42 U.S.C. 6291–6309, as codified), established the Energy Conservation Program for Consumer Products Other Than Automobiles.[2] Pursuant to EPCA, any new or amended energy conservation standard that DOE prescribes for certain equipment, such as metal halide lamp fixtures (MHLFs or ''fixtures''[3]), shall 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 notice, DOE is adopting new and amended energy conservation standards for MHLFs. The new and amended standards, which are the minimum allowable ballast efficiencies[4] based on fixture location, ballast type, and rated lamp wattage, are shown in Table I.1. These new and amended standards apply to all equipment listed in Table I.1 and manufactured in, or imported into, the United States on or after the compliance date in the **DATES** section of this notice (additionally, see section II.B.3 of this notice for more information on the compliance date determination).

TABLE I.1—ENERGY CONSERVATION STANDARDS FOR MHLFS

Designed to be operated with lamps of the following rated lamp wattage	Indoor/outdoor	Test input voltage †	Minimum standard equation ‡ %
≥50 W and ≤100 W	Indoor	480 V	(1/(1+1.24×P^(−0.351))) − 0.0200.
≥50 W and ≤100 W	Indoor	All others	1/(1+1.24×P^(−0.351)).
≥50 W and ≤100 W	Outdoor	480 V	(1/(1+1.24×P^(−0.351))) − 0.0200.
≥50 W and ≤100 W	Outdoor	All others	1/(1+1.24×P^(−0.351)).
>100 W and <150 W *	Indoor	480 V	(1/(1+1.24×P^(−0.351))) − 0.0200.
>100 W and <150 W *	Indoor	All others	1/(1+1.24×P^(−0.351)).
>100 W and <150 W *	Outdoor	480 V	(1/(1+1.24×P^(−0.351))) − 0.0200.
>100 W and <150 W *	Outdoor	All others	1/(1+1.24×P^(−0.351)).
≥150 W ** and ≤250 W	Indoor	480 V	0.880.
≥150 W ** and ≤250 W	Indoor	All others	For ≥150 W and ≤200 W: 0.880. For >200 W and ≤250 W: 1/(1+0.876×P^(−0.351)).
≥150 W ** and ≤250 W	Outdoor	480 V	0.880.

[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), Public Law 112–210 (Dec. 18, 2012).

[3] The scope of this rulemaking encompasses entire MHLFs, including the metal halide lamps and metal halide ballasts the fixtures contain. Therefore, the ratings of individual components are often discussed at a system level. For example, when referring to the rated wattages or available input voltages of the lamps and ballasts a fixture is designed to operate with, this final rule frequently uses shorthand such as ''100 W ballast'' for a ballast operating a lamp rated at 100 watts or ''480 V fixture'' for a fixture housing a ballast with a dedicated input voltage of 480 volts.

[4] DOE is proposing to continue using a ballast efficiency metric for regulation of MHLFs, rather than a system or other approach. See section 0 for further discussion.

TABLE I.1—ENERGY CONSERVATION STANDARDS FOR MHLFS—Continued

Designed to be operated with lamps of the following rated lamp wattage	Indoor/outdoor	Test input voltage †	Minimum standard equation ‡ %
≥150 W ** and ≤250 W	Outdoor	All others	For ≥150 W and ≤200 W: 0.88. For >200 W and ≤250 W: 1/(1+0.876×P^(−0.351)).
>250 W and ≤500 W	Indoor	480 V	For >250 W and <265 W: 0.880. For ≥265 W and ≤500 W: (1/(1+0.876×P^(−0.351))) − 0.0100.
>250 W and ≤500 W	Indoor	All others	1/(1+0.876×P^(−0.351)).
>250 W and ≤500 W	Outdoor	480 V	For >250 W and <265 W: 0.880. For ≥265 W and ≤500 W: (1/(1+0.876×P^(−0.351))) − 0.0100.
>250 W and ≤500 W	Outdoor	All others	1/(1+0.876×P^(−0.351)).
>500 W and ≤1000 W	Indoor	480 V	>500 W and ≤750 W: 0.900. >750 W and ≤1000 W: 0.000104×P + 0.822. For >500 W and ≤1000 W: may not utilize a probe-start ballast.
>500 W and ≤1000 W	Indoor	All others	For >500 W and ≤750 W: 0.910. For >750 W and ≤1000 W: 0.000104×P+0.832. For >500 W and ≤1000 W: may not utilize a probe-start ballast.
>500 W and ≤1000 W	Outdoor	480 V	>500 W and ≤750 W: 0.900. >750 W and ≤1000 W: 0.000104×P + 0.822. For >500 W and ≤1000 W: may not utilize a probe-start ballast.
>500 W and ≤1000 W	Outdoor	All others	For >500 W and ≤750 W: 0.910. For >750 W and ≤1000 W: 0.000104×P+0.832. For >500 W and ≤1000 W: may not utilize a probe-start ballast.

* Includes 150 W fixtures specified in paragraph (b)(3) of this section, which are fixtures rated only for 150 watt lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

** Excludes 150 W fixtures specified in paragraph (b)(3) of this section, which are fixtures rated only for 150 watt lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

† Tested input voltage is specified in 10 CFR 431.324.

‡ P is defined as the rated wattage of the lamp the fixture is designed to operate.

A. Benefits and Costs to Customers

Table I.2 presents DOE's evaluation of the economic impacts of today's standards on customers of MHLFs, as measured by the average life-cycle cost (LCC) savings and the median payback period. The average LCC savings are positive for a majority of users for all equipment classes.

TABLE I.2—IMPACTS OF TODAY'S STANDARDS ON CUSTOMERS OF MHLFS *

Representative equipment class	Representative wattage	Average LCC savings *2012$*	Median payback period *years*
≥50 W and ≤100 W (indoor, magnetic baseline)	70 W	27.00	4.5
≥50 W and ≤100 W (outdoor, magnetic baseline)	70 W	34.88	4.5
>100 W and <150 W ** (indoor)	150 W	24.63	7.3
>100 W and <150 W ** (outdoor)	150 W	30.70	8.1
≥150 W † and ≤250 W (indoor)	250 W	4.51	14.2
≥150 W † and ≤250 W (outdoor)	250 W	6.74	17.4
>250 W and ≤500 W (indoor)	400 W	7.95	15.0
>250 W and ≤500 W (outdoor)	400 W	13.15	18.4
>500 W and ≤1000 W (indoor)	1000 W	1221.54	0.8
>500 W and ≤1000 W (outdoor)	1000 W	1631.94	0.8

* On average, indoor and outdoor fixtures have 20- and 25-year lifetimes, respectively.

** Includes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the National Electrical Code 2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2001.

† Excludes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the National Electrical Code 2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2001.

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 (2014 to 2046). Using a real discount rate of 8.9 percent, DOE estimates that the base case INPV for manufacturers of MH ballasts ranges from $67 million in the low-shipment scenario to $74 million in the high-shipment scenario in 2012$. Under today's standards, DOE expects that ballast manufacturers may lose up to 26.7 percent of their INPV, which is approximately $17.9 million, in the low-shipment, preservation of operating profit markup scenario.

For MHLF, using a real discount rate of 9.5 percent, DOE estimates that the base case INPV for manufacturers of MHLFs ranges from $346 million in the low-shipment scenario to $379 million in the high-shipment scenario in 2012$. Under today's standards, DOE expects that MHLF manufacturers may lose up to 1.0 percent of their INPV, which is approximately $3.6 million, in the low-shipment, preservation of operating profit markup scenario.

When adding these two MH industries together (MHLF and MH ballast), DOE estimates that the combined base case INPV for manufacturers of MHLFs and MH ballasts ranges from $413 million in the low-shipment scenario to $453 million in the high-shipment scenario in 2012$. Under today's standards, DOE expects that all MH manufacturers (MHLF and MH ballast manufacturers) may lose up to 5.2 percent of their INPV, which is approximately $21.5 million, in the low-shipment, preservation of operating profit markup scenario.

Additionally, based on DOE's interviews with manufacturers of MHLFs and ballasts, DOE does not expect any plant closings or significant loss of employment.

C. National Benefits[5]

DOE's analyses indicate that today's standards would save a significant amount of energy. The lifetime savings for MHLFs purchased in the 30-year period that begins in the year of compliance with new and amended standards (2017–2046) amount to 0.39–0.49 quads.

The cumulative net present value (NPV) of total customer costs and savings of today's standards for MHLFs ranges from $0.29 billion (at a 7-percent discount rate, low shipments scenario) to $1.1 billion (at a 3-percent discount rate, high shipments scenario). This NPV expresses the estimated total value of future operating cost savings minus the estimated increased equipment costs for equipment purchased in 2017–2046.

In addition, today's standards would have significant environmental benefits. The energy savings would result in cumulative greenhouse gas emission reductions of approximately 22.5–27.8 million metric tons (Mt)[6] of carbon dioxide (CO_2), 105.9–132.4 thousand tons of methane, 0.5–0.6 thousand tons of nitrous oxide (N_2O), 37.5–47.2 thousand tons of sulfur dioxide (SO_2), 28.2–35.0 tons of nitrogen oxides (NO_X) and 0.05–0.06 tons of mercury (Hg).[3] Through 2030, the estimated energy savings would result in cumulative emissions reductions of 6.3–6.8 Mt of CO_2.

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 interagency process.[7] The derivation of the SCC values is discussed in section V.M. Using discount rates appropriate for each set of SCC values, DOE estimates that the net present monetary value of the CO_2 emissions reductions is between $0.15 billion and $2.55 billion. DOE also estimates that the net present monetary value of the NO_X emissions reductions is $17.34 million at a 7-percent discount rate, and $44.20 million at a 3-percent discount rate.[8]

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

TABLE I.3—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF MHLF ENERGY CONSERVATION STANDARDS *

Category	Present value million 2012$	Discount rate (%)
Benefits		
Operating Cost Savings	754	7
	1,636	3
CO_2 Reduction Monetized Value ($11.8/t case) **	146	5
CO_2 Reduction Monetized Value ($39.7/t case) **	682	3
CO_2 Reduction Monetized Value ($61.2/t case) **	1,088	2.5
CO_2 Reduction Monetized Value ($117/t case) **	2,106	3
NO_X Reduction Monetized Value (at $2639/ton) **	17	7
	37	3
Total Benefits †	1,453	7
	2,355	3
Costs		
Incremental Installed Costs	465	7
	721	3
Net Benefits		
Including CO_2 and NO_X † Reduction Monetized Value	988	7
	1,634	3

* This table presents the primary (low shipments scenario) estimate of costs and benefits associated with fixtures shipped in 2017–2046. These results include benefits to customers which accrue after 2047 from the equipment purchased in 2017–2046. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule.

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

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

The benefits and costs of today's standards, for equipment sold in 2017–2046, can also be expressed in terms of annualized values. The annualized monetary values are the sum of (1) the annualized national economic value of the benefits from operating the equipment (consisting primarily of operating cost savings from using less energy, minus increases in equipment purchase and

[5] All monetary values in this section are expressed in 2012 dollars and are discounted to 2013. Value ranges correspond with estimates for the low and high shipment scenarios.

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

[3] DOE calculated emissions reductions relative to the *Annual Energy Outlook* (*AEO*) 2013 Reference case, which generally represents current legislation and environmental regulations for which implementing regulations were available as of December 31, 2012.

[7] Technical Support Document: 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). *www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf.*

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

installation costs, which is another way of representing customer NPV), plus (2) the annualized monetary value of the benefits of emission reductions, including CO_2 emission reductions.[9]

Although adding the value of customer 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. customer monetary savings that occur as a result of market transactions, while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and CO_2 savings are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of MHLFs shipped in 2017–2046. 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 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 average SCC series that uses a 3-percent discount rate, the cost of the standards in today's rule is $46 million per year in increased equipment costs, while the benefits are $74 million per year in reduced equipment operating costs, $38 million in CO_2 reductions, and $1.71 million in reduced NO_X emissions. In this case, the net benefit amounts to $68 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series, the cost of the standards in today's rule is $40 million per year in increased equipment costs, while the benefits are $91 million per year in reduced operating costs, $38 million in CO_2 reductions, and $2.07 million in reduced NO_X emissions. In this case, the net benefit amounts to $91 million per year.

TABLE I.4—ANNUALIZED BENEFITS AND COSTS OF NEW AND AMENDED STANDARDS FOR MHLFS

	Discount rate	Primary (low) net benefits estimate * *Million 2012$/year*	High net benefits estimate * *Million 2012$/year*
Benefits			
Operating Cost Savings	7%	74	92
	3%	91	119
CO_2 Reduction at ($11.8 case) **	5%	11	13
CO_2 Reduction at ($39.7/t case) **	3%	38	46
CO_2 Reduction at ($61.2/t case) **	2.5%	56	68
CO_2 Reduction at ($117.0/t case) **	3%	117	142
NO_X Reduction at ($2639/ton) **	7%	1.71	1.95
	3%	2.07	2.46
Total Benefits†	7% plus CO_2 range	87 to 194	107 to 236
	7%	114	140
	3%	131	168
	3% plus CO_2 range	104 to 211	135 to 264
Costs			
Incremental Product Costs	7%	46	52
	3%	40	48
Net Benefits			
Total †	7% plus CO_2 range	41 to 148	54 to 184
	7%	68	87
	3%	91	120
	3% plus CO_2 range	64 to 171	87 to 216

* This table presents the annualized costs and benefits associated with fixtures shipped in 2017–2046. These results include benefits to consumers which accrue after 2046 from the fixtures purchased from 2017–2046. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary (Low) and High Benefits Estimates utilize projections of energy prices from the *AEO2013* Reference case and High Estimate, respectively. The Primary (Low) and High Benefits Estimates are also based on projected fixture shipments in the Low Shipments, Roll-up and High Shipments, Roll-up scenarios, respectively. In addition, the Primary (Low) estimate uses incremental equipment costs that assume fixed equipment prices throughout the analysis period. The High estimate uses incremental equipment costs that reflect a declining trend for equipment prices, using *AEO* price trends (deflators). The methods used to derive projected price trends are explained in section V.F.1.

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

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

D. Conclusion

Based on the analyses culminating in this final rule, DOE found the benefits to the nation of the standards (energy savings, customer LCC savings, positive NPV of customer benefit, and emission reductions) outweigh the burdens (loss of INPV and LCC increases for some users of this equipment). DOE has concluded that the standards in

[9] DOE used a two-step calculation process to convert the time-series of costs and benefits into annualized values. First, DOE calculated a present value in 2013, the year used for discounting the NPV of total customer costs and savings, for the time-series of costs and benefits using discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions. For the latter, DOE used a range of discount rates, as shown in Table I.3. From the present value, DOE then calculated the fixed annual payment over a 30-year period (2017 through 2046) that yields the same present value. The fixed annual payment is the annualized value. Although DOE calculated annualized values, this does not imply that the time-series of cost and benefits from which the annualized values were determined is a steady stream of payments.

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 standards for MHLFs.

A. Authority

Title III, Part B [10] of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (42 U.S.C. 6291–6309, as codified) established the Energy Conservation Program for Consumer Products Other Than Automobiles, a program covering most major household appliances (collectively referred to as ''covered equipment''),[11] which includes the types of MHLFs that are the subject of this rulemaking. (42 U.S.C. 6292(a)(19)) EPCA, as amended by the Energy Independence and Security Act of 2007 (EISA 2007) prescribes energy conservation standards for this equipment (42 U.S.C. 6295(hh)(1)), and directs DOE to conduct a rulemaking to determine whether to amend these standards. (42 U.S.C. 6295(hh)(2)(A)) DOE notes that under 42 U.S.C. 6295(hh)(3)(A), the agency must conduct a second review of energy conservation standards for MHLFs and publish a final rule no later than January 1, 2019.

Pursuant to EPCA, DOE's energy conservation program for covered equipment 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 covered equipment. (42 U.S.C. 6293) Manufacturers of covered equipment must use the prescribed DOE test procedure as the basis for certifying to DOE that their equipment complies with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of that equipment. (42 U.S.C. 6293(c) and 6295(s)) Similarly, DOE must use these test procedures to determine whether the equipment complies with standards adopted pursuant to EPCA. *Id.* DOE test procedures for MHLFs currently appear at title 10 of the Code of Federal Regulations (CFR) section 431.324.

DOE must follow specific statutory criteria for prescribing new or amended standards for covered equipment. As indicated above, any new or amended standard for covered equipment 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 equipment, including MHLFs, if no test procedure has been established for the equipment, or (2) if DOE determines by rule that the new or amended standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)–(B)) In deciding whether a new or 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 factors:

1. The economic impact of the standard on manufacturers and customers of the equipment subject to the standard;
2. The savings in operating costs throughout the estimated average life of the covered equipment in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered equipment 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 equipment 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 new or amended standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of covered equipment. (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 equipment 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 customer of purchasing equipment 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 customer 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 equipment that has two or more subcategories. DOE must specify a different standard level than that which applies generally to such type or class of equipment for any group of covered equipment that has the same function or intended use if DOE determines that equipment within such group (A) consumes a different kind of energy from that consumed by other covered equipment within such type (or class); or (B) has a capacity or other performance-related feature that other equipment within such type (or class) does 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 equipment, DOE must consider such factors as the utility to the customer 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 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 covered equipment 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 equipment. (42 U.S.C. 6295(gg)(3)(A)–(B)) DOE's current test procedures and standards for MHLFs address standby mode and off mode energy use. However, in this rulemaking, DOE only addresses active mode energy consumption as the equipment included in the scope of coverage only consumes energy in active mode.

B. Background

1. Current Standards

EISA 2007 prescribed the current energy conservation standards for MHLFs manufactured on or after January 1, 2009. (42 U.S.C. 6295(hh)(1)) The current standards are set forth in Table II.1. EISA 2007 excludes from the standards: MHLFs with regulated-lag ballasts, MHLFs with electronic ballasts that operate at 480 volts (V); and MHLFs that (1) are rated only for 150 watt (W) lamps; (2) are rated for use in wet locations; and (3) contain a ballast that is rated to operate at ambient air temperatures higher than 50 °C.

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

[11] All references to EPCA in this document refer to the statute as amended through the American Energy Manufacturing Technical Corrections Act (AEMTCA), Public Law 112–210 (Dec. 18, 2012).

TABLE II.1—FEDERAL ENERGY EFFICIENCY STANDARDS FOR MHLFS *

Ballast type	Operated lamp rated wattage range	Minimum ballast efficiency %
Pulse-start	≥150 and ≤500 W	88
Magnetic Probe-start	≥150 and ≤500 W	94
Nonpulse-start Electronic	≥150 and ≤250 W	90
Nonpulse-start Electronic	≥250 and ≤500 W	92

* (42 U.S.C. 6295(hh)(1)).

2. History of Standards Rulemaking for MHLFs

DOE is conducting this rulemaking to review and consider amendments to the energy conservation standards in effect for MHLFs, as required under 42 U.S.C. 6295(hh)(2) and (4). On December 30, 2009, DOE published a notice announcing the availability of the framework document, ''Energy Conservation Standards Rulemaking Framework Document for Metal Halide Lamp Fixtures,'' and a public meeting to discuss the proposed analytical framework for the rulemaking. 74 FR 69036. DOE also posted the framework document on its Web site; this document is available at *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/16*. The framework document described the procedural and analytical approaches that DOE anticipated using to evaluate energy conservation standards for MHLFs, and identified various issues to be resolved in conducting this rulemaking.

DOE held a public meeting on January 26, 2010, during which it presented the contents of the framework document, described the analyses it planned to conduct during the rulemaking, sought comments from interested parties on these subjects, and in general, sought to inform interested parties about, and facilitate their involvement in, the rulemaking. At the meeting and during the period for commenting on the framework document, DOE received comments that helped identify and resolve issues involved in this rulemaking.

DOE then gathered additional information and performed preliminary analyses to help develop potential energy conservation standards for MHLFs. On April 1, 2011, DOE published in the **Federal Register** an announcement (the preliminary analysis notice) of the availability of the preliminary technical support document (the preliminary TSD) and of another public meeting to discuss and receive comments on the following matters: (1) The equipment classes DOE planned to analyze; (2) the analytical framework, models, and tools that DOE was using to evaluate standards; (3) the results of the preliminary analyses performed by DOE; and (4) potential standard levels that DOE could consider. 76 FR 1812 (April 1, 2011). In the preliminary analysis notice, DOE requested comment on these issues. The preliminary TSD is available at *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/16*.

The preliminary TSD summarized the activities DOE undertook in developing standards for MHLFs, and discussed the comments DOE received in response to the framework document. It also described the analytical framework that DOE uses in this rulemaking, including a description of the methodology, the analytical tools, and the relationships among the various analyses that are part of the rulemaking. The preliminary TSD presented and described in detail each analysis DOE performed up to that point, including descriptions of inputs, sources, methodologies, and results.

The public meeting announced in the preliminary analysis notice took place on April 18, 2011. At this meeting, DOE presented the methodologies and results of the analyses set forth in the preliminary TSD. Interested parties discussed the following major issues at the public meeting: (1) Alternative approaches to performance requirements and the various related efficiency metrics; (2) the possibility of including design standards; (3) amendments to the test procedures for metal halide (MH) ballasts to account for multiple input voltages; (4) the cost and feasibility of utilizing electronic ballasts in MHLFs; (5) equipment class divisions; (6) overall pricing methodology; (7) lamp lifetimes; (8) cumulative regulatory burden; (9) shipments; and (10) the possibility of merging the MHLF and the high-intensity discharge (HID) lamp rulemakings.

In August 2013, DOE published a notice of proposed rulemaking (NOPR) in the **Federal Register** proposing new and amended energy conservation standards for MHLFs. In conjunction with the NOPR, DOE also published on its Web site the complete TSD for the proposed rule, which incorporated the analyses DOE conducted and technical documentation for each analysis. The NOPR TSD was accompanied by the LCC spreadsheet, the national impact analysis spreadsheet, and the manufacturer impact analysis (MIA) spreadsheet—all of which are available on DOE's Web site.[12] The proposed standards were as shown in Table II.2.78 FR 51463 (August 20, 2013).

TABLE II.2—ENERGY CONSERVATION STANDARDS PROPOSED IN THE NOPR

Designed to be operated with lamps of the following rated lamp wattage	Indoor/outdoor †	Test input voltage ††	Minimum standard equation ‡ %
≥50 W and ≤100 W	Indoor	480 V	99.4/(1+2.5×P^(−0.55)).‡
≥50 W and ≤100 W	Indoor	All others	100/(1+2.5×P^(−0.55)).
≥50 W and ≤100 W	Outdoor	480 V	99.4/(1+2.5×P^(−0.55)).
≥50 W and ≤100 W	Outdoor	All others	100/(1+2.5×P^(−0.55)).
>100 W and <150 W *	Indoor	480 V	99.4/(1+0.36×P^(−0.30)).
>100 W and <150 W *	Indoor	All others	100/(1+0.36×P^(−0.30)).
>100 W and <150 W *	Outdoor	480 V	99.4/(1+0.36×P^(−0.30)).
>100 W and <150 W *	Outdoor	All others	100/(1+0.36×P^(−0.30)).
≥150 W ** and ≤250 W	Indoor	480 V	For ≥150 W and ≤200 W: 88.0. For >200 W and ≤250 W: 0.06×P + 76.0.
≥150 W ** and ≤250 W	Indoor	All others	For ≥150 W and ≤200 W: 88.0. For >200 W and ≤250 W: 0.07×P + 74.0.
≥150 W ** and ≤250 W	Outdoor	480 V	For ≥150 W and ≤200 W: 88.0 For >200 W and ≤250 W: 0.06×P + 76.0.
≥150 W ** and ≤250 W	Outdoor	All others	For ≥150 W and ≤200 W: 88.0. For >200 W and ≤250 W: 0.07×P + 74.0.

[12] All the spreadsheets models developed for this rulemaking proceeding are available at: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/16*.

TABLE II.2—ENERGY CONSERVATION STANDARDS PROPOSED IN THE NOPR—Continued

Designed to be operated with lamps of the following rated lamp wattage	Indoor/outdoor †	Test input voltage ††	Minimum standard equation ‡ %
>250 W and ≤500 W	Indoor	480 V	91.0.
>250 W and ≤500 W	Indoor	All others	91.5.
>250 W and ≤500 W	Outdoor	480 V	91.0.
>250 W and ≤500 W	Outdoor	All others	91.5.
>500 W and ≤2000 W	Indoor	480 V	For >500 W to <1000 W: 0.994×(0.0032×P + 89.9). For ≥1000 W to ≤2000 W: 92.5 and may not utilize a probe-start ballast.
>500 W and ≤2000 W	Indoor	All others	For >500 W to <1000 W: 0.0032×P + 89.9. For ≥1000 W to ≤2000 W: 93.1 and may not utilize a probe-start ballast.
>500 W and ≤2000 W	Outdoor	480 V	For >500 W to <1000 W: 0.994×(0.0032×P + 89.9). For ≥1000 W to ≤2000 W: 92.5 and may not utilize a probe-start ballast.
>500 W and ≤2000 W	Outdoor	All others	For >500 W to <1000 W: 0.0032×P + 89.9. For ≥1000 W to ≤2000 W: 93.1 and may not utilize a probe-start ballast.

* Includes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

** Excludes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

† DOE's proposed definitions for "indoor" and "outdoor" MHLFs are described in section V.A.2.

†† Input voltage for testing would be specified by the test procedures. Ballasts rated to operate lamps less than 150 W would be tested at 120 V, and ballasts rated to operate lamps ≥150 W would be tested at 277 V. Ballasts not designed to operate at either of these voltages would be tested at the highest voltage for which the ballast is designed to operate.

‡ P is defined as the rated wattage of the lamp that the MHLF is designed to operate.

In the NOPR DOE invited comment, particularly on the following issues: (1) The expanded scope of coverage, (2) the proposed amendments to the test procedure, (3) equipment class divisions, (4) the efficiency levels (ELs) analyzed, (5) the method of estimating magnetically ballasted system input power, (6) the determination to include a design standard that would prohibit the sale of probe-start ballasts in newly sold MHLFs for certain wattages, (7) the derived manufacturer selling prices (MSPs), (8) the equipment class scaling factor for tested input voltage, and (9) the proposed trial standard level (TSL 3). 78 FR 51463 (August 20, 2013).

DOE held a NOPR public meeting on September 27, 2013, to hear oral comments and solicit information relevant to the proposed rule (hereafter the NOPR public meeting). Interested parties in attendance discussed the following major issues: (1) The compliance date, (2) amendments to the test procedure, (3) scope of the rulemaking, (4) equipment class divisions, (5) impacts on the magnetic ballast footprint, (6) impacts on fixture design, (7) testing and manufacturing variation, and (8) impacts of solid-state lighting market penetration on MHLF shipments.

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 notice.

3. Compliance Date

EPCA, as amended by EISA 2007, contains guidelines for the compliance date of the standards amended by this rulemaking. EPCA requires DOE to determine whether to amend the standards in effect for MHLFs and whether any amended standards should apply to additional MHLFs. The Secretary was directed to publish a final rule no later than January 1, 2012 to determine whether the energy conservation standards established by EISA 2007 for MHLFs should be amended, with any amendment applicable to equipment manufactured after January 1, 2015. (42 U.S.C. 6295(hh)(2)(B)) As discussed in section VI.C, DOE has determined it will maintain the three-year interval between the publication date of the final rule in the **Federal Register** and the compliance date.

III. Issues Affecting the Scope of This Rulemaking

A. Additional MHLFs for Which DOE Is Setting Standards

The existing energy conservation standards for MHLFs are established in EPCA through amendments made by EISA 2007. (42 U.S.C. 6295(hh)(1)(A)) The statute excludes from coverage MHLFs with regulated-lag ballasts; electronic ballasts that operate at 480 V; and ballasts that are rated only for (1) use with 150 W lamps, (2) use in wet locations, and (3) operation in ambient air temperatures higher than 50 °C.[13] DOE considered expanding the coverage of its energy conservation standards to include these exempted MHLF types and additional rated lamp wattages. For each previously exempted MHLF type and for all expansions of the covered wattage range, DOE considered potential energy savings, technological feasibility, and economic justification when determining whether to include them in the scope of coverage.

Some stakeholders expressed confusion at the NOPR public meeting, stating that they interpreted this rulemaking as establishing efficiency standards for all metal halide ballasts rather than just ballasts in new metal halide lamp fixtures. The Edison Electric Institute (EEI) contended that the rule is misleading because the title indicates it is a rule for metal halide lamp fixtures when it actually establishes standards for all metal halide ballasts, including replacement ballasts. (EEI, Public Meeting Transcript, No. 48 at pp. 14–15, 67–69)[14] DOE clarifies that the scope of this rulemaking affects all new MHLFs. Ballasts sold with new fixtures after the compliance date must meet or exceed the standards promulgated by this rulemaking. Any ballasts sold on the replacement market do not need to comply with these standards.

Regarding the additional fixtures that DOE proposed including in the scope of coverage, the California Energy Commission (CEC) generally supported the expanded scope for MHLFs DOE proposed in the NOPR. (CEC, No. 52 at p. 3) DOE received no other comment regarding the general approach to expand the scope of coverage and considers specific scope comments in the following sections.

[13] As a point of reference, 50 °C is equivalent to 122 °F.

[14] A notation in the form "EEI, Public Meeting Transcript, No. 48 at pp. 14–15, 67–69" identifies a comment that DOE has received and included in the docket of this rulemaking. This particular notation refers to a comment: (1) Submitted by EEI; (2) in the transcript of the MHLF NOPR public meeting, document number 48 in the docket of this rulemaking; and (3) appearing on pages 14–15 and 67–69 of that transcript.

1. EISA 2007 Exempted MHLFs

a. MHLFs With Regulated-Lag Ballasts

Regulated-lag ballasts are mainly used for specialty applications where line voltage variation is large. Regulated-lag ballasts are designed to withstand significant line voltage variation with minimum wattage variation to the lamp, which results in an efficiency penalty compared to ballasts whose output changes more significantly with line voltage variation. The power regulation provided by regulated-lag ballasts is higher than any other magnetic ballast. To be able to withstand large variations, regulated-lag ballasts are designed to be significantly larger than standard ballasts. Through manufacturer interviews and market research, DOE determined that the size and weight of regulated-lag ballasts limit their use as substitutes in traditional applications. Manufacturers and market research confirmed that their exemption did not lead to a significant market shift to regulated-lag ballasts. Furthermore, DOE's market research found none of this equipment available in major manufacturers' catalogs. The absence of regulated-lag ballasts from catalogs indicates a very small market share and therefore limited potential for significant energy savings. Thus, in the NOPR DOE proposed continuing to exempt MHLFs with regulated-lag ballasts from energy conservation standards.

Universal Lighting Technologies (ULT) and the National Electrical Manufacturers Association (NEMA) agreed with DOE's proposal to continue exempting regulated-lag ballasts from the scope of this rulemaking. NEMA further added that this higher cost technology is used in limited and specific applications, such as heavy industrial, security, and street and tunnel lighting, in order to avoid lamp failures caused by severe voltage dips. (ULT, No. 50 at p. 2; NEMA, No. 56 at p. 5; NEMA, Public Meeting Transcript, No. 48 at p. 48) Agreeing with this description of a limited, niche market and receiving no comments to the contrary, in this final rule DOE exempts regulated-lag ballasts from energy conservation standards.

b. MHLFs With 480 V Electronic Ballasts

In the NOPR, DOE concluded that 480 V electronic ballasts have a very small market share as they are only manufactured by one company and have limited availability from distributors. As a result, DOE determined that there is limited potential for significant energy savings, and in the NOPR proposed continuing to exempt MHLFs with 480 V electronic ballasts from energy conservation standards.

Philips Lighting (Philips), ULT, and NEMA agreed with DOE's decision to exclude 480 V electronic ballasts in the scope of this rulemaking. ULT noted that very few 480 V electronic ballasts are in the market, while Philips commented that 480 V electronic ballasts do not exist at any wattage. (Philips, Public Meeting Transcript, No. 48 at p. 130; ULT, No. 50 at p. 2; NEMA, No. 56 at p. 5) Having received no comments in disagreement, DOE continues to exempt 480 V electronic ballasts from energy conservation standards in this final rule.

c. Exempted 150 W MHLFs

After receiving exemption from energy conservation standards in EISA 2007, shipments of 150 W outdoor MHLFs rated for wet and high-temperature locations increased. Further, some indoor applications use the exempted outdoor MHLFs, negating possible energy savings for indoor 150 W MHLFs. Therefore, in the NOPR DOE concluded that including the currently exempt 150 W MHLFs in the scope of coverage has the potential for significant energy savings. Additionally, as a range of ballast efficiencies exists in commercially available ballasts, DOE found that improving the efficiencies of the ballasts included in these fixtures is technologically feasible and economically justified. Accordingly, in the NOPR DOE proposed including 150 W MHLFs in wet locations and ambient temperatures greater than 50 °C in the scope of this rulemaking.

NEMA, ULT, CEC, and the Southern Company disagreed with DOE's decision to include all 150 W ballasts in the scope of this rulemaking. (NEMA, No. 56 at pp. 5, 12; ULT, No. 50 at pp. 2–3; CEC, No. 52 at p. 3; Southern Company, No. 64 at p. 2; No. 64 at p. 2) NEMA commented that while DOE does have the authority to include this equipment, it must be done in a technologically and economically feasible manner. NEMA stated that the efficiencies adopted in the final rule must be substantially lowered from those proposed in the NOPR to be technologically feasible. (NEMA, No. 56 at pp. 5, 24) In support of this point, ULT and NEMA noted that the industry has not yet been able to create a 150 W MHLF with a magnetic ballast that achieves 88 percent efficiency, which is the minimum efficiency requirement proposed in the NOPR for previously exempt 150 W MHLFs. (ULT, Public Meeting Transcript, No. 48 at pp. 108–109; ULT, No. 50 at pp. 5–6, 23–24; NEMA, No. 56 at p. 13)

In contrast, in a joint comment the Pacific Gas and Electric Company, Southern California Gas Company, San Diego Gas and Electric, and Southern California Edison (hereafter referred to as the California investor-owned utilities or the ''CA IOUs'') supported DOE's proposal to include previously exempt 150 W MHLFs in the scope of coverage. CA IOUs were unaware of any specific attributes that limit 150 W ballasts from reaching greater efficiency, and believe the lower efficiencies of these ballasts are more likely due to their prior exemption from standards, as there is significant room for improvement. Therefore, CA IOUs supported the inclusion of these ballasts. (CA IOUs, No. 54 at pp. 1–2) Also, in a joint comment the Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, National Consumer Law Center, Natural Resources Defense Council, Northwest Energy Efficiency Alliance, and Northwest Power and Conservation Council (hereafter referred to as the ''Joint Comment'') supported including 150 W MHLFs previously exempted by EISA 2007 in the scope of this final rule. (Joint Comment, No. 62 at p. 9)

DOE agrees that commercially available magnetic ballasts cannot meet the EISA 2007 specified 88 percent efficiency. However, the 150 W fixtures exempted by EISA 2007 have a range of magnetic ballast efficiencies available below 88 percent and therefore energy conservation standards are technologically feasible. These fixtures can be considered separately from those 150 W fixtures covered by EISA 2007 by separating them into different equipment classes and DOE therefore finds no reason the previously exempt 150 W fixtures should not be covered by this rulemaking. Therefore in this final rule, DOE has included 150 W fixtures rated for use in wet locations and ambient temperatures greater than 50 °C in the scope of coverage.

NEMA, ULT, and Southern Company commented that the inclusion of 150 W ballast efficiency requirements would practically prohibit usage of 150 W magnetic ballasts, thereby forcing the usage of electronic ballasts in new fixtures. (NEMA, No. 56 at p. 6; ULT, No. 50 at pp. 2–3; Southern Company, No. 64 at p. 2) ULT and Southern Company expressed concerns that electronic ballasts for MH lamps are not proven in outdoor applications and are vulnerable to failures due to moisture, temperatures higher than 50 °C, and voltage variations and surges caused by lightning and other natural events. (ULT, No. 50 at pp. 2–3; Southern Company, No. 64 at p. 2)

DOE considered both more efficient magnetic and more efficient electronic ballasts as replacements for ballasts in the previously exempt 150 W fixtures. DOE has determined that, with the proper fixture adjustments, electronic ballasts can be used in the same applications as magnetic ballasts. For detailed discussion of this decision, see section V.A. DOE has concluded that the standard levels adopted in this final rule are economically justified.

General Electric (GE) commented that energy conservation standards for previously exempt 150 W MHLFs could actually increase rather than decrease national energy consumption. GE noted that the purpose of the 150 W exemption from EISA 2007 was to shift the market from 175 W fixtures to 150 W fixtures, thereby saving energy. Thus, GE disagreed with the way DOE analyzed 150 W fixtures and noted that the previously exempt fixtures should not be subject to standards higher than max tech. (GE, Public Meeting Transcript, No. 48 at pp. 135–136)

CA IOUs acknowledged that 150 W ballasts can be a low-wattage replacement for 175 W applications. Accordingly, CA IOUs encouraged increasing efficiency standards for both wattage levels equally, so as not to inadvertently push customers to the higher-wattage alternatives. (CA IOUs, No. 54 at pp. 1–2) CEC agreed, stating that by incentivizing 150 W fixtures through minimal efficiency standards, the market would be driven toward purchasing these lower-wattage fixtures instead of 175 W or 200 W fixtures. (CEC, No. 52 at p. 3)

The Joint Comment noted that while customers may choose to shift between different wattage MHLFs, continuing to exempt 150 W MHLFs is not the best solution. For example, a continued exemption might create market distortions and hinder the transitions to more efficient light-emitting diode (LED) lamps in this wattage category. (Joint Comment, No. 62 at p. 9) The Joint Comment also stated that even if the inclusion of 150 W fixtures leads to the use of more 175 W or 200 W fixtures, it might not result in more energy consumption as switching to higher-wattage fixtures could also reduce the number of fixtures installed. In situations where the number of fixtures installed is not reduced, additional energy use could be offset by increased ballast efficiency in this wattage bin. In addition, the increased price of the 175 W fixtures provides more disincentive to purchase them over 150 W fixtures. Finally, the Joint Comment argued that if the standards apply to all wattage ranges from 50 W to 500 W, switching from 150 W to a higher-wattage fixture would not be a concern because all fixtures would be subject to the same standards. (Joint Comment, No. 62 at p. 9)

DOE notes that the exemption of certain 150 W fixtures from EISA 2007 resulted in a shift from 175 W to the exempted 150 W fixtures, which resulted in energy savings. In the shipments analysis, DOE considers how different standards for 150 W and 175 W MHLFs may impact customer choices. For example, when the initial first cost for 150 W fixtures exceeds that of 175 W fixtures, the shipments analysis models a shift to 175 W MHLFs. Even with some customers shifting to higher wattage MHLFs, energy conservation standards for 150 W fixtures still result in energy savings due to increased ballast efficiency. In this final rule, DOE has determined that standards for previously exempt 150 W MHLFs are technologically feasible, economically justified, and would result in significant energy savings (see section VII.C for details). Therefore, DOE has included previously exempt 150 W fixtures in the scope of coverage of this rulemaking.

2. Additional Wattages

Based on equipment testing and market research, DOE found in the NOPR that energy conservation standards for MHLFs rated for wattages greater than 50 W and less than 150 W, and MHLFs rated for wattages greater than 500 W, are technologically feasible, economically justified, and would result in significant energy savings. DOE determined that MHLFs rated for wattages greater than 2000 W only served small-market-share applications like graphic arts, ultraviolet (UV) curing, and scanners. Therefore, in the NOPR DOE proposed to include in the scope of coverage 50 W–150 W MHLFs and 501 W–2000 W MHLFs, in addition to the 150 W–500 W MHLFs [15] covered by EISA 2007.

NEMA and ULT opposed the expansion of coverage of this rulemaking to include 50 W–150 W MHLFs. They further commented that coverage of 50 W–100 W MHLFs would require redesign of all magnetic ballasts in that range, which would be nearly equivalent to banning magnetic ballasts. (NEMA, No. 56 at p. 6; ULT, No. 50 at pp. 2–3)

DOE has found MHLFs with a variety of ballast efficiencies in the 50 W–150 W range, including the 50 W–100 W range specifically cited by NEMA and ULT. Therefore, DOE believes energy conservation standards for 50 W–150 W MHLFs are technologically feasible. DOE considered both more efficient magnetic and more efficient electronic ballasts as replacements for ballasts in this rulemaking. DOE has determined that, with the proper fixture adjustments, electronic ballasts can be used in the same applications as magnetic ballasts. For detailed discussion of this decision, see section V.A. Economic impacts of standard levels on individual customers, manufacturers, and the nation are discussed in section VII.B. DOE has concluded that the standard levels adopted in this final rule for 50 W–150 W MHLFs are economically justified and would result in significant energy savings. Therefore, DOE has included 50 W–150 W MHLFs in the scope of coverage for this final rule.

DOE received several comments regarding the inclusion of MHLFs greater than 500 W in the scope of coverage. CA IOUs and Earthjustice supported the expansion of the scope of coverage to include 50 W–2000 W fixtures. (CA IOUs, No. 54 at pp. 1–2; Earthjustice, Public Meeting Transcript, No. 48 at p. 171) CA IOUs commented that because 18 percent of MH ballasts are designed to operate lamps greater than 500 W, there exists an opportunity for significant energy savings. (CA IOUs, No. 54 at pp. 1–2)

In contrast, NEMA and ULT disagreed with the inclusion of MHLFs greater than 500 W, noting that coverage of the 501 W–2000 W range would require redesign of the 750 W fixture family and this would come with significant cost increase. (NEMA, No. 56 at pp. 6–7; ULT, No. 50 at pp. 2–3)

DOE believes that standards for 500 W–1000 W MHLFs are technologically feasible because MHLFs in this wattage range contain ballasts that exhibit a range of efficiencies, indicating it is possible for a standard to improve the efficiency of ballasts already on the market. Specifically, DOE has found 750 W MHLFs with ballasts at multiple efficiencies that span both EL1 and EL2. Furthermore, DOE has analyzed MHLFs in this wattage range and concluded that standards for these MHLFs are economically justified and result in significant energy savings (see section VII.B of this notice for more details). Therefore, DOE includes 500 W–1000 W MHLFs in the scope of coverage for this rulemaking.

NEMA, GE, ULT, Musco Sports Lighting, LLC (Musco Lighting), Venture Lighting International, Inc. (Venture), and OSRAM SYLVANIA Inc. (OSI) all asserted that fixtures greater than 1000 W should not be covered by this rulemaking, as they are only operated in ''specialty lighting'' applications. They stated that the lamps' limited applications and low hours of operation do not result in appreciable savings opportunities, provide little energy gains at a significant cost, and pose an unjustified burden on manufacturers. (NEMA, Public Meeting Transcript, No. 48 at p. 114; NEMA, No. 56 at pp. 6–7; GE, Public Meeting Transcript, No. 48 at pp. 115, 172; ULT, No. 50 at pp. 2–3; Musco Lighting, Public Meeting Transcript, No. 48 at pp. 118, 180; Musco Lighting, No. 55 at pp. 3–4; Venture, Public Meeting Transcript, No. 48 at p. 170; OSI, Public Meeting Transcript, No. 48 at p. 172) Further, NEMA cited the 2010 U.S. Lighting Market Characterization (2010 LMC),[16] as evidence that stadium and sports lighting, the most common application for fixtures greater than 1000 W, is a niche market, unsuitable for energy savings exploration. Specifically, NEMA noted that in the 2010 LMC, the 839,000 MH lamps in stadium applications represent 2.8 percent of outdoor MH lamps (0.4 percent of all outdoor lamps) and only 1.2 percent of all installed MH lamps (see Table 4.1 in the 2010 LMC). For MH lamps in stadium applications, the average wattage is 1554 W (see Table 4.28 in the 2010 LMC) with an average usage of just 1 hour per day (see Table 4.29 in the 2010 LMC). NEMA agreed with the 2010 LMC that this is a reasonable average usage profile for MH lamps greater than 1000 W. In contrast, typical outdoor MH lamps average 12.1 hours per day ranging from 8.8 hours on building exteriors to 15 hours in parking areas. (NEMA, No. 56 at pp. 6–7)

Musco Lighting pointed out that DOE's decision to not directly analyze 480 V magnetic ballasts due to low shipment volume supported their assertion that 1500 W fixtures should be exempt from energy conservation standards. Musco Lighting specified that as more than 50 percent of their shipments of 1500 W MHLFs contained a 480 V ballast, both MHLF types should be exempt. (Musco Lighting, Public Meeting Transcript, No. 48 at p. 129)

DOE determined that sports lighting, which is the predominant application for lamps above 1000 W, fits the definition of general lighting and is therefore included in the scope of this rulemaking (see the following section III.A.3 for additional discussion). Although these higher wattage MHLFs do not comprise a large percentage of the market, their high wattage could potentially result in significant energy savings. DOE notes that MHLFs greater than 1000 W exist in a variety of efficiencies and therefore standards for these MHLFs are technologically feasible. DOE acknowledges, however, that MHLFs greater than 1000 W have a different cost-efficiency relationship than 501 W to 1000 W MHLFs. Therefore, in this final rule, DOE created a separate equipment class to analyze these MHLFs. See section V.A.2 for additional detail. After considering the economic impacts of standards for MHLFs greater than 1000 W on individual customers, manufacturers, and the nation, DOE has concluded that standards for these MHLFs are not economically justified. Therefore, in this final rule, DOE has not included MHLFs greater than 1000 W in the scope of coverage and has not adopted energy conservation standards for these MHLFs. See section VII for a discussion of the economic impacts.

[15] DOE uses this shorthand to refer to MHLFs with ballasts designed to operate lamps rated greater than or equal to 50 W and less than 150 W, MHLFs with ballasts designed to operate lamps rated greater than 500 W and less than or equal to 2000 W, and MHLFs with ballasts designed to operate lamps rated greater than or equal to 150 W and less than or equal to 500 W, respectively.

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

3. General Lighting

EISA 2007 defines the scope of this rulemaking as applying to MHLFs used in general lighting applications. (42 U.S.C. 6291(64)) In section 2 of 10 CFR Part 430, Subpart A, a general lighting application is defined as lighting that provides an interior or exterior area with overall illumination. In the NOPR, DOE proposed to add this definition to 10 CFR Part 431.2,[17] the section of the CFR that relates to commercial and industrial equipment, such as MHLFs. DOE's research indicated that there are a number of applications, such as outdoor sports lighting and airfield lighting, which commonly use MH ballasts of 1000 W to 2000 W and provide general illumination to an exterior area. In the NOPR, DOE proposed that such applications are general lighting applications and are covered by this rulemaking.

ULT, NEMA, GE, Musco Lighting stated that all MHLFs above 1000 W have limited operating hours and are for specialty applications, not general lighting. (ULT, No. 50 at pp. 2–3; NEMA, No. 56 at pp. 6–7; GE, Public Meeting Transcript, No. 48 at p. 115; Musco Lighting, Public Meeting Transcript, No. 48 at p. 118) Earthjustice commented that the definition of ''general lighting'' refers to overall illumination of an interior or exterior area, not to the hours of use of an application. Therefore, Earthjustice stated that these higher-wattage lamps that serve applications such as sports lighting, parks, and airfields that provide overall illumination to exterior areas should not be considered niche equipment. (Earthjustice, Public Meeting Transcript, No. 48 at pp. 171, 174)

DOE agrees that the higher wattages fall under the CFR definition of general lighting. As mentioned previously, DOE also acknowledges that these lamps have limited operating hours and used these hours of use to calculate their energy savings potential. However, DOE does not believe that low operating hours impacts whether high wattage MHLFs are used in general lighting applications. DOE has determined that sports lighting is a general lighting application because it is ''lighting that provides an interior or exterior area with overall illumination.'' In this final rule, DOE adopts this definition for general lighting application in 10 CFR 431.2.

4. High-Frequency Electronic Ballasts

Electronic ballasts can be separated into two main types, low-frequency electronic (LFE) and high-frequency electronic (HFE). HFE ballasts are electronic ballasts with frequencies greater than or equal to 1000 hertz (Hz). DOE received comment that HFE ballasts should not be included in the scope of coverage based on compatibility issues and the lack of test procedure (DOE's proposed test procedure is discussed in section IV.A).

Venture and NEMA commented that there are no ANSI standards for the HFE ballasts that may be required to meet the analyzed standard levels, and therefore there will be limited MH lamps for use with these ballasts for a substantial period of time. (Venture, Public Meeting Transcript, No. 48 at p. 29; NEMA, No. 56 at p. 9) NEMA elaborated that many MH lamps are not compatible with existing HFE ballasts because of variation in arc tube size and shape. Due to this variation, HFE acoustic resonances can cause arc instability or even lamp failure. (NEMA, No. 44 at p. 6) NEMA specifically noted that high-frequency electronic ballasts are incompatible with the most efficacious lamps (ceramic metal halide). A standard that requires high frequency electronic ballasts could reduce overall energy savings because these ballasts are not compatible with the most efficacious MH lamps. (NEMA, No. 56 at p. 9) Furthermore, a standard that eliminates ballasts capable of operating ceramic metal halide lamps would be a violation of EPCA section 325(o)(4) which prohibits DOE from adopting a standard that interested parties have demonstrated results in the elimination of product features from the market. (NEMA, No. 44 at pp. 6–7) NEMA stated that industry standards for high frequency ballasts and lamps have only just begun to be developed and without these standards there will continue to be limited compatibility between high frequency ballasts and lamps (NEMA, No. 44 at p. 7). Even when acceptable frequency ranges are found, NEMA commented that HFE ballasts can also cause electrode back arcing, leading to shortened lamp life. (NEMA, No. 44 at p. 6)

As in the NOPR, DOE recognizes there are compatibility issues associated with HFE ballasts and some MH lamps, in particular ceramic metal halide (CMH) lamps. A standard that requires HFE ballasts could result in a full or partial elimination of CMH lamps from the market due to these compatibility issues. The elimination of CMH lamps could increase energy usage, as CMH lamps are some of the most efficacious MH lamps on the market. In the NOPR, DOE indicated it would take compatibility issues with HFE ballasts into account when selecting the eventual adopted standard of today's final rule. However, as detailed in section IV.A of this notice, DOE has not adopted a test procedure for HFE ballast, based on the lack of an industry consensus test method for this ballast type. DOE has found that in the absence of an applicable test method for these lamps, HFE ballasts cannot be subject to energy conservation standards. Therefore, DOE has not included HFE ballasts in the scope of coverage of this rulemaking.

5. Outdoor Fixtures

In the NOPR, DOE included both indoor and outdoor MHLFs in the scope of coverage because DOE determined that standards for both types of fixtures were technologically feasible, economically justified, and would result in significant energy savings. Because DOE concluded that indoor and outdoor fixtures had different cost-efficiency relationships, DOE analyzed them in separate equipment classes.

The American Public Power Association (APPA) noted that separating the outdoor and indoor lamps or exempting outdoor lamps is necessary because the usage patterns of outdoor lamps differ immensely from indoor. As the circumstances are different when considering both classes, APPA furthered, it is difficult to understand the effects of proposed efficiency standards on each group. APPA also noted that it may make sense to exempt outdoor fixtures from energy conservation standards because the electronic ballasts will have difficulty in extreme weather conditions. APPA, No. 51 at p. 4; APPA, Public Meeting Transcript, No. 48 at p. 103)

As mentioned previously, in the NOPR DOE determined that standards for both types of fixtures were technologically feasible, economically justified, and would result in significant energy savings. This conclusion is reaffirmed by the analysis in the final rule and DOE therefore includes both indoor and outdoor fixtures in the scope of coverage for this rulemaking. DOE agrees with analyzing outdoor and indoor fixtures separately by placing indoor and outdoor MHLFs into separate equipment classes. While the efficiencies achievable by indoor and outdoor fixtures are the same, the different costs affect the resultant cost-efficiency curves. See section V.A.2 of this notice for details on the equipment classes.

6. Hazardous Locations

Although DOE did not consider exempting fixtures designed for use in hazardous locations in the NOPR, NEMA commented that these fixtures need to be exempt from energy conservation standards. As these fixtures are used in potentially explosive atmospheres and listed to Underwriters Laboratories Inc. standard (UL) 844, any change in ballast size would require the fixture to be redesigned and re-tested, creating a tremendous burden on manufacturers. This is because the redesign, retesting, and relisting of these MHLFs would take significantly longer than three years, and leave this equipment type unavailable for an extended period of time. This would result in serious safety concerns until these fixture types were available again. NEMA also finds it would be very difficult for manufacturers to recoup the investment in standards-induced efficiency improvement for these types of MHLFs due to their limited market. Therefore, NEMA suggested that hazardous location fixtures should be granted an exemption from the rulemaking. (NEMA, No. 56 at p. 14)

As discussed in section V.C.8, the standard levels analyzed in this rulemaking do not require an increase in ballast size. Therefore, DOE does not believe hazardous location fixtures would need to be modified due to a change in ballast size. DOE notes that the vast majority of hazardous location fixtures are specified for use with magnetic ballasts. Therefore, DOE investigated existing fixtures, and the requirements of UL 844, to determine whether higher standards for ballasts, specifically those that require electronic ballast technology, would cause existing hazardous location fixtures to be redesigned and/or retested. After reviewing the UL 844 requirements, DOE found no constraints that would specifically or effectively preclude the use of electronic ballasts. Instead, UL 844 contains explosion protection requirements

[17] The general lighting application definition prescribed by EISA 2007 was previously incorporated into the consumer products section (10 CFR Part 430), but has not yet been added to the commercial and industrial equipment section (10 CFR Part 431).

for a luminaire, including requirements that no part of the fixture reach the thermal ignition temperature of a particulate or gas in the environment. DOE's survey of existing hazardous location fixtures found that these fixtures are commonly rated for use with a type of MH ballast and specific wattage. For example, a hazardous location fixture may be rated for use with a magnetic MH ballast of a given wattage (e.g., a 750 W magnetic MH ballast). Most hazardous location fixtures that are currently available are certified for use with magnetic ballasts, with offerings at a variety of wattages.[18] DOE only identified one hazardous location fixture that was rated for use with electronic ballasts (in this case, a 150 W electronic ballast). DOE was unable to confirm that hazardous location fixtures compatible with electronic ballasts were available at the same wattages as hazardous location fixtures compatible with magnetic ballasts that are currently offered on the market. However, as discussed in section VII.C, DOE is not adopting standards that are expected to require the use of electronic ballast technology. Therefore, DOE does not believe the adopted standards in this rulemaking will require hazardous location fixtures to be redesigned and retested and does not exempt them from the standards adopted in this final rule.

7. Summary of MHLFs for Which DOE Is Setting Standards

EISA 2007 established energy conservation standards for MHLFs with ballasts designed to operate lamps with rated wattages between 150 W and 500 W. As previously discussed, EISA 2007 also exempted three types of fixtures within the covered wattage range from energy conservation standards. In this final rule, DOE extends coverage to MHLFs with ballasts designed to operate lamps rated 50 W–150 W and 501 W–1000 W. DOE also includes one type of previously exempt fixture in the scope of coverage: 150 W MHLFs rated for use in wet locations and containing a ballast that is rated to operate at ambient air temperatures greater than 50 °C. DOE continues to exempt regulated-lag ballasts and 480 V electronic ballasts. For all ballasts included in the scope of coverage, DOE has determined that energy conservation standards are technologically feasible, economically justified, and would result in significant energy savings. As such, DOE adopts standards for these MHLFs in this final rule.

B. Alternative Approaches to Energy Conservation Standards: System Approaches

As discussed in the NOPR, DOE considered several alternatives to establishing energy conservation standards for MHLFs by regulating the efficiency of the ballast contained within the fixture. Specifically, DOE considered a lamp-and-ballast system metric, fixture-level metrics, and the compliance paths specified in California's Title 20 regulations (which are now preempted by federal energy conservation standards in 10 CFR 431.326, 74 FR 12058; March 23, 2009). DOE concluded that, after considering all of these alternate approaches, maintaining the EISA 2007 approach of regulating MHLFs by specifying a minimum ballast efficiency was the most widely accepted, least burdensome approach that would ensure energy conservation standards resulted in energy savings. Therefore, in the NOPR DOE proposed standards for MHLFs by requiring that MHLFs contain ballasts that comply with minimum specified efficiencies. NEMA agreed, citing the increased testing burden associated with testing every combination of lamp and ballast sold in a fixture, and recognizing that the majority of MHLFs are not shipped with a lamp. (NEMA, No. 56 at p. 8) Receiving no comment to the contrary, DOE maintains this approach in this final rule.

C. Standby Mode and Off Mode Energy Consumption

EPCA requires energy conservation standards adopted for covered equipment after July 1, 2010 to address standby mode and off mode energy use. (42 U.S.C. 6295(gg)(3)) The requirement to incorporate standby mode and off mode energy use into the energy conservation standards analysis is therefore applicable in this rulemaking.

DOE determined that it is not possible for MHLFs to meet off mode criteria because there is no condition in which the components of an MHLF are connected to the main power source and are not already in a mode accounted for in either active or standby mode. DOE recognizes that MHLFs could be designed with auxiliary control devices that could consume energy in standby mode. However, DOE has yet to encounter such a control device design, or other type of MHLF that uses energy in standby mode, on the market. Therefore, in the NOPR DOE concluded that it cannot establish a standard that incorporates standby mode or off mode energy consumption. Receiving no comment to the contrary, DOE maintains this conclusion in the final rule and does not include standby mode or off mode energy consumption in the standards adopted in this final rule.

IV. General Discussion

A. Test Procedures

1. Current Test Procedures

The current test procedures for MH ballasts and MHLFs are outlined in Subpart S of 10 CFR Part 431. The test conditions, setup, and methodology generally follow the guidance of ANSI C82.6–2005. Testing requires the use of a reference lamp, which is to be driven by the ballast under test conditions until the ballast reaches operational stability. Ballast efficiency for the fixture is then calculated as the measured ballast output power divided by the ballast input power. In the NOPR, DOE considered changes to the test procedure regarding input voltage, the testing of HFE ballasts, and rounding requirements.

2. Test Input Voltage

MH ballasts can be operated at a variety of voltages. The most common voltages are 120 V, 208 V, 240 V, 277 V, and 480 V. Ballasts will also commonly be rated for more than one voltage, such as dual-input-voltage ballasts that can be operated at 120 V or 277 V, or quad-input-voltage ballasts that can be operated at 120 V, 208 V, 240 V, or 277 V. Through manufacturer feedback and testing, DOE found that the specific design of a ballast and the voltage of the lamp operated by the ballast can affect the trend between input voltage and efficiency.

The existing test procedures do not specify the voltage at which a ballast is to be tested, and the majority of ballasts sold are capable of operating at multiple input voltages. Therefore, to ensure consistency among testing and reported efficiencies, DOE considered methods of standardizing this aspect of testing in the NOPR.

a. Average of Tested Efficiency at All Possible Voltages

One method analyzed in the NOPR was testing ballasts at each input voltage at which they are able to operate, and then having a standard for the average of these efficiencies. As averaging the efficiencies could misrepresent the performance of the ballast in its common uses and could increase the testing burden, in the NOPR, DOE did not propose this method. Having received no comments to the contrary, DOE continues to reject using the average of tested efficiency at all possible voltages in this final rule.

b. Posting the Highest and Lowest Efficiencies

A second approach considered in the NOPR was requiring testing at each input voltage and listing the best and worst efficiencies on the MHLF label. DOE found that, similar to averaging efficiencies, this approach would increase the compliance testing burden for manufacturers compared to a requirement to test ballasts only at a single voltage. Therefore, DOE did not propose this method. Having received no comments to the contrary, DOE continues to reject the posting of the highest and lowest efficiencies on an MHLF label in this final rule.

c. Test at Single Manufacturer-Declared Voltage

A third approach considered in the NOPR was that the test procedures should allow testing at a single voltage determined by the manufacturer and declared in the test report. DOE concluded that this approach would not be favorable as the efficiency at the manufacturer-declared voltage and the efficiency at the more commonly used voltages may not be the same, and as such could potentially reduce the energy savings of this rulemaking. Thus, DOE did not propose to test ballast efficiency at a single manufacturer-declared voltage.

GE agreed that a multi-tap ballast should be tested at just one input voltage. Rather than testing at the designated highest voltage, GE stated that it should be up to the manufacturer to choose the voltage at which the ballast was optimally designed for purposes of reporting efficiencies. (GE, Public Meeting Transcript, No. 48 at p. 83)

DOE agrees with testing multi-tap ballasts at a single voltage. DOE's position against allowing manufacturers to declare their testing input voltage stems from concerns

[18] While not comprehensive, DOE identified hazardous location fixtures certified for use with magnetic ballasts that operate lamps with rated wattages between 150 W and 750 W.

that manufacturers could optimize efficiency at a voltage that is most convenient or least expensive, rather than the voltage most commonly used by customers. If optimal efficiency is achieved at a less commonly used voltage, the reported ballast efficiency would not be representative of the ballast efficiency in the ballast's more common applications. If the efficiency at the tested voltage and at the most commonly used voltage are not directly correlated, energy savings could potentially be reduced. For these reasons, DOE rejects the proposal to allow manufacturers to select the voltage at which ballasts are tested in this final rule.

d. Test at Highest Rated Voltage

Another input voltage specification that DOE considered was testing the ballast at the highest voltage possible. However, DOE concluded that a ballast's highest rated voltage is not always its most common input voltage, and therefore testing and enforcing standards at the highest voltage could reduce the potential energy savings of this rulemaking. Accordingly, in the NOPR DOE did not propose to test ballast efficiency at the highest rated voltage. Having received no comments to the contrary, DOE continues to reject testing at the highest rated voltage in this final rule.

e. Test on Input Voltage Based on Wattage and Available Voltages

The final approach analyzed was testing the most common input voltages for each wattage range. This meant, when possible, ballasts less than 150 W are tested at 120 V, ballasts greater than or equal to 150 W are tested at 277 V, and if those specified voltages are unavailable, the ballast is tested at the highest available voltage. DOE concluded that because this proposal only requires testing at one input voltage, it minimizes testing burden. In addition, because the input voltage specification matches the most commonly used voltage, the requirement encourages optimization of efficiency around an input voltage commonly used in practice.

NEMA and ULT agreed with DOE's NOPR proposals regarding the input voltage for testing. (NEMA, No. 56 at p. 8; ULT, No. 50 at p. 4) Having received no comments to the contrary, in this final rule, DOE amends the test procedure to require that ballasts be tested at the following input voltages:

- For ballasts less than 150 W with an available voltage of 120 V, ballasts will be tested at 120 V.
- For ballasts less than 150 W that lack 120 V as an available voltage, ballasts will be tested at the highest available input voltage.
- For ballasts operated at 150 W–2000 W that also have 277 V as an available input voltage, ballasts will be tested at 277 V.
- For ballasts operated at 150 W–2000 W that lack 277 V as an available input voltage, ballasts will be tested at the highest available input voltage.

3. Testing High-frequency Electronic Ballasts

MHLF test procedures reference the 2005 version of ANSI C82.6 for testing both electronic and magnetic MH ballasts. However, ANSI C82.6–2005 does not provide a method for testing HFE ballasts. In the NOPR, DOE found that the instrumentation commonly used for HFE MH ballast testing is the same instrumentation used for electronic fluorescent lamp ballast testing. Therefore, DOE proposed the same instrumentation used in electronic fluorescent lamp ballast testing be used for testing HFE MH ballasts. These proposed requirements specified that once the output frequency of a MH ballast is determined to be greater than or equal to 1000 Hz (the frequency at which DOE defines HFE ballasts) the test procedure instrumentation would be required to include a power analyzer that conforms to ANSI C82.6–2005 with a maximum of 100 picofarads (pF) capacitance to ground and a frequency response between 40 Hz and 1 MHz. The test procedures would also require a current probe compliant with ANSI C82.6–2005 that is galvanically isolated and has a frequency response between 40 Hz and 20 MHz, and lamp current measurement where the full transducer ratio is set in the power analyzer to match the current to the analyzer. The full transducer ratio would be required to satisfy the following equation:

$$\frac{I_{in}}{V_{out}} \times \frac{R_{in}}{R_{in} + R_s}$$

Where:

I_{in} is current through the current transducer;
V_{out} is the voltage out of the transducer;
R_{in} is the power analyzer impedance; and
R_s is the current probe output impedance.

DOE received comment on the lack of compatibility standards between HFE ballasts and MH lamps. NEMA commented that no work has begun on the ANSI C82.6 test procedure standard for HFE ballasts. (NEMA, No. 44 at p. 7) Philips noted that as HFE ballasts do not have testing standards, measurement errors and testing differences could lead to false efficiency values. (Philips, Public Meeting Transcript, No. 48 at p. 70) Similarly, NEMA stated that lack of industry testing standard meant efficiencies are computed using internal test procedures. Therefore, using catalog data gathered from more than one manufacturer combines different test procedures. (NEMA, Public Meeting Transcript, No. 48 at p. 31; NEMA, No. 44 at p. 8) NEMA also noted that labs cannot be accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) to submit HFE ballast testing to DOE without a test procedure to accredit to. (NEMA, No. 56 at p. 9) Further, NEMA noted that it is difficult to precisely measure the power of these HFE ballasts at frequencies over 100 kHz, which experience a 2–5 percent measurement uncertainty. With a tenth of a percentage precision on ballast efficiency, it will be very difficult to attain these levels of measurement. (NEMA, Public Meeting Transcript, No. 48 at p. 30; NEMA, No. 44 at p. 8)

DOE agrees that there are no industry test procedures for HFE ballasts. While the addition of instrumentation requirements addresses some concerns, specifications for lamps to be paired with the ballast during testing and a complete test method specific to HFE ballasts (an equivalent document to ANSI C82.6—which covers magnetic ballasts and LFE ballasts, but not HFE ballasts) are not currently available. Therefore, in this final rule, DOE is not adopting any changes to the test procedure for HFE ballasts. As discussed in section III.A.4 of this notice, DOE is not considering standards for HFE ballasts because a test procedure for HFE ballasts does not exist.

4. Rounding Requirements

Through testing, DOE found that testing multiple samples of the same ballast yielded a range of ballast efficiencies typically differing by less than one percent. Because this data introduces both test measurement and sample to sample variation, the test measurement itself should be at least this accurate. Therefore, DOE came to the conclusion that test procedures can resolve differences of less than one percent and rounding to the tenths of a percent would be reasonable. In the NOPR, DOE proposed amending the MH ballast test procedure for measuring and recording input wattage and output wattage to require rounding to the nearest tenth of a watt, and the resulting calculation of efficiency to the nearest tenth of a percent.

ULT, EEI, and NEMA commented that most test equipment for MHLFs is not calibrated to the proposed level of precision. ANSI standards require wattmeters to have 0.5 percent accuracy. (ULT, Public Meeting Transcript, No. 48 at p. 82; EEI, Public Meeting Transcript, No. 48 at p. 85; NEMA, No. 44 at p. 13). Further, NEMA noted that white paper NEMA LSD–63–2012 on variability estimated the tolerance for a sample of four magnetic ballasts to be 4.7 percent when 99 percent confidence factor is required. (NEMA, No. 56 at p. 8) On the contrary, CA IOUs commented that efficiency measurement equipment accurate to plus or minus 0.5 percent is already capable of measuring efficiency to the nearest watt for lamps of 100 W and above, and the nearest tenth of a watt for lamps below 100 W. CA IOUs argued this supports tenths place rounding of an efficiency figure and setting of standards to the tenth of a percent. (CA IOUs, No. 54 at pp. 2–3). Finally, EEI commented that if the difference between EL1 and EL2 is 0.6 percent, and there is a testing tolerance of plus or minus 1 percent, there could be a classing issue. (EEI, Public Meeting Transcript, No. 48 at p. 159).

DOE reviewed ANSI C82.6–2005 and found that the instrumentation requirements stipulate that watts be measured with 3.5 digits of resolution, with basic accuracy of 0.5 percent. For an efficiency calculation that involves output power divided by input power, 3.5 digits of resolution allows for rounding efficiency to three significant figures (e.g., 0.895 or 89.5 percent) using only three digits. DOE also notes that some manufacturers have submitted compliance data to DOE's certification, compliance, and enforcement (CCE) database rounded to three significant figures and, in response to the NOPR, manufacturers had responded to certain issues using efficiency data rounded to three significant figures. Both of these suggest that manufacturers already have the capability to accomplish these measurements. DOE also considered LSD–63, as suggested by NEMA, but found that it details the population distribution from all sources of variation and did not find that it provides any information regarding the ability to measure the efficiency of an individual ballast to three significant figures. For these reasons, this final rule amends the test procedure to require measuring and calculating ballast efficiency to three significant figures. DOE also adopts energy conservation standards that are specified to three significant figures.

B. Technological Feasibility

1. General

In each standards rulemaking, DOE conducts a screening analysis based on information gathered on all current technology options and prototype designs that could improve the efficiency of the equipment that is 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 equipment or in working prototypes to be technologically feasible. 10 CFR 430, subpart C, appendix A, section 4(a)(4)(i).

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

2. Maximum Technologically Feasible Levels

When DOE adopts a new or amended standard for a type or class of covered equipment, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such equipment. (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 MHLFs, using the design parameters for the most efficient equipment available on the market or in working prototypes. For MHLFs from 50–500 W, the max-tech fixtures use high-grade electronic ballasts. For MHLFs from 501–2000 W, the max-tech fixtures use magnetic ballasts that incorporate high-grade, grain-oriented steel (M6 [19]). (See chapter 5 of the final rule TSD for additional detail.) The max-tech levels that DOE determined for this rulemaking are listed in Table IV.1.

TABLE IV.1—MAX-TECH LEVELS

Equipment class wattage range	Efficiency level *	Efficiency-level equation † %
≥50 and ≤100	EL4	1/(1+0.360×P^(−0.297))
>100 and <150 *	EL4	1/(1+0.360×P^(−0.297))
≥150 ** and ≤250	EL4	1/(1+0.360×P^(−0.297))
>250 and ≤500	EL4	1/(1+0.360×P^(−0.297))
>500 and ≤1000	EL2	For >500 W and ≤750 W: 0.910 For >750 W and ≤1000 W: 0.000104×P+0.832
>1000 and ≤2000	EL2	0.936

* Includes 150 W fixtures exempted by EISA 2007, which are fixtures rated only for 150 watt lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

** Excludes 150 W fixtures exempted by EISA 2007, which are fixtures rated only for 150 watt lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

† P is defined as the rated wattage of the lamp that the fixture is designed to operate.

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 new and amended standards (2017–2046). The savings are measured over the entire lifetime of equipment purchased in the 30-year period.[20] 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 new or amended mandatory efficiency standards, and considers

[19] The American Iron and Steel Institute type numbers and AK Steel designations for electrical steel grades consist of the letter M followed by a number. The M stands for magnetic material; the number is representative of the core loss of that grade.

[20] 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 equipment 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.

market forces and policies that affect demand for more efficient equipment. For example, in the base case, DOE models a migration from covered metal halide lamp fixtures to higher efficiency technologies such as high-intensity fluorescent (HIF), induction lights, and LEDs. DOE also models a move to other HID fixtures such as high-pressure sodium, based on data given by manufacturers during the 2010 Framework public meeting. (Philips, Public Meeting Transcript, No. 8 at p. 91)

DOE used its NIA spreadsheet model to estimate energy savings from new and amended standards for the metal halide lamp fixtures that are the subject of this rulemaking. The NIA spreadsheet model (described in section V.G 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. To calculate this quantity, DOE derives annual conversion factors from the model used to prepare the Energy Information Administration's (EIA) *Annual Energy Outlook 2013* (*AEO2013*).

DOE has begun to also estimate full-fuel-cycle energy savings. 76 FR 51282 (August 18, 2011), as amended at 77 FR 49701 (August 17, 2012). The full-fuel-cycle (FFC) metric includes the energy consumed in extracting, processing, and transporting primary fuels, and thus presents a more complete picture of the impacts of energy efficiency standards. DOE's evaluation of FFC savings is driven in part by the National Academy of Science's (NAS) report on FFC measurement approaches for DOE's Appliance Standards Program.[21] The NAS report discusses that FFC was primarily intended for energy efficiency standards rulemakings where multiple fuels may be used by a particular product. In the case of this rulemaking pertaining to metal halide lamp fixtures, only a single fuel—electricity—is consumed by the equipment. DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered equipment. Although the addition of FFC energy savings in the rulemakings is consistent with the recommendations, the methodology for estimating FFC does not project how fuel markets would respond to this particular standards rulemaking. The FFC methodology simply estimates how much additional energy, and in turn how many tons of emissions, may be displaced if the estimated fuel were not consumed by the equipment covered in this rulemaking. It is also important to note that inclusion of FFC savings does not affect DOE's choice of adopted standards.

2. Significance of Savings

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

D. Economic Justification

1. Specific Criteria

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

a. Economic Impact on Manufacturers and Customers

In determining the impacts of an amended standard on manufacturers, DOE first uses an annual cash-flow approach to determine the quantitative impacts. This step includes both a short-term assessment—based on the cost and capital requirements during the period between when a regulation is issued and when entities must comply with the regulation—and a long-term assessment over a 30-year period.[22] The industry-wide impacts analyzed include INPV, which values the industry on the basis of expected future cash flows; cash flows by year; changes in revenue and income; and other measures of impact, as appropriate. Second, DOE analyzes and reports the impacts on different types of manufacturers, including impacts on small manufacturers. Third, DOE considers the impact of standards on domestic manufacturer employment and manufacturing capacity, as well as the potential for standards to result in plant closures and loss of capital investment. Finally, DOE takes into account cumulative impacts of various DOE regulations and other regulatory requirements on manufacturers.

For individual customers, 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 customers 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 customers 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 equipment compared to any increase in the price of the covered equipment 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 equipment (including its installation) and the operating expense (including energy, maintenance, and repair expenditures) discounted over the lifetime of the equipment. To account for uncertainty and variability in specific inputs, such as equipment 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 ELs are calculated relative to a base case that reflects projected market trends in the absence of amended standards. DOE identifies the percentage of customers estimated to receive LCC savings or experience an LCC increase, in addition to the average LCC savings associated with a particular standard level.

c. Energy Savings

Although significant conservation of energy is a separate statutory requirement for imposing an energy conservation standard, EPCA requires DOE, in determining the economic

[21] "Review of Site (Point-of-Use) and Full-Fuel-Cycle Measurement Approaches to DOE/EERE Building ApplianceEnergy-Efficiency Standards," (Academy report) was completed in May 2009 and included five recommendations. A copy of the study can be downloaded at: *www.nap.edu/catalog.php?record_id=12670.*

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

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 V.G, DOE uses the NIA spreadsheet to project national site energy savings.

d. Lessening of Utility or Performance of Equipment

In establishing classes of equipment, 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 equipment. (42 U.S.C. 6295(o)(2)(B)(i)(IV)) The standards adopted in today's final rule will not reduce the utility or performance of the equipment under consideration in this rulemaking. One piece of evidence for this claim includes that magnetic ballast ELs are allowed for every covered MHLF wattage and application, meaning that manufacturers are not required to change the electronic configuration of their current offerings. A second piece of evidence is that commercially available stack height and footprint is being maintained for all ballasts, resulting in no required change from current MHLF size. Another piece of evidence is that no standards were adopted for MHLFs greater than 1000 W, so that all commercially available MHLFs at such wattages are subjected to no mandatory adjustments. Overall, the adopted standards were selected to protect the interest of customers and do not lessen MHLF performance or utility.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the imposition of a standard. (42 U.S.C. 6295(o)(2)(B)(i)(V)) It also directs the Attorney General to determine the impact, if any, of any lessening of competition likely to result from a 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. DOE addresses the Attorney General's determination in this final rule.

f. Need for National Energy Conservation

The energy savings from new and 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 new and amended standards also are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases associated with 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.

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 customer of equipment 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 customers. 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 customers, 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 of this final rule.

V. Methodology and Discussion

DOE used two spreadsheets to estimate the impact of the adopted standards. The first spreadsheet calculates LCCs and PBPs of potential new energy conservation standards. The second provides shipments forecasts and then calculates national energy savings and NPV impacts of new energy conservation standards. The Department also assessed manufacturer impacts, largely through use of the Government Regulatory Impact Model (GRIM).

Additionally, DOE uses a version of EIA's National Energy Modeling System (NEMS) to estimate the impacts of energy efficiency standards on electric utilities and the environment. The NEMS model simulates the energy sector of the U.S. economy. The version of NEMS used for appliance standards analysis is called NEMS–BT (BT stands for DOE's Building Technologies Program), and is based on the *AEO2013* version of NEMS with minor modifications.[23] The NEMS–BT accounts for the interactions between the various energy supply and demand sectors and the economy as a whole. For more information on NEMS, refer to *The National Energy Modeling System: An Overview,* DOE/EIA–0581 (98) (Feb. 1998), available at: *tonto.eia.doe.gov/FTPROOT/forecasting/058198.pdf.*

As a basis for this final rule, DOE has continued to use the approaches explained in the NOPR. DOE used the same general methodology as applied in the NOPR, but revised some of the assumptions and inputs for the final rule in response to public comments. The following sections discuss these revisions.

A. Market and Technology Assessment

1. General

When completing an energy conservation standards rulemaking, DOE develops information that provides an overall picture of the market for the equipment concerned, including the purpose of the equipment, the industry structure, and the market characteristics. This activity includes both quantitative and qualitative assessments based on publicly available information. The subjects addressed in the market and technology assessment for this rulemaking include: equipment classes and manufacturers; historical

[23] The EIA does not approve use of the name ''NEMS'' unless it describes an *AEO* version of the model without any modification to code or data. Because the present analysis entails some minor code modifications and runs the model under various policy scenarios that deviate from *AEO* assumptions, the name ''NEMS–BT'' refers to the model as used here.

shipments; market trends; regulatory and non-regulatory programs; and technologies or design options that could improve the energy efficiency of the equipment under examination. See chapter 3 of the final rule TSD for further discussion of the market and technology assessment.

2. Equipment Classes

When evaluating and establishing energy conservation standards, DOE divides covered equipment into equipment 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 customer of the feature and other factors DOE determines are appropriate. (42 U.S.C. 6295(q)) DOE then considers separate standard levels for each equipment class based on the criteria set forth in 42 U.S.C. 6295(o). In the NOPR, DOE proposed to divide equipment classes by input voltage, rated lamp wattage, and designation for indoor versus outdoor applications.

a. Input Voltage

MHLFs are available in a variety of input voltages (most commonly 120 V, 208 V, 240 V, 277 V, and 480 V), and the majority of fixtures are equipped with ballasts that are capable of operating at multiple input voltages (for example, quad-input-voltage ballasts are able to operate at 120 V, 208 V, 240 V, and 277 V). DOE determined that input voltage represents a feature affecting consumer utility as certain applications demand specific input voltages. DOE's ballast testing did not indicate a prevailing relationship (*e.g.,* higher voltages are not always more efficient) between discrete input voltages and ballast efficiencies, with one exception. In the NOPR, DOE found that ballasts tested at 480 V were less efficient on average than ballasts tested at 120 V or 277 V.

As discussed in section IV.A of this final rule, MH ballasts will be tested at a single input voltage based on the lamp wattage operated by the ballast. Ballasts that operate lamps less than 150 W shall be tested at 120 V, and all others shall be tested at 277 V, unless the ballast is incapable of operating at the specified input voltage; in that case, the ballast shall be tested at the highest input voltage possible. Because dedicated 480 V ballasts have a distinct utility in that certain applications require 480 V operation and a difference in efficiency relative to ballasts tested at 120 V and 277 V, in the NOPR DOE proposed separate equipment classes for ballasts tested at 480 V (in accordance with the test procedure).

Philips noted that when manufacturing multi-tap magnetic ballasts, each tap must be precisely placed. The voltage variation in each tap makes it more difficult for multi-tap ballasts to meet efficiency requirements than ballasts with dedicated voltage. (Philips, Public Meeting Transcript, No. 48 at p. 99) NEMA, ULT, and Southern Company supported a separate equipment class for dedicated 480 V ballasts. (NEMA, No. 56 at p. 12; ULT, No. 50 at p. 5; Southern Company, No. 64 at p. 2)

DOE acknowledges that the existence of multiple voltage taps could cause multi-tap ballasts to be less efficient than dedicated voltage ballasts. However, DOE's testing of commercially available ballasts did not identify this trend. Rather, DOE's test results indicated that the only obvious relationship between input voltage and ballast efficiency is that ballasts tested at 480 V were less efficient on average than ballasts tested at 120 V or 277 V. As stated above, DOE believes that input voltage offers unique utility because certain applications require specific input voltages. Therefore, in this final rule, DOE creates a separate equipment class for ballasts that are tested at 480 V.

b. Lamp Wattage

As lamp wattage increases, lamp-and-ballast systems generally produce increasing amounts of light (lumens). Because certain applications require more light than others, wattage often varies by application. For example, low-wattage (less than 150 W) lamps are typically used in commercial applications for general lighting. Medium-wattage (150 W–500 W) lamps are commonly used in warehouse, street, and general commercial lighting. High-wattage (greater than 500 W) lamps are used in searchlights, stadiums, and other applications that require powerful white light. Because different applications require different amounts of light and the light output of lamp-and-ballast systems is typically reflected by the wattage, wattage affects consumer utility. Additionally, the wattage of a lamp operated by a ballast is correlated with the ballast efficiency; ballast efficiency generally increases as lamp wattage increase. Because wattage affects consumer utility and has a strong correlation to efficiency, DOE determined in the NOPR that separate equipment classes based on wattage were warranted.

DOE found that even within a designated wattage range (such as 101 W–150 W), the potential efficiencies ballasts can achieve is not constant, but rather varies with wattage. Thus for certain wattage bins, instead of setting a constant efficiency standard, DOE used an equation-based energy conservation standard (see section V.C). DOE combined the wattage bins and equations rather than using a single equation spanning all covered wattages for two reasons. First, the range of ballast efficiencies considered can differ significantly by lamp wattage, making it difficult to construct a single continuous equation for ballast efficiency from 50 W to 2000 W. This efficiency difference can be attributed to the varying cost of increasing ballast efficiency for different wattages and the impact of legislated (EISA 2007) standards that affect only some wattage ranges. Second, different wattages often serve different applications and have unique cost-efficiency relationships. Analyzing certain wattage ranges as separate equipment classes allows DOE to establish the energy conservation standards that are cost-effective for every wattage.

In the NOPR, DOE proposed to define MHLF equipment classes by the following rated lamp wattage ranges: 50 W–100 W, 101 W–150 W, 150 W–250 W, 251 W–500 W, and 501 W–2000 W.[24] As discussed previously in section III.A.1, there is an existing EISA 2007 exemption for ballasts rated for only 150 W lamps, used in wet locations, and that operate in ambient air temperatures higher than 50 °C. This exemption has led to a difference in the commercially available efficiencies for ballasts that are contained within fixtures exempted versus not exempted from EISA 2007. The exempted fixtures have ballasts with a range of efficiencies similar to ballasts that operate lamps less than 150 W. Fixtures not exempted by EISA 2007 have ballasts that follow efficiency trends representative of ballasts greater than 150 W. As a result, DOE proposed that 150 W MHLFs previously exempted by EISA 2007 be included in the 101 W–150 W range, while 150 W MHLFs subject to EISA 2007 standards continue to be included in the 150 W–250 W range.

[24] DOE uses this shorthand to refer to MHLFs designed to operate lamps rated at equal to or greater than 50 W and equal to or less than 100 W, greater than 100 W and less than 150 W (however, including MHLFs designed to operate lamps rated at 150 W and exempted from EISA 2007), equal to or greater than 150 W and less than or equal to 250 W, greater than 250 W and less than or equal to 500 W, and greater than 500 W and less than or equal to 2000 W, respectively.

ULT and NEMA stated that industry data shows ballast losses are significantly higher in 150 W ballasts relative to 175 W to 500 W ballasts due to the increased lamp current in 150 W MHLFs. (ULT, Public Meeting Transcript, No. 48 at p. 108; ULT, No. 50 at pp. 5–6, 23; NEMA, No. 56 at p. 13) ULT explained that for 150 W–175 W fixtures, the lower the wattage, the larger the ballast needed to maintain efficiency. ULT noted that this relationship is the net effect of three main factors: (1) Higher lamp current, (2) increased impedance, and (3) decreased wire cross-section. In conjunction, these factors make it impossible to have an 88 percent efficient 150 W ballast on a 3.25 inch by 3.75 inch (commonly referred to as a ''3x4'') frame. (ULT, No. 50 at pp. 23–24) ULT believed that 150 W fixtures could belong to the lower wattage bin; otherwise, the proposed standards would result in a ban of magnetic autotransformer 150 W ballasts. (ULT, No. 50 at p. 5)

DOE agrees with ULT and NEMA that 150 W ballasts have a lower maximum achievable efficiency relative to 175 W ballasts because of the resistive losses characteristic to ballasts at 150 W. Commercially, DOE also found that 150 W ballasts have a range of efficiencies similar to wattages below 150 W. Both of these trends support 150 W fixtures being categorized in separate equipment classes than 175 W fixtures. While DOE continues to group 150 W fixtures covered by EISA 2007 in the 150 W–250 W equipment class, in this final rule DOE maintains the NOPR approach to group 150 W fixtures previously exempt by EISA 2007 in the 101 W–150 W equipment class.

NEMA proposed that DOE establish a separate equipment class for 575 W ballasts but did not provide supporting detail for this proposal. (NEMA, No. 56 at p. 17) DOE examined the efficiency distribution of 575 W ballasts and found that efficiency varied in a manner similar to that of other ballasts within the 500 W to 1000 W wattage range. DOE is unaware of significant differences in the cost-efficiency relationship, consumer utility, or application of 575W fixtures relative to 1000 W fixtures, and therefore is not establishing a separate equipment class for these MHLFs. DOE continues to group all 501 W–1000 W MHLFs in one wattage bin, using 1000 W fixtures as representative of the entire class.

Musco Lighting disagreed with the grouping of fixtures in the 501 W–2000 W range. Musco Lighting stated that there are significant differences between the markets and applications of 1500 W and 1000 W MHLFs, and, accordingly, they should not be grouped together. (Musco Lighting, Public Meeting Transcript, No. 48 at p. 107) Musco Lighting commented that 1500 W fixtures should not be in the same equipment class as 1000 W fixtures. Musco Lighting commented that a majority of 1500 W fixtures operate at 480 V input, which distinguishes them from other equipment classes. (Musco Lighting, Public Meeting Transcript, No. 48 at p. 129) Musco Lighting further commented that annual operating hours should be taken into account so that MHLFs used in applications with very different operating hours would not be included in the same equipment class. Musco Lighting gave the example of sports lighting having much fewer operating hours than indoor warehouse lighting. (Musco Lighting, Public Meeting Transcript, No. 48 at p. 161)

Upon further review, DOE agrees that there are differences between 1500 W and 1000 W fixtures. DOE determined that the trend between increasing wattage and increasing efficiency found from 501 W–1000 W did not continue above 1000 W. DOE found that above 1000 W, efficiency increased to a lesser extent with increased wattage. This is consistent with the NOPR analysis, in which different equations were used above and below 1000 W. DOE also found that lamp lifetime and annual operating hours are much shorter for 1500 W fixtures relative to 1000 W fixtures because 1500 W fixtures are predominantly used in sports lighting. This causes 1500 W fixtures to have different cost-efficiency relationships relative to 1000 W fixtures. There is also a different cost-efficiency relationship based on the MSP of the fixtures themselves, representing a different portfolio of applications used from 501–1000 W and above 1000 W. Therefore, DOE determined that separate equipment classes should be established for 501 W–1000 W and 1001 W–2000 W fixtures.[25]

In summary, DOE established MHLF equipment classes by the following rated lamp wattage bins: 50 W–100 W, 101 W–150 W, 150 W–250 W, 251 W–500 W, 501 W–1000 W, and 1001 W–2000 W. DOE maintained that 150 W fixtures previously exempted by EISA 2007 are included in the 101 W–150 W range, while 150 W fixtures subject to EISA 2007 standards are included in the 150 W–250 W range.

c. Fixture Application

MHLFs are used in a variety of applications such as parking lots, roadways, warehouses, big-box retail, and flood lighting. Although the fixture size, shape, and optics are often tailored to the application, generally the same type of ballast is utilized for most of the applications. DOE found in the NOPR, however, that indoor and outdoor MHLFs are subject to separate cost-efficiency relationships, specifically at the electronic ballast levels.

As outdoor applications can be subject to large voltage transients, MHLFs in such applications require 10 kV voltage transient protection. Magnetic MH ballasts are typically resistant to voltage variations of this magnitude, while electronic MH ballasts are generally not as resilient. Therefore, in order to meet this requirement, electronic ballasts in outdoor MHLFs would need either (1) an external surge protection device or (2) internal transient protection of the ballast using metal-oxide varistors (MOVs) in conjunction with other inductors and capacitors.

DOE also noted that indoor fixtures can require the inclusion of a 120 V auxiliary tap. This output is used to operate an emergency incandescent lamp after a temporary loss of power while the MH lamp is still too hot to restart. These taps are generally required for only one out of every ten indoor lamp fixtures. A 120 V tap is easily incorporated into a magnetic ballast due to its traditional core and coil design, and incurs a negligible incremental cost. Electronic ballasts, though, require additional design to add this 120 V auxiliary power functionality.

These added features impose an incremental cost to the ballast or fixture (further discussed in section V.C.12 of this notice). As these incremental costs could affect the cost-effectiveness of fixtures for indoor versus outdoor applications, in the NOPR DOE proposed separate equipment classes for indoor and outdoor fixtures.

DOE proposed that outdoor fixtures be defined as those that (1) are rated for use in wet locations and (2) have 10 kV of voltage transient protection. DOE proposed to define the wet location rating as specified by the National Fire Protection Association (NFPA) 70–2002,[26] section 410.10(A) or UL 1598

[25] DOE uses this shorthand to refer to MHLFs designed to operate with lamps rated at greater than 500 W and less than or equal to 1000 W, and greater than 1000 W and less than or equal to 2000 W, respectively.

[26] The NFPA 70–2002 states that fixtures installed in wet or damp locations shall be installed such that water cannot enter or accumulate in wiring components, lampholders, or other electrical parts. All fixtures installed in wet locations shall be marked, ''Suitable for Wet Locations.'' All fixtures installed in damp locations shall be marked

Continued

Wet Location Listed.[27] Providing two possible definitions will reduce the compliance burden as many manufacturers are already familiar with one or both of these ratings (the NFPA 70–2002 definition was included in EISA 2007 and both are used in California energy efficiency regulations). For 10 kV voltage transient protection, DOE proposed to use the 10 kV voltage pulse withstand requirement from ANSI C136.2–2004.

APPA agreed with separating equipment classes for indoor and outdoor fixtures, as they have separate uses that create differences in the frequency and length of use. APPA stated that because the circumstances are different when considering both classes, it is difficult to understand the effects of proposed efficiency standards on each group. (APPA, No. 51 at p. 4; APPA, Public Meeting Transcript, No. 48 at p. 103) Conversely, NEMA noted that separate equipment classes for indoor and outdoor fixtures could be problematic as, at the ballast level, there is no way of knowing whether equipment will be used indoors or outdoors. (NEMA, No. 56 at p. 14) Acuity Brands Lighting, Inc. (Acuity) commented that fixture application should also take into account the probability of transient voltages and extreme conditions, even in indoor applications. (Acuity, Public Meeting Transcript, No. 48 at p. 162) NEMA and ULT suggested combining indoor and outdoor equipment classes, except for electronic ballasts, as fewer classes will mean fewer reporting requirements. NEMA acknowledged that this will conflict with DOE's desire to encourage electronic ballasts in outdoor applications. (NEMA, No. 56 at p. 9; ULT, No. 50 at p. 4)

DOE believes that indoor and outdoor MHLFs should be placed into separate equipment classes. While the efficiencies achievable indoors and outdoors are the same, the different costs between indoor and outdoor fixtures result in different cost-efficiency curves. When electronic ballasts are used in outdoor applications, they require additional transient protection because of the potential for voltage surges in outdoor locations. Indoor fixtures with electronic ballasts also have an added cost to provide 120 V auxiliary power functionality for use in the event of a power outage. Both of these cost adders are discussed in more detail in section V.C.12. As these costs adders differ based on a fixture being used indoors or outdoors, the cost-efficiency relationships differ based on indoor or outdoor application, and therefore separate equipment classes are warranted. Thus, in this final rule DOE establishes separate equipment classes for indoor and outdoor fixtures. DOE defines outdoor fixtures as those that (1) are rated for use in wet locations and (2) have 10 kV of voltage transient protection. Conversely, fixtures that do not meet these requirements will be defined as indoor fixtures. DOE continues to use the wet location rating definition from the National Fire Protection Association 70–2002, section 410.10(A) or UL 1598 Wet Location listing.

d. Electronic Configuration

Of the two MH ballast types (electronic and magnetic), magnetic ballasts are currently more common, making up more than 90 percent of MH ballast shipments. Magnetic ballasts typically use transformer-like copper or aluminum windings on a steel or iron core. The newer electronic ballasts, which are more efficient but less common, rely on integrated circuits, switches, and capacitors or inductors to control current and voltage to the lamp. Both electronic and magnetic ballasts are capable of producing the same light output and, with certain modifications (*e.g.,* thermal management, transient protection, 120 V auxiliary power functionality), can be used interchangeably in all applications. In the NOPR, DOE concluded that electronic configuration and circuit type do not affect consumer utility. With the necessary design alterations, electronic ballasts can provide the same utility as any magnetic ballast circuit type. Because electronic ballasts are typically more efficient than magnetic ballasts, utility is not lost with increasing efficiency. Therefore, DOE did not propose to define equipment classes based on electronic configuration.

ULT stated that electronic HID ballasts were originally intended for indoor, niche purposes. Therefore, automatically expecting that electronic MH ballasts would be able to perform in outdoor conditions, including applications subjected to wind, extreme temperature, and transient surges, is not reasonable. ULT noted that electronic ballasts' vulnerability in outdoor applications is known throughout the industry. (ULT, Public Meeting Transcript, No. 48 at p. 52)

NEMA also disagreed with DOE not dividing equipment classes by electronic configuration. NEMA stated that performance requirements should be separated for electronic and magnetic ballasts to avoid an enormous burden on the industry. (NEMA, No. 56 at p. 12, 24) NEMA commented that they disagreed with DOE's suggestion that an electronic ballast is a design option for a magnetic ballast, as they are completely different technologies. (NEMA, No. 56 at p. 14).

DOE has determined that these electronic ballasts, when fitted in an appropriate fixture, can be used in the same applications as magnetic ballasts. As mentioned in the previous section, various protections will be required for electronic ballasts in these applications. See section V.C.8.b for more detail about the feasibility of electronic ballasts as more efficient replacements for magnetic ballasts. After adjusting outdoor fixture prices to account for the modifications necessary to incorporate electronic ballasts, DOE has found that electronic ballasts can be reliably used in the same outdoor applications as magnetic ballasts. Therefore, DOE did not find that magnetic ballasts provided a unique utility over electronic ballasts. Thus, in this final rule, DOE included electronic and magnetic ballasts in the same equipment class.

e. Circuit Type

NEMA disagreed with DOE not dividing equipment classes by circuit type, citing the fluorescent lamp ballast rule as precedent. (NEMA, No. 56 at pp. 12, 24) ULT and NEMA proposed three different technology classes; magnetic series reactors, magnetic autotransformers, and electronic. (ULT, No. 50 at p. 5; NEMA, No. 44 at p. 17) NEMA explained the need for dividing equipment classes in this way by describing the technologies' different utilities and relationships to efficiency. Specifically, NEMA stated that series reactors circuits are the most efficient, although they do not offer any power regulation. Power factor correction is weak with this ballast type, and high power factor increases total harmonic distortion. This circuit type only works for lamps that require an open circuit voltage lower than the mains. It results in an increased inrush and current, and reduced maximum number of lamps per circuit. (NEMA, No. 44 at p. 18) Autotransformer ballasts may be used on various mains voltages, and the ballast open circuit voltage may be higher than the mains voltage. Constant-wattage autotransformer (CWA) designs

''Suitable for Wet Locations'' or ''Suitable for Damp Locations.''

[27] UL Standard Publication 1598 defines a wet location is one in which water or other liquid can drip, splash, or flow on or against electrical equipment. A wet location fixture shall be constructed to prevent the accumulation of water on live parts, electrical components, or conductors not identified for use in contact with water. A fixture that permits water to enter the fixture shall be provided with a drain hole.

include a secondary coil and operate with lower harmonic distortion. They offer better power regulation than series reactors and are highly reliable. (NEMA, No. 44 at p. 19) Electronic circuits are typically less reliable than autotransformer circuits, but operate with similar energy efficiency to series reactors. (NEMA, No. 44 at p. 20)

DOE agrees that within magnetic ballasts there are multiple circuit types, such as reactor and autotransformer. However, DOE has found that electronic ballasts can provide the same utility as any magnetic circuit type and can be substituted in all applications, while being generally more efficient than all magnetic ballasts. DOE also notes that all of the magnetic ELs in this final rule are determined by autotransformer magnetic ballasts, as autotransformer ballasts are the most common type on the market. Because reactor ballasts are typically more efficient than autotransformer ballasts, DOE found that setting a magnetic ballast EL based on autotransformer efficiency would not prohibit reactor ballasts. For these reasons, DOE did not find it necessary in this final rule to separate equipment classes by circuit type.

f. Summary

DOE developed equipment classes in this final rule using three class-setting factors: input voltage, rated lamp wattage, and fixture application. DOE presents the resulting equipment classes in Table V.1

TABLE V.1—MHLF EQUIPMENT CLASSES TABLE

Designed to be operated with lamps of the following rated lamp wattage	Indoor/outdoor †	Input voltage type‡
≥50 W and ≤100 W	Indoor	Tested at 480 V.
≥50 W and ≤100 W	Indoor	All others.
≥50 W and ≤100 W	Outdoor	Tested at 480 V.
≥50 W and ≤100 W	Outdoor	All others.
>100 W and <150 W *	Indoor	Tested at 480 V.
>100 W and <150 W *	Indoor	All others.
>100 W and <150 W *	Outdoor	Tested at 480 V.
>100 W and <150 W *	Outdoor	All others.
≥150 W ** and ≤250 W	Indoor	Tested at 480 V.
≥150 W ** and ≤250 W	Indoor	All others.
≥150 W ** and ≤250 W	Outdoor	Tested at 480 V.
≥150 W ** and ≤250 W	Outdoor	All others.
>250 W and ≤500 W	Indoor	Tested at 480 V.
>250 W and ≤500 W	Indoor	All others.
>250 W and ≤500 W	Outdoor	Tested at 480 V.
>250 W and ≤500 W	Outdoor	All others.
>500 W and ≤1000 W	Indoor	Tested at 480 V.
>500 W and ≤1000 W	Indoor	All others.
>500 W and ≤1000 W	Outdoor	Tested at 480 V.
>500 W and ≤1000 W	Outdoor	All others.
>1000 W and ≤2000 W	Indoor	Tested at 480 V.
>1000 W and ≤2000 W	Indoor	All others.
>1000 W and ≤2000 W	Outdoor	Tested at 480 V.
>1000 W and ≤2000 W	Outdoor	All others.

* Includes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A);); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

** Excludes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A);); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

† DOE's proposed definitions for ''indoor'' and ''outdoor'' MHLFs are described in section V.A.2.c.

‡ Input voltage for testing would be specified by the test procedures. Ballasts rated to operate lamps less than 150 W would be tested at 120 V, and ballasts rated to operate lamps ≥150 W would be tested at 277 V. Ballasts not designed to operate at either of these voltages would be tested at the highest voltage the ballast is designed to operate. See section IV.A for further detail.

B. Screening Analysis

For the screening analysis, DOE consults with industry, technical experts, and other interested parties to determine which technology options to consider further and which to screen out. Appendix A to subpart C of 10 CFR Part 430, ''Procedures, Interpretations, and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products'' (the Process Rule), sets forth procedures to guide DOE in its consideration and promulgation of new or revised energy conservation standards. These procedures elaborate on the statutory criteria provided in 42 U.S.C. 6295(o) and, in part, eliminate problematic technologies early in the process of prescribing or amending an energy conservation standard. In particular, sections 4(b)(4) and 5(b) of the Process Rule provide guidance to DOE for determining which design options are unsuitable for further consideration:

Technological feasibility. DOE will consider technologies incorporated in commercial products or in working prototypes to be technologically feasible.

Practicability to manufacture, install, and service. If mass production and reliable installation and servicing of a technology in commercial products 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 would have significant adverse impacts on the utility of the product to significant subgroups of consumers, or would result in the unavailability of any covered equipment type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as equipment generally available in the United States at the time, it will not consider this technology further.

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

In the NOPR, DOE screened out one technology option: laminated sheets of amorphous steel. For magnetic metal halide ballasts, DOE found one method of decreasing transformer losses is to create the core of the inductor from laminated sheets of amorphous steel, insulated from each other. DOE screened out amorphous steel technology because it failed to pass the ''practicable to manufacture, install, and service'' criterion, and using amorphous steel could have adverse impacts on consumer utility because increasing the size and weight of the ballast may limit the places a customer could use the ballast. DOE received no comments to the contrary, and thus continues to screen out amorphous steel in the final rule.

DOE identified the design options listed in Table V.2 as technologies that could improve MHLF ballast efficiency and pass the screening criteria discussed above. For further details on these design options, see chapter 3 of the final rule TSD.

TABLE V.2—METAL HALIDE LAMP FIXTURE DESIGN OPTIONS

Ballast type	Design option		Description
Magnetic	Improved Core Steel		Use a higher grade of electrical steel, including grain-oriented silicon steel, to lower core losses.
	Copper Wiring		Use copper wiring in place of aluminum wiring to lower resistive losses.
	Increased Stack Height		Add steel laminations to lower core losses.
	Increased Conductor Cross Section		Increase conductor cross section to lower winding losses.
	Electronic Ballast		Replace magnetic ballasts with electronic ballasts.
Electronic	Improved Components.	Magnetics	Use grain-oriented or amorphous electrical steel to reduce core losses.
			Use optimized-gauge copper or litz wire to reduce winding losses.
			Add steel laminations to lower core losses.
			Increase conductor cross section to lower winding losses.
		Diodes	Use diodes with lower losses.
		Capacitors	Use capacitors with a lower effective series resistance and output capacitance.
		Transistors	Use transistors with lower drain-to-source resistance.
	Improved Circuit Design.	Integrated Circuits.	Substitute discrete components with an integrated circuit.

C. Engineering Analysis

1. Approach

The engineering analysis develops cost-efficiency relationships depicting the manufacturing costs of achieving increased ballast efficiency. DOE applies two methodologies to estimate manufacturing costs for the engineering analysis: (1) The design-option approach, which provides the incremental costs of adding the design options discussed in section V.B of this notice to improve the efficiency of a baseline model; and (2) the efficiency-level approach, which estimates the costs of achieving increases in ELs through ballast efficiency testing, manufacturer catalogs, and teardowns. Details of the engineering analysis are in chapter 5 of the final rule TSD. The following discussion summarizes the general steps of the engineering analysis:

Determine Representative Equipment Classes. When multiple equipment classes exist, to streamline testing and analysis, DOE selects certain classes as ''representative,'' primarily because of their high market volumes. DOE then scales the ELs from representative equipment classes to those equipment classes it does not analyze directly.

Determine Representative Wattages. Within each representative equipment class, DOE also selects a particular wattage fixture as ''representative'' of the wattage range, primarily because of their high market volumes. In this final rule, DOE assigns only one representative wattage per representative equipment class.

Representative Fixture Types. To calculate the typical cost of a fixture at each representative wattage, DOE selects certain types of fixtures to analyze as representative.

Select Baseline Units. DOE establishes a baseline unit for each representative wattage. The baseline unit has attributes (circuit type, input voltage capability, electronic configuration) typical of ballasts used in fixtures of that wattage. The baseline unit also has the lowest (baseline) efficiency for each representative wattage. DOE measures changes resulting from potential amended energy conservation standards compared with this baseline. For fixtures subject to existing federal energy conservation standards, a baseline unit is a MHLF with a commercially available ballast that just meets existing standards. If no standard exists for a fixture, the baseline unit is the MHLF at a representative wattage with a ballast with the lowest tested ballast efficiency that is sold. To determine energy savings and changes in price, DOE compares each higher EL with the baseline unit.

To determine the ballast efficiency, DOE tested a range of MH ballasts from multiple ballast manufacturers. In some cases, when test data was unavailable, DOE used efficiency values listed in manufacturer catalog data sheets. Appendix 5A of the final rule TSD presents the test results. When necessary, DOE selects more than one baseline for a representative wattage to ensure consideration of different fixture and ballast types and their associated customer economics.

Select More-Efficient Units. DOE selected both commercially available MHLFs and modeled MHLFs with higher-than-baseline-efficiency ballasts as replacements for each baseline model in each representative equipment class. In general, DOE can identify the design options associated with each more-efficient ballast model by considering the design options that meet the criteria of the screening analysis (chapter 4 of the final rule TSD). For electronic ballasts, where design options cannot be identified for that class by the product number or catalog description, DOE conducts testing to determine their efficiency. Appendix 5A of the final rule TSD presents these test results. These ballast efficiencies were calculated according to the MH ballast test procedures (10 CFR 431.324), unless otherwise specified. DOE estimates the design options likely to be used to achieve a higher efficiency based on information gathered during manufacturer interviews and information presented in ballast catalogs.

Determine Efficiency Levels. DOE develops ELs based on: (1) The design options associated with the equipment class studied and (2) the max-tech EL for that class. As previously noted and as discussed in section IV.B.2, DOE's ELs are based on test data collected from commercially available equipment, catalog data, manufacturer input, and ballast modeling.

Conduct Price Analysis. DOE generated a bill of material (BOM) by disassembling multiple manufacturers' ballasts from a range of ELs and fixtures that span a range of applications for each equipment class. The BOMs describe the equipment in detail, including all manufacturing steps required to make and assemble each part. DOE then developed a cost model to convert the BOMs for each representative unit into manufacturer production costs (MPCs). By applying derived manufacturer markups to the MPCs, DOE calculated the MSPs [28] and constructed industry cost-efficiency curves. In cases where DOE was not able to generate a BOM for a given ballast, DOE estimated an MSP based on the relationship between teardown data and retail data. DOE also estimated ballast and fixture cost adders necessary to allow replacement of more-efficient substitutes for baseline models.

2. Representative Equipment Classes

As described in the previous section, DOE selects certain equipment classes as "representative" to focus its analysis. The 24 equipment classes (based on rated lamp wattage, indoor or outdoor designation, and test voltage) and the criteria used for development are presented in section V.A.2. Due to their low shipment volume (as indicated through manufacturer interviews), DOE does not directly analyze the equipment classes containing only fixtures with ballasts tested at 480 V. DOE selected all other equipment classes as representative, resulting in a total of 12 representative classes that cover the full range of lamp wattages, as well as indoor and outdoor designations. DOE had only analyzed 10 representative equipment classes in the NOPR. This increase is a result of DOE's decision to split the 501 W–2000 W equipment classes into 501 W–1000 W and 1001 W–2000 W. This new equipment class structure is discussed in section V.A.2.

3. Representative Wattages

In the NOPR, DOE selected five representative wattages of MHLFs (70 W, 150 W, 250 W, 400 W, and 1000 W) to analyze in the engineering analysis. Each representative wattage was typically the most commonly sold wattage within each equipment class, based on analysis of fixture availability from catalogs and manufacturer input.

As discussed in section V.A.2, DOE has split the 501 W–2000 W equipment classes from the NOPR into 501 W–1000 W and 1001 W–2000 W in the final rule. From 501 W–1000 W, DOE still finds 1000 W to be an appropriate representative wattage based on it being the most commonly sold. In the final rule, DOE is analyzing 1500 W as the representative wattage for the 1001 W–2000 W equipment classes based on this wattage being the most commonly shipped in the wattage range.

4. Representative Fixture Types

After selecting representative wattages for analysis, DOE identified the applications commonly served by each equipment class's wattage range in order to select representative fixture types. DOE recognizes that technological changes in the ballast caused by standards considered in this rulemaking, especially moving from magnetic ballasts to electronic ballasts, could necessitate alterations to the fixture. These changes often incur additional costs depending on the fixture type that needs to be altered. In the engineering analysis, DOE estimates a baseline fixture cost, as well as incremental costs to the fixture based on the type of ballast used (*e.g.,* electronic ballasts require specific fixture adaptations that magnetic ballasts do not). The cost adders to the fixtures are discussed in section V.C.12.

In the NOPR, DOE selected one to three representative fixture types for each rated wattage range based on the most common application(s) within that range. For the 50 W–100 W range, DOE selected canopy fixtures as the representative fixture types. For the 101 W–150 W and 150 W–250 W range, DOE selected canopy, low bay, and wallpack fixtures as representative fixture types. For wattages greater than 250 W, DOE chose canopy, flood, and high bay fixtures as representative fixture types.[29]

In this final rule, DOE has expanded its analysis of representative fixtures to account for separate uses in indoor and outdoor applications. This allows DOE to develop separate prices for indoor and outdoor fixtures, taking into account the weather protection built into outdoor fixtures. The new representative fixture types, which include from one to four applications for each equipment class, are shown in Table V.3.

TABLE V.3—REPRESENTATIVE WATTAGES AND FIXTURES

Designed to be operated with lamps of the following rated lamp wattage	Representative wattage	Representative fixture types	
		Indoor	Outdoor
≥50 W and ≤100 W	70 W	Recessed Can	Wallpack, Post Top, Flood.
>100 W and <150 W *	150 W	Low Bay	Parking Lot, Area, Wallpack, Flood.
≥150 W and ≤250 W **	250 W	Low Bay	Area, Flood, Wallpack.
>250 W and ≤500 W	400 W	Flood, High Bay	Pole Top, Flood.
>500 W and ≤1000 W	1000 W	High Bay	Flood, Sports.
>1000 W and ≤2000 W	1500 W	Sports	Sports.

* Includes 150 W fixtures exempted by EISA 2007, which are fixtures rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

[28] The MSP is the price at which the manufacturer can recover all production and non-production costs and earn a profit. Non-production costs include selling, general, and administration (SG&A) costs, the cost of R&D, and interest.

[29] Descriptions of each of these fixtures types can be found in chapter 3 of the final rule TSD.

** Excludes 150 W fixtures exempted by EISA 2007, which are fixtures rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

5. Ballast Efficiency Testing

After selecting representative wattages and fixture types, DOE purchased and tested MH ballasts, ranging from low-efficiency magnetic to high-efficiency electronic, in order to evaluate the range of commercially available ballast efficiencies. In selecting units for testing and analysis, DOE focused its effort on representative wattage ballasts with operating characteristics similar to ballasts most prevalent in the market. For example, through interviews and an assessment of commercially available MH ballasts, DOE learned that the majority of MH ballasts sold are quad-input voltage ballasts. Thus, DOE primarily tested MH ballasts capable of quad-input operation. Similarly, DOE found that at low wattages (less than or equal to 150 W), high-reactance autotransformer (HX) ballasts and CWA ballasts are most prevalent. At higher wattages, CWA ballasts compose the vast majority of the market. In consideration of these findings, DOE focused its testing and analysis on HX and CWA ballasts for the 70 W to 150 W range and CWA ballasts for all other wattage units.

DOE calculated average ballast efficiencies, across four samples, in accordance with MH ballast test procedures (10 CFR 431.324) by dividing measured output power by measured input power. As discussed in sections V.C.7 and V.C.8 of this notice, DOE selects baseline and higher-efficiency representative units for analysis based on these average efficiencies. Also, as discussed in the following section, DOE determines representative ballast input power for each EL based on these tested ballast efficiencies. To determine the ELs under consideration, as discussed in section V.C.9 of this notice, DOE uses a reported efficiency value based on the four tested samples, pursuant to the MH ballast certification procedures in 10 CFR 429.54.

6. Input Power Representations

As MH lamps age, they exhibit higher voltages, which can lead to higher system input power over the life of the lamp. Electronic ballasts have the capability to sense that the lamp voltage has increased and, in response, decrease their output current to maintain constant wattage throughout the life of the ballast. In the NOPR, DOE noted that magnetic ballasts do not have this capability and therefore the system wattage of magnetic MH ballasts would increase in response to an increase in lamp voltage over the lamp life. Therefore, DOE used a 5.5 percent increase in the NOPR when calculating the representative input power of magnetic ballasts.

Venture, NEMA, and ULT commented that while there is a voltage rise over the life of MH lamps, it can be extremely variable based on lamp design and manufacturing tolerances. Venture cautioned against applying a single factor to increase power across all ballasts. (Venture, Public Meeting Transcript, No. 48 at p. 178; NEMA, No. 56 at p. 15; ULT, No. 50 at pp. 8–9) ULT further asserted that DOE did not consider that ballast efficiency increases with a lamp's voltage and age, and also that many lamps have voltage below the nominal level when new. (ULT, No. 50 at pp. 8–9) In contrast, CA IOUs agreed with DOE on the increase in system input power and voltage that occurs over a ballast's life, but remarked that this increase may not be linear, and that the increase is smaller with electronic ballasts than with magnetic ballasts. They suggested that DOE continue to research this area, as the 5.5 percent figure determined could be an underestimation of the advantages of electronic ballasts. (CA IOUs, No. 54 at p. 7)

In the NOPR, DOE's inclusion of a 5.5 percent increase in input power for magnetic ballasts was based on feedback from manufacturers gathered during interviews. After reviewing the NOPR interview feedback in light of the new comments and conducting additional research on this topic, it was unclear whether the input power of magnetic ballasts actually increased over the ballasts' lifetime and, if it did increase, what the magnitude of that increase would be. Therefore, in this final rule DOE has not applied a scaling factor to increase the input power of magnetic ballasts.

7. Baseline Ballast Models

DOE selected baseline models as reference points for each representative equipment class, against which DOE measured changes in energy use and price resulting from potential amended energy conservation standards. For MHLFs and MH ballasts subject to existing federal energy conservation standards, a baseline model is a commercially available ballast that just meets existing standards and provides basic consumer utility. If no standard exists for a specific fixture type (*e.g.,* less than 150 W or greater than 500 W fixtures), DOE chooses baselines that represent the least efficient equipment (based on average tested ballast efficiencies) or highest-volume equipment within the representative parameters defined (*e.g.,* representative wattage, magnetic circuit type, input voltage).

For the NOPR, DOE analyzed a CWA, quad-input voltage, pulse-start baseline ballast for the 70 W, 150 W, 250 W, and 400 W representative wattages. As electronic ballasts comprise a significant portion of the 50 W–100 W ballasts shipped with indoor fixtures, for the 70 W representative wattage DOE analyzed a second baseline ballast utilizing an LFE circuit and operating at quad-voltage. For the 1000 W representative wattage, DOE analyzed a CWA, quad-input voltage, probe-start baseline ballast.

a. 70 W Baseline Ballast

In the NOPR, DOE analyzed an electronic ballast as a second baseline ballast for the 70 W representative wattage. DOE included this second baseline because it had determined that electronic ballasts comprise a significant portion (estimated as more than 25 percent) of the 50 W–100 W ballasts shipped with indoor fixtures. NEMA agreed with the addition of the electronic 70 W baseline ballast. (NEMA, No. 56 at p. 15) Receiving no comments in opposition, DOE has continued analyzing both an electronic and magnetic baseline ballast at 70 W for this final rule.

b. 1000 W Baseline Ballast

In the NOPR, DOE identified a probe-start ballast as the 1000 W baseline unit. While DOE acknowledged that pulse-start ballasts are available at the 1000 W level, it noted that probe-start, CWA, quad-voltage units are predominant in the high-wattage category, and are therefore the most appropriate baselines.

Musco Lighting questioned why a probe-start ballast was used as the 1000 W baseline ballast if this standard is suggesting a shift towards pulse-start in all equipment classes. (Musco Lighting, Public Meeting Transcript, No. 48 at p. 130) As discussed previously, a baseline ballast is the most common, least efficient ballast at the representative wattage, without the imposition of standards (*i.e.,* the base case). The baseline unit is meant to measure changes resulting from potential amended energy conservation standards compared with this baseline. DOE found that while pulse-start ballasts are available at the 1000 W level, probe-start ballasts currently dominate the market. As it is much more common for 1000 W ballasts to be probe-start, DOE continued to analyze a probe-start ballast as the 1000 W baseline unit in this final rule.

c. 1500 W Baseline Ballast

In the NOPR, a 1000 W baseline was analyzed in the 501 W to 2000 W equipment class. In this final rule, DOE divided this wattage range into a 501 W–1000 W equipment class and a 1001 W–2000 W equipment class (see section V.A.2 of this notice). DOE continued to analyze a 1000 W baseline in the 501 W to 1000 W equipment class. In the 1001 W–2000 W equipment class, DOE analyzed the 1500 W wattage as representative. Therefore, DOE added a baseline model at the new representative wattage, 1500 W, to represent the most common, least efficient ballast in the 1001 W–2000 W representative equipment class. The baseline unit for 1500 W is a magnetic CWA ballast and has a ballast efficiency of 92.9 percent.

d. Summary of Baseline Ballasts

In summary, after considering the comments received and changes to the equipment class structure, DOE has selected seven baseline units for analysis: 70 W magnetic, 70 W electronic, 150 W magnetic, 250 W magnetic, 400 W magnetic, 1000 W magnetic, and 1500 W magnetic.

8. Selection of More-Efficient Units

After the selection of baseline models, DOE used a combination of two methods to determine more-efficient units for analysis within each representative equipment class. The first method was examining DOE's own test data (discussed in section V.C.5 of this notice) to select commercially available ballasts to represent higher ELs. The second method involved filling in large gaps of efficiency present in the test data (often between commercially available magnetic and electronic ballasts) by modeling ballasts with improved efficiency due to the implementation of several of the design options described in section V.B of this notice. DOE derived those estimates based on manufacturer interviews and by validating or supplementing that feedback with independent modeling of potential reductions in ballast losses. Specifically, DOE used the watts loss per pound characteristics for various steel types to determine the levels of efficiency modeled ballasts could achieve.

DOE developed a max-tech magnetic ballast based on either commercially available equipment or a modeled ballast that utilized the highest grade steel practicable for manufacturing MH ballasts. For further details on the higher-efficiency units analyzed in this final rule, see chapter 5 of the final rule TSD.

a. Higher-Efficiency Magnetic Ballasts

DOE recognizes that several commercially available magnetic ballasts may already utilize the most efficient design options and have reached their efficiency limit. However, based on feedback from manufacturer interviews, DOE has learned that for each of the representative wattages analyzed, there exist design options to improve efficiency of magnetic ballasts. Therefore, DOE utilizes these design options to estimate the max-tech efficiency for magnetic ballasts for each representative wattage. DOE received a number of comments in response to the NOPR regarding the modeled higher-efficiency magnetic ballasts, specifically regarding the modeling method, performance characteristics of the modeled more-efficient units, and the impacts on fixture and ballast redesign.

Modeling Method

In modeling more-efficient magnetic ballasts for the NOPR, DOE maintained the physical size of the higher-efficiency models relative to commercially available magnetic ballasts within the representative wattages (*i.e.,* the modeled ballasts did not increase in size compared to what's currently available on the market). By using design information provided by manufacturers, DOE assumed improvements to the core steel and conductor of the commercially available magnetic ballasts to determine the higher-efficiency magnetic ballast efficiency and prices.

NEMA explained that core losses are determined by the type of material being used, the most efficient being M6 steel. Wire loss is generated from electrical resistance, and the most efficient wire material used is copper. (NEMA, No. 56 at p. 3) NEMA cited that for EL1 and EL2, the model assumes a higher quality steel will be used than is provided in the baseline unit. (NEMA, No. 56 at p. 10) NEMA and ULT noted that the EL2 calculation appears speculative, and that to move from EL1 to EL2 would require a 17 percent reduction (in the case of 70 W ballasts) in ballast losses, which is unfeasible. (NEMA, No. 56 at p. 10; ULT, No. 50 at pp. 6–7) NEMA commented that DOE underestimated both core steel losses and winding losses, which led to overestimates of feasible efficiencies. (NEMA, No. 56 at p. 11)

Regarding core losses, NEMA and ULT noted that the watts loss per pound of core steel constants DOE provided in the NOPR TSD are correct numbers obtained by an Epstein test [30] per the ASTM A–343 standard. However, NEMA and ULT stated that those numbers would be more appropriate to use for power transformers than for ballasts, and that the values are deceiving when applied directly to ballast core loss calculations. NEMA and ULT gave the example that M6 steel is shown to have 0.66 W/lb losses at 1.5 Tesla 60 Hz sine flux along the grain, when losses across the grain for M6 steel in an MH ballast are approximately 1.2 W/lb. Furthermore, NEMA and ULT explained that when ballast laminations are welded during manufacturing, grain-oriented material degrades substantially, and the losses increase. (NEMA, No. 56 at p. 11; ULT, No. 50 at p. 7) Philips agreed, commenting that the watts per pound loss for M6 steel would more than double during the manufacturing process, limiting the benefit of using this steel. (Philips, Public Meeting Transcript, No. 48 at p. 120) Philips also explained that the increase in M6 core losses is because welding disrupts the magnetic properties of the material. (Philips, Public Meeting Transcript, No. 48 at p. 121) Additionally, NEMA and ULT commented that magnetic flux in MH ballasts is not purely sinusoidal, rather it also includes harmonic frequencies that increase losses. They commented that even relative ratios of the losses provided in the NOPR TSD would not work, because data for grain-oriented steels are found using the 100 percent along the grain Epstein test, while data for cold-rolled steels, such as M19, use the 50 percent Epstein test. This 50/50 Epstein test takes into account and averages losses along the grain and across the grain. Therefore, DOE is not comparing equivalent measurements when simply using the already calculated core loss values presented in the NOPR. (NEMA, No. 56 at p. 11; ULT, No. 50 at p. 7)

In this final rule, DOE has revised its approach to modeling the efficiency of magnetic ballasts. The efficiency of

[30] An Epstein test is a method for evaluating a steel's magnetic properties by testing its performance with a standardized Epstein frame. During the measurement the Epstein frame, comprising a primary and a secondary winding, behaves as an unloaded transformer and the power losses are then measured with a wattmeter.

commercially available ballasts is established by independent test data conducted in accordance with the DOE test procedure, or taken directly from a manufacturer's ballast data sheet when test data was unavailable. Based on feedback obtained during individual manufacturer interviews, DOE assigned design characteristics to these commercially available ballasts. Design characteristics included core steel type, core mass, wire material, and wire mass. To analyze more-efficient ballast designs than those currently on the market, DOE calculated the change in efficiency (*i.e.,* change in ballast losses) resulting from a substitution of steel type.

Regarding the core loss calculations, DOE revised its loss values for M6 steel in response to the comments received. In the NOPR, the losses per pound values for M6 steel were based on alignment of the magnetic field longitudinally (in the same direction as the grain orientation) to the core steel. However, portions of the magnetic field are aligned transverse (perpendicular to the grain orientation) to the core steel. The core losses in the transverse orientation are much higher. For this final rule, DOE calculated a weighted average of longitudinal and transverse losses as the core loss factor for M6 steel and found that about one third of losses are in the transverse direction. Using this information, DOE calculated the average core losses, in W/lb, for M6 steel. See chapter 5 of the final rule TSD for additional detail. With this revision, the M6 loss value is comparable with the conventional cold-rolled steel (such as M19) 50/50 Epstein-test-based loss per pound values.

To calculate the losses associated with an EL2 ballast that uses M6 steel, DOE first calculated the losses of the EL1 ballast of the same wattage, by dividing lamp wattage by ballast efficiency, and then subtracting the lamp wattage. Next, DOE calculated the core losses of the EL1 ballast based on the mass of the EL1 core and the watts per pound loss value associated with the type of steel used in the EL1 ballast. Then, assuming the footprint and stack height cannot change, DOE assumed the EL2 M6 core would have the same mass. DOE therefore multiplied the M6 loss per pound value by the mass of the EL1 core to calculate the losses assuming an M6 steel substitution. DOE assumed all other losses remained constant, and therefore reduced the total EL1 ballast losses by the incremental decrease in core losses associated with the M6 steel. Regarding the 70 W ballasts, this final rule now models an increase in ballast efficiency from 76.6 percent to 78.4 percent, based on the decrease in core losses (and therefore increase in ballast efficiency) from M19 to M6 steel. This is a reduction in losses of 9.1 percent relative to EL1.

Regarding the resistive losses in the windings, NEMA and ULT stated that DOE's assumption that the current in the primary side of the transformer was approximately equal to the input current to the ballast is incorrect. This incorrect assumption would lead to calculated losses substantially lower than actual losses. (NEMA, No. 56 at p. 11; ULT, No. 50 at pp. 7–8) NEMA and ULT pointed out that the current in the secondary coil of the transformer does not need to be estimated, as it is equal to lamp current. (NEMA, No. 56 at p. 11; ULT, No. 50 at p. 8) NEMA and ULT suggested that as lamp current is responsible for winding losses, it should be used as a technical parameter when screening ballast design options. (NEMA, No. 56 at p. 10; ULT, No. 50 at p. 6)

DOE agrees with NEMA and ULT's description of current in various stages of the magnetic ballast. In an HX ballast, the presence of a capacitor in parallel with the primary transformer winding increases the current in the primary winding relative to the input current from the power source. With the secondary winding, the current is equal to the lamp current, which is given in ANSI C78.43–2010. However, for the final rule, modeled ELs are only based on substitution of electrical steel, assuming all else remains equal. Therefore, the comments relating to resistive losses based on current are not applicable to DOE's final rule calculations.

Modeled More-Efficient Units

In the NOPR, DOE used the modeling ballast methodology to calculate the efficiency of ballasts more efficient than those currently available for sale. NEMA, Philips, and ULT stated that 150 W fixtures could not meet the proposed efficiency requirement. (NEMA, Public Meeting Transcript, No. 48 at p. 33; Philips, Public Meeting Transcript, No. 48 at p. 48; ULT, No. 50 at pp. 23–24) ULT commented that an efficiency requirement for 150 W magnetic ballasts higher than currently commercially available equipment would practically ban 150 W magnetic autotransformer ballasts. (ULT, No. 50 at pp. 23–24) NEMA and ULT suggested that DOE made a mistake in considering how magnetic ballast efficiency behaves as a result of design considerations. As ballast wattage decreases, efficiency loss factors are compounded and the ballast size necessary to achieve potential efficiency gains increases, making it difficult to further raise the efficiency of ballasts 150 W and below. (NEMA, No. 56 at p. 3; ULT, No. 50 at pp. 19–24) ULT noted that typically, as lamp wattage decreases, so does lamp current. As 150 W lamps have higher lamp current than 175 W ballasts, it is more difficult for the 150 W ballasts to achieve high efficiencies. ULT noted that this relationship is the net effect of three main factors: (1) Higher current, (2) increased inductance, and (3) wire cross-section. In conjunction, these factors make it impossible to have an 88 percent efficient 150 W magnetic ballast on a 3x4 frame. Hence, the industry has not developed a 150 W MHLF with an 88 percent efficient magnetic autotransformer ballast in response to EISA 2007. (ULT, No. 50 at pp. 23–24) Furthermore, ULT stated that as ballasts ranging from 50 W to 150 W would need to increase in size in order to meet the EL proposed in the NOPR, these ballasts would not fit in the fixtures for which they were previously suitable. (ULT, No. 50 at p. 6) Philips clarified that the increase in size comes from the magnetic ballast stack height. Philips noted there are options for electronic ballasts, but they are not necessarily interchangeable and might be too big for existing fixtures. (Philips, Public Meeting Transcript, No. 48 at p. 50)

DOE notes that the level proposed at 150 W in the NOPR was intended to only be met by electronic ballasts, as are all EL3 and EL4 levels in both the NOPR and this final rule. DOE agrees with ULT that 150 W autotransformer ballasts cannot reach 88 percent efficiency with today's technology. In the NOPR, the magnetic ELs were set at 84.0 percent for EL1 and 86.5 percent for EL2. DOE disagrees that an EL above commercially available equipment would ban 150 W magnetic ballasts, as improving the core steel to M6, even while maintaining the same core footprint and weight, would improve the magnetic ballast efficiency beyond commercially available levels. DOE agrees that 150 W ballasts have a lower maximum achievable efficiency relative to 175 W ballasts, and has analyzed the 150 W fixture exempted by EISA 2007 accordingly. For this final rule, DOE revised the magnetic ballasts analyzed as more efficient replacements for the 150 W representative wattage. DOE selected a more common replacement ballast for EL1. At EL2, revisions in the magnetic ballast modeling resulted in changes to the performance characteristics. In the final rule, as in the NOPR, the ballast efficiencies analyzed at both EL1 and EL2 are less than 88 percent.

APPA and NEMA commented that the modeled magnetic ELs are not technologically feasible, as modeling and calculations are not proof of concept and do not account for variability in manufacturing. (APPA, No. 51 at pp. 7–8; NEMA, No. 56 at pp. 2, 24) NEMA and ULT also commented that the proposed characteristics of the modeled magnetic ballasts are based on theories, but have not been proven in manufacturing or physical testing and are therefore infeasible and cannot be tested for form, fit, or functions compatibility. ULT further asserted that the max-tech magnetic levels would require higher grade steel and wire, and would therefore increase ballast size. (NEMA, No. 56 at p. 11; ULT, No. 50 at pp. 4, 8, 30) In addressing the technological feasibility of the max-tech levels, NEMA stated that most max-tech levels selected for magnetic ballasts are possible only in laboratory conditions, and even then only with electronic ballasts. In cases where magnetic ballasts could reach the EL, they would need to be enlarged, and might not fit in existing fixtures. (NEMA, No. 56 at p. 10) Philips questioned whether a modeled product proves technological feasibility. (Philips, Public Meeting Transcript, No. 48 at p. 214) Philips also questioned whether interviews with manufacturers were enough to constitute an assessment of technological feasibility without actual proof. (Philips, Public Meeting Transcript, No. 48 at p. 215) NEMA stated that many other rulemakings select products of the highest efficiency that are already commercially available, as opposed to modeling something that has not been produced yet. Philips stated that it is unreasonable to think that there would not be other changes required in order to implement the modeled product. (Philips, Public Meeting Transcript, No. 48 at p. 221)

DOE conducted interviews with individual manufacturers for the NOPR analysis and received information through that process describing the design characteristics of ballasts more efficient than those currently in production. DOE then validated that information by calculating the incremental change in losses associated with substituting the electrical steel of a commercially available ballast for a higher grade of steel. While it is true that the ballasts directly analyzed at EL2 are not currently commercially available, the design option (M6 steel) used to create these ballasts is commercially available. M6 steel designs are used for 175 W ballasts with a 3x4 footprint, as evidenced by public comment during the preliminary analysis and NOPR phases of this rulemaking. In addition, DOE purchased and inspected a 175 W 3x4 magnetic ballast, and found the lamination thickness (0.14 inches) was indicative of M6 steel. DOE has modified its calculations of the benefits of M6 steel based on comment received from industry, but continues to analyze modeled ballasts for some ELs.

APPA and NEMA commented that meeting EL2, which DOE based on modeled magnetic ballasts, will actually require electronic ballasts. APPA and NEMA especially noted that the 91.5 percent efficiency requirement for 250 W ballasts is only achievable with electronic ballasts. (APPA, No. 51 at pp. 7–8; NEMA, No. 56 at pp. 2, 24) Overall, ULT stated that EL2 is too high for magnetic ballasts. (ULT, Public Meeting Transcript, No. 48 at p. 137) NEMA and ULT commented that the proposed efficiency standards would only be achievable by magnetic ballasts in some lab conditions, and would therefore require everything less than or equal to 750 W to be redesigned. (NEMA, Public Meeting Transcript, No. 48 at pp. 32, 37; NEMA, No. 56 at pp. 2, 10; NEMA, No. 44 at p. 9; ULT, No. 50 at pp. 2, 4, 10) Therefore, NEMA suggested that the max-tech magnetic levels (EL2) of this rule be lower than proposed. (NEMA, No. 56 at p. 12) However, the Joint Comment provided a listing of various magnetic ballasts capable of meeting the max tech magnetic levels (EL2), 13 of which exceeded both EL2 and EL3, and two exceeded EL4. (Joint Comment, No. 62 at p. 6) The Joint Comment noted that reactor ballasts represent a high-efficiency magnetic alternative to electronic ballasts for many applications and urged DOE to model these ballasts as the equipment chosen by customers in many cases when the standard is set at EL3 or EL4. (Joint Comment, No. 62 at p. 7)

DOE found that after revising its assumptions for M6 core losses, EL2 at 250 W (and other wattages) decreased relative to the NOPR. The 250 W EL2 is now set at 91.0 percent based on an M6 ballast design. DOE's analysis indicates both magnetic ballasts (using M6 steel) and electronic ballasts would be compliant with EL2 at 250 W. In response to the model list given by the Joint Comment, the commercially available magnetic ballasts that were noted as capable of meeting EL2 were single-voltage reactor ballasts. DOE agrees that there are commercially available reactor ballasts that have increased efficiency compared to more common magnetic ballast circuit types, but has chosen not to model them for EL3 and EL4. Reactor ballasts have limited utility due to their single input voltage and reduced ability to mitigate input voltage variation relative to HX or CWA ballasts, though these limited features do lead to increased efficiency. As discussed in section V.C.7 of this notice, DOE bases its analysis on CWA and HX magnetic ballasts. DOE has accounted for the thermal and voltage transient concerns with electronic ballasts with the design changes discussed in section V.C.8 of this notice.

Fixture and Ballast Redesign

DOE noted in the NOPR that its modeling method would not require changes in ballast or fixture size relative to those currently commercially available. NEMA, ULT, and GE commented that DOE's assumption that proposed ELs will not require changes to the size of the ballast is incorrect, especially for ballasts in the 50 W–150 W range, noting that the fixtures would need to be replaced to reach those levels. (NEMA, No. 56 at p. 14; ULT, No. 50 at p. 6; GE, Public Meeting Transcript, No. 48 at p. 190) ULT stated that as the ballast size would increase, the proposed financial analysis, and market and manufacturer impact, might be incorrect. (ULT, Public Meeting Transcript, No. 48 at p. 66) ULT asked how DOE could be sure that ballast size would not increase if in some cases ballasts meeting the max tech magnetic ELs were not yet commercially available. (ULT, Public Meeting Transcript, No. 48 at p. 140) Similarly, NEMA requested that DOE explain its assumption that there will be no size increase. (NEMA, No. 56 at p. 14) However, CA IOUs and the Joint Comment supported DOE's modeled teardown approach as an indicator of potential higher-efficiency equipment that could be manufactured in the future, and an indicator that the max tech magnetic standard levels would not necessarily increase ballast size. (CA IOUs, No. 54 at p. 2; Joint Comment, No. 62 at p. 6)

As discussed previously, DOE's modeling approach for magnetic ballasts does not change the ballast footprint or stack height relative to a commercially available ballast. For example, when modeling an EL2 magnetic ballast, all parameters remain constant except for a substitution of the electrical steel. The cost and efficiency associated with the DOE's magnetic ballast analysis is based on the constraint that ballast size (footprint and stack height) is not allowed to change. As discussed in section V.I of this notice, DOE notes that any modifications to fixtures necessary so that the fixture can be used in conjunction with electronic ballasts can be completed during the manufacturing process, and the costs associated with these new processes are accounted for in the MIA. This regulation does not require retrofitting of MHLFs already installed in the field.

CA IOUs also illustrated the existence of high efficiency magnetic ballasts throughout the wattage ranges, which conflicts with manufacturer claims that ELs beyond EL1 could not be achieved by magnetic ballasts. (CA IOUs, No. 54 at pp. 3–7) DOE notes that the ballasts found with higher than EL1 efficiencies in the CEC database were either reactor ballasts or ballasts capable of only one input voltage. As discussed in section V.C.7, DOE only identified ballasts that were quad-voltage and either CWA or HX as representative. While there are more efficient ballasts, if DOE were to set an EL that only permitted single input voltage or reactor ballasts then there would be significant utility lost.

NEMA and ASAP cautioned that any standard requiring a larger ballast for one wattage will likely require a larger ballast to be designed for all wattages within the associated range. This will increase the ballast size, weight, and the cost of materials (steel and aluminum) for a broad range of equipment—not just the wattage directly analyzed. (NEMA, No. 56 at p. 14; ASAP, Public Meeting Transcript, No. 48 at p. 63) For example, ULT commented that coverage of the 50 W–100 W range would require redesign of all magnetic ballasts of that range. EEI and Acuity commented that increasing the size of a ballast would require increasing the size of the accompanying fixture, which would use more natural resources and would impact wind-loading requirements. (EEI, Public Meeting Transcript, No. 48 at p. 59; Acuity, Public Meeting Transcript, No. 48 at p. 59) ULT further affirmed that bigger ballasts would lead to alterations of fixture housing, and thus to a complicated replacement process affecting the entire installed base. Replacing all the MHLFs currently installed, especially in applications, such as light poles, where more than the fixture would have to change to accommodate the mounting of a larger ballast, would have a negative impact on the whole market. (ULT, Public Meeting Transcript, No. 48 at p. 61) APPA noted that altered design specifications and wind-loading requirements are significant cost adders. (APPA, Public Meeting Transcript, No. 48 at p. 62)

As stated previously, DOE does not analyze a level that would require an increase in ballast size relative to commercially available ballasts. All magnetic ballasts are either commercially available, or modeled using the size constraints of a commercially available ballast. All electronic ballasts analyzed are commercially available. Thus, DOE does not find that the ballast efficiencies analyzed in this final rule would necessitate an increase in ballast size. Regarding ballast weight, electronic ballasts tend to be lighter than magnetic ballasts. For fixtures, DOE analyzed the size of fixtures on pole tops (parking/area fixtures and acorn-style post tops) to determine if any ELs would increase the surface area of fixtures to the point of causing concerns with wind loading. DOE found no evidence that fixtures listed for only magnetic ballasts, versus those listed for both electronic and magnetic or only electronic had a systematically different wind resistance (effective projected area—surface area of the largest side) or overall weight. Thus, DOE does not find that the ballast efficiencies analyzed in this final rule would necessitate an increase in fixture size.

GE commented that manufacturers could choose to rate ballasts conservatively (i.e., overdesign the ballast) compared to standards, thus providing a cushion between the regulation and the ballasts' tested efficiency. This approach would translate into increased size and material costs. (GE, Public Meeting Transcript, No. 48 at p. 89)

DOE acknowledges that manufacturers have flexibility in choosing how to design and rate their products. However, DOE does not require manufacturers to rate a product at a certain increment above the adopted standard level. Therefore, DOE has not accounted for any increase in ballast size or material cost that may result from such a decision.

b. Electronic Ballasts

In the NOPR, DOE analyzed electronic ballasts as higher-efficiency replacements for magnetic ballasts and based max-tech efficiencies for 50 W to 500 W MHLFs on commercially available electronic ballasts independently tested by DOE. In response to that approach, DOE received several comments, discussed below, regarding outdoor transient protection, thermal protection, fixture and ballast redesign, electronic ballast applications, HFE ballasts, lumen maintenance, and other issues.

Transient Protection

In the NOPR, DOE recognized the necessity for outdoor fixtures to be able to withstand large voltage transients, primarily due to lightning strikes. While MHLFs with magnetic ballasts are robust and do not require any additional devices or enhancements to withstand these transients, based on its evaluation of commercially available MHLFs, DOE found that fixtures with electronic ballasts usually require additional design features in order to have adequate protection. Some manufacturers indicated that a portion of their electronic ballasts already have 10 kV surge protection built in, but most electronic ballasts are only rated for 2.5 kV–6 kV voltage spikes. Though magnetic ballasts are known to provide protection in excess of the 10 kV specified by the ANSI C62.41.1–2002 Class C rating, for the NOPR DOE only considered the cost of meeting the 10 kV requirement.

NEMA asserted the proposed efficiency standards would lead to a shift from magnetic to electronically ballasted fixtures that are more susceptible to transient surges. (NEMA, No. 56 at pp. 5–6; NEMA, No. 44 at p. 9; NEMA, Public Meeting Transcript, No. 48 at pp. 32–33) The South Carolina Electric and Gas Company (SCE&G), APPA, NEMA, and ULT noted that the need for additional surge protection in outdoor applications using electronic ballasts is real, as they will not handle transient surges as well as magnetic ballasts. (SCE&G, No. 49 at p. 1; APPA, No. 51 at p. 5; NEMA, No. 56 at p. 16; ULT, No. 50 at pp. 9–10) Acuity expressed concern that the efficiency standards could preclude necessary fixtures used in environments with transient voltage. (Acuity, Public Meeting Transcript, No. 48 at p. 162) SCE&G explained that magnetic ballasts contain larger coils and steel cores that better absorb energy. SCE&G added that the more robust protection required for electronic ballasts would add cost and complexity. (SCE&G, No. 49 at p. 1) Specifically, APPA and NEMA stated that transient surge protection would require a much larger front end or an external sacrificial device, resulting in additional reengineering cost. (APPA, No. 51 at p. 6; NEMA, No. 56 at p. 2)

DOE agrees that electronic ballasts need additional surge protection in outdoor applications. In this final rule, DOE continues to find that by providing external surge protection up to the 10 kV requirement of ANSI C62.41.1–200, electronic ballasts can be used in the same outdoor locations as magnetic ballasts. The cost of the additional equipment in outdoor applications is added to the total fixture MSP (see section V.C.12.c). Using electronic ballasts outdoors may also result in increased maintenance or replacement costs for the voltage surge protection devices. These costs are accounted for in the LCC analysis (section V.F of this notice).

APPA, NEMA, and ULT noted that while it is not difficult to add extra surge protection, it is impossible to predict when the protection device will need to be replaced and how many strikes any given surge protector can handle over its lifetime before the ballast and lamp are affected. APPA, NEMA, and ULT added that voltage transients can be variable in severity and timeframe. The current requirements for surge protection only cover 10 kV, even though surges of 20 kV are common. ULT stated that even with transient protection, electronic ballasts would likely not withstand voltage transients as well as magnetic ballasts do. When the surge protector has reached the end of its life, the next surge will cause the ballast to fail. (APPA, No. 51 at pp. 5, 6; NEMA, No. 56 at pp. 2, 16; ULT, No. 50 at pp. 12–13. 16). SCE&G further commented that resources will be consumed while installing and repairing fixtures with electronic ballasts damaged by lightning. (SCE&G, No. 49 at p. 1) The Joint Comment agreed that the surge protection device might need to be replaced during a fixture's lifetime for some fixtures and this additional maintenance and repair cost should be analyzed by DOE. (Joint Comment, No. 62 at p. 5)

DOE has included the cost of transient protection capable of surge protection up to 10 kV in its estimates of the initial cost of outdoor MHLFs with electronic ballasts, as that is the level specified in ANSI C136.2–2004. DOE agrees that one difficulty arising from the addition of transient protection to electronic ballasts in voltage transient affected areas is the uncertainty in how many strikes the protection will be able to absorb and when the protective device will be sacrificed and the ballast made vulnerable. This vulnerability will affect the maintenance costs and average lifetime of outdoor electronic ballasts. See section V.F of this notice for discussion of these costs.

APPA suggested that DOE take into account data regarding the frequency and severity of lightning strikes in the United States and revise the forecasts for maintenance costs given the frequency and effect of strikes. A lightning strike can affect fixtures within a square kilometer, and according to National Lightning Safety Institute data, which would affect hundreds of ballasts each year. (APPA, No. 51 at p. 6) APPA and NEMA noted that besides lightning, there could be many other causes of transient surges, such as wind, transmission line movement, wind generator surges, equipment or load switching, and collapse of sections of a distribution network. (APPA, No. 51 at p. 6; NEMA, No. 56 at p. 17) APPA and NEMA urged DOE not to eliminate the desirable performance characteristics of magnetic ballasts from the market. APPA and NEMA predicted that replacement rates for outdoor fixtures would increase significantly for utilities and could cause safety and security concerns. (APPA, No. 51 at p. 6; NEMA, No. 56 at p. 16) Therefore, APPA and NEMA stated that the many causes of transient surges make magnetic ballasts necessary in outdoor applications. (APPA, No. 51 at p. 6; NEMA, No. 56 at p. 17)

As discussed previously, DOE has determined that electronic ballasts can be used as substitutes for magnetic ballasts when the necessary design changes are included. DOE agrees that transient protection is a critical consideration, which is why DOE is modeling electronically ballasted fixtures sold with transient protection devices, and also including transient protection device and ballast replacement costs. See section V.F of this notice for details on how DOE models the frequency with which outdoor ballasts encounter surges, and how those translate directly to increased maintenance and replacement costs, and the cost-effectiveness of these measures.

NEMA and ULT noted that indoor applications also expose ballasts to high voltage transients. While transient protection is needed to protect against lighting strikes in any outdoor application, it is also needed in heavy industrial indoor applications where large machinery can send massive transients across the power lines when they are turned on. (NEMA, No. 56 at p. 16; ULT, No. 50 at pp. 9–10)

In researching transient protection for the final rule, DOE found that indoor industrial fixtures are also subject to voltage surges. DOE has thus included voltage transient protection in its price analysis for indoor electronic ballasts experiencing transient surges in these industrial applications. Specifically, DOE analyzes the indoor industrial applications that require additional surge protection as an LCC subgroup. DOE found that indoor industrial MHLFs could experience voltage surges up to 6 kV. The voltage transient protection device used in DOE's analysis can withstand 120 surges of 3 kV, 18 surges of 6 kV, or 5 surges of 10 kV before failure. LCC subgroups are discussed in section V.H and the results of the subgroup analysis are presented in section VII.B.1.b.

Thermal Protection

In the NOPR, DOE found that fixtures with electronic ballasts had to be designed to tolerate electronic ballasts' higher sensitivity to temperatures. Manufacturers must design new and often larger brackets, and apply additional potting material, for example, to create an adequate thermal contact between the ballast and fixture housing. Based on manufacturer feedback and fixture teardown costs, DOE found that there was an approximately 20 percent increase in fixture MPCs to include thermal management for electronic ballasts.

Several stakeholders commented on the heat sensitivity of electronic ballasts. SCE&G stated that the most serious flaw of the electronic MH ballast concept is heat dissipation. The heat sensitivity of electronic ballasts would lead to a larger fixture, so that the fixture could achieve proper thermal management, adding cost and using more resources. (SCE&G, No. 49 at p. 1) One issue identified by stakeholders regarding the thermal management of electronic ballasts is that electronic ballasts cannot operate in the same temperature environments as magnetic ballasts. SCE&G, APPA, and NEMA stated that most electronic ballasts have an 80 °C internal operating temperature (or case temperature) limit, while their magnetic counterparts are in the greater than 180 °C range. (SCE&G, No. 49 at p. 1; APPA, No. 51 at p. 5; NEMA, No. 56 at pp. 5–6; NEMA, No. 44 at p. 9; NEMA, Public Meeting Transcript, No. 48 at pp. 32–33) ULT commented that this case temperature limitation results in the unavailability of electronic ballasts rated for operation in ambient air with a temperature higher than 50 °C. (ULT, No. 50 at pp. 2, 8–10) APPA and NEMA stated that this poses significant maintenance and operations issues for existing fixtures. In some cases, protecting against temperature sensitivity would require a utility to move from ballast replacement to entire fixture replacement. (APPA, No. 51 at pp. 5, 8; NEMA, No. 56 at pp. 2, 16, 24) Acuity expressed concern for high wattage fixtures used in extreme applications, stating that the efficiency standards could preclude necessary fixtures from being available for use in environments with high temperatures. (Acuity, Public Meeting Transcript, No. 48 at p. 162)

In addition, several stakeholders noted that the design of existing fixtures may create high temperature environments within the fixture itself, which would be unsuitable for electronic ballasts. Philips commented that many MHLFs are designed with the core and coil of the ballast directly above the lamp, which creates a high temperature environment in which electronic ballasts cannot survive. (Philips, Public Meeting Transcript, No. 48 at p. 188) In addition, Philips stated that with higher system input power, there are often higher temperature environments, and it is difficult to find components, especially capacitors, rated at those high temperatures. (Philips, Public Meeting Transcript, No. 48 at pp. 194–195) GE questioned whether the EL models took into account thermal conditions and luminaire design, or if it just assumed the boundary conditions would match the ballast. GE ultimately agreed that DOE's model does not include the thermal characteristics of the fixture or the boundary conditions. (GE, Public Meeting Transcript, No. 48 at pp. 147, 217)

DOE agrees that thermal protection is required to render electronic ballasts suitable substitutes for magnetic ballasts in all applications. DOE accounts for this cost in section V.C.12 of this final rule. DOE also analyzed the commercially available fixtures that are advertised for use with electronic ballasts in outdoor locations. In extreme heat conditions, DOE has determined that electronic ballasts typically operate up to case temperatures of 80–90 °C. While magnetic ballasts themselves are able to handle temperatures as extreme as 180 °C, a magnetic ballast must be paired with a capacitor and DOE has determined that the capacitor typically only carries a temperature rating of about 100 °C. Furthermore, pulse start magnetic ballasts must be paired with an igniter in addition to a capacitor and DOE has determined that the igniter also typically carries a temperature rating of about 100 °C. Based on manufacturer interviews and assessment of commercially available fixtures, DOE believes that thermal design changes, such as new brackets or additional potting material to create an adequate thermal contact between the ballast and fixture housing, can address this 10–20 °C difference in temperature rating between electronic and magnetic ballasts. Therefore in this final rule, as in the NOPR, DOE has included a 20 percent increase in fixture MPCs to account for increased thermal management for electronic ballasts.

DOE acknowledges that existing fixtures designed for magnetic ballasts may not be suitable for electronic ballasts due to the need for increased thermal management. This rulemaking does not require retrofits of fixtures currently installed in the field. Any modifications to fixture design would be completed by the fixture manufacturer and incorporated in any new fixture sales. Fixture manufacturers already sell fixtures rated for use with electronic ballasts.

Fixture and Ballast Redesign

When analyzing electronic ballast levels (EL3 and EL4) in the NOPR, DOE assumed that the main design changes required to allow electronic ballasts were to increase thermal management, add voltage transient suppression, and add 120 V auxiliary power functionality. The costs of these design changes are discussed in section V.C.12 of this notice. In addition to the increased costs associated with these design changes, DOE also accounted for manufacturer conversion costs in the MIA.

ASAP agreed with DOE's methodology in analyzing the challenges and costs associated with using electronic ballasts in outdoor applications. (ASAP, Public Meeting Transcript, No. 48 at pp. 57, 62) CA IOUs and the Joint Comment stated that major manufacturers already offer electronic ballasts designed to be used outdoors. Further, electronic ballasts generate less internal heat and already make up approximately 25 percent of sales for some wattage bins. In addition, using the CEC compliance database, CA IOUs illustrated the high efficiency and availability of electronic ballasts for indoor and outdoor applications. (CA IOUs, No. 54 at pp. 3–7; CA IOUs, Public Meeting Transcript, No. 48 at p. 202; Joint Comment, No. 62 at pp. 4–5)

DOE also received several comments that questioned the feasibility of using electronic ballasts in all applications, in particular how requiring electronic ballasts could impact the need for ballast and fixture redesign. ULT stated that there is a difference between commercially available LFE ballasts and commercially available MHLFs effectively incorporating such ballasts. (ULT, Public Meeting Transcript, No. 48 at p. 204) APPA, the National Rural Electric Cooperative Association (NRECA), ULT, and EEI stated that magnetic ballasts are better suited to withstand temperature and transient extremes, wet locations, heat from the lamp, and would require larger fixtures. Therefore, the switch to electronic ballasts would require new designs, retooling, and cause a lack of replacements for existing fixtures. (APPA, No. 51 at p. 4; NRECA, No. 61 at p. 2; ULT, No. 50 at p. 2; EEI, No. 53 at p. 3) NEMA commented further that electronic ballasts for outdoor applications would need to be redesigned, and hardened and sealed, and thus made larger. (NEMA, No. 56 at p. 6) While California has regulations that require electronic ballasts in certain situations, NEMA pointed out that efficiency standards in California are low enough that the amount of redesign was not as challenging as it would be for some of the levels presented in the NOPR. (NEMA, Public Meeting Transcript, No. 48 at p. 199)

Stakeholders further stated that, because of the increased size of electronic ballasts and fixtures, there would be significant impacts on existing fixtures. APPA, NRECA, ULT, and EEI commented that the switch to electronic ballasts would require new designs, retooling, and cause a lack of replacements for existing fixtures. (APPA, No. 51 at p. 4; NRECA, No. 61 at p. 2; ULT, No. 50 at p. 2; EEI, No. 53 at p. 3) EEI elaborated, stating that electronic ballasts used for outdoor fixtures are larger and heavier than magnetic ballasts, which would make it harder to replace ballasts in existing fixtures. (EEI, No. 53 at p. 3) GE asserted that switching to electronic ballasts, especially outdoors, would take a great deal of care, attention, design, and development because it is not possible to put an electronic ballast into an existing magnetic fixture. (GE, Public Meeting Transcript, No. 48 at p. 198) APPA expressed concern regarding the ability to maintain existing infrastructure and Cooper Lighting (Cooper) cautioned against replacement fixtures not matching installations. (APPA, Public Meeting Transcript, No. 48 at p. 196; Cooper, Public Meeting Transcript, No. 48 at p. 71) In addition, Cooper commented that lighting fixtures are usually UL listed with a certain type of ballast and have fit and thermal issues among different suppliers. (Cooper, Public Meeting Transcript, No. 48 at p. 74) NEMA asserted the proposed efficiency standards would force a shift from magnetic to larger electronic ballasts that would not be interchangeable in fixtures. (NEMA, No. 56 at pp. 5–6; NEMA, No. 44 at p. 9; NEMA, Public Meeting Transcript, No. 48 at pp. 32–33)

DOE agrees that there would need to be adjustments made to the MHLF system to allow electronic ballasts to be used outdoors. DOE determined that electronic ballasts are capable of use outdoors by adding transient protection, thermal protection, and using fixtures specifically designed to be used outdoors. Outdoor fixtures that use electronic ballasts already exist in the marketplace and DOE research did not indicate any trend of these fixtures being larger than comparable magnetic fixtures for the same wattage products. Furthermore, as discussed in section V.C.12, DOE revised its methodology for determining fixture pricing to ensure that the costs for outdoor fixtures housing electronic ballasts also incorporate the necessary weatherization.

DOE contends that the levels analyzed in this rulemaking will not require increases in ballast size. All magnetic ballast levels are designed to be achievable with magnetic ballasts commercially available or using magnetic ballasts that are the same size as commercially available ballasts. When switching to electronic ballasts, DOE notes that the sizes and shapes of electronic ballasts are typically different from magnetic ballasts (longer length but narrower width), but do not increase to a size that would cause concern about their use in any applications where magnetic ballasts are used. Any fixture redesign that is required to ensure fixtures comply with adopted standards was taken into account in the economic analyses of the final rule. As discussed above, DOE acknowledges that the surge protection device might need to be replaced during the fixture's lifetime and this maintenance cost, as well as potential early replacement costs from the surge protection being sacrificed and the next strike compromising the electronic ballast, are taken into account in the LCC analysis (section V.F of this final rule).

DOE has determined that replacement fixtures should have no issues with the adopted standard, as the size and weight of fixtures do not need to increase for any of the levels. While certain fixtures may require redesign for new ballast types, such as electronic, the overall size and weight of fixtures does not increase. DOE agrees that certain fixtures are UL listed and have compatibility assured with specific types of ballasts—but the ballasts affected by this rulemaking are those being placed in new fixtures and not those being used as replacements in existing fixtures. Any new fixture sold will be able to be cleared for UL listing and compatibility with the ballast included in the final assembly.

Regarding the most efficient levels analyzed, which require electronic ballasts, Philips stated that LFE MH ballasts cannot be made more efficient than the equipment already available. (Philips, Public Meeting Transcript, No. 48 at p. 70) DOE agrees that the efficiency of low frequency ballasts cannot be improved beyond that of currently commercially available ballasts. DOE's max tech electronic level (EL4) is based on commercially available low frequency ballasts.

In summary, in this final rule, DOE continues to model the cost of switching from magnetic ballasts to electronic ballasts, accounting for thermal management, transient protection, and general weatherization of the fixture in applications in which it is required.

Applications

Because DOE concluded that electronic ballasts and magnetic ballasts could provide the same utility in the wattages that electronic ballasts are offered (50 W to 500 W), DOE concluded in the NOPR that there was no application unique to magnetic or electronic ballasts. With the proper adjustments to the fixture, electronic ballasts could be used anywhere magnetic ballasts are used.

Several manufacturers commented on the prevalence of commercially available MHLFs listed for use with electronic ballasts. Cooper commented that they only use electronic ballasts in select MHLFs, including a very limited number of low-wattage fixtures in some garage applications. (Cooper, Public Meeting Transcript, No. 48 at p. 191) GE stated that they carry a 400 W electronic ballast, but it is used in retail applications with ideal operating conditions. (GE, Public Meeting Transcript, No. 48 at p. 191) Philips, on the other hand, commented that they make a lot of electronic MH ballasts, anywhere from 25 W to 400 W, mostly used in retail applications. However, these ballasts are primarily for use with CMH lamps and would not be suitable in existing fixtures, regardless of lamp type, without significant redesign. Philips added that there are no components available for applications greater than 400 W and the costs are approximately three times higher than magnetic ballasts (Philips, Public Meeting Transcript, No. 48 at pp. 192–193, 195) Acuity commented that the only applications with which they use electronic ballasts and low-wattage fixtures are downlights, cylindrical architectural lighting, and spaces meant for low-wattage fixtures where there is good power quality and no extreme temperatures. (Acuity, Public Meeting Transcript, No. 48 at p. 192) CA IOUs clarified that as this ruling applies to new fixtures only, they do not see a problem with electronic ballasts being used outdoors. (CA IOUs, Public Meeting Transcript, No. 48 at p. 196)

DOE identified fixtures for sale with electronic ballasts that were advertised for and intended for use in outdoor applications, such as exterior post top, outdoor area, bollard, canopy, security, and wall pack lighting. Manufacturers selling these fixtures did not provide any indication that they were to be used in a more limited set of applications relative to magnetic ballasts and did not contain warnings with regard to particular conditions that should be avoided when using those fixtures. For the previously described reasons, DOE has found that electronic ballasts can be used in outdoor applications assuming the proper adjustments have been made to the fixtures. Any overall fixture redesign or conversion costs incurred by the manufacturer to switch production to fixtures meeting these levels are accounted for in the MIA (see section V.I.4). DOE emphasizes that this rulemaking only applies to new fixtures.

High-Frequency Electronic Ballasts

In the NOPR, DOE analyzed HFE ballasts and determined that they were a valid design option to improve ballast efficiency. DOE acknowledged the lack of compatibility with CMH lamps, but proposed to take those impacts into account when adopting any amended standards.

NEMA commented that in the 320 W–400 W range, when developing electronic ballasts the industry is split between low-frequency square wave and high-frequency. (NEMA, Public Meeting Transcript, No. 48 at p. 28) However, NEMA warned that HFE ballasts are not compatible with all MH lamps; the size of the arc tube could lead to acoustic resonance problems, which cause arc instability and possible rupture of the arc tube. This would lead to compatibility problems where a ballast or lamp could not be readily replaced. (NEMA, Public Meeting Transcript, No. 48 at p. 28) NEMA expressed concern that there would likely be very limited lamp models that could be used with these high-efficiency, high-frequency ballasts. (NEMA, Public Meeting Transcript, No. 48 at p. 29; NEMA, No. 56 at p. 15) ULT agreed, commenting that there are applications where an electronic ballast will not work and an HFE-only standard would therefore be a mistake. (ULT, No. 50 at p. 8)

DOE agrees that there are compatibility issues with HFE ballasts and CMH lamps and that there are no industry standards in place for HFE ballasts. As discussed in section III.A.4, DOE has decided to not consider standards for HFE ballasts in this rulemaking. Given that HFE ballasts are no longer in the scope of the final rule, DOE revised the 400 W EL4 representative unit to be an LFE ballast. The final rule only analyzes LFE ballasts as representative units.

Lumen Maintenance

When analyzing the potential energy savings of electronic ballasts in the NOPR, DOE only considered the savings that would come from increased ballast efficiency. It was assumed that increased ballast efficiency when using the same wattage electronic MH system would still provide an equivalent light output.

The Joint Comment expressed its belief that DOE has significantly underestimated the energy and economic savings from electronic ballasts because lamps driven by electronic ballasts experience better lumen maintenance, which allows for fewer fixtures or lower-wattage lamps and less frequent re-lamping. (Joint Comment, No. 62 at pp. 1–2) The Joint Comment cited the following sources in support of the positive impact electronic ballasts have on lumen maintenance: (1) Natural Resources Canada stated an electronic ballast produced 15 percent more light output after 8000 hours; (2) GE claimed their UltraMaxTM electronic ballast produced 13 percent higher mean lumens at 40 percent of rated life than an MH system using a pulse-start magnetic ballast; (3) Advance claimed that their DynaVision® electronic ballast delivered a 20 percent improvement in lumen maintenance at 40 percent of rated life over a pulse-start MH system; and (4) Holophane claimed that electronic ballast technology increased mean lumen output by 13 percent on pulse-start lamps and stated that improved lumen maintenance is the most fundamental benefit of electronic HID ballasts. (Joint Comment, No. 62 at p. 2)

DOE researched the potential increase in lumen maintenance when switching from magnetic to electronic ballasts. While the comments cited several different examples of systems whose lumen maintenance was increased with electronic ballasts, DOE did not find universal agreement across the industry regarding the impact of electronic ballasts on lumen maintenance. While there seemed to be general agreement that electronic ballasts may have increased lumen maintenance, the literature indicated that specific claims may be unique to certain combinations of lamps and ballasts. There is no assurance that customers would choose an electronic ballast or lamp that would increase lumen maintenance if DOE adopted an electronic ballast standard level. As such, DOE maintains the approach from the NOPR to only consider the energy savings from increased ballast efficiency.

Additional Considerations

NEMA stated that mandating ELs that preclude any technology but pulse-start electronically ballasted MHLFs would cause increased maintenance and material costs due to surge and lightning resistance, increased fixture size and price, added weather resistance, remote igniter installation, and the higher maintenance cost and considerations of high-mast lighting fixtures. (NEMA, No. 56 at p. 8) APPA and Florida Power and Light were skeptical about electronic ballasts being able to withstand all types of outdoor threats, such as extreme cold, extreme heat, humidity, salt water, salt air, surge, sag, and swell. (APPA, Public Meeting Transcript, No. 48 at p. 196; Florida Power and Light, Public Meeting Transcript, No. 48 at p. 204) NEMA stated that electronic ballasts would require added capabilities of weather resistance, surge resistance, and thermal resilience. (NEMA, Public Meeting Transcript, No. 48 at p. 70)

DOE has accounted for the additional costs at any level requiring the use of electronic ballasts. DOE also agrees that electronic ballasts used outdoors require general weatherization. To account for this, DOE conducted additional fixture teardowns for this final rule to come up with a fixture price at each representative wattage that was unique for indoor versus outdoor applications. This way the outdoor fixtures incorporating electronic ballasts will account for the necessary weatherization. Weather resistance, voltage transient protection, and thermal protection are incorporated into the full fixture MSPs (see section V.C.12). Any potential redesign required of manufacturers is considered in the MIA (see section V.I.4). Maintenance is considered in the LCC analysis (see section V.F). DOE investigated whether a standard that requires an electronic ballast would negatively impact high-mast lighting applications using remote ballast placement. Some electronic ballasts are capable of starting lamps up to 33 feet, but magnetic ballasts can perform remote starting and lamp operation from longer distances. Unlike magnetic pulse-start ballasts, the ballast to lamp distance cannot be increased with a remote igniter, because this remote igniter device is not available for use with electronic ballasts. DOE investigated high-mast applications and determined some roadway applications with 30 to 40 foot poles could be utilizing the remote starting feature. It is unclear what percentage, if any, of the 30 to 40 foot poles use remote ballast placement, such that the remote starting ability of electronic ballasts would be an issue. Further, DOE notes that electronic ballasts are capable of starting lamps at distances exceeding 30 feet. The other main category of high-mast applications includes those at extreme heights, at least 100 feet, typical of sports stadium or airfield lighting. These applications require fixtures of 1000 W or higher. Because DOE is not analyzing efficiency levels that would require electronic ballasts at these high wattages, these high-mast, high-wattage MHLFs do not pose a concern. In summary, DOE concluded the need for remote starting does not necessitate the usage of magnetic ballasts.

Florida Power and Light commented that electronic ballasts are designed to work on a National Electrical Safety Code (NESC) three-wire system. However, Florida Power and Light runs a NESC two-wire system and is having difficulties with electronic drivers. Florida Power and Light stated that they have heard of similar issues from other utilities, such as Duke Energy and National Grid, and are very concerned about being forced into using electronic ballasts. (Florida Power and Light, Public Meeting Transcript, No. 48 at p. 204) DOE reviewed manufacturer literature for a variety of electronic ballasts and found no requirements that they be used in conjunction with a specific wiring scheme. The literature does stipulate that the electronic ballast should be grounded to earth, but does not speak to preferred or required wiring systems. DOE continued to analyze electronic ballasts in outdoor locations for this final rule.

9. Efficiency Levels

Based on the higher-efficiency ballasts selected for analysis, discussed in section V.C.8, DOE developed ELs for the representative equipment classes. EL1 represented a moderately higher-efficiency magnetic ballast, and EL2 represented the max-tech magnetic ballast. EL1 and EL2 were characterized by a combination of commercially available and modeled magnetic ballasts. EL3 represented the least efficient commercially available electronic ballast, and EL4 represented the max-tech level for all ballasts incorporated into MHLFs. In the NOPR, DOE created four ELs for the equipment classes with the 70 W, 150 W, 250 W, and 400 W representative wattages. Due to the fact that DOE did not analyze electronic ballasts for the 1000 W representative wattage, DOE analyzed only two ELs in the equipment class above 500 W.

NEMA and ULT offered revised efficiency equations, suggesting efficiencies lower than the NOPR proposed levels. The levels are set with linear equations from 50 to 150 W and 500 to 1000 W, with a flat efficiency of 88 percent from 150 to 500 W. (NEMA, No. 56 at pp. 17–19; ULT, No. 50 at pp. 10–11) Philips commented that opportunities to further increase efficiency in this market have been explored and all economically feasible efficiency gains have already been achieved. (Philips, Public Meeting Transcript, No. 48 at p. 55) NEMA added to this point, stating that commercial markets, such as sports lighting, are already aggressively managing their costs and trying to get the most efficient equipment. (NEMA, Public Meeting Transcript, No. 48 at p. 56)

In this final rule, all of the max-tech levels are commercially available. All lower ELs analyzed are either commercially available or technologically feasible based on DOE's revised ballast modeling. To develop efficiency-level equations in this final rule, DOE utilized its own efficiency test data as well as catalog efficiency data and modeling to develop the equation forms and efficiency trends for each wattage range. The efficiency-level equations are generally designed to closely match the efficiency of the more-efficient representative units identified for each equipment class. The discussion below describes the equations used in each wattage bin. For further details, see chapter 5 of the final rule TSD.

For the lowest two wattage bins, which consist of 50 W–150 W ballasts, DOE used its own test data, as well as efficiency trends according to catalog data and modeled more-efficient units, to generate separate power-law equations for magnetic (EL1 and EL2) and electronic (EL3 and EL4) ballasts.

The next wattage bin consists of 150 W ballasts, excluding those in the currently exempt 150 W fixtures, through and including 250 W ballasts. Because EISA 2007 covered equipment in this wattage bin, DOE can only evaluate efficiencies equal to or above the existing standards to avoid backsliding. 150 W magnetic ballasts cannot be designed to meet the EISA 2007 standard of 88 percent efficiency and 175 W ballasts only reach 88 percent by using M6 steel. DOE's test data also indicated that there are no 150 W or 175 W magnetic ballasts available that exceed 88 percent efficiency. Though DOE did not test any 200 W ballasts, a review of the CCE database indicates that 200 W ballasts are typically only available at about 88 percent efficiency. Because DOE has no specific information indicating that these ballasts can be designed to be more efficient, DOE assumed that 88 percent is also the max-tech magnetic ballast efficiency for wattages up through 200 W. Thus, DOE maintained the EISA 2007 efficiency requirement of 88 percent for ELs designed to represent levels met by magnetic ballasts. DOE did not have any information available about the achievable efficiencies for 201 W–250 W ballasts, as ballasts in this range are not commercially available. Therefore, DOE gradually increased the magnetic ELs (EL1 and EL2) between 200 W and 250 W ballasts using a linear trend from 88 percent to the efficiency of the EL1 and EL2 250 W representative units. For the electronic ballast levels (EL3 and EL4), DOE continued the power-law function fit from the 50 W–150 W range to 250 W.

The next wattage bin consists of 251 W–500 W ballasts. Because the 250 W and 400 W magnetic representative units at EL1 and EL2 have the same efficiency and utilize similar design options, DOE created a flat efficiency requirement for magnetic ballasts in this wattage bin. For the electronic ballast levels (EL3 and EL4), DOE continued the power-law function fit from the 50 W–250 W range to 500 W.

The next wattage bin consists of 501 W–1000 W ballasts. DOE examined catalog data for market availability and found no electronic ballasts for general lighting applications commercially available above 500 W. Thus, there are only two ELs at this wattage range rather than four. NEMA submitted written comments indicating that different groups of ballasts have different relationships between lamp current squared and lamp wattage. (NEMA, No. 56 at p. 13) Through review of ANSI C78.81–2010 and lamp datasheets, DOE found lamps with rated wattages between 501 W and 750 W generally had different lamp voltages than lamps with rated wattages between 751 W and 1000 W, suggesting a difference in ballast efficiency trends across the 750 W threshold. Therefore, DOE used linear equations from 501 W–750 W that (1) connect to the EL1 and EL2 equations from the 251 W–500 W equipment class, and (2) connect to the least efficient 750 W ballasts on the market at 91 percent. Then from 751 W–1000 W DOE used linear equations that (1) connect to 91 percent at the low wattage end, and (2) connect to the EL1 and EL2 representative unit efficiencies at 1000 W. This approach to the 501 W–1000 W equipment class also has the advantage of encouraging purchase of lower wattage ballasts, by ensuring that commercially available options remain on the market at EL1 and EL2.

The highest wattage bin consists of 1001 W–2000 W ballasts. DOE again found no electronic ballasts in this wattage range, so there are only two levels of efficiency at the highest wattage range rather than four. After examining the efficiency trends among commercially available ballasts in this wattage bin, DOE used a flat linear equation above 1000 W due to the limited data available regarding an efficiency trend for these wattages. DOE anchored the line from the previous wattage bin's 1000 W efficiencies at EL1 and EL2 and confirmed the equation allows the representative units at 1500 W to just meet their respective ELs.

Table V.4 summarizes all of the functions and efficiencies describing each equipment class.

TABLE V.4—EFFICIENCY LEVEL DESCRIPTIONS FOR THE REPRESENTATIVE EQUIPMENT CLASSES

Representative equipment class	Rep. wattage	EL	Minimum efficiency equation† %	
≥50 W and ≤100 W	70 W	EL1	1/(1+1.33×P^(−0.346))†	
		EL2	1/(1+1.24×P^(−0.351))	
		EL3	1/(1+0.600×P^(−0.340))	
		EL4	1/(1+0.360×P^(−0.297))	
>100 W and <150 W*	150 W	EL1	1/(1+1.33×P^(−0.346))	
		EL2	1/(1+1.24×P^(−0.351))	
		EL3	1/(1+0.600×P^(−0.340))	
		EL4	1/(1+0.360×P^(−0.297))	
≥150 W** and ≤250 W	250 W	EL1	≥150 W and ≤200 W: 0.880	>200 W and ≤250 W: 0.000400×P + 0.800
		EL2	≥150 W and ≤200 W: 0.880	>200 W and ≤250 W: 0.000600×P + 0.760
		EL3	1/(1+0.600×P^(−0.340))	
		EL4	1/(1+0.360×P^(−0.297))	
>250 W and ≤500 W	400 W	EL1	0.900	
		EL2	0.910	
		EL3	1/(1+0.600×P^(−0.340))	
		EL4	1/(1+0.360×P^(−0.297))	
>500 W and ≤1000 W	1000 W	EL1	>500 W and ≤750 W: 0.0000400×P+0.880	>750 W and ≤1000 W: 0.0000840×P + 0.847
		EL2	>500 W and ≤750 W: 0.910	>750 W and ≤1000 W: 0.000104×P + 0.832
>1000 W and ≤2000 W	1500 W	EL1	0.931	
		EL2	0.936	

* Includes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

** Excludes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

† P is defined as the rated wattage of the lamp the MHLF is designed to operate.

10. Design Standard

Under 42 U.S.C. 6295(hh)(4), DOE is permitted to set an energy efficiency standard based on both design and performance requirements. EISA 2007 required probe-start ballasts to be 94 percent efficient, effectively banning probe-start ballasts between 150 W and 500 W (except those 150 W ballasts exempted by EISA 2007) based on their inability to meet this performance requirement. (42 U.S.C. 6295(hh)(1)(A)(ii)) Manufacturers responded to the EISA 2007 standards by shifting their inventory to pulse-start ballasts, which are subject to less stringent standards. In the NOPR, DOE proposed a design standard that would prohibit the sale of probe-start ballasts in newly sold fixtures from 501 W–2000 W.

The Joint Comment supported standards for high-wattage fixtures and agreed that a design standard prohibiting probe-start ballasts could yield additional energy savings by allowing a customer to install fewer or lower-wattage pulse-start fixtures. If DOE found that a design standard for the highest wattage products was not feasible or cost effective, the Joint Comment urged DOE to split the highest-wattage equipment class into two classes—one for 501 W–1000 W fixtures and one for 1001 W–2000 W fixtures—such that the design standard could be applied to only 501 W–1000 W fixtures. (Joint Comment, No. 62 at p. 8)

DOE agrees that the design standard could result in energy savings through various potential energy saving pathways. As discussed in section V.A.2, in the final rule DOE has established separate equipment classes for 501 W–1000 W MHLFs and 1001 W–2000 W MHLFs. As a result, DOE analyzed the feasibility of the design standard separately for these two wattage ranges.

In the NOPR, DOE based its analysis of the design standard on the 1000 W MHLFs. For the final rule DOE continues to analyze the 1000 W MHLFs, but only as representative of the 501 W–1000 W equipment class. The Joint Comment disagreed with DOE's figure proposed in the NOPR of a 5.6 increase in lumen maintenance corresponding to a 5.6 percent reduction in normalized input system power and instead predicted higher energy savings of 12.5 percent. (Joint Comment, No. 62 at p. 8) Musco Lighting also did not agree with the 5.6 percent energy savings assumed in the NOPR, but predicted it would be a smaller percentage. Musco Lighting stated that in sports lighting applications, which are common at the higher wattage range, the lamp arc tube is horizontal or in a tilted position, yielding less projected energy savings than calculated with a vertical base up position. (Musco Lighting, Public Meeting Transcript, No. 48 at p. 180) Musco Lighting provided further data demonstrating that 1500 W probe-start start applications have greater efficiency than 1000 W or 2000 W pulse-start when operated in a horizontal position. Furthermore, Musco Lighting commented that while the probe in probe-start lamps contributes to the blackening of the arc tube in lower-wattage lamps, as the size of the arc tube increases in higher-wattage lamps, the probe does not increase in size and thus has less of an impact. In larger arc tubes, the blackening is driven principally by the primary electrodes, which are present in pulse-start lamps as well. (Musco Lighting, No. 55 at p. 2) Philips commented that there are no efficiency differences between probe-start and pulse-start at or above 1000 W. (Philips, Public Meeting Transcript, No. 48 at p. 130) Acuity noted that the majority of the energy savings at 1000 W would come from the lamp rather than the ballast. Acuity questioned whether or not the statutory authority allows energy savings to be calculated using gains in lamp performance, as this MHLF rulemaking is based on ballast efficiency. (Acuity, Public Meeting Transcript, No. 48 at p. 173)

DOE notes that the intent of the design standard is to encourage customers to switch to reduced-wattage pulse-start from full-wattage probe-start systems due to the observation that pulse-start lamps have better lumen maintenance. For the 501 W–1000 W equipment classes, DOE has adjusted the assumption that pulse-start systems have 5.6 percent higher mean lumens which would result in 5.6 percent energy savings. DOE presents two commercially available pathways that an existing 1000 W probe-start customer could take in response to the design standard: Shifting to an 875 W pulse-start system, or staying at 1000 W and shifting to a pulse-start system. The shift to pulse-start at 1000 W would result in additional light output and no energy savings relative to a probe-start MHLF. The shift to 875 W would maintain equal lumen output and result in about 12.5 percent energy savings relative to 1000 W probe-start MHLFs.[31] This rulemaking regulates the efficiency of ballasts used in new MHLFs. Due to the increased mean lumens available in pulse-start lamps, the pulse-start lamp-and-ballast system can save energy relative to probe-start lamp-and-ballast systems. The design standard component of this final rule only regulates the ballast component of the lamp-and-ballast system.

NEMA, Venture, Musco Lighting, and ULT disagreed with DOE's proposed design standard regarding greater than or equal to 1000 W applications. (NEMA, Public Meeting Transcript, No. 48 at p. 168; Venture, Public Meeting Transcript, No. 48 at p. 170; Musco Lighting, Public Meeting Transcript, No. 48 at p. 180; Musco Lighting, No. 55 at pp. 1–3; ULT, No. 50 at p. 120) Musco Lighting pointed out that pulse-start has limited applicability above 1000 W and should not be considered at these higher wattages. (Musco Lighting, No. 55 at p. 3) ULT commented that MHLFs above 1000 W are typically probe-start and the proposed ruling would eliminate this class. ULT also added that there are no 1250 W or 1650 W pulse-start lamps. (ULT, No. 50 at p. 3) NEMA also stated that there would be a conspicuous cost increase for most other higher-wattage ballasts, including the change from probe- to pulse-start for 1001 W–2000 W. (NEMA, No. 56 at pp. 6–7) Musco Lighting additionally expressed concerns about involving 1500 W fixtures in the rulemaking because their principal use is sports lighting. Not only does sports lighting have very specific application standards requiring particularly uniform light levels and glare control that dictate specific pole locations, but also the transition from probe-start to pulse-start would require development of a 944 W system that does not currently exist. Due to this lack of existing commercially available technology, Musco Lighting stated that the proposed rule would go against 42 U.S.C. 6295(o)(4). (Musco Lighting, No. 55 at pp. 1–3) NEMA further explained that stadium fixtures for double-ended, pulse-start 1500 W and 2000 W MH lamps meet industry standards for containment in the event of lamp rupture, and provide a UV attenuation barrier and lens interlock, while meeting league and television network requirements for on-field illumination and uniformity. Therefore, NEMA contended that there are no direct replacements for this equipment. Elimination of the lamp type used in such fixtures would result in significant retrofitting or replacement with lamps less suitable for the application, costs that NEMA stated must also be added to feasibility estimates. (NEMA, No. 56 at p. 7)

After establishing a new equipment class for 1001 W to 2000 W fixtures, DOE reanalyzed the merits of the design standard for the 1500 W representative wattage. DOE agrees that the design standard banning probe-start lamps should not be analyzed for fixtures above 1000 W because pulse-start systems in this wattage range do not have increased lumen maintenance relative to probe-start systems. Therefore, there are no commercially available pulse start options that would offer the same light output with reduced energy consumption (industry considers changes in light output of greater than 10 percent to be perceptible by the average customer). Thus, in this final rule, DOE did not analyze a design standard in the 1001 W–2000 W equipment classes.

NEMA expanded upon its view that DOE's proposed efficiency requirements would eliminate probe-start ballasts and lamps. NEMA argued that the facility of starting probe-start lamps in the greater than 1000 W category is a highly desirable performance characteristic. NEMA described that sports lighting owners and operators prefer the ballast and other serviceable components to be located in the base of the fixture mast, for ease of maintenance and safety. With probe-start technology, the 400 V starting signal is able to travel up the mast and reliably ignite the lamp. The 3000 V–4000 V microsecond pulses from pulse-start ballasts are attenuated by long wires over the 30 ft.–40 ft. height of the masts so that the high pressure starting gas in pulse-start lamps may not ignite. NEMA noted that moisture could also cause attenuation with pulse-start ballasts, while probe-start ballasts are less susceptible to the effects of weather. NEMA acknowledged that pulse-start remote electronic igniters are available at a considerable cost premium. However, as the fixture housing is not designed for them, there are thermal concerns and the igniters themselves are difficult to access for maintenance. (NEMA, No. 56 at p. 7)

Philips, NEMA, Musco Lighting, and ULT further commented that a ruling that discontinued probe-start ballasts and lamps would create problems. There are currently no pulse-start options for MHLFs installed in high-mast locations; to make the technology work would require the addition of an igniter at the top of the pole, which would add costs and complexity. (Philips, Public Meeting Transcript, No. 48 at pp. 166, 169; NEMA, Public Meeting Transcript, No. 48 at p. 166; NEMA, No. 56 at p. 19; Musco Lighting, No. 48, Public Meeting Transcript, at p. 167; ULT, No. 50 at p. 3) ULT explained that applications at 1000 W or higher generally have a ballast-to-lamp distance that is too long for standard pulse-start ballasts and would require the addition of a special igniter and a cost adder of $10-$15 per ballast. (ULT, No. 50 at p. 12) Musco Lighting stated that the additional costs required to change from a probe-start to pulse-start system are much higher than DOE estimated. (Musco Lighting, No. 55 at p. 3) NEMA asserted that mandating ELs that preclude any technology but pulse-start electronically ballasted equipment would create increased maintenance

[31] The estimate of 12.5 percent energy savings comes from reducing a 1000 W system by 12.5 percent to get to 875 W. However, since 875 W ballasts are characteristically less efficient than 1000 W ballasts, the total energy savings will in reality be slightly less than 12.5 percent.

and material costs due to surge and lightning resistance, increased fixture size and price, added weather resistance, remote igniter installation, and the higher maintenance cost and considerations of high-mast lighting fixtures. NEMA suggested excluding such equipment from energy conservation standards in order to avoid these issues. (NEMA, Public Meeting Transcript, No. 48 at p. 168; NEMA, No. 56 at p. 8) NEMA also noted that given the previous considerations, including greater than or equal to 1000 W fixtures in the rulemaking, would go against 42 U.S.C. 62955(o)(4), as the adoption of these standards would be ''likely to result in the unavailability in the United States in any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States at the time of the Secretary's finding.'' (NEMA, No. 56 at pp. 6–7)

For 1000 W high-mast applications, DOE found that remote starting is an option that is commercially available using pulse-start technology. As mentioned in comments, this would require the addition of a remote igniter at the top of the pole. DOE has accounted for the added equipment costs that would be associated with using pulse-start technology in 1000 W applications requiring high-mast fixtures. DOE notes that the design standard would not result in a push towards electronic levels, as the design standard is only considered for fixtures between 501 W and 1000 W, where electronic ballasts are not commercially available, and thus not analyzed.

NEMA commented that DOE appears to be applying incandescent technology to ballast efficiency and lamp efficacy. NEMA and ULT asserted that a ballast will have difficulties operating at wattages other than its rating and that such operation is a violation of its intended use and should not be considered. (NEMA, No. 56 at p. 15; ULT, No. 50 at p. 8). DOE agrees that ballasts would have difficulty operating at wattages other than those listed by the manufacturer. As mentioned previously, in this final rule DOE analyzed the design standard so that 1000 W probe-start systems would be replaced with either 875 W or 1000 W pulse-start systems. The use of 875 W ballasts would be with 875 W lamps, as DOE is not modeling the design standard to use a reduced-wattage lamp on a full-wattage ballast in this MHLF rulemaking. DOE continues to agree that ballasts will have difficulties operating lamps at wattages other than their rating, and does not analyze any such scenarios in this final rule.

EEI expressed concerns that an outright ban on probe-start ballasts may hinder technological developments and higher-efficiency possibilities for the technology. (EEI, Public Meeting Transcript, No. 48 at p. 183) Further, NEMA and ULT opposed the ban, as 175 W to 400 W probe-start ballasts are already practically prohibited by existing regulation. NEMA and ULT stated that any limited remaining market should be maintained for desirable performance characteristics where it is deemed necessary. (NEMA, No. 56 at p. 19; ULT, No. 50 at p. 12)

DOE recognizes that probe-start MH ballasts have the remote-starting feature that is not provided with standard pulse-start MH ballasts. However, as discussed previously, DOE has found that pulse-start 1000 W systems can provide the remote-starting feature with the addition of a remote igniter. DOE accounts for the increased cost of the remote-start pulse-start system in section V.C.12 of this notice.

In summary, this final rule analyzes a design standard from 501 W–1000 W, but not from 1001 W–2000 W. In the 1001–2000 W equipment class pulse start systems do not have better lumen maintenance compared to probe start systems. At 501 W–1000 W, however, DOE is still analyzing a design standard banning probe-start ballasts. Customers previously purchasing 1000 W probe-start fixtures would have the option of purchasing an 875 W pulse-start system with 12.5 percent energy savings while maintaining light output, or adopting a compliant 1000 W pulse-start system.

11. Scaling to Equipment Classes Not Analyzed

DOE did not directly analyze ballasts tested at an input voltage of 480 V. Thus, it was necessary to develop a scaling relationship to establish ELs for these equipment classes. To do so in the NOPR, DOE compared quad-voltage ballasts from the representative equipment classes to their 480 V ballast counterparts using catalog data over all representative wattages at various efficiencies. In the NOPR, DOE found the average reduction to ballast efficiency to be 0.6 percent. Therefore, DOE proposed applying this reduction (in the form of a multiplier of 0.994) to develop ELs for the 480 V ballasts. For the 150 W–250 W equipment classes, DOE made adjustments to resulting scaled equations to ensure all ELs were equal to or more stringent than the existing standards (see chapter 5 of the final rule TSD for additional detail).

ULT and NEMA commented that a flat 0.6 percent efficiency gap between quad-voltage and dedicated 480 V fixtures cannot be used across all wattages. In lower wattages, this difference can be much higher, greater than 2 percent. (ULT, Public Meeting Transcript, No. 48 at p. 209; NEMA, No. 56 at p. 19) ULT and NEMA proposed a scaling factor of 2 percent for wattages less than or equal to 150 W, and 1 percent for wattages greater than 150 W (in the form of a subtraction of 2 percentage points and 1 percentage point from the representative equipment class ELs, respectively). (ULT, No. 50 at pp. 11–12; NEMA, No. 56 at p. 19) Musco Lighting noted that the 480 V scaling factor should be a 1 percent reduction instead of 0.6 percent to account for the inability to measure ballast efficiency with more precision than a whole percentage point. (Musco Lighting, No. 55 at p. 4)

In the final rule, DOE analyzed the test data and agreed that the difference in efficiency between ballasts tested at 480 V and ballasts tested at other input voltages changes based on wattage. At lower wattages, ballasts are more compact and less efficient, and the difference in efficiency between the voltages is greater. Because of this correlation, DOE has adjusted the scaling factor used to scale efficiency levels from representative equipment classes to the 480 V equipment classes from the 0.6 percent reduction in the NOPR to the values shown in Table V.5. As in the NOPR, DOE again compared quad-voltage ballasts to their 480 V ballast counterparts using catalog data over all representative wattages. DOE found the average reduction to ballast efficiency changed based on two wattage ranges: 50 W–150 W and 151 W–1000 W. For 50 W–150 W, DOE found the average reduction in ballast efficiency to be less than the 2.0 percent proposed by NEMA. However, DOE did find some instances in which the difference in efficacy was as high or higher than that noted by NEMA. Therefore, DOE determined a scaling factor of 2.0 percent (in the form of a subtraction of 2 percent from the representative equipment class ELs) to be appropriate from 50 W–150 W. Subtracting 2.0 percent across all wattages from 50 W–150 W, instead of applying a scaling multiplier to the EL equations, also aligns with DOE's observation that the difference in efficiency between 480 V ballasts and quad-voltage ballasts is greater at lower wattages. For 150 W–1000 W, DOE also found the average reduction to ballast efficiency to be less than the 1.0 percent proposed by NEMA. However DOE did find some instances in which the difference in efficacy was as high or higher than that noted by NEMA. Therefore, DOE determined a scaling factor of 1.0 percent (in the form of a subtraction of 1 percent from the representative equipment class ELs) to be appropriate from 151 W–1000 W. As with the 50 W–150 W range, DOE applied this scaling factor as a subtraction from the representative equipment class ELs instead of as a multiplier. Even though the 1001 W–2000 W equipment class no longer shows a difference in efficiency between 480 V and non-480 V classes, DOE continues to consider the 480 V and non-480 V equipment classes separately for the purposes of this rulemaking. This separation allows DOE to continue comparing consistent representative classes, of ballasts not tested at 480 V, for each wattage bin. Additionally, for the 150 W–250 W equipment classes, DOE made adjustments to the resulting scaled equations to ensure all ELs were equal to or more stringent than the existing standards (see chapter 5 of the final rule TSD for additional detail).

TABLE V.5—FINAL RULE SCALING FACTORS

Wattage range	Scaling factor (percent)
50 W–150 W	2.0
151 W–1000 W	1.0
1001 W–2000 W	0.0

12. Manufacturer Selling Prices

a. Manufacturer Production Costs

DOE developed the MSPs for MHLFs and MH ballasts by determining an MPC, either through a teardown or retail pricing analysis, and then applying a manufacturer markup to arrive at the MSP. For the NOPR, DOE conducted teardown analyses on a total of 32 commercially available MH ballasts and eight MHLFs. Using the information from these teardowns, DOE summed the direct material, labor, and overhead costs used to manufacture a MHLF or MH ballast, to calculate the MPC.[32] For further details on this analysis, see chapter 5 of the final rule TSD.

APPA noted that if this rulemaking requires larger and heavier ballasts, the replacement costs would increase substantially and have a large effect on the LCC and PBP analyses since the fixture may need to be replaced. (APPA, No. 51 at p. 7) As described in section III.A, this rulemaking only covers ballasts in new fixtures. A replacement ballast for an existing fixture would not need to comply with DOE standards. As described in section V.C.8, DOE also notes that the ballasts needed to meet the standards adopted by this final rule are not notably larger than the baseline ballasts. Efficiency levels based on magnetic ballasts are either based on commercially available ballasts, or modeled using the constraint that ballast size cannot increase relative to less efficient commercially available designs. As such, DOE concluded fixtures would not need to be redesigned to account for an increase in ballast size. See section V.F of this notice for details about the costs that are accounted for in the LCC and PBP analyses.

ULT commented that the fixture price assumptions are too low, as a majority of the fixtures would have to be redesigned, requiring engineering time, new tools, and testing time. (ULT, No. 50 at p. 15) DOE's final fixture prices account for the MPC of the fixture, as detailed in chapter 5 of the final rule TSD. DOE also determined that for the levels analyzed in this rulemaking, fixtures would not be required to be substantially redesigned. Further, any costs associated with redesign, tooling, testing and the general manufacturing process are accounted for in the MIA as detailed in section V.I of this notice.

b. Empty Fixture Costs

DOE conducted fixture teardowns for the NOPR to determine appropriate empty fixture prices. When referring to the ''empty fixture'' component of a MHLF, DOE means the lamp enclosure and optics. The empty fixture does not include the ballast or lamp. DOE added the other components required by the system (including ballasts and any cost adders associated with electronically ballasted systems) and applied appropriate markups to get the final full fixture MSP. In the NOPR, a representative fixture price was developed for each wattage (using the same MSP for indoor and outdoor fixtures), resulting in five unique fixture prices to account for the five representative wattages.

As detailed in section V.C.4 of this notice, DOE has expanded its analysis of representative fixtures in the final rule to account for the varying fixture types used in indoor and outdoor applications. This new division allows DOE to develop separate empty fixture prices for indoor and outdoor fixtures, and thus take the weather protection built into outdoor fixtures into account. These new empty fixture MPCs can be found in chapter 5 of the final rule TSD. The updated pricing results in 12 unique empty fixture prices, namely an indoor and an outdoor price for each of the six representative wattages.

c. Incremental Costs for Electronically Ballasted MHLFs

After determining baseline MH ballast and fixture MPCs, DOE considered whether transitioning from magnetic to electronic ballast technology would require any further ballast or fixture design changes to accommodate the electronic ballast or maintain similar utility to the baseline magnetic ballast. In the NOPR, DOE proposed three sources of incremental costs: (1) Outdoor transient protection, (2) thermal management, and (3) 120 V auxiliary power functionality.

Transient Protection

DOE recognizes the necessity for outdoor fixtures to be able to withstand at least 10 kV voltage transients. While MHLFs with magnetic ballasts are robust and do not require any additional devices or enhancements to withstand these transients, based on its evaluation of commercially available MHLFs, DOE finds that fixtures with electronic ballasts usually require additional design features in order to have adequate protection. Some manufacturers indicated that a portion of their electronic ballasts already have surge protection built in, but most electronic ballasts are only rated for 2.5 kV–6 kV voltage spikes. In the NOPR, DOE proposed an incremental fixture cost of $19 for 10 kV inline (external to the ballast) surge protection for electronically ballasted outdoor fixtures. CA IOUs and the Joint Comment supported DOE's approach to modeling the incremental cost for electronic ballasts over magnetic ballasts to account for 10 kV surge protection. (CA IOUs, No. 54 at pp. 3–7; CA IOUs, Public Meeting Transcript, No. 48 at p. 202; Joint Comment, No. 62 at pp. 4–5)

In the final rule, DOE updated the price of 10 kV voltage transient protection devices. Based on a review of selling prices from transient manufacturers, DOE assigned a cost adder to manufacturers of $10.31 for 10 kV inline surge protection for electronic ballasts, as most electronic ballasts do not have this feature built in. The $10.31 cost adder reflects a high volume purchase, which would be representative of a fixture manufacturer. As such, DOE applies this adder to the fixture MPC for fixtures that require voltage surge protection. DOE also

[32] When viewed from the company-wide perspective, the sum of all material, labor, and overhead costs equals the company's sales cost, also referred to as the cost of goods sold.

assigned a cost to end-users of $21.45 to purchase a replacement voltage transient protection device at a single unit quantity.

In response to public comment, DOE researched indoor industrial fixtures and found these fixtures can also be subject to voltage surges. DOE has thus accounted for the issue of indoor electronic ballasts experiencing voltage surges in these industrial applications. Specifically, DOE analyzes the indoor industrial applications that require additional surge protection as an LCC subgroup. In order for electronic ballasts to be used in these applications, the voltage transient device costs were added to total fixture MSPs in the subgroup. The costs for the transient protection devices for electronic ballasts assigned to the manufacturer and the end user are the same for indoor industrial applications as for outdoor applications. Additionally, when these surge protection devices are compromised from repeated transient events, the additional maintenance and replacement are incorporated in the LCC analysis and NIA.

Thermal Management

Electronic ballasts are more vulnerable than magnetic ballasts to high ambient temperatures which, if not managed well, can cause premature ballast failure. In order to correct for this difference, fixtures housing electronic ballasts would need to be redesigned to account for thermal management in both indoor and outdoor applications. Manufacturers must design new and often larger brackets, and apply additional potting material to create an adequate thermal contact between the ballast and fixture. During interviews, manufacturers gave DOE information about the cost to add thermal management to fixtures with electronic ballasts. In aggregate, manufacturers indicated a 20 percent increase in fixture MPCs associated with thermal management. Additionally, DOE conducted teardown analyses of empty MHLFs. Through analysis of pairs of fixtures designed for electronic ballasts and fixtures designed for comparable magnetic ballasts, DOE also found an approximately 20 percent increase in fixture MPCs to include thermal management for electronic ballasts. Accordingly, in the NOPR cost analysis, all electronically ballasted MHLFs incur a 20 percent incremental cost to the empty fixture MPCs.

Philips and Georgia Power both expressed concerns that the MSP will increase more substantially than DOE projected. (Philips, Public Meeting Transcript, No. 48 at p. 207; Georgia Power, Public Meeting Transcript, No. 48 at p. 207) Philips emphasized that DOE's 20 percent figure for electronic ballasts in outdoor fixtures is understated and would become much higher with pole, fixture, and ballast redesign. However, CA IOUs and the Joint Comment supported DOE's approach to modeling the incremental cost for electronic ballasts over magnetic ballasts to account for thermal management and the potential need for fixture redesign. (CA IOUs, No. 54 at pp. 3–4; CA IOUs, Public Meeting Transcript, No. 48 at p. 202; Joint Comment, No. 62 at pp. 4–5)

As previously mentioned, any price increases required for MHLFs are accounted for in this MSP analysis, while any capital conversion and redesign costs are addressed in the MIA (see section V.I of this notice). DOE has determined that ballast size and weight are not required to change in response to the ELs analyzed, so DOE did not analyze a change in pole size or cost. DOE believes that a cost adder for thermal management is necessary, and given that the costs cited by manufacturers are either not required or are accounted for in another part of the analysis, DOE continues to apply a 20 percent increase in fixture MPCs to reflect thermal management for electronic ballasts

120 V Auxiliary Tap

For indoor applications, a number of magnetic ballasts include a 120 V auxiliary tap. This output is used to operate an emergency incandescent lamp after a temporary loss of power and while the MH lamp is still too hot to restart. These taps are generally required for only one out of every ten indoor lamp fixtures. A 120 V tap is easily incorporated into a magnetic ballast due to its traditional core and coil design, and incurs a negligible incremental cost. Electronic ballasts, though, require additional design to add this 120 V auxiliary power functionality. Using a combination of manufacturer information and market research, DOE proposed in the NOPR that a representative value for electronic ballasts to incorporate this auxiliary tap is $7.50. Because this functionality is only needed for 10 percent of ballasts in indoor fixtures, that number was multiplied by 0.10 to get an incremental ballast cost of $0.75 per indoor ballast.

ULT questioned why DOE scaled down the price of an auxiliary power 120 V tap using a 1:10 ratio just because 10 percent of indoor fixtures require the auxiliary power functionality. (ULT, No. 50 at p. 14) Philips commented that auxiliary power is not always available for electronic ballasts and would require an additional transformer, increasing costs. (Philips, Public Meeting Transcript, No. 48 at p. 189)

DOE scaled down the price of an auxiliary power 120 V tap using a 1:10 ratio because that was the simplest way to characterize the cost that the average fixture will incur when adding this functionality. Based on manufacturer feedback, DOE determined that 10 percent of indoor fixtures require auxiliary 120 V power functionality. Therefore, this method continued to be used to account for these costs in this final rule. DOE agrees that the auxiliary power is not always available with electronic ballasts, and therefore included this incremental ballast cost to account for integrating the additional tap. DOE maintains that the representative value for electronic ballasts to incorporate the auxiliary tap is $7.50. As mentioned previously, as this functionality is only needed for 10 percent of ballasts in indoor fixtures, the resulting incremental ballast cost is $0.75 per indoor ballast.

d. Costs Associated With the Design Standard

In the NOPR, DOE analyzed a design standard banning probe-start ballasts for fixtures greater than 500 W. Pulse-start MH systems require an igniter to start the lamp, while probe-start MH systems do not. In DOE's NOPR cost model, the additional cost of this igniter in pulse-start systems was the only source of cost difference between probe- and pulse-start systems.

Musco Lighting commented that at 1500 W, the cost to shift from a probe-start to a pulse-start system would be much higher than DOE estimated. Musco estimated a more representative value would be four times the incremental cost currently utilized and noted that the igniter could lead to increased maintenance costs. (Musco Lighting, No. 55 at p. 3)

As noted in section V.C.10 of this notice, DOE has chosen to not analyze a design standard for lamps above 1000 W. Therefore, the costs of a transition to pulse-start technology at 1500 W are no longer needed for the final rule analysis.

However, DOE did find that at 1000 W, the design standard could create challenges with certain customers switching to pulse-start technology. Customers who use high-mast applications often see probe-start systems as preferable because they can be easily mounted remotely. This means that the ballast can be at the bottom of the pole for easy maintenance, while the lamp is operated at the top of the pole. In order for a pulse-start system to allow for this remote mounting, DOE found that there are commercially available remote-start igniters that allow pulse-start ballasts to also be remotely mounted. This comes at increased cost due to the addition of this more complex igniter at the top of the pole. When comparing commercially available standard and remote-start igniters, DOE found that remote-start igniter costs were about two times greater. As such, when modeling customers who require remote starting in design standard scenarios, DOE applied a multiplier of 2.07 to the igniter costs.

e. Manufacturer Markups

The last step in determining MSPs is development and application of manufacturer markups to scale the MPCs to MSPs. DOE developed initial manufacturer markup estimates by examining the annual SEC 10–K reports filed by publicly traded manufacturers of MH ballasts and MHLFs, among other products. Based on feedback from manufacturers, in the NOPR DOE proposed separate markups for ballast manufacturers (1.47) and fixture manufacturers (1.58). DOE also assumed that fixture manufacturers apply the 1.58 markup to the ballasts used in their fixtures rather than to only the empty fixtures. In aggregate, the markup also accounted for the different markets served by fixture manufacturers. The 1.47 markup for ballast manufacturers applied only to ballasts sold to fixture original equipment manufacturers (OEMs) directly impacted by this rulemaking. For the purpose of the LCC and NIA analysis, DOE assumed a higher markup of 1.60 for ballasts that are sold to distributors for the replacement market. Receiving no comments to the contrary, DOE continued using these manufacturer markups in the final rule.

D. Markups To Determine Equipment Price

By applying markups to the MSPs estimated in the engineering analysis, DOE estimated the amounts customers would pay for baseline and more-efficient equipment. At each step in the distribution channel, companies mark up the price of the equipment to cover business costs and profit margin. Identification of the appropriate markups and the determination of customer equipment price depend on the type of distribution channels through which the equipment moves from manufacturer to customer.

1. Distribution Channels

Before it could develop markups, DOE needed to identify distribution channels (*i.e.,* how the equipment is distributed from the manufacturer to the end user) for the MHLF designs addressed in this rulemaking. In an electrical wholesaler distribution channel, DOE assumed the fixture manufacturer sells the fixture to an electrical wholesaler (*i.e.,* distributor), who in turn sells it to a contractor, who sells it to the end user. In a contractor distribution channel, DOE assumed the fixture manufacturer sells the fixture directly to a contractor, who sells it to the end user. In a utility distribution channel, DOE assumed the fixture manufacturer sells the fixture directly to the end user (*i.e.,* electrical utility).

2. Estimation of Markups

To estimate wholesaler and utility markups, DOE used financial data from 10–K reports from publicly owned electrical wholesalers and utilities. DOE's markup analysis developed both baseline and incremental markups to transform the fixture MSP into an end-user equipment price. DOE used the baseline markups to determine the price of baseline designs. Incremental markups are coefficients that relate the change in the MSP of higher-efficiency designs to the change in the wholesaler and utility sales prices, excluding sales tax. These markups refer to higher-efficiency designs sold under market conditions with new and amended energy conservation standards.

In the NOPR, DOE assumed a wholesaler baseline markup of 1.23 and a contractor baseline markup of 1.13, for a total wholesaler distribution channel baseline markup of 1.39. DOE also assumed utility baseline markups of 1.00 and 1.13 for the utility distribution channel in which the manufacturer sells a fixture directly to the end user, and the channel in which a manufacturer sells a fixture to a contractor who in turn sells it to the end user, respectively.

The sales tax represents state and local sales taxes applied to the end-user equipment price. DOE obtained state and local tax data from the Sales Tax Clearinghouse.[33] These data represent weighted averages that include state, county, and city rates. DOE then calculated population-weighted average tax values for each census division and large state, and then derived U.S. average tax values using a population-weighted average of the census division and large state values. For the NOPR, this approach provided a national average tax rate of 7.13 percent.

3. Summary of Markups

Table V.6 summarizes the markups at each stage in the distribution channels and the overall baseline and incremental markups, and sales taxes, for each of the three identified channels.

TABLE V.6—SUMMARY OF FIXTURE DISTRIBUTION CHANNEL MARKUPS

	Wholesaler distribution		Utility distribution			
			Via wholesaler & contractor		Direct to end user	
	Baseline	Incremental	Baseline	Incremental	Baseline	Incremental
Electrical Wholesaler (Distributor)	1.23	1.05	(1)	(1)	(1)	(1)
Utility	(1)	(1)	1.00	1.00	1.00	1.00
Contractor or Installer	1.13	1.13	1.13	1.13	(1)	(1)
Sales Tax	1.07		1.07		1.07	
Overall	1.49	1.27	1.21	1.21	1.07	1.07

[1] Not applicable.

[33] The Sales Tax Clearinghouse. Available at *https://thestc.com/STRates.stm.* (Last accessed June 24, 2013.)

Using these markups, DOE generated fixture end-user prices for each EL it considered, assuming that each level represents a new minimum efficiency standard. Chapter 6 of the final rule TSD provides additional detail on the markups analysis.

E. Energy Use Analysis

For the energy use analysis, DOE estimated the energy use of metal halide lamp fixtures in actual field conditions. The energy use analysis provided the basis for other DOE analyses, particularly assessments of the energy savings and the savings in operating costs that could result from DOE's adoption of new and amended standard levels.

To develop annual energy use estimates for the August 2013 NOPR, DOE multiplied annual usage (in hours per year) by the lamp-and-ballast system input power (in watts). DOE characterized representative lamp-and-ballast systems in the engineering analysis, which provided measured input power ratings. To characterize the country's average use of fixtures for a typical year, DOE developed annual operating hour distributions by sector, using data published in the 2010 LMC, the Commercial Building Energy Consumption Survey (CBECS),[34] and the Manufacturer Energy Consumption Survey (MECS).[35] 78 FR 51464, 51501 (Aug. 20, 2013).

Musco Lighting and NEMA commented that metal halide lamp fixtures over 1000 W–particularly 1500 W fixtures—are principally confined to sports lighting applications, and Musco Lighting noted that their monitoring data indicates average usage of 250 hours per year for these fixture types. (Musco Lighting, No. 55 at pp. 1, 4; NEMA, No. 56 at pp. 6–7) The CA IOUs stated that high-wattage MH fixtures are also commonly used in high mast applications, with operating hours similar to other outdoor lighting applications. (CA IOUs, No. 54 at p. 2) DOE acknowledges that high-wattage MH fixtures may be used in high mast applications but notes that the 2010 LMC indicates an average MH lamp wattage of less than 250 W for roadway and parking applications, suggesting a negligible contribution by high mast lighting. As discussed in section V.A.2, DOE created a separate 1500 W equipment class for this final rule to address the unique design features and application of these fixture types. Musco did not provide detailed operating hours data with their written comments; however, NEMA cited the 2010 LMC estimate of 1 hour per day for stadium lighting as reasonable for MHLF applications greater than 1000 W. DOE agrees with NEMA that this 2010 LMC estimate is reasonable for sports lighting applications, and DOE assumed annual operation of 350 hours per year (based on the actual LMC value of 0.958 hours per day) for the 1500 W equipment class in its final rule energy use analysis.

The August 2013 NOPR analysis assumed full operating power and no dimmed operation to estimate MHLF energy use. 78 FR 51464, 51502 (Aug. 20, 2013). DOE received no comments regarding its operating power assumption, and retained its approach for the energy use analysis in today's final rule. Chapter 7 of the final rule TSD provides a more detailed description of DOE's energy use analysis.

F. Life-Cycle Cost and Payback Period Analyses

DOE conducted the LCC and PBP analysis to evaluate the economic effects of potential energy conservation standards for metal halide lamp fixtures on individual customers. For any given efficiency level, DOE measured the PBP and the change in LCC relative to an estimated baseline equipment efficiency level. The LCC is the total customer expense over the life of the equipment, consisting of purchase, installation, and operating costs (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 equipment. The PBP is the estimated amount of time (in years) it takes customers to recover the increased purchase cost (including installation) of more efficient equipment through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost (normally higher) by the change in average annual operating cost (normally lower) that results from the more efficient standard.

Inputs to the calculation of total installed cost include the cost of the equipment—which includes MSPs, distribution channel markups, 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, equipment lifetimes, discount rates, and the year that compliance with new and amended standards is required. To account for uncertainty and variability, DOE created distributions for selected inputs, including operating hours, equipment lifetimes, electricity prices, discount rates, and sales tax rates. 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 variations across building types, lighting applications, and metal halide systems for three sectors (commercial, industrial, and outdoor stationary). In contrast, fixture MSPs were specific to the representative designs evaluated in DOE's engineering analysis, and price markups were based on limited publicly available financial data. Consequently, DOE used discrete values instead of distributions for these inputs.

The computer model DOE uses to calculate the LCC and PBP, which incorporates Crystal Ball (a commercially available software program), relies on a Monte Carlo simulation to incorporate uncertainty and variability into the analysis. The Monte Carlo simulations randomly sample input values from the probability distributions and fixture user samples. The final rule TSD chapter 8 and its appendices provide details on the spreadsheet model and all the inputs to the LCC and PBP analysis.

Table V.7 summarizes the approach and data DOE used to develop inputs to the LCC and PBP calculations for the August 2013 NOPR as well as the changes made for today's final rule. The subsections that follow discuss the calculation inputs and DOE's changes to them.

[34] U.S. Department of Energy, Energy Information Agency. *Commercial Building Energy Consumption Survey: Micro-Level Data, File 2 Building Activities, Special Measures of Size, and Multi-building Facilities.* 2003. Available at *www.eia.doe.gov/emeu/cbecs/public_use.html*.

[35] U.S. Department of Energy, Energy Information Agency. *Manufacturing Energy Consumption Survey, Table 1.4: Number of Establishments Using Energy Consumed for All Purposes.* 2006. Available at *www.eia.doe.gov/emeu/mecs/mecs2006/2006tables.html*.

TABLE V.7—SUMMARY OF INPUTS AND KEY ASSUMPTIONS IN THE LCC AND PBP ANALYSIS *

Inputs	NOPR	Changes for the final rule
Equipment Cost	Derived by multiplying MHLF MSPs by distribution channel markups and sales tax.	No change.
Installation Cost	Calculated costs using estimated labor times and applicable labor rates from "RS Means Electrical Cost Data" (2009) and U.S. Bureau of Labor Statistics.	Calculated costs using estimated labor times and applicable labor rates from "RS Means Electrical Cost Data" (2013); Sweets Electrical Cost Guide 2013; and U.S. Bureau of Labor Statistics.
Annual Energy Use	Determined operating hours separately for indoor and outdoor fixtures. Used lighting market data: 2010 LMC (2012).	No change.
Energy Prices	Electricity: Based on EIA's Form 826 data for 2012	No change.
	Variability: Energy prices determined at state level; incorporated off-peak electricity prices in the Monte Carlo analysis.	
Energy Price Projections	Projected using *AEO2013*	No change.
Replacement Costs	Included labor and material costs for lamp and ballast replacement through the end of their lifetimes.	No change.
Equipment Lifetime	Ballasts: Assumed 50,000 hours for magnetic ballasts and 40,000 hours for electronic ballasts.	Ballasts: No change.
	Fixtures: Assumed 20 years for indoor fixtures and 25 years for outdoor fixtures.	Fixtures: No change.
	Variability: Incorporated lamp and ballast lifetimes in the Monte Carlo analysis.	Variability: Incorporated lamp, ballast and fixture lifetimes in the Monte Carlo analysis.
Discount Rates	Commercial/Industrial: Developed a distribution of discount rates for each end-use sector.	Commercial/Industrial: No change.
	Outdoor Stationary: Developed a distribution of discount rates for each end-use sector.	Outdoor Stationary: 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.

1. Equipment Cost

To calculate customer equipment costs, DOE multiplied the MSPs developed in the engineering analysis by the distribution channel markups described in section V.D.1 (along with sales taxes). DOE used different markups for baseline equipment and higher efficiency equipment because the markups estimated for incremental costs differ from those estimated for baseline models. For the August 2013 NOPR, DOE also examined historical price data for various appliances and equipment that—along with economic literature—suggest that the real costs of these products may in fact trend downward over time, partially because of ''learning'' or ''experience.''[36] 78 FR 51464, 51503 (Aug. 20, 2013).

On February 22, 2011, DOE published a notice of data availability (February 2011 NODA; 76 FR 9696) stating that DOE may consider improving regulatory analysis by addressing equipment price trends. DOE notes that learning-curve analysis characterizes the reduction in production cost mainly associated with labor-based performance improvement and higher investment in new capital equipment at the microeconomic level. Experience-curve analysis tends to focus more on entire industries and aggregates over various causal factors at the macroeconomic level: ''Experience curve'' and ''progress function'' typically represent generalizations of the learning concept to encompass behavior of all inputs to production and cost (*i.e.,* labor, capital, and materials). The economic literature often uses these two terms interchangeably. The term ''learning'' is used here to broadly cover these general macroeconomic concepts.

For the August 2013 NOPR and consistent with the February 2011 NODA, DOE examined two methods for estimating price trends for metal halide lamp fixtures: using historical producer price indices (PPIs), and using projected price indices (called deflators). With PPI data, DOE found both positive and negative real price trends, depending on the specific time period examined, and did not use this method to adjust fixture prices. DOE instead adjusted fixture prices using deflators used by EIA to develop the *AEO2011.* When adjusted for inflation, the deflator-based price indices decline from 100 in 2010 to approximately 75 in 2046. 78 FR 51464, 51503 (Aug. 20, 2013).

DOE received no comments related to equipment price trends, and retained its deflator-based approach to adjust fixture prices for this final rule. Using updated (*AEO2013*) deflators, DOE estimated that the price indices decline from 100 in 2010 to approximately 90 in 2046. A more detailed discussion of price trend modeling and calculations is provided in appendix 8B of the final rule TSD.

2. Installation Cost

Installation costs for metal halide lamp fixtures include the costs to install the fixture, maintain the ballast, and replace the lamp. For the August 2013 NOPR, DOE used data collected for its July 2010 HID lamps determination,[37] labor rates for electricians from *RS Means,*[38] and other research to estimate the installation costs. DOE assumed that installation costs varied between equipment classes as a function of fixture size and mounting locations but were the same between efficiency levels within a given equipment class. For maintenance costs, DOE employed a methodology that allows the use of annualized maintenance costs while maintaining the integrity of the NPV calculations in the NIA. 78 FR 51464, 51503 (Aug. 20, 2013).

DOE received comments that larger ballasts and housings—and larger poles required for outdoor fixtures—would increase costs and payback periods for higher-efficiency designs. (Acuity Brands, Public Meeting Transcript, No. 48 at p. 60; GE, Public Meeting

[36] A draft paper, *Using the Experience Curve Approach for Appliance Price Forecasting,* posted on the DOE Web site at *www.eere.energy.gov/buildings/appliance_standards*, provides a summary of the data and literature currently available to DOE that is relevant to price forecasts for selected appliances and equipment.

[37] U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy. *Energy Conservation Program for Consumer Equipment: Preliminary Technical Support Document: High-Intensity Discharge Lamps.* 2010. Washington, DC. Available at <*www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/60*>.

[38] R.S. Means Company, Inc. *2010 RS Means Electrical Cost Data.* 2010. Kingston, MA.

Transcript, No. 48 at pp. 231–232; NEMA, No. 56 at p. 2) As discussed previously in section V.C of this final rule, DOE's engineering analysis indicated that higher-efficiency fixture designs would not incur significant increases in housing size, effective projected area, or required pole size. DOE, therefore, did not include the added cost of larger poles in the installation costs for higher efficiency fixture designs. For this final rule, DOE also referenced Sweets Electrical Cost Guide[39] in developing installation cost estimates for the LCC and PBP analysis. For further detail, see chapter 8 of the final rule TSD.

3. Annual Energy Use

As discussed in section V.E, DOE estimated the annual energy use of representative metal halide systems using system input power ratings and sector operating hours. For the August 2013 NOPR, DOE based the annual energy use inputs to the LCC and PBP analysis on weighted average annual operating hours. 78 FR 51464, 51503 (Aug. 20, 2013). For this final rule, DOE based the annual energy use inputs on sectoral operating hour distributions (commercial, industrial, and outdoor stationary sectors), with the exception of a discrete value (350 hours per year) for the 1500 W equipment class that is primarily limited to sports lighting. DOE used operating hour (and, by extension, energy use) distributions to better characterize the potential range of operating conditions faced by MHLF customers.

4. Energy Prices

For the August 2013 NOPR, DOE estimated electricity prices for commercial, industrial and outdoor stationary sectors by state using data from EIA Form 826, ''Monthly Electric Utility Sales and Revenue Data, 2011.'' 78 FR 51464, 51503 (Aug. 20, 2013). DOE received no comments related to electricity prices and used 2012 data for this final rule. For more information, see chapter 8 of the final rule TSD.

5. Energy Price Projections

To estimate the trends in energy prices, DOE used the price projections in *AEO2013.* To arrive at prices in future years, DOE multiplied current average prices by the projected annual average price changes in *AEO2013.* Because *AEO2013* projects prices to 2040, DOE used the average rate of change from 2030 to 2040 to estimate the price trend for electricity after 2040. In addition, the spreadsheet tools that DOE used to conduct the LCC and PBP analysis allow users to select price forecasts from the *AEO* low-growth, high-growth, and reference-case scenarios to estimate the sensitivity of the LCC and PBP to different energy price forecasts. 78 FR 51464, 51504 (Aug. 20, 2013). DOE received no comments related to energy price projections, and retained its approach for this final rule. For more information, see chapter 8 of the final rule TSD.

6. Replacement Costs

In the August 2013 NOPR, DOE addressed ballast and lamp replacements that occur within the LCC analysis period. Replacement costs include the labor and materials costs associated with replacing a ballast or lamp at the end of their lifetimes and are annualized across the years preceding and including the actual year in which equipment is replaced. For the LCC and PBP analysis, the analysis period corresponds with the fixture lifetime that is assumed to be longer than that of either the lamp or the ballast. For this reason, ballast and lamp prices and labor costs are included in the calculation of total installed costs.

DOE received numerous comments indicating that electronic HID lamp ballasts require additional voltage transient (surge) protection, in comparison to magnetic ballasts. High-voltage transients could result from, *e.g.,* lightning or wind effects and could shorten electronic ballast life in outdoor applications. (APPA, No. 51 at pp. 5–7; CA IOUs, No. 54 at p. 4; FP&L, Public Meeting Transcript, No. 48 at pp. 232–233; NEMA, No. 56 at pp. 16–17; ULT, No. 50 at p. 13; SCE&G, No. 49 at p. 1) NEMA stated that voltage transients are also a concern in indoor heavy industrial applications. (NEMA, No. 56 at p. 16) Several commenters also stated that it is not possible to determine when transient protection has reached its end of life, other than when it fails and causes a ballast failure in the process. (APPA, No. 51 at p. 5; NEMA, No. 56 at p. 16; Universal, No. 50 at p. 13) ASAP and GE suggested that transient-induced failures and maintenance should also be addressed in the LCC and PBP analysis. (ASAP, No. 62 at p. 5; GE, Public Meeting Transcript, No. 48 at p. 248)

For this final rule, DOE examined the potential effects of voltage transients on electronically ballasted fixtures in outdoor and heavy industrial indoor applications. As discussed previously in section V.C of this final rule, DOE's engineering analysis considers the additional cost of transient protection in determining the total cost for fixtures using electronic ballasts. DOE assumed that outdoor fixtures of all wattages could face transient-induced damage, and that industrial indoor fixtures in the 250 W and 400 W equipment classes were most susceptible to voltage transients, based on 2010 LMC data for average HID lamp wattages in indoor applications.

For outdoor fixtures, DOE examined data on the frequency and geographic distribution of lightning strikes from the National Lightning Safety Institute[40] and other sources to estimate additional surge protection and ballast replacements due to voltage transients. Lightning is more prevalent in the southern and lower midwestern regions of the United States, which leaves high concentrations of outdoor lighting fixtures, *e.g.,* in western and northeastern metropolitan areas, less affected by lightning. On a national level, DOE estimated that direct lightning strikes would be exceedingly rare—approximately 0.01 strikes per year on average, or approximately 1 direct strike per 100 years. DOE estimated that ''near-strikes,'' which occur within a larger radius of the fixture and may be survivable by a protected electronic ballast, are also rare—approximately 0.04 strikes per year on average, or approximately 1 near-strike per 25 years. DOE, therefore, considered the probability of lightning-induced ballast replacements to be negligible for the average MHLF customer and did not consider this replacement event in its main LCC and PBP analysis. DOE expects that MHLF customers in lightning-prone areas will experience a higher probability of transient-induced ballast failures, and DOE estimated the related LCC and PBP effects in its subgroup analysis (see section V.H of this final rule).

For indoor applications, DOE assumed some 250 W and 400 W electronically ballasted fixtures were used in heavy industrial settings susceptible to voltage transients. The 2010 Lighting Market Characterization estimates that 434 W is the average wattage of metal halide lamps in the industrial sector. This means the vast majority of metal halide lamp fixtures in the industrial sector range between 250 W to 1000 W. The engineering analysis only proposed electronic ballasts for 250 W and 400 W light fixtures—thus those fixture types were the only types analyzed the LCC subgroup analysis. DOE's research determined that 60–80 percent of interior transients are

[39] Sweets-McGraw Hill Construction. *Sweets Electrical Cost Guide 2013.* 2012. Vista, CA.

[40] National Lightning Safety Institute. See *http://lightningsafety.com.*

generated by equipment (*e.g.,* elevators, machinery, air-conditioners) within the building. The magnitude of the transients generated ranged in size as did the frequency of the transients. Transient voltage surge suppressors (known mostly as TVSS) and/or other surge protection devices have become more common in industrial buildings. DOE found electronic fluorescent ballasts (although a different technology, an example of what can be accomplished) that manufacturers claimed could survive in industrial settings. DOE assumed that transients could reduce the life of electronic metal halide ballasts by 20 percent and thus modeled this reduction in the LCC subgroup analysis. DOE, therefore, considered the probability of transient-induced surge protection and ballast replacements to be negligible for the average MHLF customer and did not consider this replacement event in its main LCC and PBP analysis. DOE expects that some MHLF customers in heavy industrial indoor applications areas will experience a higher probability of transient-induced surge protection and ballast failures, and DOE estimated the related LCC and PBP effects in its subgroup analysis (see section V.H of this final rule).

For more information regarding replacement costs, see chapter 8 of the final rule TSD.

7. Equipment Lifetime

For the August 2013 NOPR, DOE defined equipment lifetime as the age (in hours in operation) when a fixture, ballast, or lamp is retired from service. The time period used for the LCC and PBP analysis in this rulemaking is the average lifetime of the baseline metal halide lamp fixture. For fixtures in all equipment classes, DOE assumed average lifetimes for indoor and outdoor fixtures of 20 and 25 years, respectively.

Metal halide lamp fixtures are operated by either magnetic or electronic ballasts. In the August 2013 NOPR, DOE assumed that magnetic ballasts last for 50,000 hours and electronic ballasts last for 40,000 hours. Similarly, MH lamp lifetimes vary by lamp technology and equipment class. DOE assumed that ballast and lamp lifetimes can vary due to both physical failure and economic factors (*e.g.,* early replacements due to retrofits); consequently, DOE accounted for variability in lifetimes in LCC and PBP via the Monte Carlo simulation, and in the shipments and NIA analyses by assuming a Weibull distribution for lifetimes to accommodate failures and replacements.[41] 78 FR 51464, 51504 (Aug. 20, 2013).

DOE received comments that its analysis unfairly penalized electronically ballasted designs by modeling an additional ballast replacement late in the fixture lifetime. For example, a customer with an electronically ballasted indoor fixture (20-year lifetime) would have to install a second replacement ballast approximately 2 years before retiring the fixture, which the commenters considered unrealistic. In comparison, a customer with a magnetically ballasted fixture would face only one ballast replacement, given the longer ballast lifetime. To more fairly model the late ballast replacements, the commenters suggested assigning a residual value to remaining ballast life at the end of the fixture's life. (ASAP, No. 62 at pp. 3–4; CA IOUs, No. 54 at pp. 4–5) DOE agrees with this approach, and included the residual value remaining in both lamps and ballasts in its LCC and PBP analysis. ASAP also suggested an alternative that uses a distribution of fixture lifetimes in the LCC and PBP analysis instead of a single average value. (ASAP, No. 62 at p. 4) DOE agrees with the use of a distribution of fixture lifetimes, which captures both early fixture failures (avoiding a second ballast replacement) and customers using fixtures beyond the average lifetimes (more fully using the second replacement ballast). For this final rule, DOE used a distribution of fixture, ballast, and lamp lifetimes as inputs to its LCC and PBP analysis.

For more information regarding equipment lifetimes, see chapter 8 of the final rule TSD.

8. Discount Rates

The discount rate is the rate at which future expenditures are discounted to estimate their present value. In this final rule, DOE estimated separate discount rates for commercial, industrial, and outdoor stationary applications. For all related customers, DOE estimated the cost of capital for commercial and industrial companies by examining both debt and equity capital, and DOE developed an appropriately weighted average of the cost to the company of equity and debt financing. For this final rule, DOE also developed a distribution of discount rates for each end-use sector from which the Monte Carlo simulation samples.

For each sector, DOE assembled data on debt interest rates and the cost of equity capital for representative firms that use metal halide lamp fixtures. DOE determined a distribution of the weighted-average cost of capital for each class of potential owners using data from the Damodaran online financial database.[42] The average discount rates, weighted by the shares of each rate value in the sectoral distributions, are 4.9 percent for commercial end users, 4.7 percent for industrial end users, and 3.4 percent for outdoor stationary end users.

For more information regarding discount rates, see chapter 8 of the final rule TSD.

9. Analysis Period Fixture Purchasing Events

DOE designed the LCC and PBP analysis for this rulemaking around scenarios where customers need to purchase a metal halide lamp fixture. The ''event'' that prompts the purchase of a new fixture (either a ballast failure or new construction/renovation) was assumed to influence the cost-effectiveness of the customer purchase decision. DOE assumed that a customer will replace a failed fixture with an identical fixture in the base case, or a new standards-compliant fixture with comparable light output in the standards case. DOE analyzed six representative equipment classes for fixtures and presented the results for each of these representative equipment classes by fixture purchasing event, which influenced the LCC and PBP results.

For more information regarding fixture purchasing events for the LCC analysis, see chapter 8 of the final rule TSD.

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

DOE's NIA assessed the national energy savings (NES) and the national net present value (NPV) of total customer costs and savings that would be expected to result from new or amended standards at specific efficiency levels.

DOE used a Microsoft Excel spreadsheet model to calculate the energy savings and the national customer costs and savings from each TSL. The TSD and other documentation for the rulemaking help explain the models and how to use them, enabling interested parties to review DOE's analyses by changing various input quantities within the spreadsheet.

[41] Weibull distribution is a probability density function; for more information, see *www.itl.nist.gov/div898/handbook/eda/section3/eda3668.htm.*

[42] The data are available at *pages.stern.nyu.edu/~adamodar.* (Last accessed August 21, 2013.)

DOE used the NIA spreadsheet to calculate the NES, and the NPV of costs and savings, based on the annual energy use and total installed cost data from the energy use and LCC analyses. DOE projected the energy savings, energy cost savings, equipment costs, and NPV of customer benefits for each equipment class for equipment sold from 2017 through 2046. The projections provided annual and cumulative values for all four output parameters.

DOE evaluated the impacts of new and amended standards for metal halide lamp fixtures by comparing base-case projections with standards-case projections. The base-case projections characterize energy use and customer costs for each equipment class in the absence of new or amended energy conservation standards. DOE compared these projections with projections characterizing the market for each equipment class if DOE adopted new or amended standards at specific energy efficiency levels (*i.e.,* the TSLs or standards cases) for that class. In characterizing the base and standards cases, DOE considered historical shipments, the mix of efficiencies sold in the absence of new standards, and how that mix may change over time. Additional information about the NIA spreadsheet is in the final rule TSD chapter 11.

Table V.8 summarizes the approach and data DOE used to derive the inputs to the NES and NPV analyses for the August 2013 NOPR, as well as the changes to the analyses for the final rule. A discussion of selected inputs and changes follows. See chapter 11 of the final rule TSD for further details.

TABLE V.8—APPROACH AND DATA USED FOR NATIONAL ENERGY SAVINGS AND CUSTOMER NET PRESENT VALUE ANALYSES

Inputs	Proposed rule	Changes for the final rule
Shipments	Developed annual shipments from shipments model	See Table V.9.
Annual Energy Consumption per Unit	Established in the energy use analysis (NOPR TSD chapter 7)	See section V.E.
Rebound Effect	0%	No change.
Electricity Price Forecast	*AEO2013*	*No change.*
Energy Site-to-Source Conversion Factor	Used annually variable site kWh to source Btu conversion factor	*No change.*
Discount Rate	3% and 7% real	No change.
Present Year	2013	No change.

1. Shipments

Equipment shipments are an important component of any estimate of the future impact of a standard. Using a three-step process, DOE developed the shipments portion of the NIA spreadsheet, a model that uses historical data as a basis for projecting future fixture shipments. First, DOE used U.S. Census Bureau fixture shipment data, NEMA lamp shipment data, and NEMA ballast sales trends to estimate historical shipments of each fixture type analyzed. Second, DOE estimated an installed stock for each fixture in 2017 based on the average service lifetime of each fixture type. Third, DOE developed annual shipment projections for 2017–2046 by modeling fixture purchasing events, such as replacement and new construction, and applying growth rate, replacement rate, and alternative technologies penetration rate assumptions. For details on the shipments analysis, see chapter 10 of the final rule TSD.

TABLE V.9—APPROACH AND DATA USED FOR THE SHIPMENTS ANALYSIS

Inputs	Proposed rule	Changes for the final rule
Historical Shipments	Used historical HID fixture and lamp shipments to develop shipments for MH fixtures.	Revised historical MH fixture shipments based on updated NEMA MH ballast shipment trends.
Fixture Stock	Based projections on the shipments that survive up to a given date; assumed Weibull lifetime distribution.	No change.
Growth	Adjusted based on fixture market	No change.
Base Case Scenarios	Developed “low” and “high” shipments scenarios	Revised “low” and “high” shipments scenarios based on revised historical MH fixture shipments.
Standards Case Scenarios	Analyzed Roll-up only	No change.

a. Historical Shipments

For the August 2013 NOPR, DOE reviewed U.S. Census Bureau data from 1993 to 2001 for metal halide lamp fixtures.[43] DOE compared the MHLF census data to NEMA data for historical metal halide lamp shipments from 1990 to 2008 taken from DOE’s final determination for HID lamps published on July 1, 2010. 75 FR 37975. DOE found a correlation between metal halide lamp fixture and metal halide lamp shipments. From 1993 to 2001, the number of MHLF shipments on average represented 37 percent of the amount of lamp shipments, with a standard deviation of 3 percent. Using this relationship, DOE multiplied all of the metal halide lamp shipments from 1990 to 2010 by 37 percent to estimate the historical shipments of metal halide lamp fixtures. DOE assumed that shipments for metal halide lamp fixtures would peak somewhere between 2010 and 2015, and generally decline thereafter. 78 FR 51464, 51506 (Aug. 20, 2013).

DOE received multiple comments indicating that its shipments analysis significantly underestimated the rate of decline in the MHLF market, and thereby overestimated total MHLF shipments. (APPA, No. 51 at p. 2; NEMA, No. 56 at pp. 2, 4, 22; ULT, No. 50 at p. 15) NEMA presented new MH ballast sales trend graphs at the NOPR public meeting, suggesting a much

[43] U.S. Census Bureau. *Manufacturing, Mining, and Construction Statistics.* Current Industrial Reports, Fluorescent Lamp Ballasts, MQ335C. 2008. (Last accessed October 28, 2013). *www.census.gov/mcd/.*

steeper decline in fixture shipments from 2008 to 2013 than assumed in the August 2013 NOPR. (NEMA, No. 44 at p. 15) For this final rule, DOE retained its peak in fixture shipments, and revised its trend for subsequent historical shipments to approximate the new sales trend information provided by NEMA. As a result, total estimated MHLF shipments for 2013 were approximately 31 percent lower than in the August 2013 NOPR. By extension, DOE also revised its projected base case shipments downward, as discussed in section V.G.1.c of this final rule.

b. Fixture Stock Projections

In the August 2013 NOPR shipments analysis, DOE calculated the installed fixture stock using estimated historical fixture shipments and its projected shipments for future years. DOE estimated the installed stock during the analysis period by using fixture shipments and calculating how many will survive up to a given year based on a Weibull lifetime distribution for each fixture type. 78 FR 51464, 51506 (Aug. 20, 2013). DOE received no comments on the August 2013 NOPR regarding its fixture stock projection method and retained this approach for this final rule.

c. Base Case Shipment Scenarios

For the August 2013 NOPR, DOE assumed that shipments for MHLFs peaked somewhere between 2010 and 2015. For projected fixture shipments in the ''low'' and ''high'' shipment scenarios, DOE projected a decline that fell back to the levels in 2000 and 2006, respectively.[44] 78 FR 51464, 51506 (Aug. 20, 2013). As discussed previously, several commenters stated that DOE overestimated total MHLF shipments in its NOPR analysis. (APPA, No. 51 at p. 2; NEMA, No. 56 at pp. 2, 4, 22; ULT, No. 50 at p. 15) For this final rule, DOE used new MH ballast sales trend information provided by NEMA to revise its historical fixture shipments, resulting in significantly lower shipment estimates for 2008 to 2013. As a result, DOE's projected fixture shipments through 2047 were also significantly lower; *for example,* the ''low'' scenario shipments for 2020 were 31 percent lower than the corresponding NOPR estimate and declined to approximately pre-1990 levels by the end of the shipments analysis period.

d. Standards-Case Efficiency Scenarios

Several of the inputs for determining NES (*e.g.,* the annual energy consumption per unit) and NPV (*e.g.,* the total annual installed cost and the total annual operating cost savings) depend on equipment efficiency. For the August 2013 NOPR, DOE used a ''Roll-up'' shipment efficiency scenario, which is a standards case in which all equipment efficiencies in the base case that do not meet the standard would ''roll up'' to the lowest level that can meet the new standard level. Equipment efficiencies in the base case above the standard level are unaffected in the Roll-up scenario, as these customers are assumed to continue to purchase the same base-case fixtures. The Roll-up scenario characterizes customers primarily driven by the first cost of the analyzed equipment, which DOE believes more accurately characterizes the metal halide lamp fixture marketplace. 78 FR 51464, 51506 (Aug. 20, 2013).

NEMA and ULT commented on the August 2013 NOPR, stating that setting a standard for 150 W fixtures that requires electronic ballasts will steer customers to higher wattage, magnetically ballasted fixtures. (NEMA, Public Meeting Transcript, No. 48 at pp. 33–34; NEMA, No. 44 at p. 9; NEMA, No. 56 at p. 24; ULT, Public Meeting Transcript, No. 48 at pp. 144–145; ULT, No. 50 at p. 2)

DOE agrees that there is some possibility of a shift between the technologies. The ballast types play a role in the decision, but so do initial costs, life-cycle costs, and utility features of the light source. DOE assume that customer would not opt for the 175 W magnetically ballasted fixture if the 150 W light fixture is cheaper. DOE's analysis has the 175 W metal halide lamp fixture at the baseline and efficiency levels 1–3 to be greater than the 150 W metal halide lamp fixture at the baseline and efficiency levels 1–3. Therefore, DOE assumes that only if a standard that were set requiring efficiency level 4 would customers chose to install 175 W metal halide lamp fixtures. In this shift scenario, DOE did not assume an overwhelming number of customers would shift to 175 W because the economics and utility features between the two options were similar. Because the options were so similar, there was no an overwhelming reason for customers to make large shifts to the 175 W metal halide lamp fixture as a result of a standard requiring electronic ballasts for 150 W metal halide lamp fixtures.

Similarly, DOE modeled a shift of customers migrating from 1000 W probe-start fixtures to either 875 W pulse-start or 1000 W pulse-start fixtures as a result of the design standard being part of this rule. In order to examine the market shift that would be expected to occur under a design standard for the 500 W–1000 W equipment class, DOE developed an econometric-based consumer choice model to estimate the relative fraction of 1000 W probe-start fixture customers who migrate to 1000 W pulse-start and 875 W pulse-start fixtures. The consumer choice model was based on a conditional logit model to establish consumer preference between these two options, based on economic parameters, coupled with a market diffusion curve to estimate the rapidity of movement in the market toward the consumer preference predicted by the logit model. Data underlying the consumer choice model reflected that for commercial and industrial lighting purchasers as presented in DOE's General Service Fluorescent Lamps preliminary analysis technical support document.[45] DOE estimated that approximately 27 percent of those customers using 1000 W probe-start fixtures in the base case shipment forecast would shift to 875 W pulse-start fixtures and the remaining 73 percent of 1000 W probe-start customers would migrate to 1000 W pulse-start fixtures. These market shifts were used in the shipments estimates underlying the calculation of the design standard benefits in the NIA.

DOE also received comments on the August 2013 NOPR stating that additional costs resulting from potential standards could increase the rate at which MHLF customers migrate to other lighting technologies. (APPA, No. 51 at pp. 2–3; NEMA, No. 56 at p. 23; ULT, No. 50 at p. 15) NEMA noted that costs for many fixture types had already increased to meet recent new National Electrical Code requirements. (NEMA, No. 56 at p. 23) NEMA and ULT observed that applications requiring high lumen output and high-temperature operating environments still favor metal halide lamp fixtures, however. (NEMA, No. 56 at p. 22; ULT, No. 50 at p. 15) DOE believes that its

[44] The August 2013 NOPR text at 78 FR 51463, 51506 (August 20, 2013) incorrectly indicated that fixture shipments in the ''high'' scenario in 2040 roughly equaled the shipments in 2006. Several commenters stated that the declining MHLF market would not return to 2006 shipment levels. (APPA, No. 51 at p. 2; NEMA, No. 56 at p. 4) DOE's actual modeled fixture shipments for 2040 were roughly equal to pre-2000 shipments, significantly lower than the 2006 peak.

[45] U.S. Department of Energy—Office of Energy Efficiency and Renewable Energy. Energy Conservation Program for Consumer Products: Preliminary Technical Support Document: Energy Efficiency Standards for Consumer Products: General Service Fluorescent Lamps and Incandescent Reflector Lamps. February 2013. Washington, DC. *http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0006-0022.*

revised base case shipments (that incorporate new NEMA sales trend information) capture the main effect of migration to other lighting technologies, and illustrate a significant decrease in total MHLF shipments compared to the NOPR analysis. DOE reserved the standards-case shipments scenario to characterize the purchasing behaviors of remaining MHLF customers, and retained its Roll-up approach for this final rule.

2. Site-to-Source Energy Conversion

To estimate the national energy savings expected from appliance standards, DOE uses a multiplicative factor to convert site energy consumption into primary or source energy consumption (the energy required to convert and deliver the site energy). These conversion factors account for the energy used at power plants to generate electricity and losses in transmission and distribution, as well as for natural gas losses from pipeline leakage and energy used for pumping. For electricity, the conversion factors vary over time due to projected changes in generation sources (*i.e.,* the types of power plants projected to provide electricity to the country). The factors that DOE developed are marginal values, which represent the response of the system to an incremental decrease in consumption associated with appliance standards.

For the August 2013 NOPR, DOE used the annually variable site-to-source conversion factors based on the version of NEMS that corresponds to *AEO2013,* which provided energy forecasts through 2035. For 2036–2044, DOE used conversion factors that remain constant at the 2035 values. 78 FR 51464, 51506 (Aug. 20, 2013). DOE received no comments regarding site-to-source conversion factors, and retained its approach for today's final rule.

DOE has historically presented NES in terms of primary energy savings. In response to the recommendations of a committee on ''Point-of-Use and Full-Fuel-Cycle Measurement Approaches to Energy Efficiency Standards'' appointed by the National Academy of Science, DOE announced its intention to use FFC measures of energy use and greenhouse gas and other emissions in the national impact analyses and emissions analyses included in future energy conservation standards rulemakings. 76 FR 51281 (August 18, 2011) While DOE stated in that notice that it intended to use the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model to conduct the analysis, it also said it would review alternative methods, including the use of NEMS. After evaluating both models and the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in the **Federal Register** in which DOE explained its determination that NEMS is a more appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701 (August 17, 2012). DOE received one comment, which was supportive of the use of NEMS for DOE's FFC analysis.[46]

The approach used for today's final rule, and the FFC multipliers that were applied, are described in appendix 11B of the final rule TSD. NES results are presented in both primary and FFC savings in section VII.B.3.a.

H. Customer Subgroup Analysis

The life-cycle cost subgroup analysis evaluates impacts of standards on identifiable groups, such as different customer populations or business types that may be disproportionately affected by any national energy conservation standard level. For the August 2013 NOPR, DOE estimated LCC savings and payback periods for three subgroups: Utilities, transportation facility owners, and warehouse owners. These three subgroups were distinguished from average MHLF customers by higher maintenance costs (utilities), higher operating hours (transportation facility owners), and lower operating hours (warehouse owners). 78 FR 51464, 51507 (Aug. 20, 2013).

Several utilities commented that DOE incorrectly assigned the same retail electricity rates to all three subgroups, when utilities would instead pay lower wholesale rates, resulting in lower energy cost savings and longer payback periods. (APPA, No. 51 at pp. 8–9; EEI, No. 53 at p. 4; NRECA, No. 61 at p. 2) DOE agrees with this distinction, and DOE referenced EIA wholesale electricity prices[47] for the utility subgroup in its final rule analysis. As discussed previously in section V.F.6 of this final rule, DOE is also evaluating two new customer subgroups for transient-prone fixtures in outdoor and heavy industrial indoor applications. DOE assumed that owners of transient-prone outdoor fixtures would face shortened surge protection and electronic ballast lifetimes because of lightning-induced voltage transients, resulting in a 15 percent shorter electronic ballast life requiring more frequent electronic ballast and surge protection device replacements during the fixture lifetime. For indoor fixtures, DOE assumed that fixture owners in heavy industrial environments would face shortened surge protection and electronic ballast lifetimes because of voltage transients, resulting in a 20% shorter electronic ballast life requiring more frequent electronic ballast and surge protection device replacements during the fixture lifetime.

For more information regarding the customer subgroup analysis, see chapter 12 of the final rule TSD.

I. Manufacturer Impact Analysis

DOE conducted an MIA to estimate the financial impact of new and amended energy conservation standards on manufacturers of MHLFs and ballasts, and to estimate the impact of new and amended standards on employment and manufacturing capacity. The quantitative aspect of the MIA relies on the GRIM, an industry cash-flow model customized for MHLFs and ballasts covered in this rulemaking. The GRIM is used to calculate INPV, which is the key MIA output. In its analysis, DOE used the GRIM to calculate cash flows using standard accounting principles and to compare the difference in INPV between the base case and various TSLs (the standards cases). The difference in INPV between the base and standards cases represents the financial impact of new and amended MHLF standards on MHLF and ballast manufacturers. DOE employed different assumptions about markups and future shipments to produce ranges of results that represent the uncertainty about how the MHLF and ballast industries will respond to energy conservation standards.

In the MIA, DOE typically groups its estimates of manufacturer impacts by the major equipment types that are produced by the same manufacturers. The covered equipment in today's rulemaking is MHLFs; however, by requiring particular MH ballast efficiencies in this regulation, MH ballast manufacturers will also be affected by new and amended MHLF standards. The MHLF and ballast markets are served by separate groups of manufacturers. DOE therefore presents impacts on MHLF manufacturers and MH ballast manufacturers separately.

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

1. Manufacturer Production Costs

Manufacturing higher-efficiency equipment is typically more expensive than manufacturing baseline equipment

[46] Docket ID: EERE–2010–BT–NOA–0028, comment by Kirk Lundblade.

[47] See *www.eia.gov/electricity/wholesale/* (Last accessed December 2013).

due to the need for more costly components. The resulting changes in the MPCs of the analyzed equipment can affect the revenues, gross margins, and cash flows of manufacturers. DOE strives to accurately model the potential changes in these equipment costs, as they are a key input for the GRIM and DOE's overall analysis. For the final rule, DOE updated the MHLF and some ballast MPCs based on stakeholder comments. For a complete description of the changes made to the MPCs see section V.C.12 of this final rule.

2. Shipment Projections

Changes in sales volumes and efficiency distribution of equipment over time can significantly affect manufacturer finances. The GRIM estimates manufacturer revenues based on total unit shipment projections and the distribution of shipments by efficiency level. For the final rule, DOE reduced the number of shipments of MHLFs in both the low- and high-shipment scenarios based on stakeholder comments. For the MIA, the GRIM uses the NIA's annual shipment projections from the base year, 2014, to 2046, which is the end of the analysis period. For a complete description of the changes made to the shipment analysis see section V.G.1 of this final rule.

3. Markup Scenarios

For the MIA, 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 new and amended energy conservation standards: (1) A flat, or preservation of gross margin, markup scenario and (2) a preservation of operating profit markup scenario. These scenarios lead to different markup values, which when applied to the inputted MPCs, result in varying revenue and cash-flow impacts.

For the final rule, DOE did not alter the markup scenarios, values, or methodology used in the NOPR analysis.

4. Production and Capital Conversion Costs

New and amended energy conservation standards will cause manufacturers to incur one-time conversion costs to bring their production facilities and equipment 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 research, development, testing, marketing, and other non-capitalized costs necessary to make equipment designs comply with the new and 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 equipment designs can be fabricated and assembled. DOE created separate conversion costs for MHLF and ballast manufacturers.

In response to the NOPR, Acuity stated they believed the conversion costs for fixture manufacturers seemed surprisingly low. (Acuity, Public Meeting Transcript, No. 48 at p. 285) DOE assumed that there would not be any capital conversion costs for fixture manufacturers at efficiency levels requiring more efficient magnetic ballasts. This is based on DOE's assumption in the engineering analysis that the size of the magnetic ballast would not need to be increased at those efficiency levels and therefore, fixture manufacturers would not need to redesign their MHLFs to be compatible with the higher efficiency magnetic ballasts. Fixture manufacturers would, however, incur product conversion costs at efficiency levels requiring magnetic ballasts. Higher ballast efficiency levels would require fixture manufacturers to re-test and re-certify fixtures with ballasts that were redesigned to meet standards. DOE believes that there would be both product conversion costs, as well as capital conversion costs, for fixture manufacturers at all efficiency levels requiring electronic ballasts since fixture manufacturers producing MHLFs containing magnetic ballasts would need to redesign their fixture production process.

Several manufacturers stated there would be significant conversion costs to comply with the MHLF standards proposed in the NOPR. Cooper, for example stated that they would have to make substantial investments to comply with the standards proposed in the NOPR. (Cooper, Public Meeting Transcript, No. 48 at p. 58) ULT expressed concern that complying with the proposed standards would consume significant company time and resources. They commented that from a design cycle standpoint, one fixture could take eight to 12 months to redesign and test, which includes design validation testing, UL testing, and life-cycle testing. (ULT, Public Meeting Transcript, No. 48 at p. 201) DOE acknowledges that manufacturers would have to make investments to comply with MHLF standards. As part of the MIA, DOE attempts to quantify the time and monetary expenditures that would comprise the capital and product conversion costs, which MHLF and ballast manufacturers would need to incur to convert all their equipment to meet the standards. These conversion cost estimates were based on DOE's research and modified based on manufacturer feedback during interviews.

DOE modified the capital conversion costs for the final rule based on the reduction in shipments modeled in the final rule shipments analysis. Consequently, DOE reduced the capital conversion costs proportionally to the reduction in shipments of the final rule, since capital conversion costs are correlated to the shipment volume in the year standards require compliance. DOE did not alter the product conversion costs since these costs are correlated with the number of product designs impacted by standards, not necessarily the shipment volume in the year standards require compliance.

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 compliance period, alternative technologies, the opportunity cost of investments, the replacement ballast market, and potential impact on MH lamp manufacturers. These comments are addressed below.

a. Compliance Period

NEMA stated that based on its analysis, a three-year compliance period would be inadequate for the extensive R&D effort that MHLF and ballast manufacturers would have to undergo in order to redesign all equipment to be compliant with the efficiency levels proposed in the NOPR. NEMA stated that in their analysis, they found that manufacturers would face significant technical obstacles when trying to produce high volumes of compliant MHLFs and ballasts due to the challenging nature of processing higher-grade materials, such as M6 steel. NEMA does not believe that lighting manufacturers are willing to dedicate enough resources to MHLF and ballast technology to be able to redesign all wattages during a three-year time period. (NEMA, No. 56 at p. 3) While DOE acknowledges there are difficulties and costs associated with manufacturing higher efficiency products, all efficiency levels analyzed in DOE's engineering analysis, including max tech, are technologically feasible to manufacture. For a complete description of MHLFs and ballasts and analyzed in the engineering analysis see section V.C of this final rule.

NEMA also commented that the MHLF NOPR proposed expanding the scope of covered equipment to include wattage ranges previously not covered by the standards prescribed in EISA 2007, as well as eliminating exemptions for certain equipment that were granted by EISA 2007. According to NEMA, the number of MHLFs impacted would be significant and bringing them into compliance would be time-consuming and costly. NEMA listed some of the most significant compliance obstacles that manufacturers would face including: Evaluating ballast performance to identify compliant ballasts; determining if ballasts in fixtures need to be replaced; modifying order and quotation systems; obtaining the test data for CCE; educating manufacturing staff; educating customers; and managing order backlogs. NEMA believes that managing these logistics would divert limited resources within lighting divisions and would prevent manufacturers from focusing on developing and selling more efficient lighting technology, such as LEDs. According to NEMA, the proposed standards would delay the market transition to technologies that are more efficient than those established by this rulemaking. (NEMA, No. 56 at p. 20)

During the NOPR public meeting, NEMA further emphasized the complex logistics manufacturers would face in complying with new and amended energy conservation standards. NEMA stated that a large amount of equipment would have to be redesigned and several sales channels would be impacted if DOE expanded the scope of covered MHLFs beyond what was included in EISA 2007. (NEMA, Public Meeting Transcript, No. 48 at pp. 19–20) According to NEMA, manufacturers would have to employ significant company resources to educate internal staff, such as marketing and sales representatives, about new equipment available for purchase. Time and money would also have to be spent updating IT systems due to changes in order processing and inventory management software. (NEMA, Public Meeting Transcript, No. 48 at p. 22)

NEMA further argued that manufacturers would have to use company resources to educate their customers about redesigned compliant equipment. For fixture manufacturers, customers include OEMs, distributors, contractors, designers, home centers, and showrooms. Manufacturers would have to modify marketing materials and manage orders and contracts which might extend one to two years into the future. According to NEMA, managing these contracts would be complicated, as the prices and performances of the MHLFs are generally guaranteed and would change due to standards. (NEMA, Public Meeting Transcript, No. 48 at p. 26) Ballast manufacturers also often have one or two-year contracts with their customers, who agree to buy ballasts that achieve particular performance levels for an agreed upon price. Ballast manufacturers would have to renegotiate these contracts, which would be difficult because prices and ballast performances would change due to standards. (NEMA, Public Meeting Transcript, No. 48 at p. 23)

NEMA also stated that fixture manufacturers would not be able to start preparing for energy conservation standards until ballast manufacturers had completed their redesign and compliance efforts. Fixture manufacturers would have to assess whether redesigned ballasts were the same form and size and whether they had the same thermal characteristics before they would be able to begin redesigning fixtures. According to NEMA, if a particular ballast needed to be redesigned, that could mean dozens, if not hundreds, of unique fixtures using that particular ballast would also need to be redesigned. NEMA stated any change in a ballast's form or thermal characteristics would require a tremendous redesign effort for fixture manufacturers. (NEMA, Public Meeting Transcript, No. 48 at p. 25)

NEMA further commented that MHLFs and ballasts would also have to go through electrical, safety, thermal, and photometric testing, all of which would consume manufacturers' time and resources. NEMA expressed concern that testing of the new and modified ballasts and fixtures would take a significant amount of time and would further complicate manufacturers' efforts to abide by the three-year compliance period. NEMA pointed out that when the DOE CCE rule went into effect, manufacturers took six months to obtain accurate samples for certification. Manufacturers would have to redesign and test modified ballasts and fixtures before even beginning to collect samples for the CCE rule. NEMA argued that this would be difficult to achieve within the three-year compliance period. (NEMA, Public Meeting Transcript, No. 48 at p. 22) NEMA also questioned whether UL could handle the volume of testing that would be necessary to comply with standards in such a short period of time since all redesigned MHLFs and ballasts would need to be certified. (NEMA, Public Meeting Transcript, No. 48 at p. 26)

DOE acknowledges that new and amended energy conservation standards will require MHLF and ballast manufacturers to undergo changes to their production processes, modify existing equipment, develop new models, and make a series of complex logistical decisions. In the NOPR, DOE assumed ballast and fixture manufacturers must comply with standards as of January 1, 2015. However, as described in section VI.C, DOE has revised the compliance date in the final rule to be consistent with the three-year time frame specified in EISA 2007. DOE assumes a three-year compliance period when estimating all capital and product conversion costs, which DOE included as potential burdens when selecting standards for MHLFs.

b. Alternative Technologies

DOE recognizes that there are alternative lighting technologies that can be used in the same applications as MHLFs and that MHLF shipments are on the decline. Lighting manufacturers, for example are heavily investing in R&D for LEDs, an advanced and highly efficient lighting technology for which demand is growing rapidly. LED technology has matured to the point that it can be used in a number of applications in which MHLFs are typically used, predominantly at lower wattages. However at higher wattages, it is more difficult for customers to switch from MH to LED.

At the NOPR public meeting, Philips pointed out that a majority of R&D resources within the lighting industry have already been transferred to LEDs and away from traditional lighting technologies. (Philips, Public Meeting Transcript, No. 48 at p. 50) ULT stated that by creating new standards for a technology with declining market share, DOE is hindering this trend, as manufacturers will have to divert resources away from developing more advanced and efficient technologies to convert their metal halide product lines. (ULT, Public Meeting Transcript, No. 48 at p. 61) Acuity noted, however, that in the higher-wattage applications, LED technology has not yet developed a high-intensity lighting solution, and therefore the market will be forced to continue to develop MH lamps for those applications. (Acuity, Public Meeting Transcript, No. 48 at p. 24)

APPA, NRECA, and EEI all noted that due to market conditions and the existence of other lighting technologies, manufacturers may have no incentive to make replacement ballasts for existing MHLFs. (APPA, No. 51 at p. 7; NRECA, No. 61 at p. 2; EEI, No. 53 at p. 3) APPA pointed out that MH ballast production has been declining since 2008 and that manufacturers may decide to halt the production of replacement ballasts to focus on LEDs. APPA argued that if replacement ballasts became commercially unavailable, the original intent of the rule, which was not to force the implementation of new fixtures, would be lost. (APPA, No. 51 at p. 7) NEEA argued that to avoid this problem, regulations are needed for LEDs so that manufacturers would have incentive to perform research and development on MHLFs to make them more efficient. (NEEA, Public Meeting Transcript, No. 48 at p. 53)

DOE acknowledges that the MHLF market is currently in decline and has modeled this decline into its projections of future MHLF and ballast shipments. Any effects of increased R&D of technologies not covered by this rulemaking and the market penetration of those technologies into the MHLF market are discussed in the following section of the MIA (V.I.5.c) DOE agrees that there are a number of applications in which LED cannot provide equivalent lumen output to MHLF light levels and that there will be a continued market for this equipment. DOE expects that even with the standards adopted by this final rule there will be a market for manufacturers to make replacement ballasts.

c. Opportunity Cost of Investments

Several manufacturers commented that developing MHLFs to meet energy conservation standards would have opportunity costs. NEMA argued that diverting resources to convert MHLFs and ballasts to comply with new and amended standards would negatively impact the lighting market by delaying the introduction of products with potentially higher efficiency, better utility, and more responsive controls. (NEMA, No. 56 at p. 24) Musco Lighting commented that the proposed standard requiring pulse-start lamps would divert critical R&D resources to attempt to develop a technology that does not exist and to this point has not been determined as commercially achievable. Musco Lighting stated R&D resources in the lighting industry should remain focused on technologies that have significant opportunities for energy reduction, such as LEDs. Musco Lighting believes the proposed MHLF standards would not achieve significant energy savings and would potentially hold back substantial lighting efficiency gains by diverting resources. (Musco Lighting, No. 55 at p. 3)

Most manufacturers agreed that LEDs are the future of the lighting industry, and therefore are primarily focusing R&D resources on this technology as opposed to MH technology. As a result, NEMA pointed out that lighting manufacturers are working with fewer human resources dedicated to MH than they were when they first had to come into compliance with EISA 2007 MH standards. Meeting those standards was very complicated for manufacturers even with the more abundant resources that were available. It will be difficult for companies to simultaneously develop LEDs and upgrade MHLFs and ballasts (NEMA, Public Meeting Transcript, No. 48 at p. 20)

ULT pointed out that while LEDs are growing in market share, they are still not mature enough to work well in all applications; however, manufacturers are getting closer to achieving this through R&D. According to ULT, lighting manufacturers are working on developing fixtures that are designed to remove heat, keep water out, and help protect against surges to allow the use of LEDs in all fixtures. ULT believes that MHLF standards requiring manufacturers to spend over a year designing, testing, and validating MHLFs and ballasts would slow the integration of LEDs into the market and force manufacturers to work on lighting technologies that may not be in the market in the next five to 10 years. (ULT, No. 50 at p. 16–17) NEMA commented that if manufacturers chose to convert their MH equipment to the proposed efficiency levels, the higher priced MHLFs could cause customers to shift to LEDs anyway, which would mean that manufacturers would not recoup the cost of investment into MHLFs. (NEMA, Public Meeting Transcript, No. 48 at p. 150) Several manufacturers and NEMA said that these considerations could cause some fixture and ballast manufacturers to exit the MH market. (NEMA, Public Meeting Transcript, No. 48. 283)

NEMA argued that manufacturers may choose to exit the market due to the fact that the proposed standards could have severe impacts on manufacturers. They noted that in DOE's NOPR analysis, MH ballast manufacturers would need to invest up to 29 million dollars at the proposed TSL and this could result in up to a 25 percent loss of base case INPV. According to NEMA, the impacts will be more severe than DOE projected in the NOPR because NEMA believes that shipments of MHLFs and ballasts will decline much faster than DOE projected. NEMA argued that the rapidly declining MH market makes it difficult for manufacturers to justify the significant investments necessary to comply with MHLF standards. (NEMA, No. 56 at p. 23) DOE has adjusted the projected volume of shipments based on stakeholder feedback. In the final rule shipment analysis, there is a sharper decline in MHLF shipments as suggested by NEMA's comment. For a complete description of the changes made to the shipment analysis see section V.G.1 of this final rule.

DOE recognizes the opportunity cost associated with any investment, and agrees that manufacturers would need to spend capital and company resources to meet today's standards that they would not have to spend in the absence of standards. As a result, manufacturers must determine the extent to which they will balance investment in the MH market with investment in emerging technologies, such as LEDs. These companies will have to weigh tradeoffs between deferring investments and deploying additional capital. DOE includes the costs of meeting today's standard in the conversion costs portion of the MIA.

d. Replacement Ballast Market

As noted in the scope of coverage section, this rulemaking covers new MHLFs. Even though the metric being regulated is ballast efficiency, the standards set in this rulemaking only apply to ballasts sold with new fixtures. Ballasts sold separately, to be used as replacement ballasts for existing fixtures, are not required to comply with these standards.

There was some concern among stakeholders that manufacturers might not choose to manufacture similar wattage ballasts at multiple efficiency levels due to lack of economic viability. ULT and Cooper both commented that the proposed standard for new MHLFs would affect all MH ballasts and not just new MHLFs because it is economically infeasible to maintain two different ballast product lines—one that services the replacement market that would not be subject to standards and another that services the new MHLF market that would be subject to standards. (ULT, Public Meeting Transcript, No. 48 at p. 65–66; Cooper, Public Meeting Transcript, No. 48 at p. 67) NEEA argued that while this was probably true, as long as there is a market for replacement MH ballasts, some companies would manufacture those replacement ballasts to fulfill that market. According to NEEA, a manufacturer could continue their current MH ballast production line which would only service the replacement MH ballast market and not manufacture ballasts for new MHLFs. (NEEA, Public Meeting Transcript, No. 48 at p. 72) ULT responded by commenting that manufacturers are not going to want to redesign and manufacture two production lines for MH ballasts which would increase their inventory and carrying costs for MH ballasts and rather will continue to focus on solid state lighting. ULT believes this could open up the replacement ballasts market to offshore MH ballast manufacturers and result in an increase in products that will have quality and warranty problems, which is bad for end-users. (ULT, Public Meeting Transcript, No. 48 at p. 73)

Also several organizations commented on the impact of MHLF standards on the portfolio of ballasts available for the replacement market. APPA requested confirmation that the standards proposed in the NOPR would not eliminate the production of replacement ballasts for existing and future MHLFs. (APPA, No. 51 at p. 1) NEMA, ULT, and APPA stated manufacturers could not be expected to maintain product lines for both new fixture ballasts and for the replacement or repair of old fixtures. Therefore, customers with MHLFs currently installed might be left with stranded assets. However, NEMA, ULT, and APPA noted that if standards do not force customers to switch to electronic ballasts or magnetic ballasts to incur physical changes, the market could continue to be adequately serviced by manufacturers. (NEMA, No. 56 at pp. 10, 24; ULT, No. 50 at pp. 17–18; APPA, No. 51 at p. 8) GE noted that if the standard were to require larger ballasts, it would mean having no direct replacement for the installed base, especially in a situation such as a natural disaster, where the majority of lighting in a subdivision would need to be replaced. (GE, Public Meeting Transcript, No. 48 at p. 89) Conversely, the Joint Comment stated that there will always be a market for these replacement ballasts, regardless of the efficiency requirements, and that it would be a business decision whether manufacturers would want to fill that niche market. (Joint Comment, No. 62 at p. 7)

DOE's market analysis found that several of the largest manufacturers of MH ballasts responded to the standards mandated by EISA 2007 for 150 W–500 W ballasts sold with new fixtures by offering ballasts with efficiencies that comply with EISA 2007 standard levels, and replacement ballasts with efficiencies that do not comply with EISA 2007, at the same wattages. While DOE predicts a similar response to the standards adopted in this final rule, the financial viability of offering ballasts that fall above and below these standards will be a business decision for each manufacturer. For the MIA, DOE includes the costs of upgrading MH ballast production for new MHLFs (and not upgrading replacement ballasts) to meet the standards in its analysis and any other course of action would be a business decision made by manufacturers which is not modeled by DOE.

e. Potential Impact on Metal Halide Lamp Manufacturers

Philips commented that there could be a negative impact on MH lamp manufacturers due to MHLF standards. Philips stated as the cost of MHLFs increase due to standards more people are going to purchase LEDs and as a result, the volume of MHLFs and MH lamps will decrease. Therefore, Philips believes that DOE should take into account costs imposed on MH lamp manufacturers associated with MHLF standards. (Philips, Public Meeting Transcript, No. 48 at p. 277) DOE recognizes that LEDs are continuing to capture more and more of the lighting markets serviced by MHLFs and accounts for this shift to LEDs in the shipment analysis for this rulemaking. DOE does not believe that MHLF standards will hasten this shift to LEDs, as LEDs are not appropriate substitutes for all MHLFs given the large lumen output of the higher wattage MHLFs. Therefore, this market shift to LEDs is captured in the base case shipment scenario and is not modeled as a standards-induced market shift.

6. Manufacturer Interviews

DOE interviewed manufacturers representing more than 65 percent of MHLF sales and 90 percent of MH ballast sales. The NOPR interviews were in addition to the preliminary interviews DOE conducted as part of the interim analysis. DOE outlined the key issues for the rulemaking for manufacturers in the NOPR. 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 standards on manufacturers were discussed in the preceding sections. DOE did not conduct interviews with manufacturers between the publication of the NOPR and this final rule.

J. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a standard. Employment impacts consist of direct and indirect impacts. Direct employment impacts are any changes in the number of employees working for manufacturers of the equipment subject to standards, their suppliers, and related service firms. The MIA addresses those impacts. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than the manufacturing sector being regulated, caused by: (1) Reduced spending by end users on energy; (2) reduced spending on new energy supplies by the utility industry; (3) increased spending on new equipment to which the new standards apply; and (4) the effects of those three factors throughout the economy.

One method for assessing the possible effects of such shifts in economic activity on the demand for labor is to compare sector employment statistics developed by the Labor Department's Bureau of Labor Statistics (BLS).[48] The 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 the BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.[49] 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 customer utility bills. Because reduced customer 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 manufacturing sectors). Thus, based on the BLS data alone, DOE believes that net national employment will increase

[48] Data on industry employment, hours, labor compensation, value of production, and the implicit price deflator for output for these industries are available upon request by calling the Division of Industry Productivity Studies (202–691–5618) or by sending a request by email to*dipsweb@bls.gov*. Available at: *www.bls.gov/news.release/prin1.nr0.htm.* (Last accessed October 2013.)

[49] *See* Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II),* Washington, DC, U.S. Department of Commerce, 1992.

due to shifts in economic activity resulting from new and amended standards for metal halide lamp fixtures.

For the standard levels considered in today's final rule, DOE estimated indirect national employment impacts using an input/output model of the U.S. economy called Impact of Sector Energy Technologies (ImSET), version 3.1.1.[50] ImSET is a special-purpose version of the ''U.S. Benchmark National Input-Output'' (I–O) model, which was designed to estimate the national employment and income effects of energy-saving technologies. The ImSET software includes a computer-based I–O model having structural coefficients that characterize economic flows among 187 sectors most relevant to industrial, commercial, and residential building energy use.

DOE received several general comments at the NOPR public meeting questioning the validity of its employment analysis results. (Acuity, Public Meeting Transcript, No. 48 at p. 306; EEI, Public Meeting Transcript, No. 48 at pp. 298–301; GE, Public Meeting Transcript, No. 48 at p. 306; NEEA, Public Meeting Transcript, No. 48 at pp. 304–305; NEMA, Public Meeting Transcript, No. 48 at p. 302) DOE notes that ImSET is not a general equilibrium projection model and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may overestimate actual job impacts over the long run for this rule. Because ImSET predicts small job impacts resulting from this rule, regardless of these uncertainties, the actual job impacts are likely to be negligible in the overall economy. DOE may consider the use of other modeling approaches for examining long-term employment impacts. DOE also notes that the indirect employment impacts estimated with ImSET for the entire economy differ from the direct employment impacts in the lighting manufacturing sector estimated using the GRIM in the MIA, as described at the beginning of this section. The methodologies used and the sectors analyzed in the ImSET and GRIM models are different.

For more details on the employment impact analysis, see chapter 14 of the final rule TSD.

[50] Roop, J. M., M. J. Scott, and R. W. Schultz, *ImSET 3.1: Impact of Sector Energy Technologies* (PNNL–18412 Pacific Northwest National Laboratory) (2009). Available at *www.pnl.gov/main/publications/external/technical_reports/PNNL-18412.pdf.* (Last accessed October 2013.)

K. Utility Impact Analysis

The utility impact analysis estimates several important effects on the utility industry of the adoption of new or amended standards. For this analysis, DOE used the NEMS–BT model to generate forecasts of electricity consumption, electricity generation by plant type, and electric generating capacity by plant type, that would result from each considered TSL. DOE obtained the energy savings inputs associated with efficiency improvements to considered equipment from the NIA. DOE conducts the utility impact analysis as a scenario that departs from the latest *AEO* Reference Case. For the August 2013 NOPR analysis, the estimated impacts of standards were the differences between values forecasted by NEMS–BT and the values in the *AEO2013* Reference Case. 78 FR 51464, 51512 (Aug. 20, 2013). DOE received no comments related to its utility impact analysis and retained its approach for this final rule. Chapter 15 of the final rule TSD describes the utility impact analysis.

L. Emissions Analysis

In the emissions analysis, DOE estimated the reduction in power sector emissions of CO_2, NO_X, SO_2, and Hg from potential energy conservation standards for metal halide lamp fixtures. In addition to estimating impacts of standards on power sector emissions, DOE estimated emissions impacts in production activities that provide the energy inputs to power plants. These are referred to as ''upstream'' emissions. In accordance with the FFC Statement of Policy (76 FR 51281 [August 18, 2011]), as amended at 77 FR 49701 (Aug. 17, 2012), this FFC analysis 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 *AEO2013.* 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.[51] Site emissions of CO_2 and NO_X were estimated using emissions intensity factors from an EPA publication.[52] DOE developed separate emissions factors for power sector emissions and upstream emissions. The method that DOE used to derive emissions factors is described in chapter 16 of the final rule TSD.

[51] See *www.epa.gov/climateleadership/guidance/ghg-emissions.html.*

[52] U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emission Factors, AP–42, Fifth Edition, Volume I: Stationary Point and Area Sources.* 1998. *www.epa.gov/ttn/chief/ap42/index.html.*

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 Fourth Assessment Report of the Intergovernmental Panel on Climate Change,[53] DOE used GWP values of 25 for CH_4 and 298 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. *AEO2013* generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of December 31, 2012.

SO_2 emissions from affected electricity-generating units (EGUs) are subject to nationwide and regional emissions cap-and-trade programs. Title IV of the Clean Air Act sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous states and the District of Columbia (DC). SO_2 emissions from 28 eastern states and DC were also limited under the Clean Air Interstate Rule (CAIR; 70 FR 25162 [May 12, 2005]), which created an allowance-based trading program. CAIR was remanded to the EPA by the U.S. Court of Appeals for the District of Columbia Circuit, but it remained in effect. See *North Carolina* v. *EPA,* 550 F.3d 1176 (D.C. Cir. 2008); *North Carolina* v. *EPA,* 531 F.3d 896 (D.C. Cir. 2008). On July 6, 2011 EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (Aug. 8, 2011). On August 21, 2012, the D.C. Circuit issued a decision to vacate CSAPR. See *EME Homer City Generation, LP* v. *EPA,* 696 F.3d 7, 38 (D.C. Cir. 2012). The court ordered EPA to continue administering CAIR. The *AEO2013* emissions factors used for today's NOPR assume that CAIR remains a binding regulation through 2040.

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

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

Beginning in 2015, however, SO_2 emissions will fall as a result of the Mercury and Air Toxics Standards (MATS) for power plants. 77 FR 9304 (Feb. 16, 2012). In the final MATS rule, EPA established a standard for hydrogen chloride as a surrogate for acid gas hazardous air pollutants (HAP), and also established a standard for SO_2 (a non-HAP acid gas) as an alternative equivalent surrogate standard for acid gas HAP. The same controls are used to reduce HAP and non-HAP acid gas; thus, SO_2 emissions will be reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. *AEO2013* assumes that, in order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed by 2015. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Under the MATS, NEMS shows a reduction in SO_2 emissions when electricity demand decreases (*e.g.,* as a result of energy efficiency standards). Emissions will be far below the cap that would be established by CAIR, so it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by any regulated EGU. Therefore, DOE believes that efficiency standards will reduce SO_2 emissions in 2015 and beyond.

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

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would likely reduce Hg emissions. DOE estimated mercury emissions reduction using NEMS–BT based on *AEO2013,* which incorporates the MATS.

DOE received comments regarding the emissions analysis during the NOPR public meeting. EEI noted that the EPA recently proposed greenhouse gas emissions standards for new EGUs [54] and would issue standards for existing EGUs in 2014. EEI commented that these standards would have a significant effect on DOE's emission analysis and that they should be considered in the final rule. (EEI, Public Meeting Transcript, No. 48 at pp. 307–309) In a joint comment, the U.S. Chamber of Commerce and cosignatories [55] (hereafter the ''U.S. Chamber *et al.''*) agreed. (U.S. Chamber *et al.,* No. 58 at p. 7) As discussed previously in this section, the *AEO2013* emissions factors available for this final rule analysis reflect regulations implemented as of December 31, 2012, and DOE cannot consider proposed emission standards in setting potential equipment efficiency standards.[56] GE encouraged DOE to consider the additional emissions produced in manufacturing the larger fixtures needed to meet potential efficiency standards, and GE indicated that NEMA intended to evaluate the ''carbon footprint'' of its manufacturing processes. (GE, Public Meeting Transcript, No. 48 at pp. 311–312) DOE received no related emissions estimates in written comments; further, as discussed previously in section V.C of this final rule, DOE's engineering analysis indicated that higher efficiency fixtures would not be significantly larger than baseline fixtures. DOE believes that any incremental emissions increases from the manufacture of higher efficiency fixtures would be negligible in comparison to its overall emissions estimates, and DOE retained its *AEO*-based approach for this final rule emissions analysis.

M. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this final rule, DOE considered the estimated monetary benefits likely to result 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 customer benefit, DOE considered the reduced emissions expected to result over the lifetime of equipment shipped in the projection 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 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 17 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 CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in CO_2 emissions, while a global SCC value is meant to reflect the value of damages worldwide.

Under section 1(b) of E.O. 12866, 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.

[54] Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units—Proposed Rule (September 20, 2013); pre-publication version at *www2.epa.gov/sites/production/files/2013-09/documents/20130920proposal.pdf* (Last accessed November 22, 2013).

[55] Cosignatories include the American Forest & Paper Association, American Fuel & Petrochemical Manufacturers, American Petroleum Institute, Council of Industrial Boiler Owners, National Association of Manufacturers, National Mining Association, and the Portland Cement Association.

[56] APPA commented that EPA new source performance standards are effective upon issuance of the proposed rule. (APPA, Public Meeting Transcript, No. 48 at p. 310) DOE disagrees, citing section III.B of the proposed rule that states the emission limit would apply to affected sources on the effective date of the final action.

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 these SCC estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of CO_2 emissions, the analyst faces a number of serious challenges. A recent report from the National Research Council [57] points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of GHGs, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

Despite the serious limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing CO_2 emissions. Most Federal regulatory actions can be expected to have marginal impacts on global emissions. For such policies, the agency can estimate the benefits from reduced emissions in any future year by multiplying the change in emissions in that year by the SCC value appropriate for that year. The net present value 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. This approach assumes that the marginal damages from increased emissions are constant for small departures from the baseline emissions path, an approximation that is reasonable for policies that have effects on emissions that are small relative to cumulative global CO_2 emissions. For policies that have a large (non-marginal) impact on global cumulative emissions, there is a separate question of whether the SCC is an appropriate tool for calculating the benefits of reduced emissions. This concern is not applicable to this notice, however.

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

b. Social Cost of Carbon Values Used in Past Regulatory Analyses

Economic analyses for Federal regulations used a wide range of values to estimate the benefits associated with reducing CO_2 emissions. The model year 2011 Corporate Average Fuel Economy final rule used both a ‘‘domestic’’ SCC value of $2 per metric ton of CO_2 and a ‘‘global’’ SCC value of $33 per metric ton of CO_2 for 2007 emission reductions (in 2007$), increasing both values at 2.4 percent per year. It also included a sensitivity analysis at $80 per metric ton of CO_2.[58] The proposed rule for Model Years 2011–2015 assumed a domestic SCC value of $7 per metric ton of CO_2 (in 2006$) for 2011 emission reductions (with a range of $0–$14 for sensitivity analysis), also increasing at 2.4 percent per year.[59] A regulation for packaged terminal air conditioners and packaged terminal heat pumps finalized by DOE in 2008 used a domestic SCC range of $0 to $20 per metric ton CO_2 for 2007 emission reductions (in 2007$). 73 FR 58772, 58814 (Oct. 7, 2008) In addition, EPA's 2008 Advance Notice of Proposed Rulemaking on Regulating Greenhouse Gas Emissions Under the Clean Air Act identified what it described as ‘‘very preliminary’’ SCC estimates subject to revision. 73 FR 44354 (July 30, 2008). EPA's global mean values were $68 and $40 per metric ton CO_2 for discount rates of approximately 2 percent and 3 percent, respectively (in 2006$ for 2007 emissions).

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

c. Current Approach and Key Assumptions

Since the release of the interim values, the interagency group reconvened on a regular basis to generate improved SCC estimates. The group considered public comments and further explored the technical literature in relevant fields. The interagency group relied on three integrated assessment models commonly used to estimate the SCC: The FUND, DICE, and PAGE models. These models are frequently cited in the peer-reviewed literature and were used in the last assessment of the Intergovernmental Panel on Climate Change. Each model was given equal weight in the SCC values that were developed.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. A key objective of the interagency process was to enable a consistent exploration of the three models while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: Climate sensitivity, socioeconomic and

[57] National Research Council. *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use.* National Academies Press: Washington, DC (2009).

[58] See *Average Fuel Economy Standards Passenger Cars and Light Trucks Model Year 2011*, 74 FR 14196 (March 30, 2009) (Final Rule); Final Environmental Impact Statement Corporate Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015 at 3–90 (Oct. 2008) (Available at: *www.nhtsa.gov/fuel-economy*).

[59] See *Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015,* 73 FR 24352 (May 2, 2008) (Proposed Rule); Draft Environmental Impact Statement Corporate Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015 at 3–58 (June 2008) (Available at: *www.nhtsa.gov/fuel-economy*).

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 socioeconomic 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. Three values were based on the average SCC from three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, were included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The values estimated for 2010 grow in real terms over time. Additionally, the interagency group determined that a range of values from 7 percent to 23 percent should be used to adjust the global SCC to calculate domestic effects, although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table V.10 presents the values in the 2010 interagency group report,[60] which is reproduced in appendix 17A of the final rule TSD.

TABLE V.10—ANNUAL SCC VALUES FROM 2010 INTERAGENCY REPORT, 2010–2050

[In 2007 dollars per metric ton CO_2]

	Discount rate			
	5% Avg.	3% Avg.	2.5% Avg.	3% 95th
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.[61] Table V.11 shows the updated sets of SCC estimates in five-year increments from 2010 to 2050. The full set of annual SCC estimates between 2010 and 2050 is reported in appendix 17B of the final rule TSD. The central value that emerges is the average SCC across models at the 3 percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasized the importance of including all four sets of SCC values.

TABLE V.11—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 CO_2 emissions and the limits of existing efforts to model these effects. There are a number of concerns and problems should be addressed by the research community, including research programs housed in many of the Federal agencies participating in the interagency process

[60] *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government, 2010.

[61] Technical Support Document: 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). *www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf.*

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 2012$ using the Gross Domestic Product price deflator. For each of the four cases specified, the values used for emissions in 2015 were $11.8, $39.7, $61.2, and $117 per metric ton avoided (values expressed in 2012$).[62] DOE derived values after 2050 using the growth rate 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.

In responding to the MHLF NOPR, many commenters questioned the scientific and economic basis of the SCC values. These commenters made extensive comments about: The alleged lack of economic theory underlying the models; the sufficiency of the models for policy-making; potential flaws in the models' inputs and assumptions (including the discount rates and climate sensitivity chosen); whether there was adequate peer review of the three models; whether there was adequate peer review of the TSD supporting the 2013 SCC values; whether the SCC estimates comply with OMB's ''Final Information Quality Bulletin for Peer Review'' [63] and DOE's own guidelines for ensuring and maximizing the quality, objectivity, utility and integrity of information disseminated by DOE; whether DOE's use of the updated SCC values has precedential effect for other agency rulemakings; and why DOE is considering global benefits of carbon dioxide emission reductions rather than solely domestic benefits. (Mercatus Center, No. 57 at pp. 1–6; NEMA, No. 56 at pp. 25–31, U.S. Chamber *et al.,* No. 58 at pp. 4–8)

On November 26, 2013, the Office of Management and Budget (OMB) announced minor technical corrections to the 2013 SCC values and a new opportunity for public comment on the revised TSD underlying the SCC estimates. Comments regarding the underlying science and potential precedential effect of the SCC estimates resulting from the interagency process should be directed to that process. *See* 78 FR 70586. Additionally, several current rulemakings also use the 2013 SCC values and the public is welcome to comment on the values as applied in those rulemakings just as the public was welcome to comment on the use and application of the 2010 SCC values in the many rules that were published using those values in the past three years.

The U.S. Chamber *et al.* also stated that DOE calculates the present value of the costs of the NOPR to customers and manufacturers over a 30-year period. The SCC values, on the other hand, reflect the present value of future climate related impacts well beyond 2100. According to the U.S. Chamber *et al.,* DOE's comparison of 30 years of cost to hundreds of years of presumed future benefits is inconsistent and improper. (U.S. Chamber *et al.,* No. 58 at pp. 5–6)

For the analysis of national impacts of the adopted standards, DOE considered the lifetime impacts of fixtures shipped in a 30-year period. With respect to energy and energy cost savings, impacts continue past 30 years until all of the fixtures shipped in the 30-year period are retired. With respect to the valuation of CO_2 emissions reductions, DOE considers the avoided emissions over the same period as the energy savings. CO_2 emissions have on average a very long residence time in the atmosphere. Thus, emissions in the period considered by DOE would contribute to global climate change over a very long time period, with associated social costs. The SCC for any given year represents the discounted present value, in that year and expressed in constant dollars, of a lengthy stream of future costs estimated to result from emission of a ton of CO_2. It is worth pointing out that because of discounting, the present value of costs in the distant future is very small. DOE's accounting of energy cost savings and the value of avoided CO_2 emissions reductions is consistent: Both consider the complete impacts associated with products shipped in the 30-year period.

2. Valuation of Other Emissions Reductions

DOE investigated the potential monetary benefit of reduced NO_X emissions from the TSLs it considered. As noted in section V.L, DOE has taken into account how new energy conservation standards would reduce NO_X emissions in those 28 states that are not affected by emissions caps. DOE estimated the monetized value of 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 $468 to $4,809 per ton (in 2012$).[64] DOE calculated the monetary benefits using a medium value for NO_X emissions of $2,639 per short ton (in 2012$) and real discount rates of 3 percent and 7 percent.

DOE is evaluating appropriate monetization of avoided SO_2 and Hg emissions in energy conservation standards rulemakings. It has not included monetization in the current analysis.

VI. Other Issues for Discussion

A. Proposed Standard Levels in August 2013 NOPR

In the NOPR, DOE proposed new and revised energy conservation standards for all equipment classes. Specifically, DOE proposed TSL 3, which comprised EL2 for all equipment classes except the 100 W–150 W indoor and outdoor equipment classes, for which DOE proposed EL4. DOE received comment from several interested parties regarding these proposals.

ULT noted the proposal that 150 W MHLFs exempted by EISA 2007 (fixtures designed for use in high temperature and wet environments) were subject to EL4, while 150 W MHLFs not exempted by EISA 2007 were only subject to EL2. ULT questioned why the NOPR proposed lower efficiencies for fixtures that operate in less severe conditions. (ULT, No. 50 at p. 2) As discussed previously in section V.A.2 of this notice, the EISA 2007 exemption for certain 150 W MHLFs led to a difference in the commercially available efficiencies in MH ballasts that are exempt or are not exempt from EISA 2007. As a result, DOE proposed that 150 W MHLFs previously exempt by EISA 2007 be included in the 101 W–150 W range, while 150 W MHLFs subject to EISA 2007 standards continue to be included in the 150 W–250 W range. For the 101 W–150 W MHLFs, DOE found that EL4, the max-tech level, was economically justified. However, for the 150 W–250

[62] The interagency report presents SCC values through 2050. DOE derived values after 2050 using the 3-percent per year escalation rate used by the interagency group.

[63] Available at: *http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf*

[64] U.S. Office of Management and Budget, Office of Information and Regulatory Affairs, *2006 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities,* Washington, DC.

W MHLFs, DOE found that the maximum EL achievable with positive NPV was the magnetic ballast max-tech level, EL2 at 88.0 percent. Therefore, in the NOPR, the economic results for the nation supported a higher standard for MHLFs included in the 101 W–150 W range.

ULT commented that NOPR TSL 3 requires a shift to electronic ballasts, which will not work very well in outdoor applications. Further, ULT noted that the NOPR TSLs all appeared to be modeled or mandated without regard to the application, and seemed not to make practical sense. (ULT, Public Meeting Transcript, No. 48 at p. 215). NEMA and ULT commented that NOPR TSL 3 would require a shift to electronic ballasts in 70 W, 150 W, and 250 W fixtures, ban probe-start ballasts, and eliminate many of the magnetic ballast performance features, as these are not feasible in the mandated electronic HF ballasts. (NEMA, No. 56 at p. 24; ULT, No. 50 at p. 16). ULT commented that there should be some way to validate the TSLs. ULT suggested that DOE should build these models, and then allow the manufacturers to test them. They explained that results are much different in a lab environment with more resources and time than in manufacturing facilities that make hundreds of ballasts every 15 minutes. In situations with many variable materials, modeled and laboratory efficiencies differ greatly from those feasibly possible in a manufacturing facility. (ULT, Public Meeting Transcript, No. 48 at pp. 216, 218) ULT stated that overall the NOPR TSLs are too stringent, and proposed different standards. (ULT, No. 50 at p. 16)

DOE acknowledges that standards proposed for 100 W–150 W MHLFs in the NOPR would require a shift to electronic ballasts. While DOE recognizes that magnetic ballasts are inherently more robust than electronic ballasts, the NOPR accounted for the cost of added protection to electronic ballasts in outdoor applications. DOE continues to use this methodology in this final rule. For details of the determination that electronic ballasts could be used in these same applications with certain cost adders, see section V.C.8.b. For details of the cost adders required by electronic ballasts being used in the same application as magnetic ballasts, see section V.C.12.

DOE has modeled ballasts in both the NOPR and final rule, utilizing teardown data and manufacturer input. Further research and refinement was performed for the modeled ballasts for this final rule in response to comments. See section V.C.8 for discussion of these models. DOE has not included high-frequency electronic ballasts in the scope of this rulemaking because there is no test method for them. See section III.A.4 for more details. As a result, none of the ELs analyzed in this final rule require high-frequency electronic ballasts. A more detailed discussion of the TSLs newly analyzed and chosen in this final rule is available later in this section.

ASAP urged DOE to adopt the maximum cost-effective ELs. (ASAP, Public Meeting Transcript, No. 48 at p. 17) DOE analyzed several combinations of ELs in the NOPR and in the final rule. These combinations of ELs, called TSLs, can represent many criteria, including maximum energy savings, technology descriptions (such as all max-tech magnetic ELs), or maximum energy savings with cost effective ELs. As discussed in section VII.C of this notice, DOE adopted the TSL that saved the most energy and was economically justified for customers, manufactures, and the nation based on a weighing of costs and benefits.

ULT commented that NOPR TSL 3 did not meet the requirement of a three-year PBP, but instead PBPs seemed to range from 4 to 14 years (ULT, No. 50 at p. 15). DOE does not have a specific minimum PBP requirement. Each equipment class is analyzed individually based on the market and economic analyses and the cost and benefits of all results are weighted. See section VII.B.1.a for discussions of the PBPs associated with the levels analyzed in this final rule.

NEMA commented that it is very difficult to determine the final net benefit of TSL 3 from NOPR Tables VI.47 and VI.48, and DOE has not aided the reader in understanding its conclusion. (NEMA, No. 56 at p. 25). NEMA commented that DOE appropriately considered a range of values for carbon emissions reductions, but noted that these values are only informative and should not be used for regulatory decision-making. (NEMA, No. 56 at p. 26).

In this final rule, DOE analyzed the benefits and burdens of a number of TSLs for the metal halide lamp fixtures that are the subject of today's final rule. In accordance with (42 U.S.C. 6295(o)(2)(B)(i)), DOE must weigh the cost and benefits of seven factors, including other factors the Secretary considers relevant. DOE continues to present and consider a range of carbon emission reduction values in its weighing of the costs and benefits of any adopted standard. Regarding presentation of a final net benefit value, DOE directs NEMA to Table I.4.

The Joint Comment suggested that DOE evaluate an additional TSL, identical to NOPR TSL 5 except that efficiency levels for 250–500 W ballasts would be based on EL3, which represents low-frequency electronic ballasts. (Joint Comment, No. 62 at p. 5). As discussed in section III.A.4, DOE is no longer considering standards that require use of high-frequency electronic ballasts because they are not in the scope of this rulemaking. Therefore, the max-tech levels for 50 W–1000 W fixtures are all represented by low-frequency ballasts, removing the need for the additional TSL suggested by the Joint Comment.

B. Reported Value

The sampling and reporting for the testing of MHLFs and, by extension, MH ballasts are provided for in 10 CFR 429.54. The reported value for the tested ballast efficiency of a model must be less than or equal to the lower of the mean of the samples tested or the lower 99 percent confidence limit (LCL) of the true mean divided by 0.99.

CA IOUs supported DOE's proposal to apply a confidence interval, which is consistent with the approach used for other products and accounts for variation in product testing and manufacturing. (CA IOUs, No. 54 at p. 3). Some stakeholders commented that because of the variation present in MHLFs, standard levels should be rounded to the nearest whole number rather than tenth of a percent (i.e., 88 percent rather than 88.0 percent). ULT and NEMA noted the variations in wire cross sections (up to 3 percent) and core lamination thickness (up to 10 percent) create efficiency losses in the ballasts. The combination of efficiency losses in these two areas and variability in manufacturing combined with the 99 percent confidence factor, makes the precise proposed levels unachievable in full-scale manufacturing facilities. (ULT, Public Meeting Transcript, No. 48 at pp. 34, 90; NEMA, Public Meeting Transcript, No. 48 at p. 34; NEMA, No. 44 at pp. 10, 13; ULT, No. 50 at pp. 3–4, 25–29). Further, NEMA noted that its white paper NEMA LSD–63–2012 on variability estimated the tolerance for a sample of four magnetic ballasts to be 4.7 percent when a confidence factor of 99 percent is required. (NEMA, No. 56 at p. 8) Due to the variability of raw material properties resulting in varied efficiencies, NEMA, Musco Lighting, and ULT suggested a less precise designation of the efficiency threshold. NEMA and ULT suggested carrying out all calculations to the tenth of a decimal place, with the result then rounded to the nearest integer using the round half up rule. Musco Lighting agreed, suggesting reporting ballast efficiency as a whole integer. (NEMA, No. 56 at p. 8; Musco Lighting, No. 55 at p. 4; ULT, No. 50 at pp. 3, 4, 25; ULT, Public Meeting Transcript, No. 48 at p. 38). NEMA also commented that it would be better to have less precise standards initially, so that tolerances would not have to be created when verification and enforcement actions are made by DOE. (NEMA, Public Meeting Transcript, No. 48 at p. 82)

ULT and NEMA noted that certain ballasts they manufacture, which are currently compliant with EISA 2007, would not meet the same requirements under the proposed rounding system (to the nearest tenth of a percent). (ULT, No. 50 at pp. 3–4; ULT, No. 50 at p. 25; ULT, Public Meeting Transcript, No. 48 at p. 38; NEMA, No. 44 at p. 14). Earthjustice asserted that current equipment that would not meet standards with the new rounding regulations should not be grandfathered in under the new statute. (Earthjustice, Public Meeting Transcript, No. 48 at p. 86).

As discussed in section IV.A of this notice, DOE has determined that the calculation of ballast efficiency is possible to the a tenth of a percent. In addition to information available in industry standards, data submitted by manufacturers has substantiated this conclusion in that it is represented to the tenth of a percent for some ballasts and fixtures in DOE's CCE database. DOE will establish energy conservation standards using the same number of significant figures (three) as the test procedure provides. Test data collected in support of the energy conservation standard was conducted in accordance with the test procedure in 10 CFR 431.324. The certification requirements of 10 CFR 429.54 includes sampling plans that are designed to create conservative ratings, which ensures that customers get—at a minimum—the efficiency indicated by the certified rating. Therefore, DOE's analysis considers levels of efficiency achievable given current manufacturing and material variability. Thus, standards are established and compliance with the standards determined by rounding the reported value to three significant figures. For 150 W–200 W fixtures that will be subject to a standard of 88.0 percent, DOE has accounted for redesign and retesting costs in the MIA by estimating that all MH ballasts at the baseline efficiency level for this wattage range will need to be redesigned if higher efficiency standards are adopted. DOE includes the redesign, retesting, and recertification costs as part of conversion costs of the MIA (see section V.I.4 of this notice for a complete description of the conversion costs used in the MIA).

C. Three-Year Compliance Date

In the NOPR, DOE noted that EPCA, as amended by EISA 2007, contains guidelines for the compliance date of the standards adopted by this rulemaking. EPCA required DOE to determine whether to amend the standards in effect for metal halide lamp fixtures and whether any amended standards should apply to additional metal halide lamp fixtures. The Secretary was directed to publish a final rule no later than January 1, 2012 to determine whether the energy conservation standards established by EISA 2007 for metal halide lamp fixtures should be amended, with any amendment applicable to products manufactured after January 1, 2015. (42 U.S.C. 6295(hh)(2)(B)) In the NOPR public meeting, DOE presented the planned publication date of the final rule to be in January 2014 and proposed a compliance date of January 1, 2015.

Several stakeholders commented on DOE's plan to publish a final rule in January 2014. APPA noted that the compliance date proposed in the NOPR is unreasonable from a process standpoint. DOE would have three months between the end of the NOPR comment period to the publication of the final rule, which is a much faster turnaround than previous rules. (APPA, No. 51 at p. 3) EEI also clarified that based on a January 2014 publication, DOE is only giving itself three months between receiving comments and issuing a final rule. (EEI, Public Meeting Transcript, No. 48 at p. 44) Musco Lighting commented that issuing the final rule in January 2014 would not provide sufficient time to appropriately review comments and modify analyses. (Musco Lighting, No. 55 at p. 4) APPA commented that it is important to consider how long the review processes of the Office of Management and Budget have taken in previous rulemakings. (APPA, No. 51 at p. 3)

DOE has had sufficient time for this particular rulemaking to consider and develop responses to the comments received on the NOPR and complete the final rule analyses.

DOE received several comments regarding the proposed amount of time between the publication of the final rule and the date manufacturers are required to comply with any amended standards. APPA and EEI commented that, according to workshop handouts and based on language in EISA 2007, DOE plans to issue a final rule in January 2014 with an effective date of January 1, 2015. (APPA, No. 51 at p. 3; EEI, No. 53 at p. 2, 3) Considering this, APPA and Musco Lighting found that manufacturers could possibly be given less than 11 months to comply with the new final rule. (APPA, No. 51 at p. 3; Musco Lighting, No. 55 at p. 4) NEMA, ASAP, and NRCA noted that, while the 2015 date was stipulated by 42 U.S.C. 6295(hh)(2), this was assuming the final rule would be completed by January 1, 2012 and the intent of EISA 2007 was to provide manufacturers with a three-year period before compliance to allow for investments and manufacturing conversion, as well as allowing customers sufficient time to make any necessary changes. NEMA, APPA, and NRCA stated that adopting anything shorter than three years is not reasonable. (NEMA, No. 56 at p. 3, 20; NEMA, Public Meeting Transcript, No. 48 at p. 21; NEMA, No. 44 at p. 2; APPA, No. 51 at p. 3; NRCA, No. 61 at p. 1) ASAP agreed that it is not reasonable to provide less than one year for manufacturers to adjust for compliance, especially considering DOE did not comply with the provisions included in EISA 2007 by not issuing a final rule by January 1, 2012. (APPA, No. 51 at p. 3) ULT commented that standard practice is three years after final rule and APPA urged DOE to provide manufacturers and customers with a three-year period between publication of the final rule and the effective date. (ULT, No. 50 at p. 14; APPA, No. 51 at p. 3)

Stakeholders provided several reasons to support the need for a three-year interval between the publication of the final rule and the date of compliance. NEMA and UL noted this standard is much more complex and has a broader scope than the ones specified in EISA 2007, and that this standard has implications on both ballast and fixture manufacturers. (NEMA, Public Meeting Transcript, No. 48 at p. 19; NEMA, No. 44 at p. 2; ULT, No. 50 at p. 14) NEMA noted that, with this rulemaking's expanded scope, manufacturers would have to evaluate products not previously covered by EISA 2007, determine what products can be redesigned and which need to be eliminated, test new and modified ballasts for performance and safety, educate internal staff and customers, reevaluate inventory management, reevaluate manufacturing strategies, modify marketing materials, and work with suppliers and sellers. All of those logistics are required to take place and make January 2015 an unreasonable compliance date, according to NEMA. (NEMA, Public Meeting Transcript, No. 48 at pp. 21, 27; NEMA, No. 44 at pp. 2–3, 5) NEMA also commented that while the standards specified in EISA 2007 primarily impacted industrial and outdoor channels, this rulemaking would impact new channels, such as retail consumer products and commercial offices with the lower wattage products. (NEMA, Public Meeting Transcript, No. 48 at p. 19; NEMA, No. 44 at p. 2)

NEMA and Musco Lighting noted that with any increased efficiency numbers there are numerous product redesigns required, so it is imperative that DOE provide industry with the full three years to bring their products to compliance. (NEMA, No. 56 at pp. 20–21; Musco Lighting, No. 55 at p. 4) ULT noted the commercial market is far from the NOPR proposed levels, so there will need to be time for R&D and to prototype potential solutions. ULT commented that typical design time, taking into consideration Design Validation Testing, Life Test, UL, and other aspects of the process, is typically eight to twelve months. Even if they were moving three projects at once they would not be able to fully redesign the necessary products before January 2015, and they would run out of raw materials. (ULT, No. 50 at p. 14) NEMA and ULT also commented that DOE has to account for fixture manufacturers who would not be able to redesign their products until they had samples produced on a commercial scale from the ballast manufacturers. (NEMA, Public Meeting Transcript, No. 48 at p. 19; ULT, No. 50 at p. 14)

NEMA noted that the difficulties with completing all of these redesigns with such a short compliance period include having fewer employees working on MHLFs than there were in 2007 and having resources focused on R&D for other technologies. Taking resources from these areas to complete the necessary redesigns would also divert the speed of the market transition to more efficient technologies. (NEMA; No. 44 at p. 2) Southern Company also expressed concern that a compliance date of January 1, 2015, would force manufacturers to divert resources from the development and implementation of energy efficient technologies, such as LED, and this would increase the cost to customers and slow the conversion to LED. (Southern Company, No. 64 at p. 3)

The Joint Comment noted that if the compliance date of the rulemaking is three years after the final rule is published, the delayed compliance date would decrease the potential energy savings from the rulemaking. While the Joint Comment recognizes that compliance with standards with a one-year compliance period may not be feasible, the Joint Comment urged DOE to attempt to balance additional energy savings from an earlier effective date with the impacts on manufacturers. (Joint Comment, No. 62 at p. 10)

DOE recognizes that any compliance date subsequent to January 1, 2015, will lead to reduced energy savings compared to the NOPR. However, DOE believes that it would be difficult for both ballast and fixture manufacturers to redesign their product lines given the compliance date proposed in the NOPR. As such, this final rule has revised the compliance date to be three years after publication of this final rule in the **Federal Register**.

VII. Analytical Results

A. Trial Standard Levels

In the following sections, DOE presents the analytical results for the TSLs of the equipment classes that DOE analyzed directly. DOE scaled the ELs for these representative equipment classes to create ELs for other equipment classes that were not directly analyzed as set forth in chapter 5 of the TSD. For more details on the representative equipment classes, please see section V.C.2.

TABLE VII.1—TRIAL STANDARD LEVELS

Rep. Wattage	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
70 W Indoor	EL1	EL2	EL2	EL3	EL4.
70 W Outdoor	EL1	EL2	EL2	EL3	EL4.
150 W Indoor	EL1	EL2	EL2	EL3	EL4.
150 W Outdoor	EL1	EL2	EL2	EL3	EL4.
250 W Indoor	EL1	EL1	EL2	EL3	EL4.
250 W Outdoor	EL1	EL1	EL2	EL3	EL4.
400 W Indoor	EL1	EL2	EL2	EL3	EL4.
400 W Outdoor	EL1	EL2	EL2	EL3	EL4.
1000 W Indoor	EL2+DS	EL2+DS	EL2+DS	EL2+DS	EL2+DS.
1000 W Outdoor	EL2+DS	EL2+DS	EL2+DS	EL2+DS	EL2+DS.
1500 W Indoor	Baseline	Baseline	Baseline	EL1	EL2.
1500 W Outdoor	Baseline	Baseline	Baseline	EL1	EL2

* DS is a design standard that bans the use of probe-start ballasts in new metal halide lamp fixtures.

TSL 5 represents the max-tech efficiency levels available. TSL 5 would set energy conservation standards at EL4 for indoor and outdoor fixtures at 70 W, 150 W, 250 W, and 400 W. Energy conservation standards for indoor and outdoor fixtures at 1000 W, and 1500 W are set at EL2. TSL 5 also includes a design standard for indoor and outdoor 1000 W fixtures that prohibits the sale of probe-start ballasts in new fixtures. Standards included in TSL 5 require fixtures that contain max-tech electronic ballasts using high-grade electronic components, while indoor and outdoor fixtures at 1000 and 1500 W require max-tech magnetic ballasts using high-grade steel and copper windings. All ballasts required by TSL 5 are commercially available, except indoor and outdoor 1000 W and 1500 W ballasts, which are modeled.[65] TSL 5 sets the same standards for indoor and outdoor representative equipment classes at the same wattage.

TSL 4 represents the next highest efficiency levels in classes where efficiency levels were not justified at TSL 5. TSL 4 would set energy conservation standards at EL3 for indoor and outdoor fixtures at 70 W, 150 W, 250 W, and 400 W. Energy conservation standards for indoor and outdoor fixtures at 1000 W are set at EL2, and standards for indoor and outdoor fixtures at 1500 W are set at EL1. TSL 4 also includes a design standard for

[65] The 501 W–1000 W equipment class requires modeled 1000 W ballasts, but 875 W ballasts are commercially available.

indoor and outdoor 1000 W fixtures that prohibits the sale of probe-start ballasts in new fixtures. Standards included in TSL 4 require fixtures that include standard-grade electronic ballasts, while indoor and outdoor fixtures at 1000 W require max-tech magnetic ballasts using high grade steel and copper windings, and 1500 W ballasts are mid-grade magnetic ballasts requiring mid-grade steel and copper wiring. At TSL 4, all ballasts are commercially available, with the exception of the 1000 W ballasts, which are modeled.[65] TSL 4 sets the same standards for indoor and outdoor representative equipment classes at the same wattage.

TSL 3 represents the next highest efficiency levels in classes where efficiency levels were not justified at TSL 4, while also requiring the same EL for both indoor and outdoor fixtures at the same wattage. TSL 3 would set energy conservation standards at EL2 for all classes except 1500 W, which would remain at baseline levels. TSL 3 also includes a design standard for indoor and outdoor 1000 W fixtures that prohibits the sale of probe-start ballasts in new fixtures. Except for 1500 W fixtures, the standards included in TSL 3 require fixtures that include max-tech magnetic ballasts using high-grade steel and copper windings. Any ballast could be used with 1500 W fixtures because no efficiency level is proposed for them. At TSL 3 only the 1500 W ballasts are commercially available, while the other wattages were modeled.[65] TSL 3 sets the same standards for indoor and outdoor representative equipment classes at the same wattage.

TSL 2 represents the highest magnetic ELs that have positive NPVs, and also requires the same EL for both indoor and outdoor fixtures at the same wattage. TSL 2 would set energy conservation standards at EL2 for indoor and outdoor fixtures at 70 W, 150 W, 400 W, and 1000 W. TSL 2 would require EL1 for 250 W indoor and outdoor fixtures, while all 1500 W fixtures would have no energy conservation standards (baseline). TSL 2 also includes a design standard for indoor and outdoor 1000 W fixtures that prohibits the sale of probe-start ballasts in new fixtures. Standards included in TSL 2 require fixtures that include max-tech magnetic ballasts requiring high-grade steel and copper windings, although 250 W ballasts typically require mid-grade steel and copper windings, and any ballast could be used with the unregulated 1500 W fixtures. At TSL 2 the 70 W, 150 W, 400 W, and 1000 W indoor and outdoor ballasts are not commercially available, and have been modeled,[65] while 250 W and 1500 W indoor and outdoor ballasts are commercially available. TSL 2 sets the same standards for indoor and outdoor representative equipment classes at the same wattage.

TSL 1 represents EL1 at all equipment classes, except at 1000 W, in which EL2 and a design standard is required, and 1500 W, in which no standards are established. TSL 1 would set energy conservation standards at EL1 for indoor and outdoor fixtures at 70 W, 150 W, 250 W, and 400 W, while setting standards at EL2 for indoor and outdoor 1000 W fixtures, and no standards for 1500 W fixtures. TSL 1 also includes a design standard for indoor and outdoor 1000 W fixtures that prohibits the sale of probe-start ballasts in new fixtures. TSL 1 requires fixtures that include magnetic ballasts using mid-grade steel and copper windings, although 1000 W will require max-tech ballasts using high-grade steel and copper windings. At TSL 1 the only ballasts that are not commercially available are in the 400 W and 1000 W classes, which have been modeled.[65] TSL 1 sets the same standards for indoor and outdoor representative equipment classes at the same wattage.

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Customers

a. Life-Cycle Cost and Payback Period

To evaluate the net economic impact of standards on customers, DOE conducted LCC and PBP analyses for each TSL. In general, a higher efficiency product would affect consumers in two ways: (1) Annual operating expense would decrease; and (2) purchase price would increase. Section V.F of this rulemaking discusses the inputs DOE used for calculating the LCC and PBP.

The key outputs of the LCC analysis are a mean LCC savings relative to the baseline case, as well as a probability distribution or likelihood of LCC reduction or increase, for each TSL and equipment class. These values are reported by equipment class in Table VII.2 through Table VII.15. The LCC analysis also estimates the fraction of customers for which the LCC will decrease (net benefit) or increase (net cost) relative to the baseline case. The last column in each table contains the median PBPs for the customer purchasing a design compliant with the TSL. DOE assumed that, on average, indoor and outdoor fixtures have 20- and 25-year lifetimes, respectively.

TABLE VII.2—EQUIPMENT CLASS 1—70 WATT METAL HALIDE LAMP FIXTURES (INDOOR, MAGNETIC BASELINE): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience: Net cost	Net benefit	
	Baseline	442.74	955.48	1398.23				
1	1	445.68	925.58	1371.26	26.97	0	100	1.4
2, 3	2	454.07	917.16	1371.23	27.00	0	100	4.5
4	3	459.38	896.35	1355.72	42.50	18	82	3.7
5	4	472.78	888.19	1360.97	37.25	21	79	6.0

TABLE VII.3—EQUIPMENT CLASS 1—70 WATT METAL HALIDE LAMP FIXTURES (INDOOR, ELECTRONIC BASELINE): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
1, 2, 3, 4	Baseline/3	459.38	896.35	1355.72				
5	4	472.78	888.19	1360.97	−5.25	90	10	31.5

TABLE VII.4—EQUIPMENT CLASS 1—70 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR, MAGNETIC BASELINE): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
	Baseline	793.69	2195.72	2989.41				
1	1	796.50	2158.67	2955.17	34.24	2	98	1.4
2, 3	2	804.53	2149.99	2954.53	34.88	3	97	4.5
4	3	834.98	2159.40	2994.38	−4.98	49	51	12.0
5	4	847.83	2152.73	3000.55	−11.15	51	49	14.7

TABLE VII.5—EQUIPMENT CLASS 1—70 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR, ELECTRONIC BASELINE): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
1, 2, 3, 4	Baseline/3	834.98	2159.40	2994.38				
5	4	847.83	2152.73	3000.55	−6.17	88	12	55.8

TABLE VII.6—EQUIPMENT CLASS 2—150 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
	Baseline	483.03	1521.22	2004.25				
1	1	491.93	1489.89	1981.82	22.43	0	100	4.3
2, 3	2	504.66	1474.96	1979.62	24.63	1	99	7.3
4	3	503.20	1411.38	1914.58	89.67	6	94	2.5
5	4	522.42	1405.72	1928.14	76.11	11	89	4.8

TABLE VII.7—EQUIPMENT CLASS 2—150 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
	Baseline	808.79	2679.99	3488.78				
1	1	817.32	2644.09	3461.41	27.37	3	97	4.5
2, 3	2	829.51	2628.57	3458.08	30.70	3	97	8.1
4	3	855.33	2581.21	3436.54	52.23	34	66	7.5

TABLE VII.7—EQUIPMENT CLASS 2—150 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS—Continued

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
5	4	873.73	2578.45	3452.18	36.60	38	62	10.3

TABLE VII.8—EQUIPMENT CLASS 3—250 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
	Baseline	541.02	2122.17	2663.19				
1, 2	1	564.55	2094.13	2658.68	4.51	40	60	14.2
3	2	581.65	2082.60	2664.26	−1.07	63	37	17.9
4	3	611.53	2111.32	2722.85	−59.67	82	18	113.2
5	4	604.31	2099.21	2703.52	−40.33	71	29	38.4

TABLE VII.9—EQUIPMENT CLASS 3—250 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
	Baseline	1009.36	3153.36	4162.72				
1, 2	1	1031.89	3124.09	4155.98	6.74	33	67	17.4
3	2	1048.27	3112.97	4161.24	1.48	55	45	22.8
4	3	1109.39	3172.98	4282.37	−119.65	76	24	326.7
5	4	1102.47	3158.11	4260.58	−97.86	71	29	135.1

TABLE VII.10—EQUIPMENT CLASS 4—400 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
	Baseline	628.46	3120.84	3749.31				
1	1	669.22	3077.26	3746.48	2.83	53	47	16.2
2, 3	2	686.23	3055.12	3741.36	7.95	46	54	15.0
4	3	756.96	3100.09	3857.05	−107.74	92	8	369.2
5	4	798.21	3081.70	3879.91	−130.60	94	6	137.2

TABLE VII.11—EQUIPMENT CLASS 4—400 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
	Baseline	1077.56	4040.60	5118.16				
1	1	1116.59	3995.41	5112.00	6.16	45	55	19.9
2, 3	2	1132.88	3972.13	5105.01	13.15	38	62	18.4
4	3	1229.74	4053.72	5283.46	−165.30	81	19	Never

TABLE VII.11—EQUIPMENT CLASS 4—400 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS—Continued

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience: Net cost	Percent of customers that experience: Net benefit	
5	4	1269.24	4036.62	5305.85	−187.69	84	16	Never

TABLE VII.12—EQUIPMENT CLASS 5—1000 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience: Net cost	Percent of customers that experience: Net benefit	
	Baseline	760.77	7861.06	8621.83				
	Base+DS*	0.00	0.00	0.00	0.00	0	0	0.0
	Base+DS**	810.04	8025.13	8835.17	−213.34	100	0	N/A
	1	816.70	7795.42	8612.12	9.71	45	55	15.2
	1 + DS*	801.73	6617.67	7419.40	1202.43	0	100	0.5
	1 + DS**	865.97	7959.48	8825.46	−203.63	100	0	Never
	2	837.75	7770.63	8608.38	13.45	45	55	15.2
1, 2, 3, 4, 5	2 + DS*	830.98	6569.31	7400.29	1221.54	0	100	0.8
	2 + DS**	887.02	7934.70	8821.72	−199.89	100	0	Never

* DS = Design Standard prohibits fixtures from containing a probe-start ballast. A percentage of customers in this equipment class will migrate to these fixtures, which are reduced-wattage 875 W systems.
** Design Standard 1000 W pulse-start fixtures. Customers who do not migrate to 875 W systems will choose these 1000 W systems.

TABLE VII.13—EQUIPMENT CLASS 5—1000 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience: Net cost	Percent of customers that experience: Net benefit	
	Baseline	1184.62	9152.48	10,337.10				
	Base+DS*	0.00	0.00	0.00	0.00	0	0	0.0
	Base+DS**	1239.95	9435.92	10,675.88	−338.78	100	0	N/A
	1	1238.18	9081.54	10,319.72	17.37	30	70	17.0
	1 + DS*	1231.48	7497.64	8729.12	1607.97	0	100	0.5
	1 + DS**	1293.52	9364.98	10,658.50	−321.40	100	0	Never
	2	1258.34	9054.76	10,313.10	24.00	30	70	17.0
1, 2, 3, 4, 5	2 + DS*	1259.49	7445.67	8705.16	1631.94	2	98	0.8
	2 + DS**	1313.68	9338.20	10,651.88	−314.78	100	0	Never

* DS = Design Standard prohibits fixtures from containing a probe-start ballast. A percentage of customers in this equipment class will migrate to these fixtures, which are reduced-wattage 875 W systems.
** Design Standard 1000 W pulse-start fixtures. Customers who do not migrate to 875 W systems will choose these 1000 W systems.

TABLE VII.14—EQUIPMENT CLASS 6—1500 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience: Net cost	Percent of customers that experience: Net benefit	
1, 2, 3	Baseline	908.54	914.31	1822.86	0.00			
4	1	980.76	909.25	1890.01	−67.15	100	0	209.4
5	2	1010.83	905.09	1915.92	−93.06	100	0	162.7

TABLE VII.15—EQUIPMENT CLASS 6—1500 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
1, 2, 3	Baseline	1276.71	1203.04	2479.75	0.00			
4	1	1345.86	1197.60	2543.46	−63.71	100	0	244.5
5	2	1374.66	1193.11	2567.78	−88.03	100	0	190.0

b. Customer Subgroup Analysis

Using the LCC spreadsheet model, DOE determined the effect of the trial standard levels on the following customer subgroups: utilities, owners of transportation facilities, warehouse owners, owners of transient-prone outdoor lighting, and owners of transient-prone indoor lighting in heavy industrial facilities. DOE adjusted particular inputs to the LCC model to reflect conditions faced by the identified subgroups. For utilities, DOE assumed that maintenance costs would be higher than average maintenance costs because utilities have to maintain more equipment than the other subgroups do, and that operating costs are lower than average because utilities pay wholesale rates for electricity instead of retail rates. DOE assumed that owners of transportation facilities face higher annual operating hours than the average used in the main LCC analysis. For warehouse owners, DOE assumed lower annual operating hours than average used in the main LCC analysis. DOE assumed that owners of transient-prone outdoor lighting face more frequent surge protection and ballast replacements because of lightning than the average used in the main LCC analysis. Finally, for owners of heavy industrial facilities, DOE assumed that indoor lighting equipment (250 W and 400 W equipment classes only) faced more frequent surge protection and ballast replacements because of voltage transients than the average used in the main LCC analysis.

Table VII.16 through Table VII.27 show the LCC effects and PBPs for identified subgroups that purchase metal halide lamp fixtures. In general, the average LCC savings for the identified subgroups at the considered efficiency levels are significantly different from the average for all customers.

TABLE VII.16—EQUIPMENT CLASS 1—70 WATT METAL HALIDE LAMP FIXTURES (INDOOR, MAGNETIC BASELINE): LCC SUBGROUP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average Savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	442.76	444.35	887.11				
1	1	445.70	444.92	890.62	−3.50	100.0	0.0	Never
2, 3	2	454.09	446.85	900.94	−13.82	100.0	0.0	Never
4	3	459.40	477.98	937.38	−50.26	93.7	6.3	Never
5	4	472.80	483.06	955.86	−68.75	98.0	2.0	Never
Subgroup: Transportation Facility Owners								
	Baseline	442.76	979.64	1,422.40				
1	1	445.70	948.60	1,394.30	28.10	0.0	100.0	1.4
2, 3	2	454.09	939.88	1,393.97	28.43	0.0	100.0	4.3
4	3	459.40	923.95	1,383.35	39.05	17.4	82.6	3.8
5	4	472.80	915.84	1,388.64	33.76	20.9	79.1	6.3
Subgroup: Warehouse Owners								
	Baseline	442.76	936.53	1,379.29				
1	1	445.70	906.98	1,352.68	26.61	0.0	100.0	1.5
2, 3	2	454.09	898.53	1,352.62	26.67	0.1	99.9	4.6
4	3	459.40	878.47	1,337.87	41.42	17.4	82.6	3.5
5	4	472.80	870.24	1,343.05	36.25	19.9	80.1	5.9

TABLE VII.17—EQUIPMENT CLASS 1—70 WATT METAL HALIDE LAMP FIXTURES (INDOOR, ELECTRONIC BASELINE): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average Savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
1, 2, 3, 4	Baseline/3	459.40	477.98	937.38				
5	4	472.80	483.06	955.86	−18.49	100.0	0.0	Never
Subgroup: Transportation Facility Owners								
1, 2, 3, 4	Baseline/3	459.40	923.95	1,383.35				
5	4	472.80	915.84	1,388.64	−5.29	88.8	11.2	31.9
Subgroup: Warehouse Owners								
1, 2, 3, 4	Baseline/3	459.40	878.47	1,337.87				
5	4	472.80	870.24	1,343.05	−5.17	89.5	10.5	30.5

TABLE VII.18—EQUIPMENT CLASS 1—70 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR, MAGNETIC BASELINE): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	793.71	1,536.88	2,330.59				
1	1	796.52	1,538.23	2,334.75	−4.16	100.0	0.0	Never
2, 3	2	804.56	1,542.56	2,347.12	−16.52	100.0	0.0	Never
4	3	835.01	1,620.58	2,455.59	−125.00	87.2	12.8	Never
5	4	847.86	1,630.51	2,478.36	−147.77	89.9	10.1	Never
Subgroup: Transportation Facility Owners								
	Baseline	793.69	2,195.72	2,989.41				
1	1	796.50	2,158.67	2,955.17	34.24	1.6	98.4	1.4
2, 3	2	804.53	2,149.99	2,954.53	34.88	2.9	97.1	4.5
4	3	834.98	2,159.40	2,994.38	−4.98	49.0	51.0	12.0
5	4	847.83	2,152.73	3,000.55	−11.15	51.3	48.7	14.7
Subgroup: Warehouse Owners								
	Baseline	793.69	2,195.72	2,989.41				
1	1	796.50	2,158.67	2,955.17	34.24	1.6	98.4	1.4
2, 3	2	804.53	2,149.99	2,954.53	34.88	2.9	97.1	4.5
4	3	834.98	2,159.40	2,994.38	−4.98	49.0	51.0	12.0
5	4	847.83	2,152.73	3,000.55	−11.15	51.3	48.7	14.7
Subgroup: Owners of Transient-Prone Outdoor Lighting								
	Baseline	793.71	2,179.70	2,973.41				
1	1	796.52	2,142.44	2,938.97	34.44	1.8	98.2	1.4
2, 3	2	804.56	2,133.66	2,938.22	35.20	2.9	97.1	4.5
4	3	835.01	2,167.47	3,002.48	−29.07	59.2	40.8	31.3
5	4	847.86	2,163.21	3,011.07	−37.66	62.2	37.8	41.0

TABLE VII.19—EQUIPMENT CLASS 1—70 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR, ELECTRONIC BASELINE): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
1, 2, 3, 4	Baseline/3	835.01	1,620.58	2,455.59				
5	4	847.86	1,630.51	2,478.36	−22.77	100.0	0.0	Never
Subgroup: Transportation Facility Owners								
1, 2, 3, 4	Baseline/3	834.98	2,159.40	2,994.38				
5	4	847.83	2,152.73	3,000.55	−6.17	87.8	12.2	55.8
Subgroup: Warehouse Owners								
1, 2, 3, 4	Baseline/3	834.98	2,159.40	2,994.38				
5	4	847.83	2,152.73	3,000.55	−6.17	87.8	12.2	55.8
Subgroup: Owners of Transient-Prone Outdoor Lighting								
1, 2, 3, 4	Baseline/3	835.01	2,167.47	3,002.48				
5	4	847.86	2,163.21	3,011.07	−8.59	94.9	5.1	161.5

TABLE VII.20—EQUIPMENT CLASS 2—150 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	483.05	466.08	949.13				
1	1	491.95	468.47	960.43	−11.29	100.0	0.0	Never
2, 3	2	504.68	472.02	976.71	−27.57	100.0	0.0	Never
4	3	503.23	513.09	1,016.31	−67.18	97.0	3.0	Never
5	4	522.45	521.74	1,044.18	−95.05	99.6	0.4	Never
Subgroup: Transportation Facility Owners								
	Baseline	483.05	1,636.83	2,119.88				
1	1	491.95	1,603.44	2,095.39	24.49	0.0	100.0	4.1
2, 3	2	504.68	1,587.84	2,092.53	27.35	0.7	99.3	7.0
4	3	503.23	1,521.09	2,024.32	95.56	7.2	92.8	2.4
5	4	522.45	1,515.71	2,038.15	81.73	11.1	88.9	4.6
Subgroup: Warehouse Owners								
	Baseline	483.05	1,494.69	1,977.73				
1	1	491.95	1,463.62	1,955.58	22.16	0.0	100.0	4.4
2, 3	2	504.68	1,448.78	1,953.46	24.27	0.8	99.2	7.5
4	3	503.23	1,382.65	1,885.88	91.86	5.5	94.5	2.4
5	4	522.45	1,376.64	1,899.08	78.65	11.2	88.8	4.5

TABLE VII.21—EQUIPMENT CLASS 2—150 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	808.82	1,406.87	2,215.69				
1	1	817.35	1,411.33	2,228.68	−12.99	100.0	0.0	Never

TABLE VII.21—EQUIPMENT CLASS 2—150 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS—Continued

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
2, 3	2	829.54	1,417.89	2,247.43	−31.74	100.0	0.0	Never
4	3	855.36	1,499.15	2,354.52	−138.83	87.1	12.9	Never
5	4	873.77	1,513.42	2,387.18	−171.49	90.7	9.3	Never
Subgroup: Transportation Facility Owners								
	Baseline	808.79	2,679.99	3,488.78				
1	1	817.32	2,644.09	3,461.41	27.37	2.9	97.1	4.5
2, 3	2	829.51	2,628.57	3,458.08	30.70	3.3	96.7	8.1
4	3	855.33	2,581.21	3,436.54	52.23	33.8	66.2	7.5
5	4	873.73	2,578.45	3,452.18	36.60	38.2	61.8	10.3
Subgroup: Warehouse Owners								
	Baseline	808.79	2,679.99	3,488.78				
1	1	817.32	2,644.09	3,461.41	27.37	2.9	97.1	4.5
2, 3	2	829.51	2,628.57	3,458.08	30.70	3.3	96.7	8.1
4	3	855.33	2,581.21	3,436.54	52.23	33.8	66.2	7.5
5	4	873.73	2,578.45	3,452.18	36.60	38.2	61.8	10.3
Subgroup: Owners of Transient-Prone Outdoor Lighting								
	Baseline	808.82	2,671.89	3,480.71				
1	1	817.35	2,635.75	3,453.09	27.62	2.9	97.1	4.5
2, 3	2	829.54	2,620.05	3,449.58	31.13	3.2	96.8	8.1
4	3	855.36	2,608.06	3,463.42	17.29	47.8	52.2	11.8
5	4	873.77	2,608.78	3,482.55	−1.84	52.3	47.7	17.4

TABLE VII.22—EQUIPMENT CLASS 3—250 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	541.05	490.86	1,031.91				
1, 2	1	564.58	498.98	1,063.56	−31.66	100.0	0.0	Never
3	2	581.69	504.93	1,086.62	−54.71	100.0	0.0	Never
4	3	611.57	572.99	1,184.56	−152.65	100.0	0.0	Never
5	4	604.35	569.07	1,173.42	−141.51	99.9	0.1	Never
Subgroup: Transportation Facility Owners								
	Baseline	541.05	2,361.30	2,902.35				
1, 2	1	564.58	2,330.88	2,895.46	6.89	30.2	69.8	13.0
3	2	581.69	2,318.58	2,900.26	2.08	56.2	43.8	16.6
4	3	611.57	2,354.22	2,965.79	−63.44	81.4	18.6	147.2
5	4	604.35	2,340.54	2,944.89	−42.54	70.6	29.4	39.2
Subgroup: Warehouse Owners								
	Baseline	541.05	2,096.87	2,637.92				
1, 2	1	564.58	2,068.76	2,633.35	4.57	39.4	60.6	14.2
3	2	581.69	2,057.12	2,638.80	−0.89	62.7	37.3	17.9
4	3	611.57	2,086.19	2,697.76	−59.84	82.0	18.0	133.3
5	4	604.35	2,074.29	2,678.63	−40.72	72.1	27.9	40.0
Subgroup: Owners of Transient-Prone Indoor Lighting								
	Baseline	541.05	2,125.94	2,666.98				
1, 2	1	564.58	2,097.72	2,662.30	4.68	39.7	60.3	14.1
3	2	581.69	2,086.10	2,667.79	−0.80	63.0	37.0	17.7

TABLE VII.22—EQUIPMENT CLASS 3—250 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS—Continued

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience: Net cost	Net benefit	
4	3	633.04	2,202.92	2,835.96	−168.97	99.5	0.5	Never
5	4	625.82	2,189.03	2,814.85	−147.86	99.0	1.0	Never

TABLE VII.23 EQUIPMENT CLASS 3—250 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience: Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	1,009.40	1,274.00	2,283.40				
1, 2	1	1,031.93	1,286.12	2,318.06	−34.66	100.0	0.0	Never
3	2	1,048.32	1,294.99	2,343.30	−59.91	100.0	0.0	Never
4	3	1,109.44	1,402.28	2,511.72	−228.33	94.7	5.3	Never
5	4	1,102.53	1,396.84	2,499.37	−215.97	93.4	6.6	Never
Subgroup: Transportation Facility Owners								
	Baseline	1,009.36	3,153.36	4,162.72				
1, 2	1	1,031.89	3,124.09	4,155.98	6.74	32.6	67.4	17.4
3	2	1,048.27	3,112.97	4,161.24	1.48	55.2	44.8	22.8
4	3	1,109.39	3,172.98	4,282.37	−119.65	76.4	23.6	326.7
5	4	1,102.47	3,158.11	4,260.58	−97.86	71.2	28.8	135.1
Subgroup: Warehouse Owners								
	Baseline	1,009.36	3,153.36	4,162.72				
1, 2	1	1,031.89	3,124.09	4,155.98	6.74	32.6	67.4	17.4
3	2	1,048.27	3,112.97	4,161.24	1.48	55.2	44.8	22.8
4	3	1,109.39	3,172.98	4,282.37	−119.65	76.4	23.6	326.7
5	4	1,102.47	3,158.11	4,260.58	−97.86	71.2	28.8	135.1
Subgroup: Owners of Transient-Prone Outdoor Lighting								
	Baseline	1,009.40	3,152.36	4,161.76				
1, 2	1	1,031.93	3,122.75	4,154.68	7.08	32.0	68.0	17.3
3	2	1,048.32	3,111.43	4,159.74	2.02	54.7	45.3	22.7
4	3	1,109.44	3,240.29	4,349.73	−187.97	90.0	10.0	Never
5	4	1,102.53	3,224.03	4,326.55	−164.79	86.7	13.3	Never

TABLE VII.24—EQUIPMENT CLASS 4—400 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience: Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	628.50	448.11	1,076.61				
1	1	669.26	463.69	1,132.95	−56.34	100.0	0.0	Never
2, 3	2	686.28	470.18	1,156.45	−79.84	100.0	0.0	Never
4	3	757.01	568.72	1,325.74	−249.13	100.0	0.0	Never
5	4	798.27	592.98	1,391.25	−314.64	100.0	0.0	Never

TABLE VII.24—EQUIPMENT CLASS 4—400 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS—Continued

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Transportation Facility Owners								
	Baseline	628.50	3,542.88	4,171.38				
1	1	669.26	3,496.08	4,165.34	6.04	46.9	53.1	15.2
2, 3	2	686.28	3,472.11	4,158.39	13.00	38.9	61.1	14.1
4	3	757.01	3,527.12	4,284.13	−112.75	89.5	10.5	Never
5	4	798.27	3,508.32	4,306.59	−135.20	91.9	8.1	166.6
Subgroup: Warehouse Owners								
	Baseline	628.50	3,097.26	3,725.76				
1	1	669.26	3,053.68	3,722.95	2.82	54.0	46.0	16.1
2, 3	2	686.28	3,031.58	3,717.85	7.91	46.7	53.3	15.0
4	3	757.01	3,077.37	3,834.39	−108.63	92.0	8.0	905.6
5	4	798.27	3,058.66	3,856.92	−131.16	93.8	6.2	151.6
Subgroup: Owners of Transient-Prone Indoor Lighting								
	Baseline	628.50	3,125.34	3,753.84				
1	1	669.26	3,081.43	3,750.69	3.15	53.2	46.8	16.0
2, 3	2	686.28	3,059.14	3,745.42	8.42	45.9	54.1	15.0
4	3	778.48	3,212.60	3,991.09	−237.25	99.6	0.4	Never
5	4	819.73	3,204.61	4,024.35	−270.51	99.7	0.3	Never

TABLE VII.25—EQUIPMENT CLASS 4—400 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost 2012$			Life-cycle cost savings			Median payback period years
		Installed cost	Discounted operating cost	LCC	Average savings 2012$	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	1,077.60	1,039.14	2,116.75				
1	1	1,116.64	1,060.17	2,176.81	−60.06	100.0	0.0	Never
2, 3	2	1,132.93	1,068.93	2,201.86	−85.11	100.0	0.0	Never
4	3	1,229.80	1,210.75	2,440.55	−323.80	98.7	1.3	Never
5	4	1,269.31	1,241.30	2,510.61	−393.86	99.6	0.4	Never
Subgroup: Transportation Facility Owners								
	Baseline	1,077.56	4,040.60	5,118.16				
1	1	1,116.59	3,995.41	5,112.00	6.16	44.6	55.4	19.9
2, 3	2	1,132.88	3,972.13	5,105.01	13.15	38.1	61.9	18.4
4	3	1,229.74	4,053.72	5,283.46	−165.30	80.7	19.3	Never
5	4	1,269.24	4,036.62	5,305.85	−187.69	83.9	16.1	Never
Subgroup: Warehouse Owners								
	Baseline	1,077.56	4,040.60	5,118.16				
1	1	1,116.59	3,995.41	5,112.00	6.16	44.6	55.4	19.9
2, 3	2	1,132.88	3,972.13	5,105.01	13.15	38.1	61.9	18.4
4	3	1,229.74	4,053.72	5,283.46	−165.30	80.7	19.3	Never
5	4	1,269.24	4,036.62	5,305.85	−187.69	83.9	16.1	Never
Subgroup: Owners of Transient-Prone Outdoor Lighting								
	Baseline	1,077.60	4,044.53	5,122.13				
1	1	1,116.64	3,998.77	5,115.41	6.72	44.2	55.8	19.9
2, 3	2	1,132.93	3,975.23	5,108.17	13.97	37.6	62.4	18.3
4	3	1,229.80	4,159.95	5,389.75	−267.62	96.3	3.7	Never
5	4	1,269.31	4,150.29	5,419.60	−297.47	97.3	2.7	Never

TABLE VII.26—EQUIPMENT CLASS 5—1000 WATT METAL HALIDE LAMP FIXTURES (INDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	760.82	1,091.41	1,852.22				
	Baseline+DS*							
	Baseline+DS**	810.09	1,258.76	2,068.85	−216.63	100.0	0.0	N/A
	EL1	816.76	1,119.70	1,936.46	−84.23	100.0	0.0	Never
	EL1+DS*	801.78	720.57	1,522.35	329.87	4.0	96.0	1.5
	EL1+DS**	866.04	1,287.05	2,153.09	−300.86	100.0	0.0	Never
	EL2	837.81	1,130.34	1,968.16	−115.93	100.0	0.0	Never
1, 2, 3, 4, 5	EL2+DS*	831.04	735.29	1,566.33	285.90	4.1	95.9	2.7
1, 2, 3, 4, 5	EL2+DS**	887.09	1,297.70	2,184.79	−332.57	100.0	0.0	Never
Subgroup: Transportation Facility Owners								
	Baseline	760.82	9,226.73	9,987.55				
	Baseline+DS*							
	Baseline+DS**	810.09	9,426.57	10,236.67	−249.12	100.0	0.0	N/A
	EL1	816.76	9,153.37	9,970.13	17.41	34.0	66.0	13.7
	EL1+DS*	801.78	7,781.69	8,583.47	1,404.08	0.0	100.0	0.4
	EL1+DS**	866.04	9,353.22	10,219.25	−231.71	99.7	0.3	Never
	EL2	837.81	9,125.67	9,963.48	24.06	33.9	66.1	13.6
1, 2, 3, 4, 5	EL2+DS*	831.04	7,726.91	8,557.95	1,429.60	0.0	100.0	0.7
1, 2, 3, 4, 5	EL2+DS**	887.09	9,325.51	10,212.60	−225.06	99.6	0.4	Never
Subgroup: Warehouse Owners								
	Baseline	760.82	7,821.14	8,581.96				
	Baseline+DS*							
	Baseline+DS**	810.09	7,990.69	8,800.78	−218.83	100.0	0.0	N/A
	EL1	816.76	7,755.53	8,572.29	9.66	45.6	54.4	15.4
	EL1+DS*	801.78	6,584.62	7,386.40	1,195.55	0.0	100.0	0.5
	EL1+DS**	866.04	7,925.08	8,791.12	−209.16	99.7	0.3	Never
	EL2	837.81	7,730.76	8,568.58	13.38	45.5	54.5	15.4
1, 2, 3, 4, 5	EL2+DS*	831.04	6,536.33	7,367.37	1,214.59	0.0	100.0	0.8
1, 2, 3, 4, 5	EL2+DS**	887.09	7,900.31	8,787.40	−205.45	99.6	0.4	Never

* DS = Design Standard prohibits fixtures from containing a probe-start ballast. A percentage of customers in this equipment class will migrate to these fixtures, which are reduced-wattage 875 W systems.

** Design Standard 1000 W pulse-start fixtures. Customers who do not migrate to 875 W systems will choose these 1000 W systems.

TABLE VII.27—EQUIPMENT CLASS 5—1000 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
Subgroup: Utilities								
	Baseline	1,184.66	1,966.58	3,151.25				
	Baseline+DS*							
	Baseline+DS**	1,240.01	2,251.71	3,491.72	−340.47	100.0	0.0	N/A
	EL1	1,238.24	1,995.40	3,233.63	−82.38	100.0	0.0	Never
	EL1+DS*	1,231.53	1,229.54	2,461.07	690.17	4.3	95.7	1.2
	EL1+DS**	1,293.58	2,280.52	3,574.10	−422.86	100.0	0.0	Never
	EL2	1,258.40	2,006.24	3,264.64	−113.39	100.0	0.0	Never
1, 2, 3, 4, 5	EL2+DS*	1,259.55	1,244.54	2,504.08	647.16	5.4	94.6	2.1
1, 2, 3, 4, 5	EL2+DS**	1,313.74	2,291.37	3,605.11	−453.86	100.0	0.0	Never
Subgroup: Transportation Facility Owners								
	Baseline	1,184.62	9,152.48	10,337.10				
	Baseline+DS*							
	Baseline+DS**	1,239.95	9,435.92	10,675.88	−338.78	100.0	0.0	N/A
	EL1	1,238.18	9,081.54	10,319.72	17.37	30.4	69.6	17.0

TABLE VII.27—EQUIPMENT CLASS 5—1000 WATT METAL HALIDE LAMP FIXTURES (OUTDOOR): LCC AND PBP RESULTS—Continued

Trial standard level	Efficiency level	Life-cycle cost *2012$*			Life-cycle cost savings			Median payback period *years*
		Installed cost	Discounted operating cost	LCC	Average savings *2012$*	Percent of customers that experience		
						Net cost	Net benefit	
	EL1+DS*	1,231.48	7,497.64	8,729.12	1,607.97	0.1	99.9	0.5
	EL1+DS**	1,293.52	9,364.98	10,658.50	−321.40	99.7	0.3	Never
	EL2	1,258.34	9,054.76	10,313.10	24.00	30.3	69.7	17.0
1, 2, 3, 4, 5	EL2+DS*	1,259.49	7,445.67	8,705.16	1,631.94	1.6	98.4	0.8
1, 2, 3, 4, 5	EL2+DS**	1,313.68	9,338.20	10,651.88	−314.78	99.7	0.3	Never
Subgroup: Warehouse Owners								
	Baseline	1,184.62	9,152.48	10,337.10				
	Baseline+DS*							
	Baseline+DS**	1,239.95	9,435.92	10,675.88	−338.78	100.0	0.0	N/A
	EL1	1,238.18	9,081.54	10,319.72	17.37	30.4	69.6	17.0
	EL1+DS*	1,231.48	7,497.64	8,729.12	1,607.97	0.1	99.9	0.5
	EL1+DS**	1,293.52	9,364.98	10,658.50	−321.40	99.7	0.3	Never
	EL2	1,258.34	9,054.76	10,313.10	24.00	30.3	69.7	17.0
1, 2, 3, 4, 5	EL2+DS*	1,259.49	7,445.67	8,705.16	1,631.94	1.6	98.4	0.8
1, 2, 3, 4, 5	EL2+DS**	1,313.68	9,338.20	10,651.88	−314.78	99.7	0.3	Never
Subgroup: Owners of Transient-Prone Outdoor Lighting								
	Baseline	1,184.66	9,169.03	10,353.69				
	Baseline+DS*							
	Baseline+DS**	1,240.01	9,454.15	10,694.16	−340.47	100.0	0.0	N/A
	EL1	1,238.24	9,097.27	10,335.50	18.19	29.8	70.2	16.9
	EL1+DS*	1,231.53	7,511.15	8,742.68	1,611.01	0.1	99.9	0.5
	EL1+DS**	1,293.58	9,382.40	10,675.98	−322.29	99.7	0.3	Never
	EL2	1,258.40	9,070.18	10,328.57	25.12	29.7	70.3	16.8
1, 2, 3, 4, 5	EL2+DS*	1,259.55	7,458.67	8,718.22	1,635.47	1.8	98.2	0.8
1, 2, 3, 4, 5	EL2+DS**	1,313.74	9,355.30	10,669.04	−315.35	99.7	0.3	Never

* DS = Design Standard prohibits fixtures from containing a probe-start ballast. A percentage of customers in this equipment class will migrate to these fixtures, which are reduced-wattage 875 W systems.

** Design Standard 1000 W pulse-start fixtures. Customers who do not migrate to 875 W systems will choose these 1000 W systems.

c. Rebuttable Presumption Payback

As discussed in section IV.D.2, EPCA establishes a rebuttable presumption that, in essence, 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. (42 U.S.C. 6295(o)(2)(B)(iii)) DOE calculated a rebuttable presumption payback period for each TSL to determine whether DOE could presume that a standard at that level is economically justified. Table VII.28 shows the rebuttable-presumption payback periods for the fixture TSLs. Because only a single, average value is necessary for establishing the rebuttable-presumption payback period, rather than using distributions for input values, DOE used discrete values. As required by EPCA, DOE based the calculation on the assumptions in the DOE test procedures for microwave ovens. (42 U.S.C. 6295(o)(2)(B)(iii)) As a result, DOE calculated a single rebuttable presumption payback value, and not a distribution of payback periods, for each TSL.

TABLE VII.28—FIXTURE EFFICIENCY LEVELS WITH A REBUTTABLE PAYBACK PERIOD OF LESS THAN THREE YEARS

Equipment class	Efficiency level	Mean payback period *years*
70 W (indoor, magnetic baseline)	1	1.3
70 W (outdoor, magnetic baseline)	1	1.4
1000 W (indoor)	1 + DS*	0.4
	2 + DS*	0.7
1000 W (outdoor)	1 + DS*	0.6
	2 + DS*	1.0

* DS = Design standard requiring that all fixtures shall not contain a probe-start ballast.

All the fixture efficiency levels in the LCC and PBP results tables have rebuttable-presumption payback periods of less than 3 years. DOE believes that the rebuttable-presumption payback period criterion (*i.e.,* a limited payback period) is not sufficient for determining economic justification. Therefore, DOE has considered a full range of impacts, including those to consumers, manufacturers, the Nation, and the environment. Section IV of this rulemaking provides a complete discussion of how DOE considered the range of impacts to select the standards in today's final rule.

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of new and amended energy conservation standards on manufacturers of MHLFs and ballasts. The section below describes the expected impacts on manufacturers at each TSL. Chapter 13 of this final rule TSD explains the analysis in further detail.

a. Industry Cash-Flow Analysis Results

The tables below depict the financial impacts (represented by changes in INPV) of new and amended energy conservation standards on manufacturers as well as the conversion costs that DOE estimates manufacturers would incur at each TSL. DOE reports the impacts on manufacturers of MHLFs and ballasts separately. Within each industry, DOE presents the results for all equipment classes in one group because most equipment classes are generally made by the same manufacturers. To evaluate the range of cash-flow impacts on the MHLF and ballast industries, DOE modeled four different scenarios using different assumptions for markups and shipments that correspond to the range of anticipated market responses to new and amended standards. Each scenario results in a unique set of cash flows and corresponding INPV at each TSL.

DOE presents two of these shipment and markup scenario combinations in the following section. These scenarios represent the upper and lower bounds of market responses that DOE anticipates could occur in the standards case. The INPV results presented 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 (2014) through the end of the analysis period. The cash-flow results presented refer to the difference in cash flow between the base case and the standards case in 2016, the year before compliance is required. This figure represents the size of the required conversion costs relative to the cash flow generated by the industry in the absence of new and amended energy conservation standards.

Cash-Flow Analysis Results by TSL for Metal Halide Ballasts

To assess the upper (less severe) end of the range of potential impacts on MH ballast manufacturers, DOE modeled a flat markup scenario. The flat markup scenario assumes that in the standards case, manufacturers would be able to pass along all the higher production costs required for more efficient equipment to their customers. Specifically, the industry would be able to maintain its average base case gross margin, as a percentage of revenue, despite the higher production costs in the standards case. In general, the larger the equipment price increases, the less likely manufacturers are to achieve the cash flow from operations calculated in this scenario because it is less likely that manufacturers would be able to fully markup these larger cost increases.

DOE also used the high-shipment scenario to assess the upper bound of impacts. Under the high-shipment scenario, base case shipments of MHLFs decrease at a slower rate over the analysis period compared to the low-shipment scenario. The combination of the flat markup and high-shipment scenario provides the best conditions for cash flow generation than any other combination analyzed by DOE in the MIA. In this scenario, manufacturers experience higher annual shipment volumes and have the ability to preserve their base case gross margins. Thus, this combination of scenarios yields the greatest modeled industry profitability.

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

DOE also used the low-shipment scenario to assess the lower bound of impacts. Under the low-shipment scenario, MHLF shipments decrease at a faster rate over the analysis period compared to the high-shipment scenario. The combination of the preservation of operating profit markup and low-shipment scenario most restricts manufacturers' ability to pass on costs to customers and assumes the lowest level of shipments. Thus, this combination of scenarios estimates the largest manufacturer impacts.

TABLE VII.29—MANUFACTURER IMPACT ANALYSIS FOR METAL HALIDE BALLASTS—FLAT MARKUP AND HIGH-SHIPMENT SCENARIO

	Units	Base case	Trial standard level				
			1	2	3	4	5
INPV	(2012$ millions)	74	71	74	75	83	89
Change in INPV	(2012$ millions)		(3.1)	(0.4)	0.6	9.6	15.0
	(%)		−4.2	−0.5	0.8	12.9	20.3
Product Conversion Costs	(2012$ millions)		11	12	12	16	20
Capital Conversion Costs	(2012$ millions)		9	10	11	4	5
Total Conversion Costs	(2012$ millions)		21	22	23	21	24

TABLE VII.30—MANUFACTURER IMPACT ANALYSIS FOR METAL HALIDE BALLASTS—PRESERVATION OF OPERATING PROFIT MARKUP AND LOW-SHIPMENT SCENARIO

	Units	Base case	Trial standard level				
			1	2	3	4	5
INPV	(2012$ millions)	67	50	49	48	51	48
Change in INPV	(2012$ millions)		(16.5)	(17.9)	(19.0)	(16.2)	(19.0)
	(%)		−24.6	−26.7	−28.3	−24.1	−28.3

TABLE VII.30—MANUFACTURER IMPACT ANALYSIS FOR METAL HALIDE BALLASTS—PRESERVATION OF OPERATING PROFIT MARKUP AND LOW-SHIPMENT SCENARIO—Continued

	Units	Base case	Trial standard level				
			1	2	3	4	5
Product Conversion Costs	(2012$ millions)		11	12	12	16	20
Capital Conversion Costs	(2012$ millions)		9	10	11	4	5
Total Conversion Costs	(2012$ millions)		21	22	23	21	24

TSL 1 is baseline for two of the 12 equipment classes (1500 W indoor and outdoor), EL1 for eight of the 12 equipment classes (70 W indoor and outdoor, 150 W indoor and outdoor, 250 W indoor and outdoor, and 400 W indoor and outdoor), and EL2 for the remaining two equipment classes (1000 W indoor and outdoor). At TSL 1, DOE estimates impacts on INPV range from −$3.1 million to −$16.5 million, or a change in INPV of −4.2 percent to −24.6 percent. At TSL 1, industry free cash flow (operating cash flow minus capital expenditures) is estimated to decrease by approximately 105 percent to −$0.4 million, compared to the base case value of $7.2 million in 2016.

Impacts on INPV range from slightly negative to moderately negative at TSL 1. TSL 1 requires the use of more efficient magnetic ballasts for the 70 W indoor and outdoor, 150 W indoor and outdoor, 250 W indoor and outdoor, 400 W indoor and outdoor, and 1000 W indoor and outdoor equipment classes. DOE projects that in 2017, 92 percent of 70 W indoor shipments, 13 percent of 150 W indoor shipments, 16 percent of 250 W indoor shipments, seven percent of 400 W indoor shipments, one percent of 1000 W indoor shipments, 100 percent of 1500 W indoor shipments, 40 percent of 70 W outdoor shipments, two percent of 150 W outdoor shipments, 10 percent of 250 W outdoor shipments, one percent of 1000 W outdoor shipments, and 100 percent of 1500 W outdoor shipments would meet TSL 1 or higher in the base case. No shipments from the 400 W outdoor equipment class would meet TSL 1 or higher in the base case in 2017.

Conversion costs are expected to be moderate at TSL 1. DOE expects ballast manufacturers to incur $11 million in product conversion costs for model redesigns and testing and $9 million in capital conversion costs for equipment such as stamping dies to process more efficient steel cores.

At TSL 1, the shipment-weighted average MPC increases by 29 percent relative to the base case MPC. Under the flat markup scenario, manufacturers are able to fully pass on this cost increase to customers under this scenario. Additionally, under the high-shipment scenario, shipments are 130 percent higher than shipments under the low-shipment scenario in the last year of the analysis period. Thus, manufacturers generate the most revenue under this combination (flat markup and high-shipment) of scenarios. The fairly large $21 million in conversion costs estimated at TSL 1 outweigh the moderate MPC increase even when applied to the larger quantity of shipments of the high-shipment scenario, resulting in slightly negative INPV impacts at TSL 1 under the flat markup and high-shipment scenarios.

Under the preservation of operating profit markup scenario, manufacturers earn the same operating profit as they would in the base case in 2018, however, manufacturers do not earn additional profit from their investments. In this scenario, the 29 percent MPC increase is outweighed by a lower average markup of 1.43 (compared to the flat markup scenario markup of 1.47) and $21 million in conversion costs, resulting in greater negative impacts at TSL 1. The low-shipment scenario exacerbates these impacts because the base case INPV (the figure against which the absolute change in INPV is compared) is 10 percent lower than the base case INPV in the high-shipment scenario.

TSL 2 is baseline for two of the 12 equipment classes (1500 W indoor and outdoor), EL1 for two of the 12 equipment classes (250 W indoor and outdoor), and EL2 for the remaining eight equipment classes (70 W indoor and outdoor, 150 W indoor and outdoor, 400 W indoor and outdoor, and 1000 W indoor and outdoor). At TSL 2, DOE estimates impacts on INPV to range from −$0.4 million to −$17.9 million, or a change in INPV of −0.5 percent to −26.7 percent. At this level, industry free cash flow is estimated to decrease by approximately 114 percent to −$1.0 million, compared to the base case value of $7.2 million in 2016.

For several equipment classes TSL 2 is the highest efficiency level the engineering analysis assumes manufacturers can meet with magnetic ballasts. DOE projects that in 2017, 89 percent of 70 W indoor shipments, ten percent of 150 W indoor shipments, 16 percent of 250 W indoor shipments, seven percent of 400 W indoor shipments, one percent of 1000 W indoor shipments, 100 percent of 1500 W indoor shipments, 10 percent of 250 W outdoor shipments, one percent of 1000 W outdoor shipments, and 100 percent of 1500 W outdoor shipments would meet TSL 2 or higher in the base case. No shipments from the 70 W outdoor, 150 W outdoor, or 400 W outdoor equipment classes would meet TSL 2 or higher in the base case in 2017. At TSL 2, product conversion costs slightly rise to $12 million and capital conversion costs slightly rise to $10 million as manufacturers need to purchase additional equipment and tooling to upgrade magnetic production lines.

At TSL 2, the shipment-weighted average MPC increases 38 percent over the base case MPC. In flat markup scenario, INPV impacts are slightly negative because the $22 million in conversion costs outweigh the manufacturers' ability to pass on the higher equipment costs to customers. Under the preservation of operating profit markup scenario, the 38 percent MPC increase is outweighed by a lower average markup of 1.42 and $22 million in conversion costs, resulting in negative INPV impacts at TSL 2.

TSL 3 is baseline for two of the 12 equipment classes (1500 W indoor and outdoor) and EL2 for the remaining ten equipment classes (70 W indoor and outdoor, 150 W indoor and outdoor, 250 W indoor and outdoor, 400 W indoor and outdoor, and 1000 W indoor and outdoor). At TSL 3, DOE estimates impacts on INPV to range from $0.6 million to −$19.0 million, or a change in INPV of 0.8 percent to −28.3 percent. At this level, industry free cash flow is estimated to decrease by approximately 120 percent to −$1.5 million, compared to the base case value of $7.2 million in 2016.

TSL 3 is the highest efficiency level the engineering analysis assumes manufacturers can meet with magnetic ballasts for all equipment classes. DOE projects that in 2017, 89 percent of 70 W indoor shipments, ten percent of 150 W indoor shipments, 12 percent of 250 W indoor shipments, seven percent of 400 W indoor shipments, one percent of 1000 W indoor shipments, 100 percent of 1500 W indoor shipments, one percent of 1000 W outdoor shipments, and 100 percent of 1500 W outdoor shipments would meet TSL 3 or higher in the base case. No shipments from the 70 W outdoor, 150 W outdoor, 250 W outdoor, or 400 W outdoor equipment classes would meet TSL 3 or higher in 2016 in the base case in 2017. DOE expects product conversion costs to remain constant at $12 million and capital conversion costs to increase slightly to $11 million.

At TSL 3 the shipment-weighted average MPC increases 42 percent over the base case MPC. In the flat markup scenario, the additional revenues earned from passing on these higher MPC costs outweigh the $23 million in conversion costs and higher working capital requirements, resulting in slightly positive INPV impacts. Under the preservation of operating profit markup scenario, the 42 percent MPC increase is outweighed by a lower average markup of 1.41 and $23 million in conversion costs, resulting in INPV results remaining negative at TSL 3.

TSL 4 is EL1 for two equipment classes (1500 W indoor and outdoor), EL2 for two equipment classes (1000 W indoor and outdoor), and EL3 for the remaining eight equipment classes (70 W indoor and outdoor, 150 W indoor and outdoor, 250 W indoor and outdoor, and 400 W indoor and outdoor). At TSL 4, DOE estimates impacts on INPV to range from $9.6 million to −$16.2 million, or a change in INPV of 12.9 percent to −24.1 percent. At this level, industry free cash flow is estimated to decrease by approximately 94 percent to $0.5 million, compared to the base case value of $7.2 million in 2016.

The technology changes from TSL 3 to TSL 4 are that manufacturers must now use now electronic ballasts for the 70 W indoor and outdoor, 150 W indoor and outdoor, 250 W indoor and outdoor, and 400 W indoor and outdoor equipment classes at TSL 4. DOE projects that in 2017, 89 percent of 70 W indoor shipments, 10 percent of 150 W indoor shipments, 12 percent of 250 W indoor shipments, seven percent of 400 W indoor shipments, one percent of 1000 W indoor shipments, six percent of 1500 W indoor shipments, one percent of 1000 W outdoor shipments, and four percent of 1500 W outdoor shipments would meet TSL 4 or higher in the base case. No shipments of the 70 W outdoor, 150 W outdoor, 250 W outdoor, or 400 W outdoor equipment classes would meet TSL 4 or higher in the base case in 2017. Total conversion costs decrease from $23 million at TSL 3 to $21 million at TSL 4, because of the flexibility of electronic ballast production within the lighting manufacturing industry.

At TSL 4, the shipment-weighted average MPC increases 63 percent over the base case MPC. In the flat markup scenario, the additional revenues earned from passing on these higher MPC costs outweigh the $21 million in conversion costs, resulting in moderately positive impacts on INPV. Under the preservation of operating profit markup scenario, the MPC increase is outweighed by a lower average markup of 1.40 and $21 million in conversion costs, resulting in INPV results remaining negative at TSL 4.

TSL 5 is EL2 for four of the 12 equipment classes (1000 W indoor and outdoor and 1500 W indoor and outdoor) and EL4 for the remaining eight equipment classes (70 W indoor and outdoor, 150 W indoor and outdoor, 250 W indoor and outdoor, and 400 W indoor and outdoor). At TSL 5, DOE estimates impacts on INPV to range from $15.0 million to −$19.0 million, or a change in INPV of 20.3 percent to −28.3 percent. At this level, industry free cash flow is estimated to decrease by approximately 109 percent to −$0.6 million, compared to the base case value of $7.2 million in 2016.

TSL 5 is max tech for all equipment classes. DOE projects that in 2017, one percent of 70 W indoor shipments, one percent of 1000 W indoor shipments, and one percent of 1000 W outdoor shipments will meet TSL 5 in the base case. No shipments of any of the other equipment classes will meet TSL 5 in the base case in 2017. As a result, product conversion costs increase to $24 million because of the need to redesign and test additional models. However, capital conversion costs remain fairly low at $5 million due to the flexibility of electronic ballast production.

At TSL 5, the shipment-weighted average MPC increases 82 percent over the base case MPC. In the flat markup scenario the additional revenues earned from passing on these higher MPC costs outweigh the increased conversion costs of $24 million, resulting in a moderately positive impact on INPV. Under the preservation of operating profit markup scenario, the MPC increase is outweighed by a lower average markup of 1.39 and $24 million in conversion costs, resulting in INPV results remaining negative at TSL 5.

Cash Flow Analysis Results by TSL for Metal Halide Lamp Fixtures

DOE incorporated the same scenarios to represent the upper and lower bounds of industry impacts for MHLFs as for MH ballasts: the flat markup scenario with the high-shipment scenario and the preservation of operating profit markup scenario with the low-shipment scenario. Note that the TSLs below represent the same sets of efficiency levels as discussed in the previous section in the description of impacts on MH ballast manufacturers.

TABLE VII.31—MANUFACTURER IMPACT ANALYSIS FOR METAL HALIDE LAMP FIXTURES—FLAT MARKUP AND HIGH-SHIPMENT SCENARIO

	Units	Base case	Trial standard level				
			1	2	3	4	5
INPV	(2012$ millions)	379	408	418	423	418	408
Change in INPV	(2012$ millions)		28.4	38.3	43.4	38.6	29.1
	(%)		7.5	10.1	11.4	10.2	7.7
Product Conversion Costs	(2012$ millions)		3	3	3	45	62
Capital Conversion Costs	(2012$ millions)		0	0	0	32	50
Total Conversion Costs	(2012$ millions)		3	3	3	77	112

TABLE VII.32—MANUFACTURER IMPACT ANALYSIS FOR METAL HALIDE LAMP FIXTURES—PRESERVATION OF OPERATING PROFIT MARKUP AND LOW-SHIPMENT SCENARIO

	Units	Base case	Trial standard level				
			1	2	3	4	5
INPV	(2012$ millions)	346	342	342	342	285	257
Change in INPV	(2012$ millions)		(3.6)	(3.6)	(3.6)	(60.4)	(88.6)
	(%)		−1.0	−1.0	−1.1	−17.5	−25.6
Product Conversion Costs	(2012$ millions)		3	3	3	45	62
Capital Conversion Costs	(2012$ millions)		0	0	0	32	50
Total Conversion Costs	(2012$ millions)		3	3	3	77	112

At TSL 1, DOE estimates impacts on INPV to range from $28.4 million to −$3.6 million, or a change in INPV of 7.5 percent to −1.0 percent. At TSL 1, industry free cash flow is estimated to decrease by approximately 3 percent to $38.3 million, compared to the base case value of $39.3 million in 2016.

DOE expects minimal conversion costs for fixture manufacturers at TSL 1. Fixture manufacturers would incur $3 million in product conversion costs for the testing of redesigned ballasts. Because the stack height of magnetic ballasts is not expected to change in response to the standards, fixture manufacturers would not incur any capital conversion costs at efficiency levels that can be met with magnetic ballast such as TSL 1.

At TSL 1, the shipment-weighted average MPC increases by 11 percent from the base case MPC. In the flat markup scenario manufacturers maximize revenue since they are able to fully pass on this cost increase to customers. The slight price increase applied to a large quantity of shipments outweighs the impact of the $3 million in conversion costs for TSL 1, resulting in positive impacts at TSL 1 under the flat markup and high-shipment scenarios.

Under the preservation of operating profit markup scenario a lower average markup of 1.54 (compared to the flat manufacturer markup of 1.58) and $3 million in conversion cost results in a slightly negative impacts at TSL 1. The low-shipment scenario exacerbates these impacts because the base case INPV (the figure against which the absolute change in INPV is compared) is 10 percent lower than the base case INPV in the high-shipment scenario.

At TSL 2, DOE estimates impacts on INPV to range from $38.3 million to −$3.6 million, or a change in INPV of 10.1 percent to −1.0 percent. At this level, industry free cash flow is estimated to decrease by approximately 3 percent to $38.3 million, compared to the base case value of $39.3 million in 2016.

At TSL 2, the shipment-weighted average MPC increases 15 percent over the base case MPC. In the flat markup scenario the additional revenues earned from passing on these higher MPC costs outweigh the fairly low conversion costs of $3 million, resulting in a positive impact on INPV. Under the preservation of operating profit markup scenario, the MPC increase is outweighed by a lower average markup of 1.53 and $3 million in conversion costs, resulting in slightly negative INPV results at TSL 2.

At TSL 3, DOE estimates impacts on INPV to range from $43.4 million to −$3.6 million, or a change in INPV of 11.4 percent to −1.1 percent. At this level, industry free cash flow is estimated to decrease by approximately 3 percent to $38.3 million, compared to the base case value of $39.3 million in 2016. At TSL 3, the shipment-weighted average MPC increases 16 percent over the base case MPC. In the flat markup scenario the additional revenues earned from passing on these higher MPC costs outweigh the fairly low conversion costs of $3 million, resulting in a positive impact on INPV. Under the preservation of operating profit markup scenario, the MPC increase is outweighed by a lower average markup of 1.53 and $3 million in conversion costs, resulting in slightly negative INPV results at TSL 3.

At TSL 4, DOE estimates impacts on INPV to range from $38.6 million to −$60.4 million, or a change in INPV of 10.2 percent to −17.5 percent. At this level, industry free cash flow is estimated to decrease by approximately 72 percent to $10.9 million, compared to the base case value of $39.3 million in 2016.

The technology changes from TSL 3 to TSL 4 are that manufacturers must use electronic ballasts to meet the required efficiencies for the 70 W indoor and outdoor, 150 W indoor and outdoor, 250 W indoor and outdoor, and 400 W indoor and outdoor equipment classes at TSL 4. This increases the product conversion costs from $3 million at TSL 3 to $45 million at TSL 4 and increases the capital conversion costs from zero at TSL 3 to $32 million at TSL 4.

At TSL 4, the shipment-weighted average MPC increases 44 percent over the base case MPC. In the flat markup scenario the additional revenue earned from passing on these higher MPC costs outweigh the increased conversion costs of $77 million, resulting in a positive impact on INPV at TSL 4. Under the preservation of operating profit markup scenario the MPC increase is outweighed by a lower average markup of 1.48 and $77 million in conversion costs, resulting in moderately negative INPV impacts at TSL 4.

At TSL 5, DOE estimates impacts on INPV to range from $29.1 million to −$88.6 million, or a change in INPV of 7.7 percent to −25.6 percent. At this level, industry free cash flow is estimated to decrease by approximately 107 percent to −$2.8 million, compared to the base case value of $39.3 million in 2016.

At TSL 5, product conversion costs again significantly increase to $62 million as manufacturers must redesign all equipment classes to accommodate the most efficient electronic ballasts. Capital conversion costs also significantly increase to $50 million because of the need for additional equipment and tooling, such as new castings to incorporate thermal protection in the 70 W indoor and outdoor, 150 W indoor and outdoor, 250 W indoor and outdoor, and 400 W indoor and outdoor equipment classes.

At TSL 5, the shipment-weighted average MPC increases 51 percent over the base case MPC. In the flat markup scenario the additional revenues earned from passing on these higher MPC costs outweigh the much larger conversion costs of $112 million, resulting in a positive impact on INPV. Under the preservation of operating profit markup scenario, the MPC increase is outweighed by a lower average markup of 1.47 and $112 million in conversion costs, resulting in significantly negative INPV impacts at TSL 5.

b. Impacts on Employment

DOE quantitatively assessed the impacts of potential new and 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 2014 to 2046. DOE used statistical data from the U.S. Census Bureau's 2009 Annual Survey of Manufacturers (ASM), the results of the engineering analysis, and interviews with manufacturers to determine the inputs necessary to calculate industry-wide labor expenditures and domestic employment levels. Labor expenditures involved with the manufacture of the equipment is a function of the labor intensity of the equipment, the sales volume, and an assumption that wages remain fixed in real terms over time.

In the GRIM, DOE used the labor content of the equipment and the manufacturing production costs to estimate the annual labor expenditures in the industry. DOE used Census data and interviews with manufacturers to estimate the portion of the total labor expenditures that is attributable to domestic labor.

The production worker estimates in this section cover only workers up to the line-supervisor level who are directly involved in fabricating and assembling equipment within an OEM 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 only production workers who manufacture the specific equipment covered by this rulemaking. For example, a worker on a fluorescent lamp ballast line would not be included with the estimate of the number of MHLF or MH ballast workers.

The employment impacts shown in the tables below represent the potential production employment that could result following new and 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 new and amended energy conservation standards when assuming that manufacturers continue to produce the same scope of covered equipment 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 new and amended energy conservation standards, the lower bound of the employment results includes the estimated total number of U.S. production workers in the industry who could lose their jobs if all existing production were moved outside of the United States. While the results present a range of employment impacts following 2017, the sections below also include qualitative discussions of the likelihood of negative employment impacts at the various TSLs. Finally, the employment impacts shown are independent of the employment impacts from the broader U.S. economy, which are documented in chapter 14 of this final rule TSD.

Employment Impacts for Metal Halide Ballasts

Based on 2009 ASM data and interviews with manufacturers, DOE estimates that less than 30 domestic production workers would be involved in manufacturing MH ballasts in 2017, as the vast majority of MH ballasts are manufactured abroad. DOE's view is that manufacturers could face moderate positive impacts on domestic employment levels because increasing equipment costs at each TSL would result in higher labor expenditures per unit, causing manufacturers to hire more workers to meet demand for MH ballasts, assuming that production remains in domestic facilities. Many manufacturers, however, do not expect a significant change in total employment at their facilities. Although manufacturers are concerned that higher prices for MH ballasts will drive customers to alternate technologies, most manufacturers offer these alternate technologies and can shift their employees from MH ballast production to production of other technologies in their facilities. Most manufacturers believe that domestic employment will only be significantly adversely affected if customers shift to foreign imports, causing the total lighting market share of the major domestic manufacturers to decrease.

Employment Impacts for Metal Halide Lamp Fixtures

Using 2009 ASM data and interviews with manufacturers, DOE estimates that approximately 60 percent of the MHLFs sold in the United States are manufactured domestically. With this assumption, DOE estimates that in the absence of new and amended energy conservation standards, there would be approximately 340 domestic production workers involved in manufacturing MHLFs in 2017. Table VII.33 and Table VII.34 show the range of the impacts of potential new and amended energy conservation standards on U.S. production workers in the MHLF industry.

TABLE VII.33—POTENTIAL CHANGES IN THE TOTAL NUMBER OF DOMESTIC METAL HALIDE LAMP FIXTURE PRODUCTION WORKERS IN 2017

[Flat markup and high-shipment scenario]

Base case		Trial standard level				
		1	2	3	4	5
Total Number of Domestic Production Workers in 2017 (without changes in production locations)	345	393	408	415	419	440
Potential Changes in Domestic Production Workers in 2017 *		48 – (345)	63 – (345)	70 – (345)	74 – (345)	95 – (345)

* DOE presents a range of potential employment impacts. Numbers in parentheses indicate negative numbers.

TABLE VII.34—POTENTIAL CHANGES IN THE TOTAL NUMBER OF DOMESTIC METAL HALIDE LAMP FIXTURE PRODUCTION WORKERS IN 2017

[Preservation of operating profit markup and low-shipment scenario]

Base case		Trial standard level				
		1	2	3	4	5
Total Number of Domestic Production Workers in 2017 (without changes in production locations)	339	386	401	408	412	432
Potential Changes in Domestic Production Workers in 2017 *		47 – (339)	62 – (339)	69 – (339)	73 – (339)	93 – (339)

At the upper end of the range, all examined TSLs show moderate positive impacts on domestic employment levels. The increasing equipment cost at each higher TSL would result in higher labor expenditures per unit, causing manufacturers to hire more workers to meet demand levels of MHLFs, assuming that production remains in domestic facilities. Many manufacturers, however, do not expect a significant change in total employment at their facilities. Although manufacturers are concerned that higher prices for MHLFs will drive customers to alternate technologies, most manufacturers offer these alternate technologies and can shift their employees from MHLF production to production of other technologies in their facilities. As with MH ballast manufacturers, most MHLF manufacturers believe that domestic employment will only be significantly adversely affected if customers shift to foreign imports, causing the total lighting market share of the major domestic manufacturers to decrease. Because of the potentially high cost of shipping MHLFs from overseas, many manufacturers believe that this shift is unlikely to occur, especially for the higher wattage MHLFs. This is particularly true for the significant portion of the market served by small manufacturers, for whom the per-unit shipping costs of sourcing products would be even greater because of the lower volumes that they sell.

Based on the above, DOE does not expect the adopted energy conservation standards for MHLFs, at TSL 2, to have a significant negative impact on direct domestic employment levels. DOE notes that domestic employment levels could be negatively affected in the event that small fixture businesses choose to exit the market due to standards. However, discussions with small manufacturers indicated that most small businesses will be able to adapt to new and amended regulations at the adopted standards. The impacts on small businesses are discussed in section VIII.B.

c. Impacts on Manufacturing Capacity

Both MHLF and ballast manufacturers stated that they do not anticipate any capacity constraints at efficiency levels that can be met with magnetic ballasts, which are the efficiency levels adopted for all equipment classes in today's final rule. If the production of higher-efficiency magnetic ballasts decreases the throughput on production lines, manufacturers stated that they would be able to add shifts on existing lines and maintain capacity.

At efficiency levels that require electronic ballasts, however, manufacturers are concerned about the current worldwide shortage of electrical components. The components most affected by this shortage are high-efficiency parts, for which demand would increase even further following new and amended energy conservation standards. The increased demand could exacerbate the component shortage, thereby impacting manufacturing capacity in the near term, according to manufacturers. However, there are no equipment classes requiring electronic ballasts in today's final rule. Therefore, DOE does not anticipate a significant increase in demand for electric components due to today's energy conservation standards. While DOE recognizes that the premium component shortage is currently a significant issue for manufacturers, DOE views it as a relatively short-term phenomenon to which component suppliers will ultimately adjust. According to several manufacturers, suppliers have the ability to ramp up production to meet MH ballast component demand by the compliance date of new and amended standards, but those suppliers have hesitated to invest in additional capacity due to economic uncertainty and skepticism about the sustainability of demand. The state of the macroeconomic environment through 2017 will likely affect the duration of the premium component shortage. Mandatory standards, however, could create more certainty for suppliers about the eventual demand for these components. Additionally, the premium components at issue are not new technologies; rather, they have simply not historically been demanded in large quantities by MH ballast manufacturers.

d. Impacts on Subgroups of Manufacturers

Using average cost assumptions to develop an industry cash-flow estimate may not be adequate for assessing differential impacts among manufacturer subgroups. Small manufacturers, niche equipment 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 MHLFs or ballasts 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 appliance efficiency.

During previous stages of this rulemaking, DOE identified a number of requirements, in addition to new and amended energy conservation standards for MHLFs, that manufacturers will face for products and equipment they manufacture approximately three years prior to and three years after the compliance date of the new and amended standards. The following section briefly addresses comments DOE received with respect to cumulative regulatory burden and summarizes other key related concerns that manufacturers raised during interviews and submitted comments.

Several manufacturers expressed concern about the overall volume of DOE energy conservation standards with which they must comply. Most MHLF manufacturers also make a full range of lighting products and share engineering and other resources with these other internal manufacturing divisions for different products, including certification testing for regulatory compliance.

DOE discusses these and other requirements in chapter 13 of this final rule TSD. DOE takes into account the cost of compliance with other published Federal energy conservation standards in weighing the benefits and burdens of today's rulemaking. DOE does not describe the quantitative impacts of standards that have not yet been finalized because any impacts would be speculative. DOE also notes that certain standards, such as ENERGY STAR, are optional for manufacturers.

3. National Impact Analysis

a. Significance of Energy Savings

For each TSL, DOE projected energy savings for metal halide lamp fixtures purchased in the 30-year period that begins in the year 2017, ending in the year 2046. The savings are measured over the entire lifetime of equipment 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. Table VII.35 presents the estimated primary energy savings for each TSL for the low- and high-shipments scenarios, which represent the minimum and maximum energy savings resulting from all the scenarios analyzed. Table VII.36 presents the estimated FFC energy savings for each considered TSL. Chapter 11 of the final rule TSD describes these estimates in more detail.

TABLE VII.35—CUMULATIVE NATIONAL PRIMARY ENERGY SAVINGS FOR METAL HALIDE LAMP FIXTURE TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046

Trial standard level	Equipment class	National primary energy savings *quads*	
		Low-shipments scenario	High-shipments scenario
1	70 W	0.01	0.01
	150 W	0.02	0.02
	250 W	0.02	0.02
	400 W	0.10	0.13
	1000 W	0.16	0.20
	1500 W	0.00	0.00
	Total	0.30	0.38
2	70 W	0.02	0.02
	150 W	0.04	0.05
	250 W	0.02	0.02
	400 W	0.15	0.19
	1000 W	0.16	0.20
	1500 W	0.00	0.00
	Total	0.38	0.48
3	70 W	0.02	0.02
	150 W	0.04	0.05
	250 W	0.03	0.03
	400 W	0.15	0.19
	1000 W	0.16	0.20
	1500 W	0.00	0.00
	Total	0.39	0.49
4	70 W	0.07	0.09
	150 W	0.10	0.12
	250 W	0.11	0.14
	400 W	0.25	0.31
	1000 W	0.16	0.20
	1500 W	0.00	0.00
	Total	0.69	0.86
5	70 W	0.09	0.11
	150 W	0.11	0.14
	250 W	0.13	0.16
	400 W	0.33	0.41
	1000 W	0.16	0.20
	1500 W	0.00	0.00

TABLE VII.35—CUMULATIVE NATIONAL PRIMARY ENERGY SAVINGS FOR METAL HALIDE LAMP FIXTURE TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046—Continued

Trial standard level	Equipment class	National primary energy savings *quads*	
		Low-shipments scenario	High-shipments scenario
	Total	0.81	1.02

TABLE VII.36—CUMULATIVE NATIONAL FULL-FUEL-CYCLE ENERGY SAVINGS FOR METAL HALIDE LAMP FIXTURE TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046

Trial standard level	Equipment class	National FFC energy savings quads	
		Low-shipments scenario	High-shipments scenario
1	70 W	0.01	0.01
	150 W	0.02	0.02
	250 W	0.02	0.02
	400 W	0.11	0.13
	1000 W	0.16	0.21
	1500 W	0.00	0.00
	Total	0.31	0.39
2	70 W	0.02	0.02
	150 W	0.04	0.05
	250 W	0.02	0.02
	400 W	0.16	0.20
	1000 W	0.16	0.21
	1500 W	0.00	0.00
	Total	0.39	0.49
3	70 W	0.02	0.02
	150 W	0.04	0.05
	250 W	0.03	0.03
	400 W	0.16	0.20
	1000 W	0.16	0.21
	1500 W	0.00	0.00
	Total	0.40	0.50
4	70 W	0.08	0.09
	150 W	0.10	0.13
	250 W	0.12	0.14
	400 W	0.25	0.32
	1000 W	0.16	0.21
	1500 W	0.00	0.00
	Total	0.71	0.88
5	70 W	0.09	0.11
	150 W	0.11	0.14
	250 W	0.13	0.16
	400 W	0.33	0.42
	1000 W	0.16	0.21
	1500 W	0.00	0.00
	Total	0.83	1.03

Circular A–4 requires agencies to present analytical results, including separate schedules of the monetized benefits and costs that show the type and timing of benefits and costs. Circular A–4 also directs agencies to consider the variability of key elements underlying the estimates of benefits and costs. For this rulemaking, DOE undertook a sensitivity analysis using nine rather than 30 years of fixture 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.[66] DOE notes that the

[66] 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

review time frame established in EPCA generally does not overlap with the equipment lifetime, equipment manufacturing cycles or other factors specific to metal halide lamp fixtures. 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 a 9-year analytical period are presented in Table VII.37. The impacts are counted over the lifetime of fixtures purchased in 2017–2025.

TABLE VII.37—CUMULATIVE NATIONAL PRIMARY ENERGY SAVINGS FOR METAL HALIDE LAMP FIXTURE TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2025

Trial standard level	Equipment class	National primary energy savings quads	
		Low-shipments scenario	High-shipments scenario
1	70 W	0.01	0.01
	150 W	0.01	0.01
	250 W	0.01	0.01
	400 W	0.05	0.05
	1000 W	0.08	0.08
	1500 W	0.00	0.00
	Total	0.15	0.16
2	70 W	0.01	0.01
	150 W	0.02	0.02
	250 W	0.01	0.01
	400 W	0.07	0.07
	1000 W	0.08	0.08
	1500 W	0.00	0.00
	Total	0.19	0.20
3	70 W	0.01	0.01
	150 W	0.02	0.02
	250 W	0.01	0.01
	400 W	0.07	0.07
	1000 W	0.08	0.08
	1500 W	0.00	0.00
	Total	0.19	0.20
4	70 W	0.04	0.05
	150 W	0.05	0.05
	250 W	0.06	0.06
	400 W	0.11	0.12
	1000 W	0.08	0.08
	1500 W	0.00	0.00
	Total	0.34	0.36
5	70 W	0.05	0.06
	150 W	0.05	0.06
	250 W	0.06	0.07
	400 W	0.15	0.16
	1000 W	0.08	0.08
	1500 W	0.00	0.00
	Total	0.39	0.42

b. Net Present Value of Customer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for customers that would result from the TSLs considered for metal halide lamp fixtures. 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, and 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 (OMB analysis has found the average rate of return on capital to be near this rate). The 3-percent rate reflects the potential effects of standards on private consumption (*e.g.,* through higher prices for products and reduced purchases of energy). This rate represents the rate at which society discounts future consumption flows to their present

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.

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

value. It can be approximated by the real rate of return on long-term government debt (*i.e.,* yield on United States Treasury notes), which has averaged about 3 percent for the past 30 years.

Table VII.38 shows the customer NPV results for each TSL DOE considered for metal halide lamp fixtures, using both 7-percent and 3-percent discount rates. In each case, the impacts cover the lifetime of equipment purchased in 2017–2046. See chapter 11 of the final rule TSD for more detailed NPV results.

TABLE VII.38—NET PRESENT VALUE OF CUSTOMER BENEFITS FOR METAL HALIDE LAMP FIXTURE TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046

Trial standard level	Equipment class	Net present value billion 2012$			
		Low-shipments scenario		High-shipments scenario	
		7-percent discount rate	3-percent discount rate	7-percent discount rate	3-percent discount rate
1	70 W	0.018	0.033	0.019	0.035
	150 W	0.031	0.074	0.035	0.089
	250 W	0.007	0.045	0.009	0.053
	400 W	0.004	0.102	0.008	0.134
	1000 W	0.198	0.528	0.234	0.656
	1500 W	0.000	0.000	0.000	0.000
	Total	0.257	0.783	0.304	0.968
2	70 W	0.016	0.041	0.017	0.044
	150 W	0.046	0.119	0.054	0.144
	250 W	0.007	0.045	0.009	0.053
	400 W	0.022	0.183	0.030	0.236
	1000 W	0.198	0.528	0.234	0.656
	1500 W	0.000	0.000	0.000	0.000
	Total	0.289	0.915	0.343	1.134
3	70 W	0.016	0.041	0.017	0.044
	150 W	0.046	0.119	0.054	0.144
	250 W	−0.014	0.026	−0.015	0.033
	400 W	0.022	0.183	0.030	0.236
	1000 W	0.198	0.528	0.234	0.656
	1500 W	0.000	0.000	0.000	0.000
	Total	0.267	0.896	0.319	1.114
4	70 W	−0.091	−0.118	−0.102	−0.135
	150 W	0.074	0.218	0.087	0.269
	250 W	−0.352	−0.606	−0.401	−0.721
	400 W	−0.636	−1.057	−0.722	−1.244
	1000 W	0.198	0.528	0.234	0.656
	1500 W	−0.005	−0.007	−0.005	−0.008
	Total	−0.812	−1.042	−0.910	−1.183
5	70 W	−0.114	−0.146	−0.128	−0.166
	150 W	0.049	0.177	0.059	0.221
	250 W	−0.283	−0.460	−0.321	−0.543
	400 W	−0.741	−1.201	−0.839	−1.409
	1000 W	0.198	0.528	0.234	0.656
	1500 W	−0.007	−0.010	−0.008	−0.012
	Total	−0.898	−1.111	−1.004	−1.252

The NPV results based on the aforementioned 9-year analytical period are presented in Table VII.39. The impacts are counted over the lifetime of fixtures purchased in 2017–2025. As mentioned previously, this information is presented for informational purposes only and is not indicative of any change in DOE's analytical methodology or decision criteria.

TABLE VII.39—NET PRESENT VALUE OF CUSTOMER BENEFITS FOR METAL HALIDE LAMP FIXTURE TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2025

Trial standard level	Equipment class	Net present value billion 2012$			
		Low-shipments scenario		High-shipments scenario	
		7-percent discount rate	3-percent discount rate	7-percent discount rate	3-percent discount rate
1	70 W	0.018	0.033	0.019	0.035
	150 W	0.021	0.043	0.022	0.046
	250 W	0.003	0.025	0.004	0.026
	400 W	−0.004	0.038	−0.004	0.041
	1000 W	0.122	0.269	0.131	0.289
	1500 W	0.000	0.000	0.000	0.000
	Total	0.160	0.408	0.171	0.436
2	70 W	0.016	0.037	0.017	0.039
	150 W	0.030	0.065	0.032	0.070
	250 W	0.003	0.025	0.004	0.026
	400 W	0.005	0.074	0.005	0.079
	1000 W	0.122	0.269	0.131	0.289
	1500 W	0.000	0.000	0.000	0.000
	Total	0.177	0.470	0.189	0.502
3	70 W	0.016	0.037	0.017	0.039
	150 W	0.030	0.065	0.032	0.070
	250 W	−0.013	0.009	−0.013	0.010
	400 W	0.005	0.074	0.005	0.079
	1000 W	0.122	0.269	0.131	0.289
	1500 W	0.000	0.000	0.000	0.000
	Total	0.161	0.455	0.172	0.486
4	70 W	−0.064	−0.072	−0.068	−0.077
	150 W	0.046	0.112	0.049	0.120
	250 W	−0.241	−0.353	−0.253	−0.373
	400 W	−0.440	−0.635	−0.462	−0.669
	1000 W	0.122	0.269	0.131	0.289
	1500 W	−0.003	−0.004	−0.003	−0.004
	Total	−0.580	−0.683	−0.607	−0.714
5	70 W	−0.081	−0.092	−0.087	−0.099
	150 W	0.029	0.088	0.031	0.094
	250 W	−0.196	−0.274	−0.206	−0.289
	400 W	−0.514	−0.729	−0.540	−0.768
	1000 W	0.122	0.269	0.131	0.289
	1500 W	−0.005	−0.006	−0.005	−0.006
	Total	−0.645	−0.744	−0.676	−0.779

Finally, DOE evaluated the NPV results for both indoor and outdoor fixtures for each equipment class. Table VII.40 gives the NPV associated with each equipment class broken down into indoor and outdoor fixture environments.

TABLE VII.40—NET PRESENT VALUE OF CUSTOMER BENEFITS FOR METAL HALIDE LAMP FIXTURE TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046

[Low shipments, by fixture environment]

Trial standard level	Equipment class	Net present value billion 2012$			
		Indoor fixtures		Outdoor fixtures	
		7-percent discount rate	3-percent discount rate	7-percent discount rate	3-percent discount rate
1	70 W	0.001	0.001	0.017	0.033
	150 W	0.008	0.019	0.023	0.056

TABLE VII.40—NET PRESENT VALUE OF CUSTOMER BENEFITS FOR METAL HALIDE LAMP FIXTURE TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2017–2046—Continued

[Low shipments, by fixture environment]

Trial standard level	Equipment class	Net present value billion 2012$			
		Indoor fixtures		Outdoor fixtures	
		7-percent discount rate	3-percent discount rate	7-percent discount rate	3-percent discount rate
	250 W	0.003	0.014	0.004	0.031
	400 W	0.002	0.028	0.001	0.075
	1000 W	0.054	0.136	0.143	0.393
	1500 W	0.000	0.000	0.000	0.000
	Total	0.068	0.197	0.189	0.586
2	70 W	0.000	0.001	0.016	0.040
	150 W	0.022	0.051	0.024	0.068
	250 W	0.003	0.014	0.004	0.031
	400 W	0.008	0.049	0.014	0.134
	1000 W	0.054	0.136	0.143	0.393
	1500 W	0.000	0.000	0.000	0.000
	Total	0.087	0.251	0.201	0.664
3	70 W	0.000	0.001	0.016	0.040
	150 W	0.022	0.051	0.024	0.068
	250 W	−0.002	0.010	−0.012	0.016
	400 W	0.008	0.049	0.014	0.134
	1000 W	0.054	0.136	0.143	0.393
	1500 W	0.000	0.000	0.000	0.000
	Total	0.082	0.247	0.185	0.650
4	70 W	0.001	0.002	−0.092	−0.119
	150 W	0.036	0.080	0.038	0.137
	250 W	−0.050	−0.082	−0.302	−0.524
	400 W	−0.121	−0.192	−0.515	−0.865
	1000 W	0.054	0.136	0.143	0.393
	1500 W	−0.001	−0.002	−0.003	−0.005
	Total	−0.081	−0.059	−0.731	−0.983
5	70 W	−0.004	−0.003	−0.110	−0.142
	150 W	0.029	0.069	0.020	0.108
	250 W	−0.030	−0.041	−0.253	−0.419
	400 W	−0.151	−0.234	−0.589	−0.967
	1000 W	0.054	0.136	0.143	0.393
	1500 W	−0.002	−0.002	−0.005	−0.007
	Total	−0.103	−0.075	−0.794	−1.035

c. Impacts on Employment

DOE estimated the indirect employment impacts of potential standards on the economy in general, assuming that energy conservation standards for metal halide lamp fixtures will reduce energy bills for fixture users and that the resulting net savings will be redirected to other forms of economic activity. DOE used an input/output model of the U.S. economy to estimate these effects, including the demand for labor as described in section V.J.

The input/output model results suggest that today's adopted standards are likely to increase the net labor demand. The gains, however, would most likely be small relative to total national employment, and neither the BLS data nor the input/output model DOE uses includes the quality or wage level of the jobs. As shown in Table VII.41, DOE estimates that net indirect employment impacts from adopted fixture standards are small relative to the national economy.

TABLE VII.41—NET CHANGE IN JOBS FROM INDIRECT EMPLOYMENT EFFECTS UNDER FIXTURE TSLS

Analysis period year	Trial standard level	Net national change in jobs	
		Low shipments scenario, roll-up	High shipments scenario, roll-up
2018	1	−60	150
	2	−85	260

TABLE VII.41—NET CHANGE IN JOBS FROM INDIRECT EMPLOYMENT EFFECTS UNDER FIXTURE TSLS—Continued

Analysis period year	Trial standard level	Net national change in jobs	
		Low shipments scenario, roll-up	High shipments scenario, roll-up
	3	−105	405
	4	−405	820
	5	−470	705
2022	1	135	650
	2	170	945
	3	155	1,300
	4	65	2,755
	5	80	2,655

4. Impact on Utility or Performance of Equipment

As presented in section V.B of this notice, DOE concluded that none of the TSLs that were analyzed would reduce the utility or performance of the MHLFs under consideration in this rulemaking. Furthermore, manufacturers currently offer ballasts that meet or exceed the adopted standards in all equipment classes. (42 U.S.C. 6295(o)(2)(B)(i)(IV))

5. Impact of Any Lessening of Competition

EPCA directs DOE to consider any lessening of competition that is likely to result from standards. It also directs the Attorney General of the United States (Attorney General) to determine the impact, if any, of any lessening of competition likely to result from a proposed standard and to transmit such determination 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)(i)(V) and (B)(ii)). To assist the Attorney General in making a determination for MHLF standards, DOE provided the Department of Justice (DOJ) with copies of the NOPR and the TSD for review. DOE received comments from DOJ stating the proposed energy conservation standards for MHLFs are unlikely to have a significant adverse impact on competition.

6. Need of the Nation To Conserve Energy

An improvement in the energy efficiency of the products subject to today's rule is likely to improve the security of the nation's energy system by reducing overall demand for energy. Reduced electricity demand may also improve the reliability of the electricity system. Reductions in national electric generating capacity estimated for each considered TSL are reported in chapter 14 of the final rule TSD.

Energy savings from new and amended energy conservation standards for fixtures could produce environmental benefits in the form of reduced emissions of air pollutants and GHGs associated with electricity production. Table VII.42 and Table VII.43 provide DOE's estimate of cumulative emissions reductions projected to result from the TSLs considered in this rulemaking, for the low and high shipment scenarios, respectively. The tables include both power sector emissions and upstream emissions. The upstream emissions were calculated using the multipliers discussed in section V.L. DOE reports annual emissions reductions for each TSL in the emissions analysis in chapter 16 the final rule TSD.

TABLE VII.42—CUMULATIVE EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR METAL HALIDE LAMP FIXTURES

[Low shipments scenario]

	Trial standard level				
	1	2	3	4	5
Power Sector Emissions					
CO_2 (million metric tons)	16.80	21.24	21.80	38.30	44.93
NO_X (thousand tons)	8.85	11.18	11.48	20.16	23.64
Hg (tons)	0.04	0.05	0.05	0.08	0.10
N_2O (thousand tons)	0.36	0.45	0.46	0.81	0.95
CH_4 (thousand tons)	2.04	2.59	2.65	4.66	5.47
SO_2 (thousand tons)	29.48	37.29	38.26	67.25	78.95
Upstream Emissions					
CO_2 (million metric tons)	0.98	1.24	1.27	2.23	2.62
NO_X (thousand tons)	13.45	17.01	17.45	30.68	36.00
Hg (tons)	0.001	0.001	0.001	0.001	0.001
N_2O (thousand tons)	0.01	0.01	0.01	0.02	0.03
CH_4 (thousand tons)	81.69	103.31	106.01	186.34	218.69
SO_2 (thousand tons)	0.21	0.27	0.27	0.48	0.56
Total Emissions					
CO_2 (million metric tons)	17.78	22.48	23.07	40.53	47.54
NO_X (thousand tons)	22.29	28.19	28.93	50.84	59.64
Hg (tons)	0.04	0.05	0.05	0.08	0.10
N_2O (thousand tons)	0.37	0.46	0.47	0.83	0.98

TABLE VII.42—CUMULATIVE EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR METAL HALIDE LAMP FIXTURES—Continued

[Low shipments scenario]

	Trial standard level				
	1	2	3	4	5
CH_4 (thousand tons)	83.74	105.90	108.66	191.01	224.16
SO_2 (thousand tons)	29.69	37.55	38.53	67.73	79.51

TABLE VII.43—CUMULATIVE EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR METAL HALIDE LAMP FIXTURES

[High shipments scenario]

	Trial standard level				
	1	2	3	4	5
Power Sector Emissions					
CO_2 (*million metric tons*)	20.78	26.26	26.95	47.13	55.37
NO_X (*thousand tons*)	10.89	13.76	14.12	24.69	29.00
Hg (*tons*)	0.05	0.06	0.06	0.10	0.12
N_2O (*thousand tons*)	0.46	0.58	0.60	1.04	1.23
CH_4 (*thousand tons*)	2.57	3.25	3.33	5.83	6.85
SO_2 (*thousand tons*)	37.14	46.92	48.15	84.20	99.02
Upstream Emissions					
CO_2 (*million metric tons*)	1.22	1.54	1.59	2.77	3.26
NO_X (*thousand tons*)	16.83	21.26	21.81	38.16	44.85
Hg (*tons*)	0.001	0.001	0.001	0.001	0.002
N_2O (*thousand tons*)	0.01	0.02	0.02	0.03	0.03
CH_4 (*thousand tons*)	102.23	129.15	132.54	231.83	272.53
SO_2 (*thousand tons*)	0.26	0.33	0.34	0.59	0.70
Total Emissions					
CO_2 (*million metric tons*)	22.01	27.80	28.53	49.90	58.63
NO_X (*thousand tons*)	27.72	35.02	35.93	62.85	73.86
Hg (*tons*)	0.05	0.06	0.06	0.10	0.12
N_2O (*thousand tons*)	0.47	0.60	0.61	1.07	1.26
CH_4 (*thousand tons*)	104.80	132.40	135.87	237.66	279.39
SO_2 (*thousand tons*)	37.40	47.25	48.49	84.80	99.72

As discussed in section V.L, DOE did not report SO_2 emissions reductions from power plants because there is uncertainty about the effect of energy conservation standards on the overall level of SO_2 emissions in the United States due to new emissions standards for power plants under the MATS rule. DOE also did not include NO_X emissions reductions from power plants in states subject to CAIR because an energy conservation standard would not affect the overall level of NO_X emissions in those states due to the emissions caps.

As part the analysis for this final 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 V.M.1, DOE used values for the SCC developed by an interagency process. The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets 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 temperature change further out in the tails of the SCC distribution. The four SCC values for CO_2 emissions reductions in 2015, expressed in 2012$, are $11.8/ton, $39.7/ton, $61.2/ton, and $117.0/ton. These values for later years are higher due to increasing emissions-related costs as the magnitude of projected climate change increases.

Table VII.44 and Table VII.45 present the global value of CO_2 emissions reductions at each TSL for the low and high shipment scenarios, respectively. DOE calculated domestic values as a range from 7 percent to 23 percent of the global values, and these results are presented in chapter 17 of the final rule TSD.

TABLE VII.44—GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR METAL HALIDE LAMP FIXTURES

[Low shipments scenario]

TSL	SCC scenario*			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
	million 2012$			
Power Sector Emissions				
1	109.3	509.9	813.4	1,574.7
2	138.2	644.8	1,028.7	1,991.6
3	141.8	661.8	1,055.7	2,043.9
4	249.2	1,162.7	1,854.8	3,591.3
5	291.9	1,362.9	2,174.5	4,209.8
Upstream Emissions				
1	6.2	29.3	46.8	90.6
2	7.9	37.1	59.2	114.6
3	8.1	38.0	60.8	117.6
4	14.2	66.9	106.9	206.8
5	16.6	78.4	125.3	242.5
Total Emissions				
1	115	539.2	860.2	1,665.3
2	146	681.9	1,087.9	2,106.2
3	150	699.8	1,116.5	2,161.5
4	263	1,229.6	1,961.7	3,798.1
5	309	1,441.3	2,299.8	4,452.3

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $11.8, $39.7, $61.2 and $117.0 per metric ton (2012$).

TABLE VII.45—GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR METAL HALIDE LAMP FIXTURES

[High shipments scenario]

TSL	SCC scenario*			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
	million 2012$			
Power Sector Emissions				
1	130.4	617.9	988.6	1,909.5
2	164.8	780.8	1,249.3	2,413.0
3	169.1	801.4	1,282.2	2,476.6
4	296.0	1,402.5	2,243.7	4,334.3
5	347.3	1,646.3	2,634.1	5,088.0
Upstream Emissions				
1	7.5	35.9	57.6	111.1
2	9.5	45.4	72.7	140.4
3	9.7	46.6	74.7	144.1
4	17.0	81.5	130.7	252.2
5	20.0	95.7	153.5	296.2
Total Emissions				
1	137.9	653.8	1,046.2	2,020.6
2	174.2	826.2	1,322.0	2,553.4
3	178.8	848.0	1,356.8	2,620.7
4	313.1	1,484.0	2,374.3	4,586.5
5	367.2	1,742.1	2,787.6	5,384.2

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $11.8, $39.7, $61.2 and $117.0 per metric ton (2012$).

DOE is well aware that scientific and economic knowledge about the contribution of CO_2 and other GHG emissions to changes in the future global climate and the potential resulting damages to the world economy continues to evolve rapidly. Thus, any value placed in this rulemaking on reducing CO_2 emissions 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 NOPR the most recent values and analyses resulting from the ongoing interagency review process.

DOE also estimated a range for the cumulative monetary value of the economic benefits associated with NO_X and Hg emissions reductions anticipated to result from amended metal halide lamp fixture standards. Estimated monetary benefits for CO_2 and NO_X emission reductions are detailed in chapter 17 of the final rule TSD.

The NPV of the monetized benefits associated with emissions reductions can be viewed as a complement to the NPV of the customer savings calculated for each TSL considered in this rulemaking. The dollar-per-ton values that DOE used are discussed in section V.M. Table VII.46 presents the present value of cumulative NO_X emissions reductions for each TSL calculated using the average dollar-per-ton values and 7-percent and 3-percent discount rates.

TABLE VII.46—PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR POTENTIAL STANDARDS FOR METAL HALIDE LAMP FIXTURES

TSL	Low shipments scenario		High shipments scenario	
	3% discount rate	7% discount rate	3% discount rate	7% discount rate
	million 2012$			
Power Sector Emissions				
1	12.0	5.8	14.1	6.6
2	15.2	7.4	17.9	8.3
3	15.6	7.6	18.3	8.5
4	27.4	13.3	32.1	14.9
5	32.0	15.5	37.6	17.5
Upstream Emissions				
1	17.4	7.9	20.8	9.1
2	22.0	10.0	26.3	11.4
3	22.6	10.2	27.0	11.7
4	39.7	18.0	47.3	20.6
5	46.5	21.0	55.5	24.1
Total Emissions				
1	29.4	13.7	35.0	15.6
2	37.2	17.3	44.2	19.8
3	38.2	17.8	45.4	20.3
4	67.0	31.2	79.4	35.5
5	78.5	36.5	93.1	41.6

The NPV of the monetized benefits associated with emissions reductions can be viewed as a complement to the NPV of the customer savings calculated for each TSL considered in this rulemaking. Table VII.47 and Table VII.48 present 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 customer savings calculated for each TSL considered in this rulemaking, at both a 7-percent and a 3-percent discount rate, and for the low and high shipment scenarios, respectively. The CO_2 values used in the columns of each table correspond to the four scenarios for the valuation of CO_2 emission reductions discussed above.

TABLE VII.47—METAL HALIDE LAMP FIXTURE TSLS: NET PRESENT VALUE OF CUSTOMER SAVINGS COMBINED WITH NET PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS

[Low shipments scenario]

TSL	Customer NPV at 3% discount rate added with:			
	SCC value of $11.8/metric ton CO_2* and medium value for NO_X**	SCC value of $39.7/metric ton CO_2* and medium value for NO_X**	SCC value of $61.2/metric ton CO_2* and medium value for NO_X**	SCC value of $117.0/metric ton CO_2* and medium value for NO_X**
	billion 2012$			
1	0.928	1.352	1.673	2.478
2	1.099	1.634	2.040	3.059
3	1.084	1.634	2.051	3.096
4	−0.712	0.255	0.987	2.823
5	−0.724	0.409	1.268	3.420
	Customer NPV at 7% discount rate added with:			
	billion 2012$			
1	0.386	0.810	1.131	1.936
2	0.452	0.988	1.394	2.412
3	0.435	0.985	1.402	2.447
4	−0.518	0.449	1.181	3.017
5	−0.553	0.580	1.439	3.591

* These label values represent the global SCC in 2015, in 2012$. The present values have been calculated with scenario-consistent discount rates.

** Medium Value corresponds to $2,639 per ton of NO_X emissions.

TABLE VII.48—METAL HALIDE LAMP FIXTURE TSLS: NET PRESENT VALUE OF CUSTOMER SAVINGS COMBINED WITH NET PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS

[High Shipments Scenario]

TSL	Customer NPV at 3% discount rate added with:			
	SCC value of $11.8/metric ton CO_2* and medium value for NO_X**	SCC value of $39.7/metric ton CO_2* and medium value for NO_X**	SCC value of $61.2/metric ton CO_2* and medium value for NO_X**	SCC value of $117.0/metric ton CO_2* and medium value for NO_X**
	billion 2012$			
1	1.141	1.657	2.049	3.024
2	1.353	2.005	2.501	3.732
3	1.338	2.008	2.516	3.780
4	−0.790	0.380	1.271	3.483
5	−0.792	0.583	1.628	4.225
	Customer NPV at 7% discount rate added with:			
	billion 2012$			
1	0.458	0.974	1.366	2.340
2	0.537	1.189	1.685	2.916
3	0.518	1.188	1.696	2.960
4	−0.561	0.610	1.500	3.712
5	−0.595	0.780	1.825	4.422

* These label values represent the global SCC in 2015, in 2012$. The present values have been calculated with scenario-consistent discount rates.

** Medium Value corresponds to $2,639 per ton of NO_X emissions.

Although adding the value of customer savings to the values of emission reductions provides a valuable perspective, the following should be considered: (1) The national customer savings are domestic U.S. customer monetary savings found in market transactions, while the values of emissions reductions are based on estimates of marginal social costs, which, in the case of CO_2, are based on a global value; and (2) the assessments of customer savings and emissions-related benefits are performed with different computer models, leading to different time frames for analysis. For fixtures, the present value of national customer savings is measured for the period in which units shipped in 2017–2046 continue to operate. 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

DOE is subject to the EPCA requirement that any new or amended energy conservation standard for any type (or class) of covered equipment 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 to the greatest extent practicable, in light of the seven statutory factors discussed previously. (42 U.S.C. 6295(o)(2)(B)(i)) The new or amended standard must also result in a significant conservation of energy. (42 U.S.C. 6295(o)(3)(B))

DOE considered the impacts of MHLF standards at each trial standard level, beginning with the max-tech level, to determine whether that level met the evaluation criteria. If the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficiency level that is both technologically feasible and economically justified and saves a significant amount of energy.

DOE discusses the benefits and/or burdens of each trial standard level in the following sections based on the quantitative analytical results for each trial standard level (presented in section VII.A) such as national energy savings, net present value (discounted at 7 and 3 percent), emissions reductions, industry net present value, life-cycle cost, and customers' installed price increases. Beyond the quantitative results, DOE also considers other burdens and benefits that affect economic justification, including how technological feasibility, manufacturer costs, and impacts on competition may affect the economic results presented.

To aid the reader as DOE discusses the benefits and burdens of each trial standard level, DOE has included the following tables (Table VII.49 and Table VII.50) that summarize DOE's quantitative analysis for each TSL. In addition to the quantitative results presented in the tables, DOE also considers other burdens and benefits that affect economic justification. Section VII.B.1 presents the estimated impacts of each TSL for the LCC subgroup analysis.

TABLE VII.49—SUMMARY OF RESULTS FOR METAL HALIDE LAMP FIXTURES

[Low shipments scenario]

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
National Energy Savings (quads).	0.31	0.39	0.40	0.71	0.83
NPV of Customer Benefits (2012$ billion)					
3% discount rate	0.78	0.92	0.90	(1.04)	(1.11)
7% discount rate	0.26	0.29	0.27	(0.81)	(0.90)
Industry Impacts*					
Ballast + Fixture Industry NPV (2012$million) (Base Case Industry NPV of $413 million).	393	391	390	336	305
Ballast + Fixture Industry NPV (change in 2012$million).	(20.1)	(21.5)	(22.6)	(76.6)	(107.5)
Ballast + Fixture Industry NPV (% change).	−4.9%	−5.2%	−5.5%	−18.6%	−26.1%
Cumulative Emissions Reduction					
CO_2 (Mt)	17.78	22.48	23.07	40.53	47.54
SO_2 (kt)	29.69	37.55	38.53	67.73	79.51
NO_X (kt)	22.29	28.19	28.93	50.84	59.64
Hg (t)	0.04	0.05	0.05	0.08	0.10
CH_4 (kt)	83.74	105.90	108.66	191.01	224.16
N_2O (kt)	0.37	0.46	0.47	0.83	0.98
Value of Cumulative Emissions Reduction					
CO_2 (2012$ billion)**	0.1 to 1.7	0.1 to 2.1	0.1 to 2.2	0.3 to 3.8	0.3 to 4.5
NO_X—3% discount rate (2012$ million)**.	29.4	37.2	38.2	67.0	78.5
NO_X—7% discount rate (2012$ million)**.	13.7	17.3	17.8	31.2	36.5
Mean LCC Savings (and Percent Customers Experiencing Net Benefit)*** (2012$)					
50to100W_Ind_OtherV****† (magnetic baseline).	26.97 (100)	27.00 (100)	27.00 (100)	42.50 (82)	37.25 (79)
50to100W_Outd_OtherV (magnetic baseline).	34.24 (98)	34.88 (97)	34.88 (97)	−4.98 (51)	−11.15 (49)
50to100W_Ind_OtherV (electronic baseline).	—	—	—	—	−5.25 (10)

TABLE VII.49—SUMMARY OF RESULTS FOR METAL HALIDE LAMP FIXTURES—Continued

[Low shipments scenario]

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
50to100W_Outd_OtherV (electronic baseline).	—	—	—	—	−6.17 (12)
101to150W_Ind_OtherV‡	22.43 (100)	24.63 (99)	24.63 (99)	89.67 (94)	76.11 (89)
101to150W_Outd_OtherV	27.37 (97)	30.70 (97)	30.70 (97)	52.23 (66)	36.60 (62)
151to250W_Ind_OtherV‡	4.51 (60)	4.51 (60)	−1.07 (37)	−59.67 (18)	−40.33 (29)
151to250W_Outd_OtherV	6.74 (67)	6.74 (67)	1.48 (45)	−119.65 (24)	−97.86 (29)
251to500W_Ind_OtherV	2.83 (47)	7.95 (54)	7.95 (54)	−107.74 (8)	130.60 (6)
251to500W_Outd_OtherV	6.16 (55)	13.15 (62)	13.15 (62)	−165.30 (19)	−187.69 (16)
501to1000W_Ind_OtherV	1221.54 (100)	1221.54 (100)	1221.54 (100)	1221.54 (100)	1221.54 (100)
501to1000W_Outd_OtherV.	1631.94 (98)	1631.94 (98)	1631.94 (98)	1631.94 (98)	1631.94 (98)
1001to2000W_Ind_OtherV.	—	—	—	−67.15 (0)	−93.06 (0)
1001to2000W_Outd_OtherV.	—	—	—	−63.71 (0)	−88.03 (0)
Median PBP (years)					
50to100W_Ind_OtherV (magnetic baseline).	1.4	4.5	4.5	3.7	6.0
50to100W_Outd_OtherV (magnetic baseline).	1.4	4.5	4.5	12.0	14.7
50to100W_Ind_OtherV (electronic baseline).	—	—	—	—	31.5
50to100W_Outd_OtherV (electronic baseline).	—	—	—	—	55.8
101to150W_Ind_OtherV‡	4.3	7.3	7.3	2.5	4.8
101to150W_Outd_OtherV	4.5	8.1	8.1	7.5	10.3
151to250W_Ind_OtherV‡	14.2	14.2	17.9	113.2	38.4
151to250W_Outd_OtherV	17.4	17.4	22.8	326.7	135.1
251to500W_Ind_OtherV	16.2	15.0	15.0	369.2	137.2
251to500W_Outd_OtherV	19.9	18.4	18.4	Never	Never
501to1000W_Ind_OtherV	0.8	0.8	0.8	0.8	0.8
501to1000W_Outd_OtherV.	0.8	0.8	0.8	0.8	0.8
1001to2000W_Ind_OtherV.	—	—	—	209.4	162.7
1001to2000W_Outd_OtherV.	—	—	—	244.5	190.0
Employment Impacts					
Direct Employment Impacts.	47—(339)	62—(339)	69—(339)	73—(339)	93—(339)
Indirect Domestic Jobs √√.	135	170	155	65	80

* INPV results are shown under the preservation of operating profit markup scenario.

** Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions. Economic value of NO_X reductions is based on estimates at $2639/ton.

*** For LCCs, a negative value means an increase in LCC by the amount indicated.

**** "Indoor" and "outdoor" as defined in section V.A.2.

† Equipment class abbreviations in the form of 50 to100W_Ind_OtherV refers to the equipment class of fixtures with (1) a rated lamp wattage of 50 W to 100 W, (2) an indoor operating location, and (3) a tested input voltage other than 480 V. See section V.A.2 for more detail on equipment class distinctions.

‡ The >100 W and ≤150 W equipment classes include 150 W fixtures exempted by EISA 2007, which are fixtures rated only for 150 watt lamps that are also rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A) and contain a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007. The ≥150 W and ≤250 W equipment classes contain all other covered fixtures that are rated only for 150 watt lamps.

√√ Changes in 2022.

TABLE VII.50—SUMMARY OF RESULTS FOR METAL HALIDE LAMP FIXTURES

[High shipments scenario]

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
National Energy Savings (quads)	0.39	0.49	0.50	0.88	1.03
NPV of Customer Benefits (2012$ billion)					
3% discount rate	0.97	1.13	1.11	(1.18)	(1.25)
7% discount rate	0.30	0.34	0.32	(0.91)	(1.00)
Industry Impacts *					
Ballast + Fixture Industry NPV (2012$million)					
(Base Case Industry NPV of $453 million)	478	491	497	501	497
Ballast + Fixture Industry NPV (change in 2012$million)	25.3	38.0	44.0	48.1	44.2
Ballast + Fixture Industry NPV (% change)	5.6%	8.4%	9.7%	10.6%	9.7%
Cumulative Emissions Reduction					

TABLE VII.50—SUMMARY OF RESULTS FOR METAL HALIDE LAMP FIXTURES—Continued

[High shipments scenario]

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
CO_2 (Mt)	22.01	27.80	28.53	49.90	58.63
SO_2 (kt)	37.40	47.25	48.49	84.80	99.72
NO_X (kt)	27.72	35.02	35.93	62.85	73.86
Hg (t)	0.05	0.06	0.06	0.10	0.12
CH_4 (kt)	104.80	132.40	135.87	237.66	279.39
N_2O (kt)	0.47	0.60	0.61	1.07	1.26
Value of Cumulative Emissions Reduction					
CO_2 (2012$ billion) **	0.1 to 2.0	0.2 to 2.6	0.2 to 2.6	0.3 to 4.6	0.4 to 5.4
NO_X—3% discount rate (2012$ million) **	35.0	44.2	45.4	79.4	93.1
NO_X—7% discount rate (2012$ million) **	15.6	19.8	20.3	35.5	41.6
Mean LCC Savings (and Percent Customers Experiencing Net Benefit) *** (2012$)					
50to100W_Ind_OtherV ****† (magnetic baseline)	26.97 (100)	27.00 (100)	27.00 (100)	42.50 (82)	37.25 (79)
50to100W_Outd_OtherV (magnetic baseline)	34.24 (98)	34.88 (97)	34.88 (97)	−4.98 (51)	−11.15 (49)
50to100W_Ind_OtherV (electronic baseline)					−5.25 (10)
50to100W_Outd_OtherV (electronic baseline)					−6.17 (12)
100to149W_Ind_OtherV‡	22.43 (100)	24.63 (99)	24.63 (99)	89.67 (94)	76.11 (89)
100to149W_Outd_OtherV	27.37 (97)	30.70 (97)	30.70 (97)	52.23 (66)	36.60 (62)
150to250W_Ind_OtherV‡	4.51 (60)	4.51 (60)	−1.07 (37)	−59.67 (18)	−40.33 (29)
150to250W_Outd_OtherV	6.74 (67)	6.74 (67)	1.48 (45)	−119.65 (24)	−97.86 (29)
251to500W_Ind_OtherV	2.83 (47)	7.95 (54)	7.95 (54)	−107.74 (8)	130.60 (6)
251to500W_Outd_OtherV	6.16 (55)	13.15 (62)	13.15 (62)	−165.30 (19)	−187.69 (16)
501to1000W_Ind_OtherV	1221.54 (100)	1221.54 (100)	1221.54 (100)	1221.54 (100)	1221.54 (100)
501to1000W_Outd_OtherV	1631.94 (98)	1631.94 (98)	1631.94 (98)	1631.94 (98)	1631.94 (98)
1001to2000W_Ind_OtherV				−67.15 (0)	−93.06 (0)
1001to2000W_Outd_OtherV				−63.71 (0)	−88.03 (0)
Median PBP (years)					
50to100W_Ind_OtherV (magnetic baseline)	1.4	4.5	4.5	3.7	6.0
50to100W_Outd_OtherV (magnetic baseline)	1.4	4.5	4.5	12.0	14.7
50to100W_Ind_OtherV (electronic baseline)					31.5
50to100W_Outd_OtherV (electronic baseline)					55.8
100to149W_Ind_OtherV‡	4.3	7.3	7.3	2.5	4.8
100to149W_Outd_OtherV	4.5	8.1	8.1	7.5	10.3
150to25W0_Ind_OtherV‡	14.2	14.2	17.9	113.2	38.4
150to250W_Outd_OtherV	17.4	17.4	22.8	326.7	135.1
251to500W_Ind_OtherV	16.2	15.0	15.0	369.2	137.2
251to500W_Outd_OtherV	19.9	18.4	18.4	Never	Never
501to1000W_Ind_OtherV	0.8	0.8	0.8	0.8	0.8
501to1000W_Outd_OtherV	0.8	0.8	0.8	0.8	0.8
1001to2000W_Ind_OtherV				209.4	162.7
1001to2000W_Outd_OtherV				244.5	190.0
Employment Impacts					
Direct Employment Impacts	48–(345)	63–(345)	70–(345)	74–(345)	95–(345)
Indirect Domestic Jobs √√	650	945	1300	2755	2655

* INPV results are shown under the –flat markup scenario.

** Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions. Economic value of NO_X reductions is based on estimates at $2,639/ton.

*** For LCCs, a negative value means an increase in LCC by the amount indicated.

**** "Indoor" and "outdoor" as defined in section V.A.2.

† Equipment class abbreviations in the form of 50 to100W_Ind_OtherV refers to the equipment class of fixtures with (1) a rated lamp wattage of 50 W to 100 W, (2) an indoor operating location, and (3) a tested input voltage other than 480 V. See section V.A.2 for more detail on equipment class distinctions.

‡ The >100 W and ≤150 W equipment classes include 150 W fixtures exempted by EISA 2007, which are fixtures rated only for 150 watt lamps that are also rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A) and contain a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007. The ≥150 W and ≤250 W equipment classes contain all other covered fixtures that are rated only for 150 watt lamps.

√√ Changes in 2022.

1. Trial Standard Level 5

DOE first considered the most efficient level, TSL 5, which would save an estimated total of 0.83 to 1.03 quads of energy for fixtures shipped in 2017 through 2046, a significant amount of energy. For the nation as a whole, TSL 5 would have net costs ranging from a decrease of $0.90 billion to a decrease of $1.0 billion at a 7-percent discount rate, and a decrease of $1.1 billion to a decrease of $1.3 billion at a 3-percent discount rate. The emissions reductions at TSL 5 are estimated to be 48 to 59 million metric tons (Mt) of CO_2, 80 to 100 kt of SO_2, 60 to 74 kt of NO_X, and 0.10 to 0.12 tons of Hg. As seen in section VII.B.1, customers have available designs that result in positive mean LCC savings for a majority of customers for only five out of twelve of the representative equipment classes, ranging from $37 to $1632, at TSL 5. The equipment classes with positive mean LCC savings for a majority of customers at TSL 5 are indoor fixtures at 70 W (compared to the magnetic 70 W baseline), 150 W, and 1000 W; and outdoor fixtures at 150 W and 1000 W. Additionally, DOE's NPV analysis indicates (see Table VII.49) that most equipment classes experience a negative NPV at TSL 5. The equipment classes that have negative NPV at TSL 5 are indoor and outdoor 70 W, 250 W, 400 W, and 1500 W fixtures. The equipment classes with positive NPV at TSL 5 are indoor and outdoor 150 W and 1000 W fixtures. The projected change in industry value for MH ballast manufacturers would range from an increase of $15.0 million to a decrease of $19.0 million, or a net gain of 20.3 percent to a net loss of 28.3 percent in INPV. The projected change in industry value for MHLF manufacturers would range from an increase of $29.1 million to a decrease of $88.6 million, or a net gain of 7.7 percent to a net loss of 25.6 percent in INPV.

DOE based TSL 5 on the most efficient commercially available equipment for each representative equipment class analyzed. This TSL corresponds to a commercially available low-frequency electronic ballast for indoor and outdoor 70 W, 150 W, 250 W, 400 W fixtures, and a modeled magnetic ballast in 1000 W and 1500 W. TSL 5 also prohibits the use of probe-start ballasts in new 1000 W fixtures.

Although TSL 5 for 150 W MHLFs shows positive LCC savings and NPVs, DOE believes uncertainty remains regarding the cost effectiveness of electronic ballasts for these customers, especially in outdoor applications. There has been virtually no market penetration of electronic ballasts in outdoor applications according to DOE's shipment analysis. Further, DOE received comments from manufacturers and utilities that electronic ballasts are not suitable for outdoor applications due to their lower operating temperature limits, different sizes compared to magnetic ballasts, and susceptibility to transient voltage fluctuations. DOE has conducted significant research to address each one of these issues (see section V.C.8.b), but remains concerned that requiring electronic ballasts for 150 W MHLFs could cause disproportionate financial hardship for these customers. Therefore, DOE is not adopting an efficiency level that requires electronic ballasts in this final rule. DOE will continue to monitor the market share of electronic ballasts, particularly in outdoor applications, and may revisit this decision in future rulemakings.

After considering the analysis, the comments that DOE received on the NOPR, and the benefits and burdens of TSL 5, the Secretary has reached the following conclusion: The benefits of energy savings, emissions reductions (both in physical reductions and the monetized value of those reductions), and positive net economic savings to the nation for some equipment classes are outweighed by the negative NPV experienced in some equipment classes at both a 3-percent and 7-percent discount rate, the negative mean LCC savings experienced in most equipment classes, the negative mean LCC savings experienced by some customer subgroups, the potential decrease in INPV for manufacturers, and the uncertainty regarding electronic ballasts. Consequently, the Secretary has concluded that TSL 5 is not economically justified.

2. Trial Standard Level 4

DOE then considered TSL 4, which would save an estimated total of 0.71 to 0.88 quads of energy for fixtures shipped in 2017 through 2046, a significant amount of energy. For the nation as a whole, TSL 4 would have net costs ranging from a decrease of $0.81 billion to a decrease of $0.91 billion at a 7-percent discount rate, and a decrease of $1.0 billion to a decrease of $1.2 billion at a 3-percent discount rate. The emissions reduction at TSL 4 are estimated to be 41 to 50 Mt of CO_2, 68 to 85 kt of SO_2, 51 to 63 kt of NO_X, and 0.08 to 0.10 tons of Hg. As seen in section VII.B.1, for less than half of the representative equipment classes, customers have available designs that result in positive mean LCC savings for a majority of customers, ranging from $43 to $1632, at TSL 4. Additionally, DOE's NPV analysis indicates (see Table VI.34) that less than half of the representative classes have a positive NPV at TSL 4. The projected change in industry value for MH ballast manufacturers would range from an increase of $9.6 million to a decrease of $16.2 million, or a net gain of 12.9 percent to a net loss of 24.1 percent in INPV. The projected change in industry value for MHLF manufacturers would range from an increase of $38.6 million to a decrease of $60.4 million, or a net gain of 10.2 percent to a net loss of 17.5 percent in INPV.

TSL 4 represents the next highest EL for all equipment classes not justified at TSL 5. This TSL corresponds to a commercially available low-frequency electronic ballast in indoor and outdoor 70 W, 150 W, 250 W, and 400 W fixtures; a commercially available magnetic ballast in indoor and outdoor 1500 W fixtures; and a modeled magnetic ballast in indoor and outdoor 1000 W fixtures. TSL 4 also prohibits the use of probe-start ballasts in new 1000 W fixtures.

Although TSL 4 for 150 W MHLFs shows positive LCC savings and NPVs, DOE believes uncertainty remains regarding the cost effectiveness of electronic ballasts for these customers, especially in outdoor applications. There has been virtually no market penetration of electronic ballasts in outdoor applications according to DOE's shipment analysis. Further, DOE received comments from manufacturers and utilities that electronic ballasts are not suitable for outdoor applications due to their lower operating temperature limits, different sizes compared to magnetic ballasts, and susceptibility to transient voltage fluctuations. DOE has conducted significant research to address each one of these issues (see section V.C.8.b), but remains concerned that requiring electronic ballasts for 150 W MHLFs could cause disproportionate financial hardship for these customers. Therefore, DOE is not adopting an efficiency level that requires electronic ballasts in this final rule. DOE will continue to monitor the market share of electronic ballasts, particularly in outdoor applications, and may revisit this decision in future rulemakings.

After considering the analysis, the comments that DOE received on the NOPR, and the benefits and burdens of TSL 4, the Secretary has reached the following conclusion: At TSL 4, the benefits of energy savings, emissions reductions (both in physical reductions and the monetized value of those reductions), and positive net economic savings to the nation are outweighed by negative NPV experienced in some equipment classes at both 3-percent and 7-percent discount rate, the negative mean LCC savings experienced in some equipment classes, the negative mean LCC savings for the utility customer subgroup, the potential decrease in INPV for manufacturers, and the uncertainty regarding electronic ballasts. Consequently, the Secretary has concluded that TSL 4 is not economically justified.

3. Trial Standard Level 3

DOE then considered TSL 3, which would save an estimated total of 0.40 to 0.50 quads of energy for fixtures shipped in 2017 through 2046, a significant amount of energy. For the nation as a whole, TSL 3 would have positive net savings of $0.27 billion to $0.32 billion at a 7-percent discount rate and $0.90 billion to $1.1 billion at a 3-percent discount rate. The emissions reductions at TSL 3 are estimated to be 23 to 29 Mt of CO_2, 39 to 48 kt of SO_2, 29 to 36 kt of NO_X, and 0.05 to 0.06 tons of Hg. As seen in section VII.B.1, for most representative equipment classes, customers have available designs that result in positive mean LCC savings, ranging from $8 to $1632, at TSL 3.

DOE's NPV analysis indicates (see Table VI.34) that most equipment classes have a positive NPV at TSL 3, though indoor and outdoor 250 W customers experience negative NPV. The projected change in industry value for MH ballast manufacturers would range from an increase of $0.6 million to a decrease of $19.0 million, or a net gain of 0.8 percent to a net loss of 28.3 percent in INPV. The projected change in industry value for MHLF manufacturers would range from an increase of $43.4 million to a decrease of $3.6 million, or a net gain of 11.4 percent to a net loss of 1.1 percent in INPV.

TSL 3 represents the next highest EL for all equipment classes not justified at TSL 4, requiring that indoor and outdoor fixtures are set at the same ELs. This TSL corresponds to a modeled magnetic ballast in indoor and outdoor fixtures at 70 W, 150 W, 250 W, 400 W, and 1000 W. Indoor and outdoor fixtures at 1500 W would remain at baseline, with no new standards established. TSL 3 also prohibits the use of probe-start ballasts in new 1000 W fixtures.

After considering the analysis, the comments that DOE received on the preliminary analysis, and the benefits and burdens of TSL 3, the Secretary has reached the following conclusion: At TSL 3, the benefits of energy savings, emissions reductions (both in physical reductions and monetized value of those reductions), and positive net economic savings to the nation would be outweighed by the negative NPV experienced in the 250 W indoor and outdoor equipment classes at 7-percent discount rate and the potential decrease in INPV for manufacturers. Consequently, the Secretary has tentatively concluded that TSL 3 is not economically justified.

4. Trial Standard Level 2

DOE then considered TSL 2, which would save an estimated total of 0.39 to 0.49 quads of energy for fixtures shipped in 2017 through 2046, a significant amount of energy. For the nation as a whole, TSL 2 would have a positive net savings of $0.29 billion to $0.34 billion at a 7-percent discount rate, and $0.92 billion to $1.1 billion at a 3-percent discount rate. The emissions reductions at TSL 3 are estimated to be 23 to 28 Mt of CO_2, approximately 38 to 47 kt of SO_2, 28 to 35 kt of NO_X, and 0.05 to 0.06 tons of Hg. As seen in section VII.B.1, for all representative equipment classes, customers have available designs that result in positive mean LCC savings, ranging from $5 to $1,632, at TSL 2. DOE's NPV analysis indicates (see Table VI.34) that each equipment class has a positive NPV at TSL 2. The projected change in industry value for MH ballast manufacturers would range from a decrease of $0.4 million to a decrease of $17.9 million, or a net loss from 0.5 percent to 26.7 percent in INPV. The projected change in industry value for MHLF manufacturers would range from an increase of $38.3 million to a decrease of $3.6 million, or a net gain of 10.1 percent to net loss of 1.0 percent in INPV.

TSL 2 represents the highest magnetic ELs with a positive NPV, where the same ELs are required for indoor and outdoor fixtures. This TSL corresponds to a modeled magnetic ballast in 70 W, 150 W, 400 W, and 1000 W; and a commercially available magnetic ballast in 250 W. Indoor and outdoor fixtures at 1500 W would remain at baseline, with no new standards set. TSL 2 also prohibits the use of probe-start ballasts in new 1000 W fixtures.

After considering the analysis, the comments that DOE received on the NOPR, and the benefits and burdens of TSL 2, the Secretary has reached the following conclusion: TSL 2 offers the maximum improvement in efficiency that is technologically feasible and economically justified, and will result in significant conservation of energy. The benefits of energy savings, emissions reductions (both in physical reductions and the monetized value of those reductions), positive net economic savings (NPV) at discount rates of 3-percent and 7-percent at each representative equipment class would outweigh the potential reduction in INPV for manufacturers. Therefore, DOE today adopts energy conservation standards for metal halide lamp fixtures at TSL 2.

D. Final Standard Equations

As detailed in section VII.C of this notice, DOE is adopting TSL 2. TSL 2 sets an EL2 standard for indoor and outdoor metal halide fixtures for 50 W–150 W and 251 W–1000 W, and an EL1 standard for indoor and outdoor metal halide fixtures for 151 W–250 W. This creates a discontinuous combination of equations both above and below the 151 W–250 W equipment class. The discontinuity at 150 W occurs because fixtures below 150 W do not have to comply with EISA 2007, while those at 150 W and above are required to meet the 88 percent standard of EISA 2007. However, the discontinuity at 250 W occurs because TSL 2 represents EL1 from 151 W–250 W, but EL2 from 251 W–500 W. To maintain continuity, DOE developed new equations from 151 W–500 W. First, from 151 W–200 W, DOE maintained a flat 88 percent requirement. Then, from 201 W–500 W, DOE used one continuous power-law equation. Based on written comments from NEMA, lamps in this wattage range follow the same trend between lamp current squared (an indicator of ballast losses) and lamp wattage. (NEMA, No. 56 at p. 15) This implies that one equation can be used to represent the efficiency of all ballasts in this wattage range. The equation was created by connecting the 200 W ballasts with 0.880 efficiency with the 500 W EL2 efficiency (0.910) to ensure continuity with the EL equations for adjacent wattage ranges. The 250 W EL1 and 400 W EL2 representative units comply with the new equation. The resulting TSL 2 equations are shown in Table VII.51 below.

TABLE VII.51—TSL EQUATION

Wattage range	Efficiency level	EL equation	TSL equation
≥50 W and ≤100 W	EL2	1/(1+1.24×P^(−0.351)) †	1/(1+1.24×P^(−0.351))
>100 W and <150 W *	EL2	1/(1+1.24×P^(−0.351))	1/(1+1.24×P^(−0.351))
≥150 W ** and ≤250 W	EL1	≥150 W and ≤200 W: 0.88	≥150 W and ≤200 W: 0.88
		>200 W and ≤250 W: 0.000400×P + 0.800	>200 W and ≤250 W: 1/(1+0.876×P^(−0.351))
>250 W and ≤500 W	EL2	0.910	1/(1+0.876×P^(−0.351))
>500 W and ≤1000 W	EL2	>500 W and ≤750 W: 0.910	>500 W and ≤750 W: 0.910

TABLE VII.51—TSL EQUATION—Continued

Wattage range	Efficiency level	EL equation	TSL equation
		>750 W and ≤1000 W: .... 0.000104×P + 0.832	>750 W and ≤1000 W: 0.000104×P + 0.832

* Includes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

** Excludes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

† P is defined as the rated wattage of the lamp the MHLF is designed to operate.

DOE also created a continuous TSL equation for the non-representative equipment classes. As discussed in section V.C.11, the scaling factor to equipment classes tested at 480 V from equipment classes tested at all other voltages is 0.020 from 50 W–150 W and 0.010 from 151 W–1000 W. DOE applied these scaling factors to develop equations for non-representative equipment classes, with the exception of the 151 W–250 W and 251 W–500 W equipment classes. For wattages from 201 W–264 W, the scaled equation would be below 0.880. As detailed in section VII.E, DOE cannot adopt a standard below 0.880 for fixtures covered by EISA 2007. Thus the scaled TSL equation was adjusted to be 0.880 from 201–264 W, and the scaled equation is calculated as described previously at 265 W and above. The scaled TSL equation is shown in Table VII.52 below.

TABLE VII.52—TSL EQUATION

Wattage range	Efficiency level	TSL equation†
≥50 W and ≤100 W	EL2	(1/(1+1.24×P^(−0.351)) − 0.0200)
>100 W and <150 W*	EL2	(1/(1+1.24×P^(−0.351)) − 0.0200)
≥150 W** and ≤250 W	EL1	0.880
>250 W and ≤500 W	EL2	>250 W and <265 W: 0.880 ≥265 W and ≤500 W: (1/(1+0.876×P^(−0.351)) − 0.0100
>500 W and ≤1000 W	EL2	>500 W and ≤750 W: 0.900 >750 W and ≤1000 W: 0.000104×P + 0.822

* Includes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

** Excludes 150 W MHLFs exempted by EISA 2007, which are MHLFs rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

† P is defined as the rated wattage of the lamp the MHLF is designed to operate.

E. Backsliding

As discussed in section II.A of this notice, EPCA contains what is commonly known as an ''anti-backsliding'' provision, which mandates that the Secretary not prescribe 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)) DOE evaluated amended standards in terms of ballast efficiency, which is the same metric that is currently used in energy conservation standards. Therefore, DOE compared the existing standards directly to the amended standards to confirm that they do not constitute backsliding.

The existing standards for ballast efficiency for MHLFs, established by EISA 2007, mandated that ballasts rated at wattages 150 W–500 W operate at a minimum of 88 percent efficiency if pulse-start, 94 percent if probe-start magnetic, 90 percent if non-pulse-start electronic 150 W–250 W, and 92 percent if non-pulse-start electronic 251 W–500 W. These standards excluded fixtures with regulated-lag ballasts, fixtures that use 480 V electronic ballasts, and fixtures that (1) are only rated for use with 150 W lamps; (2) are rated for use in wet locations; and (3) contain a ballast that is rated to operate above 50 °C. This rulemaking adopts standards for fixtures with ballasts rated at 50 W–1000 W, retains the exemptions for fixtures with regulated-lag ballasts or 480 V electronic ballasts, and removes the exemption for 150 W fixtures used in wet locations with ballasts rated that operate above 50 °C.

The Northwest Power and Conservation Council (NPCC) commented that because certain 150 W fixtures were exempt from EISA 2007, backsliding should not be a concern in this category. (NPCC, Public Meeting Transcript, No. 48 at pp. 112–114) DOE agrees with NPCC's assertion that backsliding is not an issue for 150 W fixtures rated for use with 150 W lamps, rated for wet locations, and rated to operate at temperatures greater than 50 °C. These exempted fixtures, along with fixtures that fall within wattage ranges that do not have existing federal energy conservation standards, cannot violate the backsliding provision as no standard currently exists.

As presented in the following table, DOE's adopted efficiency standards do not qualify as backsliding. In the 50 W–150 W[68] range, there are no existing federal efficiency standards. Thus, the standards set by DOE in this rulemaking for this wattage range are not backsliding, as they are prescribing a standard where there previously was not one. As stated previously, the 150 W ballasts currently exempted by EISA 2007 (those only rated for use with 150 W lamps, rated for wet locations, and rated to operate at temperatures greater than 50 °C) are not covered by any existing federal energy conservation standards, so the standards set for such

[68] This wattage range contains those fixtures that are rated only for 150 W lamps that are also rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and contain a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

ballasts are likewise not subject to backsliding. Similarly, in the 500 W–1000 W range, there are no existing federal energy conservation standards, so standards adopted in this rulemaking for that wattage range do not backslide. Finally, for the 150 W[69] −500 W range (not including the exempt 150 W fixtures), EISA 2007 prescribes the current standards. DOE is amending the standards for fixtures in this wattage range. The adopted standard changes with wattage, but always requires ballasts in new fixtures to be at least 88 percent efficient (88 percent efficiency for pulse-start ballasts is the least stringent of the various EISA 2007 requirements). If DOE's plotted efficiency level was lower than the standard prescribed by EISA 2007 for any ballast types or wattages (*e.g.,* 94 percent efficiency requirement for probe-start ballasts), then the EISA 2007 standard was given precedence and has been incorporated into today's rule without amendment, thus preventing any potential backsliding.

On the basis of this section, the standards adopted in this final rule are either higher than the existing standards, primarily because they set standards for previously unregulated fixtures, or match existing standards because if the EISA 2007 standards were higher than the efficiency levels calculated by DOE, then the EISA 2007 standard is retained. As such, the adopted standards do not decrease the minimum required energy efficiency of the covered equipment and, therefore, do not violate the anti-backsliding provision in EPCA.

TABLE VII.53—EXISTING FEDERAL EFFICIENCY STANDARDS AND EFFICIENCY STANDARDS ADOPTED IN THIS FINAL RULE

Designed to be operated with lamps of the following rated lamp wattage	Indoor/ outdoor***	Test input voltage‡	Existing standards (efficiency)	Adopted efficiency standards/equations† %
≥50 W and ≤100 W	Indoor	480 V	N/A	(1/(1+1.24×P^(−0.351))) − 0.020
≥50 W and ≤100 W	Indoor	All others	N/A	1/(1+1.24×P^(−0.351))
≥50 W and ≤100 W	Outdoor	480 V	N/A	(1/(1+1.24×P^(−0.351))) − 0.020
≥50 W and ≤100 W	Outdoor	All others	N/A	1/(1+1.24×P^(−0.351))
>100 W and <150 W*	Indoor	480 V	N/A	(1/(1+1.24×P^(−0.351))) − 0.020
>100 W and <150 W*	Indoor	All others	N/A	1/(1+1.24×P^(−0.351))
>100 W and <150 W*	Outdoor	480 V	N/A	(1/(1+1.24×P^(−0.351))) − 0.020
>100 W and <150 W*	Outdoor	All others	N/A	1/(1+1.24×P^(−0.351))
≥150 W** and ≤250 W	Indoor	480 V	Varies from 88% to 94% depending on ballast type.	0.880
≥150 W** and ≤250 W	Indoor	All others	Varies from 88% to 94% depending on ballast type.	For ≥150 W and ≤200 W: 0.880 For >200 W and ≤250 W: 1/(1+0.876×P^(−0.351))
≥150 W** and ≤250 W	Outdoor	480 V	Varies from 88% to 94% depending on ballast type.	0.880
≥150 W** and ≤250 W	Outdoor	All others	Varies from 88% to 94% depending on ballast type.	For ≥150 W and ≤200 W: 0.880 For >200 W and ≤250 W: 1/(1+0.876×P^(−0.351))
>250 W and ≤500 W	Indoor	480 V	Varies from 88% to 94% depending on ballast type.	For >250 W and <265 W: 0.880 For ≥265 W and ≤500 W;: (1/(1+0.876×P^(−0.351))—0.010
>250 W and ≤500 W	Indoor	All others	Varies from 88% to 94% depending on ballast type.	1/(1+0.876×P^(−0.351))
>250 W and ≤500 W	Outdoor	480 V	Varies from 88% to 94% depending on ballast type.	For >250 W and <265 W: 0.880 For ≥265 W and ≤500 W;: (1/(1+0.876×P^(−0.351)) − 0.010
>250 W and ≤500 W	Outdoor	All others	Varies from 88% to 94% depending on ballast type.	1/(1+0.876×P^(−0.351))
>500 W and ≤1000 W	Indoor	480 V	N/A	For >500 W and ≤750 W: 0.900 For >750 W and ≤1000 W: 0.000104×P+0.822 For >500 W and ≤1000 W: may not utilize a probe-start ballast
>500 W and ≤1000 W	Indoor	All others	N/A	For >500 W and ≤750 W: 0.910 For >750 W and ≤1000 W: 0.000104×P+0.832 For >500 W and ≤1000 W: may not utilize a probe-start ballast
>500 W and ≤1000 W	Outdoor	480 V	N/A	For >500 W and ≤750 W: 0.900 For >750 W and ≤1000 W: 0.000104×P+0.822 For >500 W and ≤1000 W: may not utilize a probe-start ballast
>500 W and ≤1000 W	Outdoor	All others	N/A	For >500 W and ≤750 W: 0.910

[69] This wattage range contains all covered fixtures that are rated only for 150 W lamps that are *not* also rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and do not also contain a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

TABLE VII.53—EXISTING FEDERAL EFFICIENCY STANDARDS AND EFFICIENCY STANDARDS ADOPTED IN THIS FINAL RULE—Continued

Designed to be operated with lamps of the following rated lamp wattage	Indoor/ outdoor***	Test input voltage‡	Existing standards (efficiency)	Adopted efficiency standards/equations† %
				For >750 W and ≤1000 W: 0.000104×P+0.832 For >500 W and ≤1000 W: may not utilize a probe-start ballast

*Includes 150 W fixtures exempted by EISA 2007, which are fixtures rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

**Excludes 150 W fixtures exempted by EISA 2007, which are fixtures rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70–2002, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029–2007.

***DOE's definitions for ''indoor'' and ''outdoor'' MHLFs are described in section V.A.2.

†P is defined as the rated wattage of the lamp the fixture is designed to operate.

‡Input voltage for testing would be specified by the test procedures. Ballasts rated to operate lamps less than 150 W would be tested at 120 V, and ballasts rated to operate lamps ≥150 W would be tested at 277 V. Ballasts not designed to operate at either of these voltages would be tested at the highest voltage the ballast is designed to operate.

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:

There are external benefits resulting from improved energy efficiency of MHLFs that are not captured by the users of such equipment. These benefits include externalities related to environmental protection and energy security that are not reflected in energy prices, such as emissions of greenhouse gases. DOE attempts to quantify some of the external benefits through use of SCC values.

In addition, DOE has determined that today's regulatory action is an ''economically significant regulatory action'' under section 3(f)(1) of Executive Order 12866. Accordingly, section 6(a)(3) of the Executive Order requires that DOE prepare a regulatory impact analysis (RIA) on today's rule and that the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget review this rule. DOE presented to OIRA for review the draft rule and other documents prepared for this rulemaking, including the RIA, and has included these documents in the rulemaking record. The assessments prepared pursuant to Executive Order 12866 can be found in the technical support document for this rulemaking.

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

DOE emphasizes as well that Executive Order 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, 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.

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 byE.O. 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (Aug. 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's Web site (*http://energy.gov/gc/office-general-counsel*). DOE reviewed the August 2013 NOPR 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 MHLFs and ballasts, a copy of which DOE will transmit to the Chief Counsel for Advocacy of the SBA for review under 5 U.S.C. 605(b). As presented and discussed below, the FRFA describes impacts on small MHLF and ballast 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.

This FRFA incorporates the IRFA and public comments DOE received on the IRFA and the economic impacts of the rule. DOE provides responses to these comments in the discussion below on the compliance impacts of the standards and elsewhere in the preamble. DOE modified the standards adopted in today's final rule in response to comments received as described in the preamble.

1. Description and Estimated Number of Small Entities Regulated

a. Methodology for Estimating the Number of Small Entities

For manufacturers of MHLFs and ballasts, the SBA has set a size threshold which defines those entities classified as ''small businesses'' for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. 65 FR 30836, 30850 (May 15, 2000), as amended at 65 FR 53533, 53545 (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/sites/default/files/files/Size_Standards_Table.pdf*. MH ballast manufacturing is classified under NAICS 335311, ''Power, Distribution and Specialty Transformer Manufacturing.'' The SBA sets a threshold of 750 employees or less for an entity to be considered as a small business for this category. MHLF manufacturing is classified under NAICS 335122, ''Commercial, Industrial, and Institutional Electric Lighting Fixture Manufacturing.'' The SBA sets a threshold of 500 employees or less for an entity to be considered as a small business for this category.

In the NOPR, DOE identified five small businesses that produce MH ballasts sold in the United States and can be considered small business manufacturers. For MHLFs, DOE identified approximately 54 small businesses that produce MHLFs sold in the United States and can be considered small business manufacturers. DOE did not receive any comments to suggest these estimates should be altered for the FRFA.

b. Manufacturer Participation

As stated in the August 2013 NOPR, DOE attempted to contact the small business manufacturers of MHLFs and ballasts it had identified. One small MH ballast manufacturer and two small MHLF manufacturers consented to being interviewed. DOE also obtained information about small business impacts while interviewing large manufacturers.

c. Metal Halide Ballast and Fixture Industry Structure

Ballasts. Five major MH ballast manufacturers with limited domestic production supply the vast majority of the MH ballast market. None of the five major manufacturers is a small business. The remaining market share is held by a few smaller domestic companies, only one of which has significant market share. Nearly all MH ballast production occurs abroad.

Fixtures. The majority of the MHLF market is supplied by six major manufacturers with sizeable domestic production. None of these major manufacturers is a small business. The remaining market share is held by several smaller domestic and foreign manufacturers. Most of the small domestic manufacturers produce MHLFs in the United States. Although none of the small businesses holds a significant market share individually, collectively these small businesses account for approximately a third of the market. See chapter 3 of this final rule TSD for further details on the MHLF and ballast markets.

d. Comparison Between Large and Small Entities

Ballasts. The five large MH ballast manufacturers typically offer a much wider range of designs of MH ballasts than small manufacturers do. MH ballasts can vary by start method, input voltage, wattage, and design. Often large MH ballast manufacturers will offer several different ballast options for each lamp wattage. Small manufacturers generally specialize in manufacturing only a handful of different ballast types and do not have the volume to support as wide a range of products as large manufacturers do. Three of the five small MH ballast manufacturers specialize in high-efficiency electronic ballasts and do not offer any magnetic ballasts. Some small MH ballast manufacturers offer a wide variety of lighting products, but others focus exclusively on MH ballasts.

Fixtures. The six large MHLF manufacturers typically serve large-scale commercial lighting markets, while small MHLF manufacturers tend to operate in niche lighting markets such as architectural and designer lighting. Small MHLF manufacturers also frequently fill custom orders that are much smaller in volume than large MHLF manufacturers' typical orders are. Because small MHLF manufacturers typically offer specialized products and cater to individual customers' needs, they can command higher markups than most large MHLF manufacturers. Like large MH ballast manufacturers, large MHLF manufacturers offer a wider range of MHLFs than small MHLF manufacturers. A small MHLF manufacturer may offer fewer than 50 models, while a large MHLF manufacturer may typically offer several hundred models. Almost all small MHLF manufacturers offer a variety of lighting products in addition to those covered by this rulemaking, such as fluorescent, incandescent, and LED fixtures.

2. Description and Estimate of Compliance Requirements

Ballasts. Because three of the five small MH ballast manufacturers offer only electronic ballasts that already meet the standards at TSL 2, the level established in today's final rule, DOE does not expect any product or capital conversion costs for these small MH ballast manufacturers. The fourth small MH ballast manufacturer offers a wide range of magnetic and electronic ballasts, so DOE does not expect this manufacturer's conversion costs to differ significantly from those of the large manufacturers. The fifth small ballast manufacturer currently offers a large variety of lighting products, but only two models of MH ballasts. Because it would likely invest in other parts of its business, this manufacturer stated to DOE that this rulemaking is unlikely to significantly affect them.

Fixtures. As previously stated, DOE identified approximately 54 small MHLF businesses affected by this rulemaking. Based on interviews with two of these manufacturers and examinations of product offerings on company Web sites, DOE believes that approximately one-fourth of these small businesses will not face any conversion costs because they offer very few MHLF models and would, therefore, focus on more substantial areas of their business. Of the remaining small businesses DOE identified, nearly two-thirds primarily serve the architectural or specialty lighting markets. Because these products command higher prices and margins compared to the typical products offered by a large manufacturer, DOE believes that these small MHLF manufacturers will be able to pass on any necessary conversion costs to their customers without significantly impacting their businesses.

Philips commented that they believe small MHLF manufacturers might not be able to pass cost increases due to standards, because in the architectural and specialty lighting areas, LEDs are becoming extremely cost competitive. (Philips, Public Meeting Transcript, No. 48 at p. 289) Based on small business fixture manufacturer interviews, DOE believes that many of the architectural and specialty lighting fixtures are custom made orders and the conversion costs for these MHLFs would likely be small. While DOE does acknowledge that the MH ballasts used in these MHLFs could increase in price, which would result in a higher priced MHLF for customers, these small fixture manufacturers stated they also manufacture and sell LED fixtures to meet any customer's needs.

The remaining small MHLF manufacturers (roughly 14 in number) could be differentially impacted by today's established standards. These manufacturers operate partially in industrial and commoditized markets in which it may be more difficult to pass on any disproportionate costs to their customers. The impacts could be relatively greater for a typical small MHLF manufacturer because of the far lower production volumes and the relatively fixed nature of the R&D and capital resources required per fixture family.

Based on interviews, however, DOE anticipates that small manufacturers would take steps to mitigate the costs required to meet new and amended energy conservation standards. DOE believes that under the established standards, small MHLF businesses would likely selectively upgrade existing product lines to offer equipment that is in high demand or offers a strategic advantage for that company. Small manufacturers could then spread out further investments over a longer time period by not upgrading all product lines prior to the compliance date.

Additionally, DOE does not expect that small MHLF manufacturers would be significantly burdened by compliance requirements. As discussed in section IV.A, the standards adopted in this final rule provide simplifying amendments to the current testing and reporting procedures. DOE is only mandating testing at a single input voltage for MHLFs Because DOE selected the least burdensome input voltage option, DOE concludes that regulations in this final rule would not have a significantly adverse impact on the testing burden of small manufacturers.

The existing test procedures already dictate that testing for certification requires a sample of at least four MHLFs for compliance. DOE is not proposing to change this minimum sample size, and as such, does not find an increased testing burden on small manufacturers.

DOE did not receive any comments suggesting new and amended energy conservation standards would significantly impact small MHLF and ballast manufacturers.

3. Duplication, Overlap, and Conflict With Other Rules and Regulations

DOE is not aware of any rules or regulations that duplicate, overlap, or conflict with the rule being established today.

4. Significant Alternatives to the Rule

Section VII.B.2 analyzes impacts on small businesses that would result from DOE's adopted rule. In addition to the other TSLs being considered, the final rule TSD includes an RIA. For MHLFs, the RIA discusses the following policy alternatives: (1) No new regulatory action; (2) consumer tax incentives; (3) manufacturer tax incentives; (4) performance standards; (5) consumer rebates; (6) manufacturer rebates; (7) voluntary energy efficiency targets; (8) early replacement; and (9) bulk government purchases. While these alternatives may mitigate to some varying extent the economic impacts on small entities compared to the standards, DOE determined that the energy savings of these alternatives are significantly smaller than those that would be expected to result from the adopted standard levels. 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 DOE considered.)

As previously stated, DOE did not receive any comments suggesting new and amended energy conservation standards would significantly impact small MHLF and ballast manufacturers.

C. Review Under the Paperwork Reduction Act

Manufacturers of MHLFs must certify to DOE that their equipment complies with any applicable energy conservation standards. In certifying compliance, manufacturers must test their equipment according to DOE test procedures for MHLFs, 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 MHLFs. (76 FR 12422 (March 7, 2011). The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910–1400. Public reporting burden for the certification is estimated to average 20 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB control number.

D. Review Under the National Environmental Policy Act of 1969

Pursuant to the National Environmental Policy Act (NEPA) of 1969, DOE has determined that the 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 equipment that is 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, this 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. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a new and 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 this 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 MHLFs manufacturers in the years between the final rule and the compliance date for the new standards, and (2) incremental additional expenditures by customers to purchase higher-efficiency MHLFs, 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 the notice of final rulemaking and the ''Regulatory Impact Analysis'' section of the TSD for this final rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. 2 U.S.C. 1535(a). DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the 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(hh), and (o), 6317(a), today's final rule would establish energy conservation standards for MHLFs that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified. A full discussion of the alternatives considered by DOE is presented in the ''Regulatory Impact Analysis'' section of the TSD for today's 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 MHLFs, is not a significant energy action because the new and 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 not 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 431

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Reporting and recordkeeping requirements, and Small businesses.

Issued in Washington, DC, on January 27, 2014.

David T. Danielson,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE amends part 431 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 431—ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291–6317.

■ 2. Section 431.322 is amended by adding in alphabetical order definitions for ''general lighting application'' ''high-frequency electronic metal halide ballast,'' and ''nonpulse-start electronic ballast,'' to read as follows:

§ 431.322 Definitions concerning metal halide ballasts and fixtures.

* * * * *

General lighting application means lighting that provides an interior or exterior area with overall illumination.

High-frequency electronic metal halide ballast means an electronic ballast that operates a lamp at an output frequency of 1000 Hz or greater.

* * * * *

Nonpulse-start electronic ballast means an electronic ballast with a starting method other than pulse-start.

* * * * *

■ 3. Section 431.324 is amended by adding paragraph (b)(1)(iii) and revising paragraphs (b)(3) and (c)(1) to read as follows:

§ 431.324 Uniform test method for the measurement of energy efficiency and standby mode energy consumption of metal halide ballasts.

* * * * *

(b) * * *

(1) * * *

(iii) *Input Voltage for Tests.* For ballasts designed to operate lamps rated less than 150 W that have 120 V as an available input voltage, testing shall be performed at 120 V. For ballasts designed to operate lamps rated less than 150 W that do not have 120 V as an available voltage, testing shall be performed at the highest available input voltage. For ballasts designed to operate lamps rated greater than or equal to 150 W that have 277 V as an available input voltage, testing shall be conducted at 277 V. For ballasts designed to operate lamps rated greater than or equal to 150 W that do not have 277 V as an available input voltage, testing shall be conducted at the highest available input voltage.

* * * * *

(3) *Efficiency Calculation.* The measured lamp output power shall be divided by the measured ballast input power to determine the percent efficiency of the ballast under test to three significant figures.

(i) A fractional number at or above the midpoint between two consecutive decimal places shall be rounded up to the higher of the two decimal places; or

(ii) A fractional number below the midpoint between two consecutive decimal places shall be rounded down to the lower of the two decimal places.

(c) * * *

(1) *Test Conditions.* (i) The power supply and ballast test conditions with the exception of input voltage shall all conform to the requirements specified in section 4.0, ''General Conditions for Electrical Performance Tests,'' of the ANSI C82.6 (incorporated by reference; see § 431.323). Ambient temperatures for the testing period shall be maintained at 25 °C ± 5 °C. Send a signal to the ballast instructing it to have zero light output using the appropriate ballast communication protocol or system for the ballast being tested.

(ii) *Input Voltage for Tests.* For ballasts designed to operate lamps rated less than 150 W that have 120 V as an available input voltage, ballasts are to be tested at 120 V. For ballasts designed to operate lamps rated less than 150 W that do not have 120 V as an available voltage, ballasts are to be tested at the highest available input voltage. For ballasts designed to operate lamps rated greater than or equal to 150 W that have 277 V as an available input voltage, ballasts are to be tested at 277 V. For ballasts designed to operate lamps rated greater than or equal to 150 W that do not have 277 V as an available input voltage, ballasts are to be tested at the highest available input voltage.

* * * * *

■ 4. Section 431.326 is amended by adding paragraphs (c), (d), and (e) to read as follows:

§ 431.326 Energy conservation standards and their effective dates.

* * * * *

(c) Except when the requirements of paragraph (a) of this section are more stringent (*i.e.,* require a larger minimum efficiency value) or as provided by paragraph (e) of this section, each metal halide lamp fixture manufactured on or after February 10, 2017, must contain a metal halide ballast with an efficiency not less than the value determined from the appropriate equation in the following table:

Designed to be operated with lamps of the following rated lamp wattage	Tested input voltage‡‡	Minimum standard equation†† %
≥50 W and ≤100 W	Tested at 480 V	(1/(1+1.24×P^(−0.351))) − 0.020††
≥50 W and ≤100 W	All others	1/(1+1.24×P^(−0.351))
>100 W and <150† W	Tested at 480 V	(1/(1+1.24×P^(−0.351))) − 0.020
>100 W and <150† W	All others	1/(1+1.24×P^(−0.351))
≥150‡ W and ≤250 W	Tested at 480 V	0.880
≥150‡ W and ≤250 W	All others	For ≥150 W and ≤200 W: 0.880 For >200 W and ≤250 W: 1/(1+0.876×P^(−0.351))
>250 W and ≤500 W	Tested at 480 V	For >250 and <265 W: 0.880 For ≥265 W and ≤500 W: (1/(1+0.876×P^(−0.351)) − 0.010
>250 W and ≤500 W	All others	1/(1+0.876×P^(−0.351))
>500 W and ≤1000 W	Tested at 480 V	For >500 W and ≤750 W: 0.900 For >750 W and ≤1000 W: 0.000104×P+0.822 For >500 W and ≤1000 W: may not utilize a probe-start ballast
>500 W and ≤1000 W	All others	For >500 W and ≤750 W: 0.910 For >750 W and ≤1000 W: 0.000104×P+0.832 For >500 W and ≤1000 W: may not utilize a probe-start ballast

† Includes 150 W fixtures specified in paragraph (b)(3) of this section, that are fixtures rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70 (incorporated by reference, see § 431.323), section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029 (incorporated by reference, see § 431.323).

‡ Excludes 150 W fixtures specified in paragraph (b)(3) of this section, that are fixtures rated only for 150 W lamps; rated for use in wet locations, as specified by the NFPA 70, section 410.4(A); and containing a ballast that is rated to operate at ambient air temperatures above 50 °C, as specified by UL 1029.

†† P is defined as the rated wattage of the lamp the fixture is designed to operate.

‡‡ Tested input voltage is specified in 10 CFR 431.324.

(d) Except as provided in paragraph (e) of this section, metal halide lamp fixtures manufactured on or after February 10, 2017, that operate lamps with rated wattage >500 W to ≤1000 W must not contain a probe-start metal halide ballast.

(e) The standards described in paragraphs (c) and (d) of this section do not apply to—

(1) Metal halide lamp fixtures with regulated-lag ballasts;

(2) Metal halide lamp fixtures that use electronic ballasts that operate at 480 volts; and

(3) Metal halide lamp fixtures that use high-frequency electronic ballasts.

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