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10 CFR Part 430

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

DEPARTMENT OF ENERGY

10 CFR Part 430

[Docket Number EE–2006–STD–0131]

RIN 1904–AA92

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

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

ACTION: Notice of proposed rulemaking.

SUMMARY: The Energy Policy and Conservation Act (EPCA) prescribes energy conservation standards for various consumer products and commercial and industrial equipment, including general service fluorescent lamps (GSFL) and incandescent reflector lamps (IRL), and the statute also requires the Department of Energy (DOE) to subsequently determine whether more stringent, amended standards for GSFL and IRL would be technologically feasible and economically justified, and would save a significant amount of energy. In addition, EPCA directs DOE to consider adoption of standards for additional GSFL not already covered by EPCA-prescribed standards. In this notice, DOE proposes amended energy conservation standards for certain GSFL and IRL and new energy conservation standards for certain additional GSFL not currently covered by standards.

DATES: DOE held a public meeting on Tuesday, February 3, 2009 in Washington, DC. DOE began accepting comments, data, and information regarding this notice of proposed rulemaking (NOPR) at the public meeting, and will continue to accept comments until no later than June 12, 2009. See section VIII, ''Public Participation,'' of this NOPR for details.

ADDRESSES: The public meeting was held at the U.S. Department of Energy, Forrestal Building, Room 1E–245, 1000 Independence Avenue, SW., Washington, DC 20585–0121.

Any comments submitted must identify the NOPR for Energy Conservation Standards for Lighting Products, and provide the docket number EE–2006–STD–0131 and/or regulatory information number (RIN) number 1904–AA92. Comments may be submitted using any of the following methods:

- *Federal eRulemaking Portal: http://www.regulations.gov.* Follow the instructions for submitting comments.
- *E-mail: fluorescent_and_incandescent_lamps.rulemaking@ee.doe.gov.* Include the docket number EE–2006–STD–0131and/or RIN 1904–AA92 in the subject line of the message.
- *Postal Mail:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, Mailstop EE–2J, 1000 Independence Avenue, SW., Washington, DC 20585–0121. Please submit one signed paper original.
- *Hand Delivery/Courier:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, 950 L'Enfant Plaza, SW., Suite 600, Washington, DC 20024. Telephone: (202) 586–2945. Please submit one signed paper original.

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

Docket: For access to the docket to read background documents or comments received, visit the U.S. Department of Energy, Resource Room of the Building Technologies Program, 950 L'Enfant Plaza, SW., Suite 600, Washington, DC, (202) 586–2945, between 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Please call Ms. Brenda Edwards at the above telephone number for additional information regarding visiting the Resource Room.

FOR FURTHER INFORMATION CONTACT: Ms. Linda Graves, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, EE–2J, 1000 Independence Avenue, SW., Washington, DC 20585–0121. Telephone: (202) 586–1851. E-mail: *Linda.Graves@ee.doe.gov.*

Mr. Eric Stas or Ms. Francine Pinto, U.S. Department of Energy, Office of the General Counsel, GC–72, Forrestal Building, Mail Station GC–72, 1000 Independence Avenue, SW., Washington, DC 20585–0121. Telephone: (202) 586–9507. E-mail: *Eric.Stas@hq.doe.gov* or *Francine.Pinto@hq.doe.gov.*

For information on how to submit or review public comments, contact Ms. Brenda Edwards, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, EE–2J, 1000 Independence Avenue, SW., Washington, DC 20585–0121. Telephone: (202) 586–2945. E-mail: *Brenda.Edwards@ee.doe.gov.*

SUPPLEMENTARY INFORMATION:

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Acronyms and Abbreviations

ACEEE American Council for an Energy Efficiency Economy
AEO Annual Energy Outlook
ANOPR advance notice of proposed rulemaking
ANSI American National Standards Institute
ASAP Appliance Standards Awareness Project
ASE Alliance to Save Energy
BF ballast factor
BLS Bureau of Labor Statistics
BPAR bulged parabolic aluminized reflector
BR bulged reflector (reflector lamp shape)
BT Building Technologies Program
BTU British Thermal Unit
CAIR Clean Air Interstate Act
CAMR Clean Air Mercury Rule
CBECS Commercial Buildings Energy Consumption Survey
CCT correlated color temperature
CFR Code of Federal Regulations
CFL compact fluorescent lamp
CIE International Commission on Illumination
CMH ceramic metal halide
CO_2 carbon dioxide
CRI color rendering index
CSL candidate standard level
DIY do-it-yourself
DOE U.S. Department of Energy
DOJ U.S. Department of Justice
E26 Edison screw-base (incandescent lamp base type)
EERE Office of Energy Efficiency and Renewable Energy
EIA Energy Information Administration
EISA 2007 Energy Independence and Security Act of 2007
EL efficacy level
EPA Environmental Protection Agency
EPACT 1992 Energy Policy Act of 1992
EPACT 2005 Energy Policy Act of 2005
EPCA Energy Policy and Conservation Act
ER elliptical reflector (reflector lamp shape)

FEMP Federal Energy Management Program
FR Federal Register
FTC Federal Trade Commission
GE General Electric Lighting and Industrial
GRIM Government Regulatory Impact Model
GSFL general service fluorescent lamp
GSIL general service incandescent lamp
GW gigawatt
Hg mercury
HID high-intensity discharge
HIR halogen infrared reflector
HO high output
HVAC Heating, Ventilating and Air-Conditioning
IESNA Illuminating Engineering Society of North America
ImSET Impact of Sector Energy Technologies
INPV industry net present value
I–O input-output
IPCC Intergovernmental Panel on Climate Change
IR Infrared
IRFA initial regulatory flexibility analysis
IRL incandescent reflector lamp
K degrees Kelvin
kt kilotons
LCC life-cycle cost
LED Light-Emitting Diode
LMC U.S. Lighting Market Characterization Volume I
Lm/W lumens per watt
MBP medium bipin
MECS Manufacturer Energy Consumption Survey (MECS)
MIA Manufacturer Impact Analysis
MMt million metric tons
Mt metric tons
MW megawatts
NAICS North American Industry Classification System
NCLC National Consumer Law Center
NEEP Northeast Energy Efficiency Partnership
NEMA National Electrical Manufacturers Association
NEMS National Energy Modeling System
NEMS–BT National Energy Modeling System—Building Technologies
NES national energy savings
NIA National Impact Analysis
NIST National Institute of Standards and Technology
NOPR notice of proposed rulemaking
NO_X nitrogen oxides
NPCC Northwest Power and Conservation Council
NPV net present value
NRDC Natural Resources Defense Council
NVLAP National Voluntary Laboratory Accreditation Program
OEM Original Equipment Manufacturer
OIRA Office of Information and Regulatory Affairs
OMB U.S. Office of Management and Budget
PAR parabolic aluminized reflector (reflector lamp shape)
PBP payback period
PG&E Pacific Gas and Electric
quad quadrillion BTU
R reflector (reflector lamp shape)
R–CFL reflector compact fluorescent lamp
R&D research and development
RDC recessed double contact
RECS Residential Energy Consumption Survey
RIA regulatory impact analysis
RoHS Restriction on Hazardous Substances directive
SBA Small Business Administration
SCF Survey of Consumer Finances
SEC Securities and Exchange Commission
SEL spectrally-enhanced lighting
SG&A selling, general, and administrative costs
SO standard output
SO_2 sulfur dioxide
SP single pin
S&P Standard & Poor's
T8, T10, T12 tubular fluorescent lamps, diameters of 1, 1.25 or 1.5 inches, respectively
TSD technical support document
TSL trial standard level
TWh terawatt-hour
UMRA Unfunded Mandates Reform Act
U.S.C. United States Code
UV ultraviolet
V volts
VHO very high output
W watts

I. Summary of the Proposed Rule

The Energy Policy and Conservation Act (EPCA or the Act) (42 U.S.C. 6291 *et seq.*), as amended, requires DOE to consider whether to amend the existing energy conservation standards for GSFL and IRL, and to also consider whether to adopt new energy conservation standards for additional types of GSFL beyond those already covered by EPCA-prescribed standards. (42 U.S.C. 6295(i)(3)–(5)) The Act also specifies that any new or amended energy conservation standard DOE prescribes for certain consumer and/or commercial products, such as GSFL and IRL, shall be designed to ''achieve the maximum improvement in energy efficiency * * * which the Secretary determines is technologically feasible and economically justified.'' (42 U.S.C. 6295(o)(2)(A); 6316(a)) Furthermore, the new or amended standard must ''result in significant conservation of energy.'' (42 U.S.C. 6295(o)(3)(B); 6316(a)) In accordance with these and other statutory provisions discussed in this notice, DOE proposes new and amended energy conservation standards for GSFL and IRL, as shown in Table I.1 and Table I.2. The proposed standards would apply to all products listed in Table I.1 and Table I.2 that are manufactured in or imported into the United States on or after June 30, 2012.

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

Lamp type	Correlated color temperature	Proposed level lm/W	Percent increase over current standards or baseline
4-Foot Medium Bipin	≤ 4,500K	84	12%
	> 4,500K	78	4%
2-Foot U-Shaped	≤ 4,500K	78	15%/22%*
	> 4,500K	73	7%/14%*
8-Foot Slimline	≤ 4,500K	95	19%
	> 4,500K	91	14%
8-Foot High Output	≤ 4,500K	88	10%
	> 4,500K	84	5%
4-Foot Miniature Bipin Standard Output	≤ 4,500K	103	20%
	> 4,500K	97	13%
4-Foot Miniature Bipin High Output	≤ 4,500K	89	16%
	> 4,500K	85	10%

* For these product classes, EPCA has different efficacy standards for lamps with wattages less than 35W and greater than or equal to 35W.

TABLE I.2—SUMMARY OF THE PROPOSED ENERGY CONSERVATION STANDARD FOR IRL

Lamp type	Diameter	Voltage	Proposed level lm/W	Percent increase over current standards or baseline
Standard Spectrum 40W–205W	> 2.5 inches	≥ 125	$7.1P^{0.27}$	69%–100%
		< 125	$6.2P^{0.27}$	47%–75%
	≤ 2.5 inches	≥ 125	$6.3P^{0.27}$	50%–78%
		< 125	$5.5P^{0.27}$	31%–55%
Modified Spectrum 40W–205W	> 2.5 inches	≥ 125	$5.8P^{0.27}$	38%–63%
		< 125	$5.0P^{0.27}$	19%–41%
	≤ 2.5 inches	≥ 125	$5.1P^{0.27}$	21%–44%
		< 125	$4.4P^{0.27}$	7%–27%

Note: P is equal to the rated lamp wattage, in watts.

DOE's analyses indicate that the proposed standards would save a significant amount of energy—an estimated 3.2 to 7.3 quads (for GSFL) and 1.3 to 2.3 quads (for IRL) of cumulative energy over 31 years (2012–2042). The economic impacts on most GSFL and all IRL individual and commercial consumers (*i.e.*, the average life-cycle cost (LCC) savings) are positive.

The cumulative national net present value (NPV) of total consumer costs and savings of the proposed standards from 2012 to 2042 in 2007$ ranges from $3.2 billion (at a 7-percent discount rate) to $25.7 billion (at a 3-percent discount rate) for GSFL. For IRL, the NPV from 2012 to 2042 in 2007$ ranges from $3.7 billion (at a 7-percent discount rate) to $14.0 billion (at a 3-percent discount rate). This is the estimated total value of future operating-cost savings minus the estimated increased product costs, discounted to 2007. DOE estimates the GSFL industry net present value (INPV) to currently be $575–602 million in 2007$. If DOE were to adopt the proposed standards, it expects that manufacturers may lose up to 24 percent of their INPV, which is approximately $139 million. The NPV of the proposed standards for GSFL consumers (at least $3.2 billion at the 7-percent discount rate) would exceed anticipated industry losses by at least 23 times. DOE estimates the IRL industry net present value to be $207–267 million in 2007$. If DOE were to adopt the proposed standards, it expects that manufacturers may lose 29–46 percent of their INPV, which is approximately $77–94 million. The NPV of the proposed standards for IRL consumers (at least $3.7 billion at the 7-percent discount rate) would exceed anticipated industry losses by at least 39 times.

In addition, the proposed standards would have significant environmental benefits. All of the energy saved would be in the form of electricity, and DOE expects the energy savings from the proposed standards to eliminate the need for approximately 1100 to 3400 megawatts (MW) of generating capacity for GSFL and up to 450 MW for IRL by 2042. This would result in cumulative (undiscounted) greenhouse gas emission reductions of 184 to 395 million metric tons (MMT) of carbon dioxide (CO_2) for GSFL and 59 to 114 MMT for IRL from 2012 to 2042. During this same period, the standard would result in power plant emission reductions of 12 to 623 kilotons (kt) of nitrogen oxides (NO_X) for GSFL and 4 to 181 kt NO_X for IRL. Mercury (Hg) emission reductions would be up to 6.9 tons for GFSL and up to 1.7 tons avoided for IRL.

DOE has tentatively concluded that the proposed standards represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in significant conservation of energy. DOE further notes that products achieving these standard levels are already commercially available. Based upon the rulemaking analyses culminating in this proposal, DOE found that the benefits (energy savings, consumer LCC savings, national NPV increase, and emission reductions) to the Nation of the proposed standards outweigh the burdens (INPV decrease and LCC increases for some lamp users). DOE considered higher efficacy levels (ELs) as trial standard levels (TSLs), and is still considering them in this rulemaking; however, DOE has tentatively concluded that the burdens of the higher efficiency levels outweigh the benefits. Based upon consideration of public comments and related information, DOE may adopt either higher or lower ELs presented in this proposal or some level in between.

II. Introduction

A. Consumer Overview

EPCA currently prescribes efficacy standards for certain IRL and GSFL. (42 U.S.C. 6295(i)(1)) DOE proposes to raise these standards and to set efficacy standards for certain other GSFL, as shown in Table I.1 and Table I.2 above. The proposed standards would apply to products manufactured in the United States, or imported to it, three years after the final rule is published in the **Federal Register**.[1] Table I.1 and Table I.2 also show the percentage improvement in efficacy that each standard level represents, relative to the current standard levels or to products typically on the market today. The proposed standards represent an overall improvement of approximately 4 to 22 percent and 7 to 100 percent in the efficacies of the GSFL and IRL baselines, respectively, covered by the standards.

DOE's analyses suggest that residential and commercial consumers would see benefits from the proposed standards. Although DOE expects that under the proposed standards, the purchase price of high-efficacy GSFL would be higher (up to three times higher) than the average price of these products today, but that the energy efficiency gains would result in lower energy costs that more than offset such higher costs. When the potential savings due to efficiency gains are summed over the lifetime of the high-efficacy products, consumers would be expected to save up to $56.60 (depending on the lamp type), on average, compared to their expenditures on today's baseline GSFL.

The results of DOE's analyses for IRL follow a similar pattern. Although DOE expects the purchase price of the high-efficacy IRL would be higher (ranging from 56 to 63 percent) than the average price of these products today, the energy efficiency gains would result in lower energy costs that more than offset the higher costs. When these potential

[1] The final rule is expected to be published by June 30, 2009; therefore, the effective date would be June 30, 2012.

savings due to efficiency gains are summed over the lifetime of the high-efficacy IRL, it is estimated that consumers would save between $1.62 and $8.14, on average, compared to their expenditures on today's baseline IRL.

B. Authority

Title III of EPCA sets forth a variety of provisions designed to improve energy efficiency. Part A [2] of Title III (42 U.S.C. 6291–6309) established the ''Energy Conservation Program for Consumer Products Other Than Automobiles.'' The program covers consumer products and certain commercial products (referred to hereafter as ''covered products''), including GSFL and IRL. (42 U.S.C. 6292(a)(14) and 6295(i)) EPCA prescribes energy conservation standards for certain GSFL and IRL. (42 U.S.C. 6295(i)(1)) The statute further directs DOE to determine whether the existing standards for fluorescent and incandescent lamps should be amended and whether to adopt standards for additional GSFL. (42 U.S.C. 6295(i)(3)–(5)) This rulemaking represents the first round of amendments to the GSFL and IRL energy conservation standards as directed by 42 U.S.C. 6295(i)(3).

The scope of coverage for these requirements for GSFL and IRL is dictated by EPCA's definitions of these and related terms, as explained below. EPCA defines ''general service fluorescent lamp'' as follows: * * * [F]luorescent lamps which can be used to satisfy the majority of fluorescent applications, but does not include any lamp designed and marketed for the following nongeneral lighting applications: (i) Fluorescent lamps designed to promote plant growth. (ii) Fluorescent lamps specifically designed for cold temperature installations. (iii) Colored fluorescent lamps. (iv) Impact-resistant fluorescent lamps. (v) Reflectorized or aperture lamps. (vi) Fluorescent lamps designed for use in reprographic equipment. (vii) Lamps primarily designed to produce radiation in the ultra-violet region of the spectrum. (viii) Lamps with a color rendering index of 87 or greater. (42 U.S.C. 6291(30)(B))

EPCA defines ''incandescent reflector lamp'' as follows: * * * [A] lamp in which light is produced by a filament heated to incandescence by an electric current * * * [and] (commonly referred to as a reflector lamp) which is not colored or designed for rough or vibration service applications, that contains an inner reflective coating on the outer bulb to direct the light, an R, PAR, ER, BR, BPAR, or similar bulb shapes with E26 medium screw bases, a rated voltage or voltage range that lies at least partially within 115 and 130 volts, a diameter which exceeds 2.25 inches, and has a rated wattage that is 40 watts or higher.

(42 U.S.C. 6291(30)(C), (C)(ii) and (F))

EPCA further clarifies this definition of IRL by defining the lamp types excluded from the definition: The term ''rough service lamp'' means a lamp that—(i) has a minimum of 5 supports with filament configurations that are C–7A, C–11, C–17, and C–22 as listed in Figure 6–12 of the 9th edition of the IESNA Lighting handbook, or similar configurations where lead wires are not counted as supports; and (ii) is designated and marketed specifically for 'rough service' applications, with (I) the designation appearing on the lamp packaging; and (II) marketing materials that identify the lamp as being for rough service. (42 U.S.C. 6291(30)(X))

The term ''vibration service lamp'' means a lamp that—(i) has filament configurations that are C–5, C–7A, or C–9, as listed in Figure 6–12 of the 9th Edition of the IESNA Lighting Handbook or similar configurations; (ii) has a maximum wattage of 60 watts; (iii) is sold at retail in packages of 2 lamps or less; and (iv) is designated and marketed specifically for vibration service or vibration-resistant applications, with—(I) the designation appearing on the lamp packaging; and (II) marketing materials that identify the lamp as being vibration service only. (42 U.S.C. 6291(30)(AA))

The term ''colored incandescent lamp'' means an incandescent lamp designated and marketed as a colored lamp that has—(i) a color rendering index of less than 50, as determined according to the test method given in C.I.E. publication 13.3–1995; or (ii) a correlated color temperature of less than 2,500K, or greater than 4,600K, where correlated temperature is computed according to the Journal of Optical Society of America, Vol. 58, pages 1528–1595 (1986). (42 U.S.C. 6291(30)(EE)) [3]

The advance notice of proposed rulemaking (ANOPR) in this proceeding (73 FR 13620, 13622, 13625, 13628–29 (March 13, 2008)), as well as subsection II.C and section III below, provide additional detail on the nature and statutory history of EPCA's requirements for GSFL and IRL.

Under the Act, DOE's energy conservation program for covered products consists essentially of four parts: (1) Testing; (2) labeling; (3) Federal energy conservation standards, and (4) certification and enforcement procedures. The Federal Trade Commission (FTC) is responsible for labeling, and DOE implements the remainder of the program. Section 323 of the Act authorizes DOE, subject to certain criteria and conditions, to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each covered product. (42 U.S.C. 6293) The test procedures for GSFL and IRL appear at title 10 Code of Federal Regulations (CFR) part 430, subpart B, appendix R.

EPCA provides criteria for prescribing new or amended energy conservation standards for covered products. As indicated above, any new or amended standard for a covered product under Part A 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)), although EPCA precludes DOE from adopting any standard that would not result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)) Moreover, DOE may not prescribe a standard: (1) For certain products, including GSFL and IRL, if no test procedure has been established for that type (or class) of product, or (2) if DOE determines by rule that the standard would not result in significant conservation of energy or is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)) The Act also provides that, in deciding whether a 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 do so after receiving comments on the proposed standard and by considering, to the greatest extent practicable, the following seven factors:

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

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

[2] This part was originally titled Part B; however, it was redesignated Part A after Part B was repealed by Pub. L. 109–58.

[3] DOE notes that the publication year of the referenced article in the definition of ''colored incandescent lamp,'' as printed in section 321(a)(1)(B) of EISA, contains two typographical errors. The citation should read as follows: Journal of Optical Society of America, Vol. 58, pages 1528–1535 (1968).

(3) The total projected amount of energy savings likely to result directly from the imposition of the standard;

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

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

(6) The need for national energy conservation; and

(7) Other factors the Secretary considers relevant. (42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

Furthermore, 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)) Also, the Secretary may not prescribe an amended or new standard if interested persons have established by a preponderance of evidence that the standard is likely to result in the unavailability in the United States of any covered product type (or class) with 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))

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

Under 42 U.S.C. 6295(q)(1), EPCA sets forth additional requirements applicable to promulgating a standard for a type or class of covered product that has two or more subcategories. DOE must specify a different standard level than that which applies generally to such type or class of products ''for any group of covered products which have the same function or intended use, if * * * products within such group—(A) consume a different kind of energy from that consumed by other covered products within such type (or class); or (B) have a capacity or other performance-related feature which other products within such type (or class) do not have and such feature justifies a higher or lower standard'' than applies or will apply to the other products. *Id.* In determining whether a performance-related feature justifies such a different standard for a group of products, DOE must ''consider such factors as the utility to the consumer of such a feature'' and other factors DOE deems appropriate. *Id.* Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 6295(q)(2))

Federal energy efficiency requirements generally supersede State laws or regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297(a)–(c)) DOE can, however, grant waivers of Federal preemption for particular State laws or regulations, in accordance with the procedures and other provisions of section 327(d) of the Act. (42 U.S.C. 6297(d))

C. Background

1. Current Standards

EPCA prescribes the energy conservation standards that are currently applicable to specified types of GSFL and IRL. More specifically, the standards set efficacy levels and color rendering index (CRI) levels for certain GSFL, and efficacy standards for certain IRL. (42 U.S.C. 6295(i)(1); 10 CFR 430.32(n)) These statutory standard levels are set forth in Table II.1 and Table II.2 below.

TABLE II.1—EPCA STANDARD LEVELS FOR GSFL

Lamp type	Nominal lamp wattage	Minimum CRI	Minimum average efficacy lm/W
4-Foot Medium Bipin	> 35W	69	75.0
	≤ 35W	45	75.0
2-Foot U-Shaped	> 35W	69	68.0
	≤ 35W	45	64.0
8-Foot Slimline	> 65W	69	80.0
	≤ 65W	45	80.0
8-Foot High Output	> 100W	69	80.0
	≤ 100W	45	80.0

TABLE II.2—EPCA STANDARD LEVELS FOR IRL

Wattage	Min. avg. efficacy lm/W
40–50	10.5
51–66	11.0
67–85	12.5
86–115	14.0
116–155	14.5
156–205	15.0

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

As stated above, EPCA established energy conservation standards for certain types of GSFL and IRL. (42 U.S.C. 6295(i)(1)) EPCA also requires that DOE conduct two cycles of rulemakings to determine whether to amend these standards, and that DOE initiate a rulemaking to determine whether to adopt standards for additional types of GSFL. (42 U.S.C. 6295(i)(3)–(5)) This rulemaking addresses both the amendment of existing GSFL and IRL standards, and the adoption of standards for additional GSFL.

DOE initiated this rulemaking on May 31, 2006, by publishing on its Web site its ''Rulemaking Framework Document for General Service Fluorescent Lamps, Incandescent Reflector Lamps, and General Service Incandescent Lamps.''[4] DOE also published a notice in the **Federal Register** announcing the availability of the framework document

[4] A PDF copy of the framework document published in May 2006 is available at: *http://www/eere.energy.gov/buildings/appliance_standards/residential/pdfs/lamps_framework.pdf.*

and a public meeting on the document, which requested public comments on the matters raised in the framework document. 71 FR 30834 (May 31, 2006). The framework document described the procedural and analytical approaches that DOE anticipated using to evaluate energy conservation standards for the products covered by this rulemaking, and it identified various issues to be resolved in conducting the rulemaking.

DOE held the public meeting on June 15, 2006, to present the framework document, describe the analyses it planned to conduct during the rulemaking, seek comments from stakeholders on these subjects, and inform stakeholders about and facilitate their involvement in the rulemaking. At the public meeting and during the comment period, DOE received many comments that both addressed issues raised in the framework document and identified additional issues relevant to this rulemaking.

As the title of the framework document indicates, DOE initially included general service incandescent lamps (GSIL) in this rulemaking. This was done to address the requirement then present in section 325(i)(5) of EPCA that DOE consider energy conservation standards for additional GSIL. (42 U.S.C. 6295(i)(5)) However, section 321(a)(3)(A)(iii) of the Energy Independence and Security Act of 2007,[5] (EISA 2007) amended EPCA to remove this requirement, thereby eliminating DOE's authority to regulate additional GSIL. Instead, section 321(a)(3)(A)(ii) of EISA 2007 amended EPCA to prescribe energy conservation standards for GSIL. Therefore, this rulemaking no longer addresses GSIL.

DOE issued the ANOPR for this rulemaking on February 21, 2008 and published it in the **Federal Register** on March 13, 2008. 73 FR 13620. On February 22, 2008, DOE posted the ANOPR, as well as the complete ANOPR technical support document (TSD), on its Web site.[6] The TSD includes the results of the following DOE preliminary analyses: (1) Market and technology assessment; (2) screening analysis; (3) engineering analysis; (4) energy use characterization; (5) product price determinations; (6) life-cycle cost (LCC) and pay back period (PBP) analyses; (7) shipments analysis; and (8) national impact analysis (NIA).

In the March 2008 ANOPR, DOE invited comment in particular on the following issues: (1) Consideration of additional GSFL; (2) amended definitions; (3) product classes; (4) scaling to product classes not analyzed; (5) screening of design options; (6) lamp operating hours; (7) energy consumption of GSFL; (8) LCC calculation; (9) installation costs; (10) base-case market-share matrices; (11) shipment forecasts; (12) base-case and standards-case forecasted efficiencies; (13) trial standard levels; and (14) period for lamp production equipment conversion. 73 FR 13620, 13686–88 (March 13, 2008).

In the ANOPR, DOE described and sought comment on the analytical framework, models, and tools (*e.g.*, LCC and national energy savings (NES) spreadsheets) DOE was using to analyze the impacts of energy conservation standards for GSFL and IRL. DOE held a public meeting in Washington, DC, on March 10, 2008, to present the methodologies and results for the March 2008 ANOPR analyses. At this meeting, stakeholders recommended that DOE revise certain analyses in the energy conservation standard ANOPR and the scope of covered products. DOE later received written comments from the National Electrical Manufacturers Association (NEMA). In addition, DOE received a joint comment from several stakeholders. The Joint Comment was submitted by the American Council for an Energy Efficient Economy (ACEEE), Alliance to Save Energy (ASE), Appliance Standards Awareness Project (ASAP), National Consumer Law Center, National Grid, Natural Resources Defense Council (NRDC), Northeast Energy Efficiency Partnerships (NEEP), Northwest Power and Conservation Council (NPCC), Pacific Gas and Electric Company (PG&E), and Vermont Energy Investment Corporation. The comments received since publication of the March 2008 ANOPR and during the March 10, 2008 public meeting have contributed to DOE's proposed resolution of the issues in this rulemaking. This NOPR quotes, summarizes, and responds to the issues raised in these public comments. (A parenthetical reference at the end of a quotation or paraphrase provides the location of the item in the public record.)

Subsequent to the public meeting and at NEMA's request, DOE and NEMA met on June 26, 2008 to discuss appropriate lumens per watt (lm/W) standards for high correlated color temperature (CCT) fluorescent lamps. (DOE, No. 27)[7] NEMA subsequently submitted a written comment documenting its presentation at this meeting (hereafter the ''June 2008 NEMA meeting''). (NEMA, No. 26) Topics covered at this meeting included the expected market share of high-CCT fluorescent lamps, appropriate efficacy standard scaling factors for GSFL with a CCT greater than 4,500K but less than or equal to 7,000K, and coverage of GSFL with a CCT greater than 7,000K. See sections III.C.2, V.A.1.c, and V.C.7.a.i of this notice for a more detailed discussion of NEMA's comments at this meeting, as well as DOE's responses.

III. Issues Affecting the Scope of This Rulemaking

A. Additional General Service Fluorescent Lamps for Which DOE Is Proposing Standards

1. Scope of EPCA Requirement That DOE Consider Standards for Additional Lamps

As discussed above, EPCA established energy conservation standards for certain general service fluorescent lamps, (42 U.S.C. 6295(i)(1)) and directed the Secretary to ''initiate a rulemaking procedure to determine if the standards in effect for fluorescent lamps * * * should be amended so that they would be applicable to additional general service fluorescent [lamps]. * * *'' (42 U.S.C. 6295(i)(5)) Thus, DOE must consider whether to adopt energy efficacy standards for additional GSFL beyond those already covered by the statutorily-prescribed standards.

The March 2008 ANOPR notes that a wide variety of GSFL are not currently covered by energy conservation standards, and they are potential candidates for coverage under 42 U.S.C. 6295(i)(5). 73 FR 13620, 13628–29 (March 13, 2008). However, the requirement that DOE consider additional GSFL appears to conflict with EPCA's definitions of key terms, which it might be argued would preclude coverage of additional GSFL. As explained below, DOE has carefully considered these statutory provisions and is interpreting them in a manner so as to give effect to the requirement to consider additional GSFL.

Specifically, the conflict is centered on the statutory definition of ''general service fluorescent lamp.'' As set forth above and repeated here for purposes of this discussion, ''general service fluorescent lamp'' is defined in 42

[5] Pub. L. 110–140 (enacted Dec. 19, 2007).

[6] PDF copies of the ANOPR and ANOPR TSD published in March 2008 are available at: *http://www1.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps_anopr.html.*

[7] A notation in the form ''DOE, No. 27'' identifies a written comment that DOE has received and has included in the docket of this rulemaking or a written docket submission. This particular notation refers to a comment: (1) Submitted by DOE; and (2) in document number 27 in the docket of this rulemaking.

U.S.C. 6291(30)(B) to mean: ''fluorescent lamps which can be used to satisfy the majority of fluorescent lamp applications, but does not include any lamp designed and marketed for the following nongeneral lighting applications: [list of eight exclusions not relevant to the present issue].''

As such, the term ''general service fluorescent lamp'' appears to be defined by reference to the term ''fluorescent lamp,'' which is also defined under the statute as follows: ''Except as provided in subparagraph (E), the term 'fluorescent lamp' means a low pressure mercury electric-discharge source in which a fluorescing coating transforms some of the ultraviolet energy generated by the mercury discharge into light, including only the following: (i) Any straight-shaped lamp (commonly referred to as 4-foot medium bi-pin lamps) with medium bi-pin bases of nominal overall length of 48 inches and rated wattage of 28 or more. (ii) Any U-shaped lamp (commonly referred to as 2-foot U-shaped lamps) with medium bi-pin bases of nominal overall length between 22 and 25 inches and rated wattage of 28 or more. (iii) Any rapid start lamp (commonly referred to as 8-foot high output lamps) with recessed double contact bases of nominal overall length of 96 inches and 0.800 nominal amperes, as defined in ANSI C78.1–1978 and related supplements. (iv) Any instant start lamp (commonly referred to as 8-foot slimline lamps) with single pin bases of nominal overall length of 96 inches and rated wattage of 52 or more, as defined in ANSI C78.3–1978 (R1984) and related supplement ANSI C78.3a–1985.'' 42 U.S.C. 6291(30)(A) (Emphasis added).

The term ''fluorescent lamp'' is, by its terms, limited to four enumerated types of lamps. Further, the four types of lamps set forth in the definition of ''fluorescent lamp'' have corresponding energy conservation standards prescribed under the statute at 42 U.S.C. 6295(i)(1)(B). Given that the statutory definition of ''fluorescent lamp'' is limited to four specified types of lamps and that the statute prescribes standards for those four lamps, it is not possible to give effect to the congressional directive to consider establishing standards for additional GSFL if the term ''general service fluorescent lamp'' is limited by the definition of ''fluorescent lamp.''

Given this identified conflict, DOE has determined that there is an inherent ambiguity in the statute in terms of how these provisions are to be implemented. In order to move forward with this standards rulemaking, DOE must resolve this legal conundrum.

Although there is no legislative history to clarify this point, there are a number of reasons to believe that Congress did not intend to strictly limit consideration of ''additional'' GSFL. First, Congress adopted both the relevant statutory definitions and the ''additional'' lamps requirement as part of Energy Policy Act of 1992 (EPACT 1992; Pub. L. 102–486). DOE does not believe Congress would intentionally insert a legislative provision that, when read in conjunction with a simultaneously added provision, amounts to a nullity. Second, reading the definition to preclude consideration of additional GSFL would run counter to the energy-saving purposes of EPCA. It is reasonable to assume that Congress would not have intended to limit energy conservation standards to only those technologies available in 1992, but would instead cast a broader net that would achieve energy efficiency improvements in lighting products incorporating newer technologies.

Consequently, DOE interprets these statutory provisions such that, in defining ''general service fluorescent lamp,'' Congress intended to incorporate the term ''fluorescent lamp'' in a broader, more generic sense. DOE understands that the industry routinely refers to ''fluorescent lamps'' as including products in addition to the four enumerated in the statutory definition of that term. In fact, in the March 2008 ANOPR, DOE presented its plan for including additional GSFL for coverage, and did not receive adverse comment. Thus, DOE has determined to read the statutory definition of ''general service fluorescent lamp'' in this broader context.

For these reasons, and for the additional reasons set forth in the March 2008 ANOPR,[8] DOE views ''additional'' GSFL, as that term is used in 42 U.S.C. 6295(i)(5), as lamps that: (1) Meet the technical portion of the statutory definition of ''fluorescent lamp'' (*i.e.*, a low-pressure mercury electric-discharge source in which a fluorescing coating transforms some of the ultraviolet energy generated by the mercury discharge into light) (42 U.S.C. 6291(30)(A)) without restriction to the four specified lamp types in that definition; (2) can be used to satisfy the majority of fluorescent lighting applications (42 U.S.C. 6291(30)(B)); (3) are not within the exclusions from the definition of GSFL specified in 42 U.S.C. 6291(30)(B); and (4) are ones for which EPCA does not prescribe standards. Such an interpretation does not alter the existing statutory provision or standards for ''fluorescent lamps,'' but it does permit DOE to give effect to section 6295(i)(5) of EPCA by expanding the universe of GSFL open to potential regulation. The scope of coverage reflected in this NOPR is in keeping with the interpretation outlined above.

2. Identification of the Additional Lamps for Which DOE Proposes Standards

As set forth more fully in the March 2008 ANOPR, DOE took the following three steps in terms of identifying additional GSFL for which standard setting might be appropriate. DOE first conducted a comprehensive review of the fluorescent lighting market in order to identify particular types of lamps that meet the four criteria above to determine the additional GSFL for which DOE would consider adopting standards. Second, DOE examined each lamp type to determine potential energy savings that energy conservation standards would bring for that lamp. Third, DOE further evaluated selected lamps to determine if such standards would be technologically feasible and economically justified. In carrying out these steps before issuance of the March 2008 ANOPR, DOE considered comments on these issues that it had received previously. 73 FR 13620, 13629–30 (March 13, 2008).

In implementing the first of these three steps, DOE identified the following categories of GSFL as meeting the four criteria for consideration as ''additional'' GSFL under 42 U.S.C. 6295(i)(5):

- 4-foot, medium bipin (MBP), straight-shaped lamps, rated wattage of < 28W;
- 2-foot, medium bipin, U-shaped lamps, rated wattage of < 28W;
- 8-foot, recessed double contact (RDC), rapid start, high output (HO) lamps not defined in ANSI Standard C78.1–1991[9] or with current other than 0.800 nominal amperes;
- 8-foot single pin (SP), instant start, slimline lamps with a rated wattage ≥ 52, not defined in ANSI Standard C78.3–1991[10];
- Very high output (VHO) straight-shaped lamps;
- T5[11] miniature bipin (MiniBP) straight-shaped lamps;
- Additional straight-shaped and U-shaped lamps other than those listed

[8] 73 FR 13620, 13629 (March 13, 2008).

[9] Titled ''for Fluorescent Lamps—Rapid-Start Types—Dimensional and Electrical Characteristics.''

[10] Titled ''for Fluorescent Lamps—Instant-Start and Cold-Cathode Types—Dimensional and Electrical Characteristics.''

[11] T5, T8, T10, and T12 are nomenclature used to refer to tubular fluorescent lamps with diameters of 0.625, 1, 1.25, and 1.5 inches, respectively.

above (*e.g.*, alternate lengths, diameters, or bases); and

• Additional fluorescent lamps with alternate shapes (*e.g.,* circline, pin-based compact fluorescent lamps (CFL)).

73 FR 13620, 13630 (March 13, 2008).

DOE then assessed the potential energy savings of standards for these GSFL (second step) and whether candidate standards for those GSFL would be technologically feasible and economically justified (third step), in order to determine which GSFL to analyze in depth regarding whether, and at what levels, standards would be warranted under the EPCA criteria in 42 U.S.C. 6295(o). DOE's analytical process related to these additional GSFL categories is discussed generally below.

In a review of 4-foot medium bipin lamps, DOE found that the current market lacked any products with a rated wattage below 25W. Therefore, in the March 2008 ANOPR, DOE preliminarily decided not to extend coverage to 4-foot medium bipin lamps below 25W. In the following section, DOE discusses its consideration in the March 2008 ANOPR of possibly regulating lamps with rated wattages less than 28W and greater than or equal to 25W.

Similar to the 4-foot medium bipin lamps, in the March 2008 ANOPR, DOE investigated the potential for regulating 2-foot U-shaped lamps less than 28W. A review of available manufacturer catalogs found no commercially-available products in that category. Therefore, DOE concluded that lowering the minimum wattage threshold of 2-foot U-shaped lamps would likely not result in substantial energy savings and preliminarily decided not to expand coverage to these lamps.

DOE also considered whether to expand coverage to include VHO fluorescent lamps. While VHO lamps consume large amounts of energy, they are commonly used in outdoor applications where high-intensity discharge (HID) lamps are rapidly gaining market share. Further research indicated that shipments of VHO T12 lamps are declining rapidly. Although individually these products have greater per-lamp energy savings than high output or standard output lamps, the total energy savings resulting from regulation would be small and would be expected to decrease over time as these lamps disappear from the market. Therefore, DOE preliminarily decided not to extend coverage to VHO lamps.

In the March 2008 ANOPR, DOE also preliminarily decided not to expand coverage to T5 fluorescent lamps. DOE's initial analysis showed that T5 lamps currently have a relatively small share of the GSFL market, and, therefore, have limited potential to contribute to total energy savings. Although T5 lamps can serve as a substitute for T8 or T12 lamps, DOE found that T5 lamps tend to have higher efficacy. Research showed that the highest efficacy 32W 4-foot medium bipin T8 lamp is 95 lm/W, compared to 104 lm/W for a standard output 4-foot miniature bipin T5 lamps. Thus, DOE stated that excluding T5 lamps from this rulemaking would be unlikely to undermine any energy savings that would result from a T12 and T8 standard, even if the standard caused increased sales of T5 systems

Lastly, DOE preliminarily decided not to extend coverage to fluorescent lamps that had alternate lengths, diameters, bases, or shapes (or a combination thereof) than the lamps specifically mentioned. DOE reasoned that the products it had already selected for coverage represented the significant majority of the GSFL market, and, thus, the bulk of the potential energy savings. Furthermore, DOE tentatively concluded there was limited potential for lamps with miscellaneous lengths and bases to grow in market share, given the constraint of fixture lengths and socket compatibility.

After eliminating the lamps aforementioned lamps from further consideration for the reasons cited above, DOE was left with the following additional GSFL to consider evaluating in depth for potential standards:

• 4-foot, medium bipin lamps with wattages ≥ 25 and < 28;

• 8-foot, recessed double contact (RDC), rapid start, high output (HO) lamps not defined in ANSI Standard C78.1–1991 or with current other than 0.800 nominal amperes;

• 8-foot single pin (SP), instant start, slimline lamps with a rated wattage ≥ 52, not defined in ANSI Standard C78.3–1991;

73 FR 13620, 13632 (March 13, 2008).

As mentioned in the March 2008 ANOPR, DOE explored extending coverage to 4-foot medium bipin lamps with wattages less than 28W. A product review found that manufacturers marketed and sold 25W 4-foot medium bipin T8 fluorescent lamps as replacements for higher wattage 4-foot medium bipin T8 fluorescent lamps. Thus, DOE concluded that lowering the minimum wattage threshold to include these lamps would mitigate the risk of 25W lamps becoming a loophole and would maximize potential energy savings. In addition, as the technology and incremental costs associated with increased efficacy of 25W lamps are similar to their already regulated 28W counterparts, DOE tentatively concluded that standards for these lamps would be technologically feasible and economically justified.

In the March 2008 ANOPR, DOE also preliminarily decided to extend coverage to 8-foot recessed double contact, rapid start, HO lamps not defined in ANSI Standard C78.1–1991. Due to the ampere specification in the definition, the statutory standards covered only T12 8-foot recessed double contact HO lamps, but none of the T8 8-foot recessed double contact HO lamps (which usually have 0.400 nominal amperes). Since the T8 8-foot lamps serve as substitutes for their T12 counterparts, DOE risked losing potential energy savings unless such lamps are also covered by energy conservation standards. Consequently, DOE preliminarily extended coverage to T8, 8-foot recessed double contact HO lamps, thereby adding lamps previously restricted by the 0.800 nominal ampere limitation in the definition of ''general service fluorescent lamp.''

Furthermore, DOE planned to expand coverage to 8-foot recessed double contact, rapid start, high output fluorescent lamps not listed in ANSI Standard C78.1–1991. DOE made this decision because the ANSI standards referenced in DOE regulations were outdated.[12] As new lamps are introduced to the market, it is likely they would not be covered by the 1991 ANSI standard and potentially even the currently most up-to-date standard. Any of these lamps could serve as substitutes for regulated lamps. To maximize energy savings from these standards, DOE extended coverage to 8-foot recessed double contact, rapid start, high output fluorescent lamps not listed in ANSI Standard C78.1–1991.

Because the technologies of T8, 8-foot recessed double contact HO lamps and the 8-foot recessed double contact HO lamps not listed in the ANSI Standard C78.1–1991 were similar to the technologies of their already-regulated T12 counterparts, DOE tentatively concluded that standards for these lamps would meet the statutory criterion of technological feasibility. Preliminary analysis of these lamps in the LCC and NIA demonstrated substantial economic savings. Therefore, DOE tentatively concluded that energy conservation standards for these lamps would be expected to be economically justified.

[12] ANSI Standard C78.1–1991 has been updated and replaced by ANSI Standard C78.81–2005, ''for Electric Lamps—Double Capped Fluorescent Lamps—Electrical and Dimensional Characteristics.''

Similar to 8-foot recessed double contact HO lamps, in the March 2008 ANOPR, DOE considered extending coverage to 8-foot, single pin, instant start, slimline lamps not included in ANSI Standard C78.3–1991 (which includes T8 lamps as well). DOE's preliminary analysis indicated that regulation of these lamps has the potential to achieve substantial energy savings. Therefore, DOE preliminarily decided to expand the scope of energy conservation standard coverage to 8-foot single pin slimline lamps with a rated wattage greater than or equal to 52W not listed in ANSI Standard C78.3–1991. Since the technologies of T8, 8-foot single pin slimline lamps and the 8-foot single pin slimline lamps not listed in ANSI Standard C78.3–1991 are similar to the technologies of their already-regulated counterparts, DOE tentatively concluded that standards for these lamps would be expected to meet the statutory criterion of technological feasibility. Analyses in the LCC and NIA confirmed the potential for substantial economic savings associated with regulation of these lamp types. As a result, in the March 2008 ANOPR, DOE tentatively concluded that energy conservation standards for these lamps would be economically justified.

During and after the public meeting, DOE received numerous verbal and written comments regarding the lamps included in or excluded from coverage in the March 2008 ANOPR. As a general matter, commenters supported DOE's approach for consideration of additional GSFL for coverage by energy conservation standards. However, commenters urged DOE to consider changes in its approach in two areas, specifically coverage of T5 lamps and extension of lamp wattage ranges. Sections III.A.2.a and III.A.2.b of this notice immediately below discuss the submitted comments and DOE's responses.

a. Coverage of T5 Lamps

At the March 2008 ANOPR public meeting, NEMA announced that it was considering supporting coverage of T5 lamps to prevent the introduction of less-efficient T5 lamps into the market, particularly those containing halophosphors. (Public Meeting Transcript, No. 21 at pp. 71–72) [13] ACEEE likewise suggested that DOE should analyze opportunities involving regulation of T5 lamps. (Public Meeting Transcript, No. 21 at p. 73) In its written comments, NEMA stated that it would not oppose covering newer T5 fluorescent lamp technology (*e.g.*, 28W 4-foot T5 lamps), but would not recommend covering older technology (*i.e.*, T5 preheat fluorescent lamps). (NEMA, No. 22 at p. 3) In addition, the Joint Comment stated that DOE should extend coverage to T5 lamps. These organizations argued that if only T8 and T12 lamps are covered by the standard, it could possibly spur market introduction of less-efficient halophosphor T5 lamps with a lower first cost. Such a development would increase the overall market share of T5 lamps and decrease the potential energy savings associated with this rulemaking. (Joint Comment, No. 23 at pp. 2–5)

DOE agrees with these comments. While most T5 lamps are currently more efficient than the T8 and T12 lamps for which they can be substituted, excluding them from energy conservation standards could provide an incentive for less-efficient T5 lamps to enter the market. Such trend would result in increased market share of less-efficient products, thereby creating the potential for significant energy savings losses unless these lamps are regulated. Because this potential substitution effect is a primary criterion which DOE uses to determine coverage for additional GSFL, DOE is proposing in this NOPR to extend coverage to T5 miniature bipin lamps.

DOE researched the market and product availability of T5 lamps and found they exist in a variety of lengths and wattages. Standard T5 lamps include wattages ranging from 14W to 80W, and lengths ranging from nominally 2 feet to 6 feet. DOE's research indicates that the primary driver of T5 market share growth is substitution for currently regulated 4-foot MBP lamps. Therefore, DOE proposes to cover only the nominally 4-foot lengths of T5 miniature bipin lamps. DOE believes that alternate lengths of T5 lamps are not likely to gain significant market share as they are not easily substitutable for 4-foot MBP systems which represent the majority of the total fluorescent market. In addition, interviews with manufacturers and a review of product literature indicate that standard-output (approximately 28W) and high-output (approximately 54W) lamps are the highest volume T5 miniature bipin lamps. In addition to the full-wattage versions of these lamps, DOE has found that reduced-wattage versions of the standard- and high-output T5 lamp (26W and 51W respectively) are available. Therefore, in this NOPR, DOE proposes to extend coverage to 4-foot nominal, straight-shaped, T5 miniature bipin standard output lamps with rated wattages ≥ 26W and to 4-foot nominal, straight-shaped, T5 miniature bipin high output lamps with rated wattages ≥ 51W, as they present the greatest potential for energy savings. DOE estimates potential energy savings from these lamps of up to 2.05 quads over the analysis period (2012 to 2042). Because higher-efficacy versions of some of these lamps are already present in the market, DOE tentatively concludes that standards for these lamps are technologically feasible.

Based on DOE's LCC and NIA analyses, coverage of the T5 lamps discussed above would be economically justified. These analyses show that T5 lamp coverage has the potential to achieve on average $47.03 per standard-output lamp system and $56.60 per high-output lamp system in LCC savings. In addition, DOE's NIA indicates that regulating these lamps could result in an NPV of up to $6.84 billion to the Nation (discounted at 3 percent). See section VI.B.1.a.i and section VI.B.3 of this document and chapters 8 and 11 of the TSD for more details on these results.

b. Extension of Lamp Wattage Ranges

Regarding fluorescent lamp coverage, the Joint Comment suggested that DOE should extend wattage ranges to cover lower-wattage products. (Joint Comment, No. 23 at p. 4) In relevant part, section 123 of EPACT 1992 amended EPCA to establish standards for 4-foot medium bipin lamps of 28W or more. The Joint Comment notes that since that law took effect, "new products continue to be introduced, and there is an incentive to circumvent standards by producing lamps just outside of the watt range (e.g. the current 25W residential lamp)." *Id.* NEMA commented that while current standards cover 2-foot U-shaped medium bipin lamps greater than or equal to 28W, new products have been introduced at 25W. (Public Meeting Transcript, No. 21 at p. 73) To prevent this trend from continuing, the Joint Comment recommended substantially lowering watt ranges for GSFL product classes to protect the energy savings that would be accomplished by this rule. If niche products exist in the new range, the Joint Comment expressed a preference for using narrowly drawn exemptions rather than limiting the covered watt range. (Joint Comment, No. 23 at p. 4)

[13] A notation in the form "Public Meeting Transcript, No. 21 at pp. 71–72" identifies a written comment that DOE has received and has included in the docket of this rulemaking. This particular notation refers to a comment: (1) Submitted during the public meeting on March 10–11, 2008; (2) in document number 21 in the docket of this rulemaking; and (3) appearing on pages 71 through 72 of the transcript.

DOE agrees with the Joint Comment regarding the appropriateness of extending wattage ranges when commercially-available products exist. As discussed in the March 2008 ANOPR, DOE proposed to extend coverage to 4-foot medium bipin fluorescent lamps with wattages between 25W and 28W. DOE discovered these lamps were being marketed as substitutes for currently regulated lamps subject to the current and amended standards (proposed in this NOPR) on 4-foot medium bipin lamps. Therefore, consistent with that approach, in this NOPR, DOE proposes to extend coverage to 2-foot U-shaped lamps with wattages greater than 25W.

The Joint Comment expressed concern that substitutable products outside the range of covered wattages will emerge in other product classes. It suggested a proactive approach of lowering the watt ranges even further, although no products may currently exist in that range. (Joint Comment, No. 23 at p. 4) While DOE understands the Joint Comment's concern, DOE disagrees with this approach. DOE is required to consider energy conservation standards that are technologically feasible. If a lower wattage lamp does not yet exist, DOE cannot confirm that it would be technologically feasible or economically justified for such a lamp to meet a set energy conservation standard. In addition, lower wattage lamps may provide different lumen outputs, and thereby different utility. Therefore, if DOE were to include these lamps in its coverage without determining if the set energy conservation standard is technologically feasible, DOE could be reducing the utility of covered product or precluding its development entirely. Further, DOE encourages the introduction of lamps at lower wattages. Thus, DOE will only propose to extend wattage ranges for 4-foot medium bipin lamps and 2-foot medium bipin U-shaped lamps to the extent specified in this NOPR.

3. Summary GSFL Lamps to Which DOE Proposes To Extend Coverage

With the exception of the above-discussed comments, DOE received no other input related to coverage of GSFL. In addition, DOE's revised analyses indicate that energy conservation standards for the lamps which DOE preliminarily decided to extend coverage in the March 2008 ANOPR are still expected to be technologically feasible, economically justified, and would result in significant energy savings. Therefore, in summary, DOE is proposing to cover the following additional GSFL:

- 2-foot, medium bipin U-shaped lamps with a rated wattage ≥ 25 and less than < 28;
- 4-foot, medium bipin lamps with a rated wattage ≥ 25 and less than 28;
- 4-foot T5, miniature bipin, straight-shaped, standard output lamps with rated wattage ≥ 26;
- 4-foot T5, miniature bipin, straight-shaped, high output lamps with rated wattage ≥ 51;
- 8-foot recessed double contact, rapid start, HO lamps other than those defined in ANSI Standard C78.1–1991;
- 8-foot recessed double contact, rapid start, HO lamps (other than 0.800 nominal amperes) defined in ANSI Standard C78.1–1991; and
- 8-foot single pin instant start slimline lamps, with a rated wattage ≥ 52, not defined in ANSI Standard C78.3–1991.

B. Exempted Incandescent Reflector Lamps

Section 322(a)(1) of EISA 2007 amended section 321(30)(C)(ii) of EPCA to expand the portion of the definition of ''incandescent lamp'' applicable to incandescent reflector lamps to include lamps with a diameter between 2.25 and 2.75 inches, as well as ER, BR, BPAR, or similar bulb shapes. (42 U.S.C. 6291(30)(C)(ii)) Furthermore, section 322(b) of EISA 2007 incorporates several new exemptions to the IRL standards in the new section 325(i)(1)(C) of EPCA. (42 U.S.C. 6295(i)(1)(C)) These exemptions are as follows: (1) Lamps rated 50 watts or less that are ER30, BR30, BR40, or ER40; (2) lamps rated 65 watts that are BR30, BR40, or ER40 lamps; and (3) R20 incandescent reflector lamps rated 45 watts or less.

At the ANOPR stage, DOE concluded that it does not have the authority to set standards for these lamps, for the following reasons. Although Congress included ER, BR, and small-diameter (less than 2.75 inches) lamps in the definition of an ''incandescent lamp,'' it specifically exempted certain wattages and diameters from the prescribed efficacy standards, thereby indicating Congress's intent not to set standards for those products. Furthermore, DOE's reading of 42 U.S.C. 6295(i)(3), which directs DOE to amend the standards in paragraph (1), led it to believe that DOE's authority to amend the standards does not include the authority to amend the exemptions. Specifically, under 42 U.S.C. 6295(i)(1)(C), ''Exemptions,'' the statute refers to ''the standards specified in subparagraph (B),'' whose title is ''Minimum Standards.'' Therefore, in amending the standards in paragraph (1), under 42 U.S.C. 6295(i)(3), DOE reasoned that it had the authority to change the efficacy values but not the exemptions. Accordingly, DOE conducted its ANOPR analyses under the premise that it could not extend coverage to these statutorily-exempted products.

The Joint Comment argued that by covering these products in EISA 2007, Congress effectively brought them into the Federal standards program and, thus, granted DOE the authority to regulate them. The Joint Comment recommended extending coverage to 65-watt ER and BR lamps. In addition, it encouraged DOE to evaluate standards for ER and BR lamps less than 65 watts and for R20 lamps less than 45 watts. The Joint Comment further contended that by failing to extend coverage to these lamps, DOE is not meeting its obligation to maximize energy savings. The Joint Comment argued that the exempted lamps represent a large, growing market share and are a substitute for products that DOE plans to regulate. The Joint Comment stated that because 65-watt BR lamps represent a low-cost, low-efficacy alternative to the more-efficient products covered by the standards, continued exemptions could decrease the potentially significant energy savings associated with the present rulemaking. (Joint Comment, No. 23 at p. 12–14)

Accompanying the Joint Comment were two legal memoranda from the National Consumer Law Center (NCLC), maintaining that not only does DOE have the authority to regulate ER and BR lamps, but that DOE is obligated to regulate them. NCLC pointed out that with the passage of EISA 2007, Congress included BR and ER lamps that have a ''rated wattage that is 40 watts or higher'' within the definition of ''incandescent lamp'' [EISA 2007, section 322(a), amending 42 U.S.C. 6291(30)(C)] and, thus, included these BR and ER lamps as covered products under 42 U.S.C. 6291(2) and 6292(a)(14). NCLC further contended that the only explanation for Congress adding ER and BR lamps to the definition was to include them among the covered products. (Joint Comment, No. 23 at p. 27) NCLC cited the rulemaking for microwave and electric ovens as an example of a rulemaking in which DOE is considering applying standards to products for which no prescriptive efficiency standards exist. (Joint Comment, No. 23 at p. 28)

Through the initial drafting of this NOPR, DOE adhered to its earlier conclusion that it lacked authority to consider standards for ER, BR, and small-diameter lamps that had been specifically exempted by Congress. However, after carefully considering the testimony of the February 3, 2009 NOPR public meeting and reexamining the ANOPR public comments on this issue, DOE reexamined its authority under EPCA to amend standards for ER, BR, and small-diameter lamps and has concluded that its earlier view may have been in error. DOE is further considering if it has authority to consider energy conservation standards for ER, BR, and small-diameter lamps for the reasons that follow.

DOE agrees with the Joint Comment, that prior to enactment of EISA 2007 on December 19, 2007, ER, BR, and small-diameter lamps were by definition excluded from coverage under EPCA; however, once EISA 2007 amended the definition of ''incandescent lamp,'' ER, BR, and small-diameter lamps become products by the new definition. (Joint Comment, No. 23 at p. 27) Congress proceeded to expressly exempt certain types of ER, BR, and small-diameter lamps from the statutorily-set IRL standards established by EISA 2007. However, given that these expressly exempted lamp types constitute the overwhelming majority of the ER, BR, and small-diameter lamps market, DOE's original construction of the relevant statutory provisions (as expressed in the ANOPR) would have the effect of once again moving most ER, BR, and small-diameter lamps beyond the reach of energy conservation standards. Accordingly, DOE is reconsidering whether, under 42 U.S.C 6295(i)(3), the directive to amend the standards in paragraph (1) encompasses both the statutory levels and the exemptions to those standards.

As a practical matter, if DOE does conclude that it has authority to establish standards for ER, BR, and small-diameter lamps, it cannot consider such lamps as part of the present rulemaking because it has not conducted the requisite analyses to propose appropriate standard levels. At the same time, DOE does not wish to delay the present rulemaking (and the accompanying energy savings to the Nation) for the sole reason of considering this subset of ER, BR, and small-diameter lamps. The analyses to consider standards for ER, BR, and small-diameter lamps are severable from the analyses underlying the present rulemaking, so separate treatment would not impact the outcomes for any of the lamp types under consideration in this NOPR. Therefore, DOE has decided to proceed with setting energy conservation standards for the lamps that are the subject of the present rulemaking and to commence a separate rulemaking for ER, BR, and small-diameter lamps. DOE believes that much of the analytical work for the current rulemaking will benefit the ER, BR, and small diameter lamps rulemaking, thereby permitting issuance of a new NOPR and final rule on an accelerated basis, if it determined that it has the authority to do so.

For the purposes of the present NOPR, however, DOE notes that the balance of this notice (analyses and related discussions) assumes that the exempted ER, BR, and small-diameter lamps remain unregulated by energy conservation standards. DOE acknowledges that while such an assumption has no impact on the engineering and life-cycle cost analyses, the regulation of these exempted IRL may affect the future shipment of IRL and thereby the national impact and other downstream analyses. However, DOE believes that its analysis of multiple shipment scenarios (as discussed in section V.E.5) captures the broad range of possible impacts were these exempted lamps to be regulated in the future. Therefore DOE's assumption does not impact the standards proposed in this rulemaking or DOE's reconsideration of its authority, nor does it otherwise constrain DOE's ability to conduct further analyses in a separate rulemaking.

C. Amended Definitions

To clarify the scope of EPCA's coverage of GSFL, IRL, and the recently adopted standards for GSIL, DOE proposes to revise its existing definitions of ''rated wattage'' and ''colored fluorescent lamp.'' These definitional changes are discussed below.

1. ''Rated Wattage''

One element of EPCA's definitions for ''fluorescent lamp'' and ''incandescent reflector lamp'' is a lamp's rated wattage, which helps delineate the lamps for which the statute sets standards. (42 U.S.C. 6291(30)(A), (C)(ii) and (F), and 6295(i)). In addition, section 321(a)(3) of EISA 2007 amended EPCA to prescribe energy conservation standards for GSIL, requiring lamps of particular lumen outputs to have certain maximum rated wattages. (42 U.S.C. 6295(i)) However, EPCA does not define the term ''rated wattage.''

DOE has defined ''rated wattage'' in its regulations, but only for 4-foot medium bipin T8, T10, and T12 fluorescent lamps. 10 CFR 430.2. This definition references ANSI Standard C78.1–1991, ''for Fluorescent Lamps—Rapid-Start Types—Dimensional and Electrical Characteristics.'' *Id.* Although EPCA also uses the term ''rated wattage'' to delineate 2-foot U-shaped lamps (42 U.S.C. 6291(30)(A)(ii)), 8-foot slimline lamps, (42 U.S.C. 6291(30)(A)(iv)), and IRL (42 U.S.C. 6291(30)(C)), DOE has not defined ''rated wattage'' for these lamps. In the March 2008 ANOPR, DOE considered revising and updating the definition of ''rated wattage'' to cite the current version of ANSI Standard C78.1–1991, clarify and improve the definition, and apply the revised definition to those lamps for which rated wattage is a key characteristic but is not currently defined by DOE. In response to the March 2008 ANOPR, DOE received one comment regarding the definition of ''rated wattage.'' NEMA commented that it agrees with DOE's revised definition. (NEMA, No. 22 at p. 4).

Therefore, DOE proposes the following definition for ''rated wattage'':

Rated wattage means:

(1) With respect to fluorescent lamps and general service fluorescent lamps:

(i) If the lamp is listed in ANSI C78.81–2005 or ANSI C78.901–2005, the rated wattage of a lamp determined by the lamp designation of Clause 11.1 of ANSI C78.81–2005 or ANSI C78.901–2005;

(ii) If the lamp is a residential straight-shaped lamp, and not listed in ANSI C78.81–2005, the wattage of a lamp when operated on a reference ballast for which the lamp is designed; or

(iii) If the lamp is neither listed in one of the ANSI guides referenced in (1)(i) nor a residential straight-shaped lamp, the wattage of a lamp when measured according to the test procedures outlined in Appendix R to subpart B of this part.

(2) With respect to general service incandescent lamps and incandescent reflector lamps, the wattage measured according to the test procedures outlined in Appendix R to subpart B of this part.

2. ''Colored Fluorescent Lamp''

Colored fluorescent lamps are excluded from EPCA's definition of ''general service fluorescent lamp.'' (42 U.S.C. 6291 (30)(B)(iii)) However, EPCA does not define the term ''colored fluorescent lamp.'' In order to fully define the scope of EPCA's definition of GSFL, DOE currently defines ''colored fluorescent lamp'' as follows:

> ''Colored fluorescent lamp'' means a fluorescent lamp designated and marketed as a colored lamp, and with either of the following characteristics: a CRI less than 40, as determined according to the method given in CIE Publication 13.2 (10 CFR 430.3), or a correlated color temperature less than 2,500K or greater than 6,600K.

10 CFR 430.2. Because these lamps are not GSFL under EPCA, they are not covered by the standards applicable to GSFL.

The central element of EPCA's definition of ''general service fluorescent lamp'' is that they are fluorescent lamps ''which can be used to satisfy the majority of lighting applications.'' (42 U.S.C. 6291(30)(B)) The exclusions, such as the one for colored lamps, are for lamps designed and marketed for ''non-general lighting applications.'' *Id.* As detailed in the March 2008 ANOPR, DOE became aware of a lamp on the European market that meets the above definition of ''colored fluorescent lamp'' and that is intended for general illumination applications. 73 FR 13620, 13634 (March 13, 2008). Although DOE is unaware of any similar general purpose fluorescent lamps being introduced into the U.S. market, the availability of the European lamp demonstrates the potential for DOE's definition of ''colored fluorescent lamp'' to exclude new products with general service applications from the definition of ''general service fluorescent lamp,'' and thereby from the coverage of standards applicable to GSFL. For this reason, in the March 2008 ANOPR, DOE proposed to revise its definition of ''colored fluorescent lamp'' by adding the following phrase after the words ''colored lamp'': ''and not designed or marketed for general illumination applications.'' *Id.*

In submitted written comments on the ANOPR, NEMA agreed with the proposed revised definition of ''colored fluorescent lamp,'' while noting that DOE will need to give additional consideration to general illumination fluorescent lamps with higher color temperatures. NEMA cited an example of a lamp with a CCT of 8,000K that could be used for both general illumination and specialty applications (NEMA, No. 22 at p. 9). NEMA requested a meeting to discuss this matter in greater detail, since it was performing research related to this topic. (DOE, No. 27) This meeting is subsequently discussed in section II.C.2 of this NOPR.

At the June 2008 NEMA meeting and in its written comments, NEMA recommended that the range of GSFL affected by standards should be increased to 7,000K from the current coverage, which extends to only 6,600K. NEMA believes that lamps with a CCT between 4,500K and 7,000K are growing in popularity and, therefore, energy conservation standards within that range are justifiable (NEMA, No. 26 at pp. 3–4).

NEMA also stated that an efficacy standard would be inappropriate for GSFL with a CCT greater than 7,000K. Because very few GSFL with a CCT greater than 7,000K are commercially available, NEMA argued that it would be impossible to determine whether there would be an appropriate efficacy standard for these lamps that would be technologically feasible. (NEMA, No. 26 at pp. 5–6) NEMA also stated that it is unlikely that exempting these high CCT lamps would increase their sales after a standard, as these lamps are often too ''blue'' for typical consumers. Therefore, NEMA urged DOE to exempt all lamps with a CCT greater than 7,000K from energy conservation standards (NEMA, No. 26 at pp. 3–4).

DOE considered NEMA's input and agrees that because so few of these products with a CCT greater than 7,000K exist in the market, there is not enough information to reliably analyze the performance of currently-available products or the expected performance of emerging products. Manufacturing lamps with CCTs greater than 7,000K would likely require the use of new materials not currently utilized in commonly sold lamps today. In addition, manufacturers may encounter different design trade-offs when developing their products Therefore, DOE is unable to determine whether a particular standard level would be technologically feasible for these lamps.

DOE also agrees that it is appropriate to raise the 6,600K limit to 7,000K in the definition of ''colored fluorescent lamp.'' DOE believes that this amendment would further the statutory objective of maintaining the coverage of GSFL serving general application purposes under DOE's energy conservation standards. Although lamps with CCTs greater than 6,600K and less than 7,000K are not prevalent in the market, DOE's research[14] indicates that manufacturers would likely be able to produce a lamp at 7,000K using the same materials as a 6,500K lamp (a commonly sold lamp). In consideration of the technological similarity between 6,500K and 7,000K lamps, DOE believes that it would be possible to establish technologically feasible efficacy levels for 7,000K lamps.

Therefore, DOE proposes to modify the definition of ''colored fluorescent lamp'' so as to include lamps with CCT less than or equal to 7,000K exclude all lamps with a CCT greater than 7,000K from energy conservation standards. However, DOE notes that NEMA has offered to track the sales of GSFL with a CCT greater than 7,000K in order to determine in the future if energy conservation standards are necessary for these products. (NEMA, No. 26 at p. 4) If these lamp sales show significant growth, and thus the potential for significant energy savings, DOE may consider amending the definition of ''colored fluorescent lamp'' to provide for coverage of these lamps and setting an appropriate energy conservation standard for them in a future rulemaking.

As discussed in the March 2008 ANOPR, the discovery of a fluorescent lamp in the European market with a CCT of 17,000K being marketed for general illumination applications prompted DOE to consider actions to prevent such lamps from becoming a potential loophole to the GSFL energy conservation standard. However, the inherently ''blue'' color of these lamps may prevent widespread adoption as substitutes for standard CCT lamps (*e.g.,* 4,100K). Therefore, DOE no longer considers these lamps to be a potential loophole to standards set forth by this rulemaking. For this reason and because DOE is unable to determine a technologically feasible standard for these lamps, DOE believes that the addition of the phrase ''and not designed or marketed for general illumination applications'' with respect lamps with a CCT greater than 7,000K is no longer necessary.

After incorporating the changes discussed above, DOE proposes the following definition of ''colored fluorescent lamp'' for this notice:

Colored fluorescent lamp means either: (1) A fluorescent lamp designated and marketed as a colored lamp with a CRI less than 40, as determined according to the method set forth in CIE Publication 13.2 (10 CFR 430.3); (2) a fluorescent lamp designed and marketed as a colored lamp with a correlated color temperature (CCT) less than 2,500K; or (3) a fluorescent lamp with a CCT greater than 7,000K.

D. Off Mode and Standby Mode Energy Consumption Standards

Section 310(3) of EISA 2007 amended EPCA to require future energy conservation standards to address standby mode and off mode energy use. Specifically, EPCA, as amended, now requires that, when DOE adopts standards for a covered product after July 1, 2010, DOE must, if justified by the criteria for adoption of standards in 42 U.S.C. 6295(o), incorporate standby mode and off mode energy use into the standard, if feasible, or adopt a separate standard for such energy use for that product. (42 U.S.C. 6295(gg)(3)) DOE

[14] *Ex parte* communication with Edward Yandek of General Electric Company (Dec. 8, 2008) (DOE, No. 29).

notes that although the final rule in this standards rulemaking is scheduled for publication by June 2009 (*i.e.,* before the statutory deadline above), DOE nonetheless undertook a preliminary analysis of the potential for energy savings associated with the regulation of standby mode and off mode in covered lamps. DOE has tentatively determined that current technologies for the GSFL and IRL that are the subjects of this rulemaking do not use a standby mode or off mode, so a determination of the energy consumption of such features is inapplicable.

Given EISA 2007's definitions of ''active mode,'' ''off mode,'' and ''standby mode'' applicable to both GSFL and IRL, in order to meet the definition of ''off-mode'' or ''standby mode,'' the lamp must not be providing any active mode function (*i.e.,* emit light). However, to reach such a state, the lamp must be entirely disconnected from the main power source (*i.e.,* the lamp is switched off), thereby not satisfying the requirements of operating in off mode. In addition, DOE believes that all covered products that meet the definitions of ''general service fluorescent lamp'' and ''incandescent reflector lamp'' are single-function products and do not offer any secondary user-oriented or protective functions. Thus, GSFL and IRL do not satisfy the definition for ''standby mode.'' DOE received comments from NEMA in response to the March 2008 ANOPR supporting this characterization of off mode and standby mode energy consumption for these products. (NEMA, No. 22 at p. 1) Therefore, DOE maintains that it is not feasible to incorporate off mode or standby mode energy use into the energy conservation standards for GSFL and IRL and is not proposing amendments to the standard to address lamp operation in such modes. The March 2008 ANOPR provides additional details that support this conclusion. 73 FR 13620, 13627 (March 13, 2008).

E. Color Rendering Index Standards for General Service Fluorescent Lamps

Existing EPCA standards specify both lumens per watt and CRI levels that products must comply with before entering the market. (42 U.S.C. 6295(i)(1)) At the public meeting and in written comments, NEMA and the Joint Comment suggested that it may be necessary to amend the minimum CRI requirements to prevent the possible emergence of loopholes in the product classes structure and standards levels considered in the March 2008 ANOPR. (Public Meeting Transcript, No. 21 at pp. 82–84, 92, 94; Joint Comment, No. 23 at p. 6; NEMA, No. 22 at p. 4–5)

However, because CRI is not a measure of energy consumption or efficacy, but rather a measure of the color quality of the light, DOE has concluded that it does not have the authority to change the CRI standard, for the reasons that follow. According to 42 U.S.C. 6291(6), ''energy conservation standard'' means either: (1) A performance standard which prescribes a minimum level of energy efficiency or a maximum quantity of energy use; or (2) a design requirement (only for specifically enumerated products). Although CRI is a performance requirement, it is not an energy performance requirement within the meaning of the term ''energy conservation standard.'' Because, in the case of GSFL, DOE has the authority to regulate only energy conservation standards (*i.e.,* energy performance requirements), DOE is not proposing to amend the existing minimum CRI requirements.

IV. General Discussion

A. Test Procedures

DOE's test procedures for fluorescent and incandescent lamps are set forth at 10 CFR part 430, subpart B, appendix R.[15] These test procedures provide detailed instructions for measuring GSFL and IRL performance, as well as performance attributes of GSIL, largely by incorporating several industry standards. Prompted by an earlier NEMA comment (NEMA, No. 12, pp. 2–4) at the Framework stage of the energy conservation standards rulemaking, DOE examined these test procedures and decided to initiate a rulemaking, in parallel with this standards rulemaking, to revise its test procedures for GSFL, IRL, and GSIL (even though, as explained above, GSIL are no longer part of this standards rulemaking). These revisions consist largely of: (1) Referencing the most current versions of several lighting industry standards incorporated by reference; (2) adopting certain technical changes and clarifications; (3) expanding the test procedures to accommodate new classes of lamps subject to extended coverage by either EISA 2007 or this energy conservation standards rulemaking; and (4) addressing standby mode and off mode energy consumption (which were found not to apply to GSFL and IRL), as mandated by EISA 2007.

To this end, DOE published a NOPR that proposed to update the current test procedure's references to industry standards for fluorescent and incandescent lamps. 73 FR 13465 (March 13, 2008) (the test procedure NOPR). The test procedure NOPR also proposed the following: (1) A small number of definitional and procedural modifications to the test procedure to accommodate technological migrations in the GSFL market and approaches DOE is considering in this standards rulemaking (73 FR 13465, 13472–73 (March 13, 2008)); (2) revision of the reporting requirements for GSFL, such that all covered lamp efficacies would be reported with an accuracy to the tenths decimal place (73 FR 13465, 13473 (March 13, 2008)); and (3) adoption of a testing and calculation method for measuring the CCT of fluorescent and incandescent lamps (73 FR 13465, 13473–74 (March 13, 2008)). Please see the March 2008 ANOPR (73 FR 13620, 13627–28 (March 13, 2008)) and the March 2008 test procedure NOPR (73 FR 13465, 13472–74 (March 13, 2008)) for a detailed discussion of these proposals and related matters.

The public meeting for the March 2008 ANOPR also served as a public meeting to present and receive comments on the test procedure NOPR. DOE later received written remarks from NEMA responding to the proposals contained in the test procedure NOPR. (NEMA, No. 16)[16] DOE is considering these comments, and will be publishing a final rule in the near future.

B. Technological Feasibility

1. General

In each standards rulemaking, DOE conducts a screening analysis, which it bases on information it has gathered on all current technology options and prototype designs that could improve the efficiency of the product or equipment that is the subject of the rulemaking. DOE considers a design option to be ''technologically feasible''[17] if it is in the marketplace or if research has progressed to the development of a working prototype.

In consultation with manufacturers, design engineers, and other interested parties, DOE develops a list of design options for consideration in the rulemaking. In the context of the present rulemaking, when determining

[15] ''Uniform Test Method for Measuring Average Lamp Efficiency (LE) and Color Rendering Index (CRI) of Electric Lamps.''

[16] This written comment was submitted to the docket of the test procedure rulemaking (Docket No. EERE–2007–BT–TP–0013; RIN number 1904–AB72).

[17] DOE's regulations set forth the following definition of ''technological feasibility'': ''Technologies incorporated in commercially available products or in working prototypes will be considered technologically feasible.'' 10 CFR 430, subpart C, appendix A, section 4(a)(4)(i).

proposed efficacy levels for GSFL, DOE only considered commercially-available products that can meet or exceed each level. For IRL, trial standard levels 2, 3, 4, and 5 are based on commercially-available products. Although TSL1 is not based on product currently sold in the marketplace, DOE has used a design option (*i.e.*, higher-efficiency gas fills) to model the performance of a higher-efficacy lamp that meets TSL1. DOE received input from manufacturers during interviews to verify that such a design option is technologically feasible. Therefore, DOE has concluded that the all design options to achieve the proposed efficacy levels are technologically feasible.

Once DOE has determined that particular design options are technologically feasible, it evaluates each design option in light of the following criteria: (1) Practicability to manufacture, install, or service; (2) adverse impacts on product utility or availability; and (3) adverse impacts on health or safety. Chapter 4 of the TSD accompanying this notice contains a description of the screening analysis for this rulemaking. Also, see section 0 of this notice for a discussion of the design options DOE considered.

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt or to decline to adopt an amended or new standard for a type (or class) of covered product, as part of the rulemaking process, DOE must ''determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible'' for the product. (42 U.S.C. 6295(p)(1)) In response to the ANOPR, stakeholders commented that 42 U.S.C. 6295(o) requires that DOE evaluate the maximum technologically feasible, or ''max-tech,'' potential standard efficiency levels. They assert that because DOE has gathered only technical information based on products available on the market today, it may not have considered those products that are technically feasible but not yet marketed. If such options are available, stakeholders believe DOE should model them as the max-tech efficiency levels. (Joint Comment, No. 23 at p. 19)

DOE researched whether any technologies could improve the efficacy of GSFL lamps currently marketed. DOE found that higher efficacy GSFL could be achieved but require the use of a higher efficiency fill gas composition. More efficient fill gases often include higher molecular weight gases (*e.g.*, krypton) to increase ultraviolet light output, and, thus, visible light output. However, the use of these heavier gases can cause lamp instability, resulting in striations or flickering. Evidence of this effect can be seen with reduced-wattage lamps, which generally incorporate a mixture of krypton and argon gases, versus full-wattage lamps which primarily use only argon. Reduced-wattage lamps are often marketed with several application-limiting performance notes. For example, NEMA stated reduced-wattage lamps can have performance issues in low-temperature applications or when operated on rapid start or dimming ballasts. (NEMA, No. 21 at p. 10) Therefore, DOE did not consider efficacy levels for GSFL that would require the use of higher-efficiency fill gases that would result in reduced utility. DOE was unable to find any higher-efficacy prototypes or commercially-available lamps that provide the same utility and performance required of GSFL. Therefore, DOE has concluded that TSL5 was the maximum technologically feasible level for GSFL.

For IRL, DOE determined that the maximum technologically feasible efficacy level incorporates the highest technologically feasible efficiency reflector, halogen infrared coating, and filament design. From its research, DOE believes that the highest efficiency reflector employs silver, a technology that DOE understands to be proprietary. From discussions with developers of IR coating technology, DOE understands that by modifying the coating pattern and materials used, varying degrees of IR coating efficiencies can be achieved. Finally, altering filament design to obtain the highest temperature filament operation, while maintaining a lifetime similar to the baseline lamp (3,000 hours), would result in the most efficacious filament. Combining all three of these highest efficiency technologies simultaneously results in the maximum technologically feasible level; however, this level is dependent on the use of a proprietary technology (the silver reflector). Because DOE is unaware of any alternate technology pathways to achieve this efficacy level, DOE did not consider it in its analysis. Instead, DOE based the highest efficacy level analyzed for IRL on a commercially-available IRL which employs a silver reflector, an improved (but not most efficient) IR coating, and a filament design that results in a lifetime of 4,200 hours. Although, this commercially-available lamp uses silver technology, DOE believes that there are alternate pathways to achieve this level. A combination of redesigning the filament to achieve higher temperature operation (and thus reducing lifetime to 3,000 hours), employing other non-proprietary high-efficiency reflectors, or applying higher-efficiency IR coatings has the potential to result in an IRL that meets an equivalent efficacy level. For more information regarding these technologies, see chapter 3 of the TSD. Therefore, DOE has concluded that TSL5 is the maximum technologically feasible level for IRL that is not dependent on the use of a proprietary technology.

Table IV.1 and Table IV.2 list the max-tech levels (TSL5 for GSFL and TSL5 for IRL) that DOE determined for this rulemaking.[18]

TABLE IV.1—MAX-TECH LEVELS FOR GSFL

Lamp type	CCT	Max-tech efficiency lm/W
4-Foot Medium Bipin	≤ 4,500K	94
8-Foot Single Pin Slimline	≤ 4,500K	100
8-Foot RDC HO	≤ 4,500K	95
4-Foot T5 SO	≤ 4,500K	108
4-Foot T5 HO	≤ 4,500K	92

[18] As discussed in section V.C, due to scheduling and resource constraints, DOE did not analyze all GSFL and IRL product classes. Instead, DOE chose representative product classes to directly analyze and scaled analytical results to the remaining product classes. Table IV.1 and Table IV.2 present max-tech levels for only analyzed product classes. Classes not analyzed include the 2-foot U-shaped and high-CCT product classes (for GSFL) and the modified spectrum, ≥ 125 volts, and ≤ 2.5 inches diameter product classes (for IRL).

TABLE IV.2—MAX-TECH LEVEL FOR IRL

Lamp type	Diameter	Voltage	Max-tech efficiency lm/W
Standard Spectrum	> 2.5 inches	< 125	$6.9P^{0.27}$ *

* Where P is the rated wattage.

C. Energy Savings

1. Determination of Savings

DOE used its NIA spreadsheets to estimate energy savings from amended standards for the lamps currently covered by standards and from new standards for the remaining additional lamps that are the subject of this rulemaking. (The NIA spreadsheet models are described in section V.E of this notice and in chapter 11 of the TSD.) DOE forecasted energy savings over the period of analysis (beginning in 2012, the year that amended standards would go into effect, and ending in 2042) for each TSL. It quantified the energy savings attributable to amended and new energy conservation standards (*i.e.,* to each TSL) as the difference in energy consumption between the standards case and the base case. The base case represents the forecast of energy consumption in the absence of amended and new mandatory energy conservation standards. The base case considers market demand for more-efficient products. For example, for both GSFL and IRL, DOE models a shift in the base case from covered GSFL and IRL toward emerging technologies such as light emitting diodes (LED). In addition, consistent with current GSFL market trends, DOE models a shift from T12 lamps to higher-efficacy T8 and T5 lamps. For IRL in the commercial sector, the base-case shipments forecast also considers a migration from halogen IRL to higher-efficacy halogen infrared (HIR) lamps. See section 0 of this notice and chapter 10 of the TSD for details.

The NIA spreadsheet models calculate the energy savings in site energy expressed in kilowatt-hours (kWh). Site energy is the energy directly consumed at building sites by GSFL or IRL. DOE reports national energy savings in terms of the source energy savings, which is the savings in the energy that is used to generate and transmit the energy consumed at the site. To convert site energy to source energy, DOE uses annual site-to-source conversion factors based on the version of the National Energy Modeling System (NEMS) that corresponds to Annual Energy Outlook 2008 (*AEO2008).* The conversion factors vary over time because of projected changes in the nation's portfolio of generation sources. DOE estimated that conversion factors remain constant at 2030 values throughout the remainder of the forecast. See chapter 11 of the TSD for details.

2. Significance of Savings

Section 325 of EPCA prohibits DOE from adopting a standard for a covered product if that standard would not result in ''significant'' energy savings. (42 U.S.C. 6295(o)(3)(B)) While the term ''significant'' is not defined in EPCA, the U.S. Court of Appeals, in *Natural Resources Defense Council* v. *Herrington*, 768 F.2d 1355, 1373 (DC 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 are nontrivial, and therefore, DOE considers them ''significant'' within the meaning of section 325 of EPCA.

D. Economic Justification

1. Specific Criteria

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

a. Economic Impact on Manufacturers and Consumers

To determine the quantitative impacts of a new or amended standard on manufacturers, the economic impact analysis is based on an annual-cash-flow approach. This includes both a short-term assessment—based on the cost and capital requirements during the period between the announcement of a regulation and the regulation's effective start date—and a long-term assessment. The 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 appropriate measures of impact. Second, DOE analyzes and reports the impacts on different types of manufacturers, with particular attention to impacts on small manufacturers. Third, DOE considers the impact of standards on domestic manufacturer employment, manufacturing capacity, plant closures, and loss of capital investment. Finally, DOE takes into account cumulative impacts of different DOE and other regulations on manufacturers.

For consumers, measures of economic impact include the changes in price, LCC, and payback period for each trial standard level. The LCC is one of the seven factors to be considered in determining the economic justification for a new or amended standard. (42 U.S.C. 6295(o)(2)(B)(i)(II))

b. Life-Cycle Costs

The LCC is the sum of the purchase price of a product (including its installation) and the operating expense (including energy and maintenance expenditures) discounted over the lifetime of the product. For each GSFL and IRL product class, DOE calculated both LCC and LCC savings for various efficacy levels. The LCC analysis required a variety of inputs, such as product prices, installation labor costs, electricity prices, annual operating hours, product energy consumption rates, and discount rates.

To characterize variability in electricity pricing, DOE established regional differences in electricity prices. To account for uncertainty and variability in other inputs, such as annual operating hours and discount rates, DOE used a distribution of values with probabilities assigned to each value. Then for each consumer, DOE sampled the values of these inputs from the probability distributions. The analysis produced a range of LCCs. A distinct advantage of this approach is that DOE can identify the percentage of consumers achieving LCC savings due to an increased energy conservation standard, in addition to the average LCC savings. DOE presents only average LCC savings in this NOPR; however, additional details showing the distribution of results can be found in chapter 8 and appendix 8B of the TSD.

In the LCC analysis, DOE also considered several events that would prompt a consumer to purchase a lamp. For GSFL, DOE calculated LCCs for five lamp purchasing events: (1) Lamp failure; (2) standards-induced retrofit;

(3) ballast failure; (4) ballast retrofit; and (5) new construction/renovation. For IRL, DOE calculated LCCs for the lamp failure and new construction/renovation events, as these were the only lamp purchase events deemed applicable to this product type. Because each event may present the consumer with different lamp (or lamp-and-ballast) options and economics, DOE presents the LCC results for several events for each product class in this NOPR. DOE assumed that the consumer purchases the product in 2012 (the effective start date of the standard). For further detail regarding lamp purchasing events and related LCC calculations, see section V.D and chapter 8 of the TSD.

c. Energy Savings

While significant conservation of energy is a separate statutory requirement for adopting an energy conservation standard, EPCA requires DOE, in determining the economic justification of a standard, to consider the total projected energy savings that are expected to result directly from the standard. (42 U.S.C. 6295(o)(2)(B)(i)(III)) DOE used the NES spreadsheet results in its consideration of total projected savings.

d. Lessening of Utility or Performance of Products

In establishing classes of products, and in evaluating design options and the impact of potential standard levels, DOE aimed to develop standards for GSFL and IRL that would not lessen the utility or performance of these products. None of the considered trial standard levels would reduce the utility or performance of the GSFL and IRL under consideration in the rulemaking. (42 U.S.C. 6295(o)(2)(B)(i)(IV))

Since all standard levels for GSFL use full-wattage lamps, rather than requiring a shift to higher-efficacy reduced-wattage lamps (which may have application restrictions), no GSFL efficacy levels reduce the utility or performance of the covered products. For IRL, for all standard levels, there are commercially available IRL with the same utility and performance as the baseline lamps. Therefore, DOE believes that none of the considered trial standard levels would reduce the utility or performance of the IRL under consideration in this rulemaking.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider any lessening of competition likely to result from standards. It directs the Attorney General to determine the impact, if any, of any lessening of competition likely to result from a proposed standard and to transmit such determination to the Secretary no later than 60 days after the publication of a proposed rule, together with an analysis of the nature and extent of such impact. (42 U.S.C. 6295(o)(2)(B)(i)(V) and (B)(ii)) DOE has transmitted a copy of today's proposed rule to the Attorney General and has requested that the Department of Justice (DOJ) provide its determination on this issue. DOE will address the Attorney General's determination in the final rule.

f. Need of the Nation To Conserve Energy

The non-monetary benefits of the proposed standard are likely to be reflected in improvements to the security and reliability of the Nation's energy system—namely, reductions in the overall demand for energy will result in reduced costs for maintaining the Nation's electricity system. DOE conducts a utility impact analysis to estimate how standards may affect the Nation's needed power generation capacity. This analysis captures the effects of efficiency improvements on electricity consumption by the covered products that are the subject of this rulemaking.

The proposed standard also is likely to result in improvements to the environment. In quantifying these improvements, DOE has defined a range of primary energy conversion factors and associated emission reductions based on the estimated level of power generation displaced by energy conservation standards. DOE reports the environmental effects from each TSL for this equipment in the environmental assessment in the TSD. (42. U.S.C. 6295(o)(2)(B)(i)(VI) and 6316(a))

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)) Under this provision, DOE considered subgroups of consumers that may be adversely affected by the standards proposed in this rule. Specifically, DOE assessed the impact of standards on low-income consumers, institutions of religious worship, historical facilities, and institutions that serve low-income populations. In considering these subgroups, DOE analyzed variations on electricity prices, operating hours, discount rates, and baseline lamps. See section 0 of this notice for further detail.

2. Rebuttable Presumption

As set forth in section 325(o)(2)(B)(iii) of EPCA, there is a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard level is less than three times the value of the first-year energy (and, as applicable, water) savings resulting from the standard, as calculated under the applicable DOE test procedure. (42 U.S.C. 6295(o)(2)(B)(iii) and 42 U.S.C. 6316(e)(1)) DOE's LCC and PBP analyses generate values that calculate the payback period for consumers of potential energy conservation standards, which includes, but is not limited to, the three-year payback period contemplated under the rebuttable presumption test discussed above. However, DOE routinely conducts a full economic analysis that considers the full range of impacts, including those to the consumer, manufacturer, Nation, and environment, as required under 42 U.S.C. 6295(o)(2)(B)(i) and 42 U.S.C. 6316(e)(1)). The results of this analysis serve as the basis for DOE to definitively evaluate the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). Section 0 of this notice addresses the rebuttable-presumption payback calculation.

V. Methodology and Discussion of Comments

A. Product Classes

In general, in evaluating and establishing energy conservation standards, DOE divides covered products into classes by the type of energy used, capacity, or other performance-related features that affect efficiency, and factors such as the utility of the product to users. (42 U.S.C. 6295(q)) DOE normally establishes different energy conservation standards for different product classes based on these criteria.

1. General Service Fluorescent Lamps

In the March 2008 ANOPR, DOE proposed to establish product classes for GSFL based on the following three attributes that have differential utility and affect efficacy: (1) Physical constraints of lamps (*i.e.*, lamp shape and length); (2) lumen package (*i.e.*, standard versus high output); and (3) correlated color temperature. 73 FR 13620, 13636 (March 13, 2008). The following sections summarize and address comments DOE received in response to the GSFL product classes it considered for the March 2008 ANOPR.

DOE received comments related to product classes on three major topics: T12 and T8 lamps, T5 lamps, and correlated color temperature.

a. T12 and T8 Lamps

The physical constraints of the lamp relate to the shape of the lamp (*e.g.*, U-shaped versus linear) and the fact that these lamps could not be substitutes for each other, unless the entire fixture is changed. The lamp shapes provide unique utility because the shapes of these lamps prevent them from being used as replacements, even with a ballast replacement, in a given fixture. However, the shape and geometry of a lamp also impact its efficacy. In the March 2008 ANOPR, DOE acknowledged that a lamp's diameter can affect its efficacy. However, because the utility provided to the end-user is a function of the light output in lumens (which is comparable between T12 and T8 lamps) and not diameter of the bulb, DOE decided not to establish separate product classes for T12 and T8 lamps.

At the public meeting and in its written comments, NEMA stated that separate product classes might be necessary for T8 and T12 lamps. Both NEMA and General Electric (GE) noted that DOE used the 10-percent efficacy differential between 8-foot slimline and 8-foot high output lamps as one reason for establishing their separate product classes. They reasoned that because T8 lamps are at least 10 percent more efficient that T12 lamps, DOE should also split T8 and T12 lamps into separate classes. (Public Meeting Transcript, No. 21 at pp. 82–86; NEMA, No. 22 at p. 5) GE emphasized that because T8 and T12 lamps require different ballasts and because a growing number of new T8 fixtures will not fit T12 lamps, the two are not always suitable replacements and should therefore have separate product classes. GE also expressed concern that it would be impossible to set a single efficacy standard using a lumen-per-watt metric that would be suitable for both T8 and T12 lamps. (Public Meeting Transcript, No. 21 at pp. 88–89)

Conversely, the Joint Comment strongly supported combining T8 and T12 lamps under one product class because the lamps are the same length, use the same lamp holders, and provide the same utility (as measured by lumen package). At the public meeting, ACEEE emphasized that the two lamps compete directly in the marketplace because of their similar performance features. ACEEE also expressed concern that setting product classes based on efficacy could lead to separate standards for any inefficient product. (ACEEE, No. 22 at p. 91) The Joint Comment also stated that the fact that the two lamps use different ballasts is an economic issue, not a utility issue. The Joint Comment noted that large energy savings would be lost if DOE used separate classes because consumers would not migrate to the more efficient T8 lamps—a factor DOE must consider, given its obligation to set standards at the ''maximum improvement in energy efficiency'' that is ''technologically feasible and economically justified.'' (Joint Comment, No. 23 at pp. 4–5)

DOE research shows that T8 lamps are commonly used to replace T12 lamps; this implies that, in this case, lamp diameter does not significantly affect lamp utility. It also illustrates that the lamps share performance features and compete directly in the market. While DOE recognizes that lamp diameter can affect efficacy, lamp efficacy alone is not a criterion DOE uses to establish product classes; to warrant a separate product class, a unique utility feature must be present. As DOE has not identified a unique utility feature of T12 lamps, DOE has decided to combine both T8 and T12 lamps into one product class for each lamp type. However, in response to GE's comment, DOE recognizes that T8 and T12 lamps usually operate on different ballasts. Thus, DOE has structured its analytical tools to consider the impact of standards on consumers of both lamp types. That is, DOE takes the economics of purchasing another ballast into account in its LCC and NIA analyses.

b. T5 Lamps

The Joint Comment stated that T5 lamps (in this rulemaking, referred to as 4-foot miniature bipin lamps) should probably be in the same product class as T8 and T12 lamps because they compete against them in the market. The advocates noted the existence of retrofitting kits for installing T5 lamps into T8 and T12 fixtures, but acknowledged T5 lamps require different lamp holders and are ''too bright to use in direct lighting fixtures.'' The Joint Comment asked DOE to research the pros and cons of including T5 lamps with T8 and T12 lamps. (Joint Comment, No. 23 at p. 5)

Based on its research and consideration of the above comments, DOE has decided to establish a separate product class for 4-foot miniature bipin lamps because their physical constraints prevent them from being used as direct replacements for T8 and T12 lamps in many applications. For example, applications in which consumers cannot change the lamp fixture (from a 4-foot MBP to a 4-foot MiniBP) may not be appropriate for retrofitting to the 4-foot MiniBP system type. As the Joint Comment noted, these lamps require different lamp holders (due to differences in length and base type), and thereby qualify for a separate product class under the previously established ''physical constraints of lamps'' class-setting criteria.

In addition, a lamp's lumen package may result in certain application constraints. Because 4-foot T5 MiniBP lamps have similar total lumen output as 4-foot T8 and T12 MBP lamps over a significantly smaller surface area, T5 lamps are often marketed as too bright for use in direct lighting fixtures. If 4-foot T5 MiniBP lamps were regulated in the same product class as 4-foot MBP lamps, the standard could effectively mandate the use of T5 lamps. To prevent eliminating lamps appropriate for direct lighting applications, DOE believes that 4-foot miniature bipin lamps (T5 lamps) warrant a separate product class from 4-foot medium bipin lamps (primarily T8 and T12 lamps).

In researching these lamp types, DOE found that the high output lamp is rated to emit more than one and a half times the number of lumens as the standard output lamp, also potentially affecting utility. In general, lamps that have high lumen output may be installed in certain high-ceiling or outdoor installations, where large quantities of light are needed. Lamps that have standard levels of light output might be installed in lower-ceiling installations such as offices or hospitals, where distance between the light source and the illuminated surfaces is not as large. DOE also found that this significant lumen output differential in standard output and high output T5 lamps is accompanied by an efficacy difference. Considering the differences in utility (light output and their applicability in direct lighting fixtures) and efficacy, and consistent with DOE's approach in the March 2008 ANOPR, DOE is proposing separate product classes for standard output 4-foot miniature bipin lamps and high output 4-foot miniature bipin lamps.

c. Correlated Color Temperature

Correlated color temperature is a measure of the perceived color of the white light emitted from a lamp, which DOE believes affects lamp utility. Generally, as CCT increases, efficacy of the bulb decreases. The measured efficacy of lamps with different CCT is different because efficacy is measured in lumens per watt, and light emitted across the visible spectrum is not given equal weighting under this metric. Lumens are determined using the human eye's sensitivity function, and due to the fact that the human eye is less responsive to blue light, those fluorescent lamps that shift their spectral emission profiles to contain more blue light will have lower efficacies. In the March 2008 ANOPR, DOE established two product classes for GSFL based on CCT: one for high-color-temperature lamps greater than 4,500K, and another for lamps less than 4,500K.

At the public meeting and in its written comments, NEMA agreed with DOE's decision to establish two product classes based on CCT. However, at the public meeting NEMA noted additional divisions may be necessary at higher CCT levels because these lamps—NEMA specifically noted an 8,000K lamp—are capturing an increasing market share of general service applications. (Public Meeting Transcript, No. 21 at pp. 95–97) Industrial Ecology stated that lamps around 6,500K, which were once reserved for specialty applications, are increasingly being used in general service applications. Industrial Ecology argued that such a trend supports the idea of another product class above the 4,500K division. (Public Meeting Transcript, No. 21 at pp. 97–98).

At the June 2008 NEMA meeting and in a written comment, NEMA commented that growth in higher CCT lamps would likely come at the 5,000K level, although they would remain a relatively small portion of the general service market for the foreseeable future. Lamps with CCTs greater than 7,000K represent a very small portion of the general service market because most consumers consider their light to be too blue. Given the small market for lamps above 7,000K, NEMA stated it had very little practical production data related to efficacies and costs. Therefore, NEMA argued, lamps above 7,000K should be exempt from standards, especially considering that the current energy savings potential from their coverage is very small and unlikely to grow anytime soon. (NEMA, No. 26 at pp. 3–4)

NEMA also commented that an equation using a continuous function (without discontinuities) is inappropriate when developing an efficacy standard for GSFL based on CCT. According to NEMA, practical lamp designs used to develop higher CCT lamps—such as phosphor design, weight and coating formulation, and coating adherence—do not provide for a general physical equation that yields an optimum lumens-per-watt standard. Instead, NEMA stated that successive step function factors need to be applied as CCT continues to increase. (NEMA, No. 26 at p. 5) The Joint Comment said that DOE should design CCT product class divisions carefully to prevent ''gaming.'' The advocates preferred a continuous function to multiple product class divisions because the latter would encourage products to migrate to the lowest CCT value in each product class. If a continuous function were not possible, the Joint Comment strongly recommended raising the 4,500K division to 4,900K. Additionally, the Joint Comment stated, if DOE does set a product class aimed at regulating the 8,000K lamps, the boundary should be approximately 7,900K. (Joint Comment, No. 23 at pp. 5–6)

As noted above, DOE believes CCT affects consumer utility. For example, a lighting designer would likely consider the bluish color of higher color temperature lamps when specifying a luminaire for a particular application. In addition, as NEMA stated, higher CCT lamps are sometimes used for spectrally-enhanced lighting (SEL).[19] Advocates of spectrally-enhanced lighting believe that lamps with a higher CCT can help save energy and may also have health benefits. (NEMA, No. 26 at pp. 2–3) However, DOE notes that although spectrally-enhanced lighting has benefits, higher CCT lamps do emit a different color light that may not be appropriate for all applications. Given the effect on utility and the fact that lamp efficacy usually decreases with higher color temperatures, it is appropriate to establish different product classes based on CCT.

DOE agrees that a continuous function is not possible because increasing the CCT does not lead to proportional reductions in lumens per watt. This occurs because design factors that do not have a linear relationship with lumens per watt, such as rare earth phosphor mix and reformulation, must be employed to maintain efficacy, particularly as CCT increases.

DOE disagrees that a 4,900K division should be used rather than the proposed 4,500K division. If DOE were to use a 4,900K division and manufacturers introduced a 4,850K lamp to the market, it would be subject to standards based on the performance of a 4,100k lamp, which might be difficult to meet, as 4,100K lamps are generally more efficacious than their higher CCT counterparts. Likewise, if DOE used a 4,200K division and manufacturers developed a 4,300K lamp for commercial use, it would be subject to potentially lower standards based on the performance of a 5,000k lamp. This may result in a significant loss in potential energy savings. Instead, DOE proposes to use a 4,500K division, which effectively represents the midpoint between the most common commercially available ''warmer'' and ''cooler'' lamps at 4,100K and 5,000K, respectively. By establishing the product class division at the midpoint, DOE ensures that it is establishing a structure that will not subject lamps to inappropriately high standards and also not result in the loss of potential energy savings.

DOE also disagrees with the Joint Comment's argument for a third product class division around 7,900K aimed at 8,000K lamps. As discussed in section III.C.2, DOE is amending its definition of ''colored fluorescent lamp,'' such that these lamps above 7,000K would be excluded from coverage by energy conservation standards. In consideration of this exclusion, DOE feels that is unnecessary to establish a third product class for lamps with a CCT greater than 7,900K.

2. Incandescent Reflector Lamps

In the March 2008 ANOPR, DOE considered product classes for IRL based on the standard-spectrum and modified-spectrum of the lamp. DOE received numerous comments regarding establishing separate product classes for: (1) Modified-spectrum lamps; (2) long-life lamps; (3) lamp diameter; and (4) voltage. The following sections summarize and address these comments.

a. Modified-Spectrum Lamps

Modified-spectrum lamps provide a unique performance-related feature to consumers, in that they offer a different spectrum of light from the typical incandescent lamp, much like two fluorescent lamps with different CCT values. These lamps offer the same benefits as fluorescent lamps with ''cooler'' CCTs, in that they may ensure better color discrimination and often appear more similar to natural daylight, possibly resulting in psychological benefits.[20] In addition to providing a unique performance feature, DOE also understands that the technologies that modify the spectral emission from these lamps also decrease their efficacy because a portion of the light emission

[19] DOE has conducted several studies on SEL examining whether a significant amount of energy can be saved by using lamps that have less light output, but higher CCT. Lamps with higher CCT appear brighter than those with lower CCT, so the actual light output of higher-CCT lamps can be decreased, while maintaining equivalent perceived brightness and visual acuity. More information on spectrally enhanced lighting is available at: *http://www1.eere.energy.gov/buildings/spectrally_enhanced.html*.

[20] ''Full Spectrum Q&A,'' National Lighting Product Information Program, Vol. 7 Issue 5 (March 2005). Available at: *http://www.lrc.rpi.edu/programs/nlpip/lightingAnswers/fullSpectrum.*

is absorbed by the coating. NEMA and GE supported establishing separate product classes for modified-spectrum lamps. (Public Meeting Transcript, No. 21 at p. 105; NEMA, No. 22 at p. 6).

However, the Joint Comment stated that separate product classes are unnecessary because modified-spectrum products which meet all efficacy levels DOE considered in the ANOPR already exist in the market place. The Joint Comment further argued that additive methods, used for some non-IRL technologies, boost particular visible wavelengths of light to achieve a modified spectrum. These methods represent a more efficient way to achieve a modified spectrum than subtractive methods commonly used for IRL, which filter particular visible wavelengths of light. Therefore, according to the Joint Comment, establishing a separate product class could reduce energy savings because modified-spectrum technology would be subject to a needlessly lower standard. The Joint Comment contended that such a situation would run counter to the rulemaking's goals. (Joint Comment, No. 23 at pp. 14–15) At the public meeting, ACEEE and PG&E questioned whether consumers receive additional utility from modified-spectrum lamps, and, if they do, whether it is sufficient to warrant a separate product class. ACEEE and PG&E suggested DOE analyze the energy savings that could be lost with a separate product class. PG&E further noted that consumers could obtain any additional utility that modified-spectrum lamps provide from other available light sources. (Public Meeting Transcript, No. 21 at pp. 101–103) PG&E commented that modified-spectrum lamps occupy significant retail shelf space, which suggests they have a significant market share, and therefore, present a significant energy savings opportunity. (Public Meeting Transcript, No. 21 at p. 104)

DOE maintains that modified-spectrum lamps provide a unique performance-related feature (a different spectrum of light from the typical incandescent lamp) that standard spectrum lamps do not provide. However, the coatings used for modified-spectrum IRL absorb light output, thus reducing the lamps' efficacies. Given the reduction in efficacy, DOE believes that some modified-spectrum lamps may not be able to meet standards if subjected to the same levels as standard-spectrum lamps. That, in turn, could cause the unavailability of such products, thereby eliminating this performance-related feature from the IRL market. DOE notes that the statute directs DOE to maintain performance-related features for a covered product type. (42 U.S.C. 6295(o)(4))

Regarding the Joint Comment's argument that higher-efficiency, additive technologies may be substituted for subtractive technologies currently used in modified-spectrum IRL lamps, DOE is unaware of any commercially-available IRL or working IRL prototype that employs these additive technologies. Although modified-spectrum LED products may be available, because DOE has determined that modified-spectrum lamps provide a unique performance-related feature, it is unable to subject them to standards that would result in the elimination of such IRL products from the market. Thus, DOE believes it is appropriate to establish a separate product class for modified-spectrum lamps based on their unique performance feature and the impact of this performance feature on product efficacy.

b. Long-Life Lamps

DOE received several comments regarding IRL with long lifetimes. At the public meeting, NEMA commented that lamp life is a top consideration for the lighting industry's customers, particularly large retailers. NEMA stated in its written comments that the current long-life lamps on the market might be jeopardized by the proposed standard levels, which could cause manufacturers to reduce lamp life to increase efficacy—a scenario not necessarily in the market's interest. (Public Meeting Transcript, No. 21 at pp. 177–178; NEMA, No. 22 at p. 17) Although NEMA did not explicitly request a separate product class, the Joint Comment argued that DOE should not establish a separate product class for long-life lamps, noting that other existing lamp types, including halogen infrared reflector lamps and CFLs, could adequately serve long-life applications. In support of their position, the advocates stated further that Congress did not establish a separate class for ''long life'' general service incandescent lamps. (Joint Comment, No. 23 at p. 15)

DOE considers lifetime an economic issue rather than a utility issue, and accounts for lifetime in its LCC and NPV calculations. Lifetime is not considered a utility issue because it does not change the light output of the lamp. As such, DOE did not establish a separate product class based on lamp lifetime. For more details, see the engineering analysis in section V.C.4.b and chapter 5 of the TSD.

c. Lamp Diameter

In its written comments, NEMA noted that smaller diameter lamps—specifically, PAR20 lamps—are inherently less efficient than larger diameter IRL. Manufacturing PAR20 lamps to be compliant with the same efficacy standards as larger lamps would be very difficult. NEMA also commented that the technology options available to larger lamps are not necessarily applicable to PAR20 lamps. For example, the most efficient double-ended infrared halogen burner is difficult to use in PAR20 lamps because of mounting considerations. (NEMA, No. 22 at p. 17)

In response, DOE believes that the IRL diameter provides a distinct utility to the consumer (such as the ability of reduced diameter lamps to be installed in smaller fixtures) and recognizes that efficacy declines with a smaller lamp diameter. A smaller diameter lamp has an inherently lower optical efficiency than a larger diameter lamp given a similar filament size. Therefore, DOE is proposing to establish separate product classes for lamps with a diameter of 2.5 inches or less and lamps with a diameter greater than 2.5 inches.

d. Voltage

In its written comments, NEMA mentioned that DOE's proposed product classes and standards do not address how the market actually uses 130 volt (V) lamps, which represent a sizable portion of standard halogen product sales. NEMA stated that customers almost always operate these 130V lamps at 120V (normal line voltage), which doubles their lifetime but reduces their efficacy below standard levels. (NEMA, No. 22 at p. 16)

DOE agrees with NEMA and is concerned that the operation of 130V lamps at 120V has the potential to significantly affect energy savings. When operated under 120V conditions, lamps rated at 130V in compliance with existing IRL efficacy standards are generally less efficacious than lamps using equivalent technology rated at 120V. Because of this inherent difference in efficacy, it may be less costly to manufacture a lamp rated at 130V and tested at 130V that complies with a standard than a similar 120V lamp complying with the same standard. For example, if DOE were to adopt a minimum efficacy requirement that would effectively require HIR technology for 120V lamps, due to differences in the test procedures for lamps rated at 130V, a 130V lamp may only need to employ an improved halogen technology, which would be less costly. If DOE does not establish a separate standard for lamps rated at 130V, more consumers may purchase 130V lamps because they are less expensive. When consumers operate these lamps at 120V, in order to obtain sufficient light output, they may use more energy than standards-compliant 120V lamps. This practice would increase energy consumption and result in lamps operating with a lower efficacy than any cost-justified standard level. Therefore, to preserve the energy savings intended by these standards, DOE is proposing to establish two separate product classes: (1) Lamps with a rated voltage less than 125V, and (2) lamps with a rated voltage greater than or equal to 125V.

DOE recognizes that there are other possible approaches for addressing this issue of the operational efficacy of 130V lamps. One alternative approach would be that DOE could require all IRL to be tested at 120V, the most common application voltage in the market. DOE requests comment on this issue.

B. Screening Analysis

DOE uses the following four screening criteria to determine which design options are unsuitable for further consideration in the rulemaking:

(1) *Technological Feasibility.* DOE will consider technologies incorporated in commercial products or in working prototypes to be technologically feasible.

(2) *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.

(3) *Adverse Impacts on Product Utility or Product Availability.* If DOE determines a technology would have significant adverse impact on the utility of the product to significant subgroups of consumers, or would result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not consider this technology further.

(4) *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.

10 CFR part 430, subpart C, appendix A, (4)(a)(4) and (5)(b).

Considering these criteria, DOE compiled a list of design options in the March 2008 ANOPR that could be used to increase the efficacy of GSFL and IRL lamps (Table V.1). 73 FR 13620, 13644 (March 13, 2008).

TABLE V.1—GSFL AND IRL DESIGN OPTIONS

GSFL design options	IRL design options
Highly emissive electrode coatings	Higher temperature operation.
Higher efficiency lamp fill gas composition	Thinner filaments.
Higher efficiency phosphors	Efficient filament coiling.
Glass coatings	Efficient filament orientation.
Higher efficiency lamp diameter	Higher efficiency inert fill gas.
	Tungsten-halogen lamps.
	Higher pressure tungsten-halogen lamps.
	Infrared glass coatings.
	Higher efficiency reflector coatings.
	Efficient filament placement.

DOE received a number of comments in response to its list of proposed design options, as discussed below.

1. General Service Fluorescent Lamps

NEMA generally agreed with the list of design options, but mentioned that for GSFL, further efficacy improvement will likely come from improved system (lamp-ballast-luminaire) combinations, and urged DOE to aim in future rulemakings to improve overall systems. (NEMA, No. 22 at p. 9; Public Meeting Transcript, No. 21 at pp. 108–109)

DOE understands that the fluorescent lamp is only one part of a fluorescent lamp system, which also includes ballasts and fixtures. However, DOE does not have the authority to regulate a fluorescent lamp system. EPCA prescribes energy conservation standards for certain GSFL (42 U.S.C. 6295(i)(1)(B)) and fluorescent lamp ballasts. (42 U.S.C. 6295(g)(7)) EPCA does not contain any standards for fluorescent lamp systems. Since EPCA directs DOE to amend only the existing standards for GSFL and fluorescent lamp ballasts, DOE has concluded that it does not have the authority to set energy conservation standards for fluorescent lamp systems. DOE believes other approaches, such as building codes, are more appropriate for regulating a fluorescent lamp system.

a. Higher-Efficiency Lamp Fill Gas Composition

NEMA commented that fill gas mixes are already in use in both T12 and T8 reduced-wattage energy savings lamps. NEMA stated that lamps could be manufactured using even higher efficiency fill gas compositions; however, the actual achieved lumen levels may be unacceptable to the market. NEMA also commented that most manufacturers identify several application-limiting issues for both T8 and T12 reduced-wattage energy saving lamps. (NEMA, No. 22 at pp. 7, 11–12)

DOE agrees that using fill gas composition in reduced-wattage lamps can lead to lamps with limited utility. For example, when marketed, many reduced wattage lamps are not recommended to be used under low lamp ambient temperatures or in drafty locations and on dimming ballasts. These situations could result in lamp starting or stabilization problems, striation (alternating light and dark bands), pulsing or a reduction in light output. Therefore, although DOE incorporates reduced-wattage lamps into the LCC and NIA (as they are viable and likely choices for most GSFL applications), DOE does not consider any efficacy level that would force consumers to purchase these lamps. See section V.C.4.a for details.

b. Higher-Efficiency Phosphors

NEMA commented that rare earth phosphors are already at nearly 100 percent quantum efficiency.[21] While slight improvements in efficacy are

[21] "Quantum efficiency," in this context, is used to quantify the percentage of ultraviolet photons absorbed by the phosphor that are then reemitted as visible photons.

possible with a thicker phosphor coating, NEMA argued that using this option will disproportionately increase lamp costs vis-à-vis the performance improvement. NEMA stated that the opportunities for performance improvement using phosphors ''lie in tailoring phosphor blends and color temperatures to optimize appropriate light sources for specific applications.'' (NEMA, No. 22 at p. 7)

While DOE agrees that thicker phosphor coats may increase cost, DOE does not consider increased costs in the screening analysis. DOE considers potential cost increases in its economic analyses. In addition, many higher-efficiency GSFL incorporate varying thicknesses of rare earth phosphors, or blends of halophosphors and rare earth phosphors. These lamps, more efficacious than their pure halophosphor counterparts, show that using higher-efficiency phosphors is a valid design option that meets all of the screening criteria. Therefore, DOE believes there is room for significant efficacy improvement potential with this design option and, thus, continued to carry it forward in its analyses.

c. Glass Coating

NEMA commented that higher-efficiency lamps already use glass coatings. NEMA also stated that while opportunities exist to improve this technology, manufacturers need to balance costs and performance. (NEMA, No. 22 at p. 7) DOE recognizes that costs may increase with this technology option, but as stated earlier, DOE does not consider the impacts of cost in its screening analysis. Therefore, DOE has included glass coatings as a design option for GSFL, where prototypes or commercially-available products exist.

d. Lamp Diameter

NEMA commented that lamp diameter is already used to optimize luminaire optics and system efficacy, but not to improve lamp efficacy. According to NEMA, further improvements in performance can come from new luminaire designs based on different diameter lamps, but will be limited by lumen packages and the distance between the light source and the luminaire surfaces. (NEMA, No. 22 at p. 7)

In response to this comment, DOE only considered lamp diameter as a design option in the migration from T12 to T8 lamps. DOE's research indicates that T8 lamps are common replacements for T12 lamps. Although the total lumen output of T8 lamps is often lower than that of T12 lamps, these differences in lumen outputs (on the order of 10 percent) do not seem to be significant enough to affect consumer utility. Conversely, although the total lumen output of 4-foot T5 MiniBP lamps can be similar to 4-foot T8 MBP and 4-foot T12 MBP lamps, the lumen output is emitted from a more concentrated light source. DOE's research indicates that T5 lamps' higher light concentrations (and therefore brightness) may require greater distances between the light source and illuminated surfaces. Due to this limitation in utility, DOE did not consider migration to a lamp diameter associated with T5 lamps to be a design option to improve the efficacy of T8 and T12 lamps.

e. Multi-Photon Phosphors

NEMA commented that although commercial multi-photon phosphors are theoretically possible, they have yet to be developed, despite 30 to 40 years of research. (NEMA, No. 22 at p. 7) As explained in chapter 3 of the TSD, because multi-photon phosphors emit more than one visible photon for each incident ultraviolet photon, a lamp would be able to emit more light for the same amount of power, thereby increasing efficacy. DOE agrees that this technology is not sufficiently mature as to warrant further analysis, so DOE has screened out this technology option in the March 2008 ANOPR.

2. Incandescent Reflector Lamps

NEMA does not believe that xenon, a higher-efficiency inert fill gas, should be considered a design option because there is a limited supply of this gas and prices are increasing rapidly. (NEMA, No. 22 at p. 8; Public Meeting Transcript, No. 21 at pp. 108–109)

Although price is not considered in the screening criteria, DOE did conduct an in-depth market assessment of the supply of xenon, and the potential impact of xenon supply limitations on IRL standard levels. DOE determined that although xenon is a rare gas, its supply is sufficiently large to incorporate into all IRL and that the xenon supply would not affect IRL product availability. A more detailed analysis of xenon and its availability can be found in appendix 3B of the TSD.

C. Engineering Analysis

For each product class, the engineering analysis identifies potential, increasing efficacy levels above the level of the baseline model. Those technologies not eliminated in the screening analysis (design options) are inputs to this process. Design options consist of discrete technologies (*e.g.,* infrared reflective coatings, rare-earth phosphor mixes). As detailed in the March 2008 ANOPR, to ensure that efficacy levels analyzed are technologically feasible, DOE concentrated its efforts on developing product efficacy levels associated with ''lamp designs,'' based upon commercially-available lamps that incorporate a range of design options in the engineering analysis. 73 FR 13620, 13645 (March 13, 2008). However, when necessary, DOE supplemented commercially available product information with an examination of the improved performance attributable to discrete technologies so that a substitute lamp at each efficacy level would be available for each baseline lamp.

In energy conservation standard rulemakings for other products, DOE often develops cost-efficiency relationships in the engineering analysis. However, for this lamps rulemaking, DOE derived efficacy levels in the engineering analysis and end-user prices in the product price determination. By combining the results of the engineering analysis and the product price determination, DOE derived typical inputs for use in the LCC and NIA. See the chapter 7 of the TSD for further details on the product price determination.

1. Approach

For the NOPR, DOE is using the same methodology for the engineering analysis that was detailed in the March 2008 ANOPR. 73 FR 13620, 13645–46 (March 13, 2008). The following is a summary of the steps taken in the engineering analysis:

- Step 1: Select Representative Product Classes
- Step 2: Select Baseline Lamps
- Step 3: Identify Lamp or Lamp-and-Ballast Designs
- Step 4: Develop Efficiency Levels.

A more detailed discussion of the methodology DOE followed to perform the engineering analysis can be found in the engineering analysis chapter of the TSD (chapter 5).

2. Representative Product Classes

As discussed in section 0 of this notice, DOE proposes establishing several product classes for GSFL and IRL. DOE proposes eight product classes across the range of covered GSFL based on utility and performance features, such as: (1) Physical constraints of lamps (*i.e.,* lamp shape and length); (2) lumen package (*i.e.*, standard versus high output); and (3) correlated color temperature. For IRL, DOE proposes eight product classes based on spectrum, lamp diameter, and rated voltage. As detailed in the March 2008 ANOPR, due to scheduling and resource constraints, DOE was not able to analyze each and every product class. 73 FR 13620, 13646 (March 13, 2008). Instead, DOE carefully selected certain product classes to analyze, and then scaled its analytical findings for those representative product classes to other product classes that were not analyzed. 73 FR 13620, 13652 (March 13, 2008). While DOE received several stakeholder comments regarding methods of scaling to product classes not analyzed (discussed in section V.C.7), DOE did not receive objections to the decision to scale to certain product classes and the representative product classes chosen in the March 2008 ANOPR.

For the NOPR, similar to its approach in the March 2008 ANOPR, DOE continued to analyze 4-foot medium bipin, 8-foot single pin slimline, and 8-foot recessed double-contact high output GSFL product classes with CCTs less than or equal to 4,500K. DOE did not explicitly analyze U-shaped lamps, but instead scaled the results of the 4-foot medium bipin class analysis. In addition, DOE has decided to analyze 4-foot T5 miniature bipin standard output lamps and 4-foot T5 miniature bipin high output lamps with CCTs less than or equal to 4,500K as representative product classes.

As discussed in section A.2, DOE chose to subdivide IRL into eight product classes with three subdivisions: (1) High versus low voltage; (2) large versus small diameter lamps; and (3) modified spectrum versus standard spectrum. As detailed in the March 2008 ANOPR, DOE chose to analyze the standard-spectrum incandescent reflector product class because standard-spectrum lamps are more common than modified-spectrum lamps. 73 FR 13620, 13648 (March 13, 2008). After analyzing catalog data and talking to industry experts, DOE found that lamps with a diameter greater than 2.5 inches are more common than lamps of smaller diameters. Lamps with voltage ratings less than 125V also are more common than lamps with higher voltage ratings. Therefore, for the NOPR, DOE proposes to analyze the product class characterized by standard spectrum, voltage less than 125V, and diameter greater than 2.5 inches. For further information on representative product classes, see chapter 5 of the TSD.

3. Baseline Lamps and Systems

Once DOE identified the representative product classes for analysis, DOE selected the representative units for analysis (*i.e.,* baseline lamps) from within each product class. These representative units are generally what DOE believes to be the most common, least efficacious lamps in their respective product classes. DOE chose multiple baseline lamps because DOE found that the market for each product class is segmented into multiple submarkets for lamps with slightly different consumer utilities. For example, the 40W T12, 34W T12, and 32W T8 lamps are the most common lamps in the commercial four-foot medium bipin product class. The 34W T12 is a reduced wattage lamp that is not as versatile as the 40W T12, however, and consumers switching from a T12 to a T8 lamp must purchase a new ballast. Thus, these lamps are not entirely substitutable, so DOE has chosen to analyze them as separate baselines. DOE's selection of baseline lamps is discussed in further detail below.

a. General Service Fluorescent Lamps

As described in the March 2008 ANOPR, DOE took a systems approach to its GSFL analysis. 73 FR 13620, 13649 (March 13, 2008). In this approach, DOE selected typical ballasts (which provide current to the lamps) to pair with each baseline lamp and higher-efficacy lamp. Though DOE did not consider the ballast as directly affecting lamp efficacy, the ballast selection does affect the overall system efficacy (system input power and total lumen output), thereby having a significant impact on LCC and NIA results. For this reason, DOE considered a variety of ballast types (*e.g.,* electronic and magnetic) and ballast factors in its analysis.

In the March 2008 ANOPR, DOE chose three baseline lamps for 4-foot medium bipins less than or equal to 4,500K (installed on T8 electronic and T12 magnetic ballasts), three baseline lamps for 8-foot single pin slimlines less than or equal to 4,500K (installed on T8 electronic and T12 magnetic ballasts), and two baseline lamps for 8-foot recessed double-contact HOs less than or equal to 4,500K (installed on T8 magnetic and T12 magnetic ballasts). 73 FR 13620, 13647 (March 13, 2008). DOE did not receive any comments on baseline lamps for the commercial and industrial sectors and thus has retained all baseline lamps from the March 2008 ANOPR. However, as discussed below, DOE did receive comments regarding additional sectors to analyze and the ballast selected to pair with the 8-foot RDC HO baseline lamps. In addition, DOE developed baseline lamp-and-ballast systems for the 4-foot T5 MiniBP SO and HO product classes.

Regarding GSFL operating in the residential sector, several stakeholders commented that residential T12 ballasts will continue to be sold past 2009 and that the residential applications of these ballasts represent a large portion of the remaining market for these lamps. (NEMA, No. 22 at pp. 20, 25; Public Meeting Transcript, No. 21 at pp. 276–277) PG&E stated that T12 lamps on magnetic ballasts continue to exist in the residential sector in California. (Public Meeting Transcript, No. 21 at p. 279) The Joint Comment also stated that residential applications need to be factored into the analysis, but because the same lamps can be used in all sectors, a separate analysis is not needed for the residential sector. (Joint Comment, No. 23 at p. 10)

In response, in this NOPR, DOE has analyzed GSFL in the residential sector. In interviews with manufacturers and by reviewing manufacturer product catalogs, DOE found that a significant portion of T12 4-foot medium bipin lamps operate in the residential sector. DOE is maintaining the same standards case lamps used in the commercial and industrial sectors for 4-foot medium bipins in the residential sector because, as the Joint Comment stated, the same lamps can be used in all sectors. However, DOE is choosing a separate baseline lamp for the residential 4-foot medium bipin analysis. Conversations with industry experts and a published study prepared for PG&E [22] have revealed that residential consumers are more likely to buy 40W T12 lamps because 32W T8 lamps and 34W T12 lamps are less common. Therefore, in the residential sector, DOE is only analyzing the 40W T12 lamp as a baseline lamp. In addition, reviewing available catalog information, DOE has found that the most common 40W T12 lamp sold in the residential sector is different from the 40W T12 baseline lamp presented in the March 2008 ANOPR for the commercial and industrial sectors. 73 FR 13620, 13647 (March 13, 2008). Therefore, in the NOPR, DOE has chosen a 40W T12 baseline lamp for the residential sector that has a slightly lower efficacy (76.8 lm/W) and shorter lifetime (15,000 hours) than the typical 40W T12 lamp sold in the commercial sector.

[22] ''Codes and Standards Enhancement (CASE) Initiative for PY2008: Title 20 Standards Development,'' *Analysis of Standards Options for Linear Fluorescent Fixtures* (Prepared for PG&E by ACEEE, Lighting Wizards, and Energy Solutions). (Last modified May 14, 2008) Available at: *http://www.energy.ca.gov/appliances/2008rulemaking/documents/2008-05-15_workshop/other/PGE_CASE_Study_-_Linear_Fluorescent_Fixtures.pdf.*

After reviewing manufacturer literature and the study prepared for PG&E on fixtures in the residential sector,[23] DOE found that the most common residential sector ballast is a low-power-factor 2-lamp magnetic T12 system with a ballast factor of 0.68. Therefore, for the NOPR, DOE paired the baseline lamp with this ballast for the residential sector analysis.

Because DOE has decided to cover and analyze 4-foot T5 miniature bipin standard output and 4-foot T5 miniature bipin high output lamps in this rulemaking (section 0 of this notice), DOE established baseline lamps for these two product classes. NEMA and the Joint Comment both stated that if DOE does not cover T5 lamps, then less efficient, halophosphor T5 lamps may enter the market place. (Public Meeting Transcript, No. 21 at pp. 71–72; Joint Comment, No. 23 at p. 3) Because these less efficient halophosphor T5 lamps are not on the market today, DOE developed model T5 halophosphor lamps in its engineering analysis. To create these model T5 lamps, DOE used efficacy data from short halophosphor fluorescent T5 lamps currently available and developed a relationship between length and efficacy. DOE validated this relationship by comparing it to previous industry research. DOE then used this relationship to determine the efficacies of a halophosphor 4-foot T5 miniature bipin standard output lamp and a halophosphor 4-foot halophosphor T5 miniature bipin HO lamps. Specifically, the baseline 4-foot miniature bipin standard output lamp is 28W with an efficacy of 86 lm/W and a lifetime of 20,000 hours. The baseline 4-foot miniature bipin high output lamp is 54W with an efficacy of 77 lm/W and a lifetime of 20,000 hours. DOE used these lamps as baseline lamps to establish the economic impacts of a standard that would eliminate such lamps. For more information about these and other baseline lamps, see chapter 5 and appendix 5B of the TSD.

In its review of manufacturer literature, DOE found that a range of ballast factors are available for the 4-foot T5 product classes, and the most common ballast is a 2-lamp electronic ballast. DOE attempts to compare lamp-and-ballast systems with similar light output so that consumers switching to more efficient systems will be able to preserve lumen output. In order for the halophosphor baseline T5 lamps to produce light output similar to the standards-case T5 lamps, they must be paired with the highest ballast factor ballasts available on the market today. Therefore, in the NOPR, DOE is pairing its baseline 4-foot T5 SO miniature bipin lamp with a 1.15 ballast factor ballast, and its baseline 4-foot T5 miniature bipin HO lamp with a 1.0 ballast factor ballast. For further detail on the baseline lamps and ballasts selected for the 4-foot T5 product classes, see chapter 5 of the TSD.

DOE proposed in the March 2008 ANOPR that the most common ballast in use for the 8-foot T12 recessed double-contact, high-output product class is an electronic rapid-start ballast. (March 2008 ANOPR TSD chapter 5). Several stakeholders commented at the public meeting that the majority of 8-foot T12 high-output ballasts installed today are magnetic. (Public Meeting Transcript, No. 21 at pp. 124–125; Public Meeting Transcript, No. 21 at p. 126) NEMA and the Joint Comment also commented that magnetic T12 high-output ballasts are allowed under current regulations and, therefore, will continue to be sold past 2009. (Joint Comment, No. 23 at p. 7; NEMA, No. 22 at p. 25) Because the majority of the installed base is magnetic, DOE is revising its baseline T12 high-output ballast to be magnetic for the life-cycle cost analysis. However, DOE recognizes that historical shipments from the 2000 rulemaking on GSFL ballasts (hereafter ''2000 Ballast Rule'') (62 FR 56740 (Sept. 19, 2000)) indicate that T12 electronic high-output ballasts are also increasingly being shipped.[24] Therefore, in the national impacts analysis, DOE modeled the installed base on magnetic ballasts, and forecasted shipments of T12 high-output lamps operating on both electronic and magnetic ballasts in the national impacts analysis. For further detail regarding the revised baseline lamps and systems for the 8-foot RDC HO product class, see chapter 5 of the TSD.

DOE reviewed the remaining baseline lamp-and-ballast systems discussed in the March 2008 ANOPR and believes they are still appropriate, as DOE received no comments concerning these systems. Therefore, DOE maintained the same number of lamps per system and ballasts discussed in the March 2008 ANOPR for the 4-foot medium bipin and 8-foot single pin slimline product classes analyzed in the commercial and industrial sectors. 73 FR 13620, 13647 (March 13, 2008).

b. Incandescent Reflector Lamps

In the March 2008 ANOPR, DOE proposed three baseline lamps for the IRL representative product class. 73 FR 13620, 13648 (March 13, 2008). These baseline lamps, all parabolic reflector (PAR) halogen baseline lamps, are regulated by EPCA and meet the EPCA standard. (42 U.S.C. 6295(i)(1)) NEMA commented that because BR lamps remain on the market due to a Federal exemption and because they are commonly used in consumer applications, the BR lamp should be the baseline lamp instead of the halogen PAR. (Public Meeting Transcript, No. 21 at p. 162; NEMA, No. 22 at pp. 10, 16, and 18) NEMA also contends that because DOE selected halogen PAR lamps as the baseline, DOE is losing the opportunity to show additional energy savings. (NEMA, No. 22 at p. 16)

In response, although BR lamps are a common incandescent reflector lamp on the market today, DOE believes they should not be selected as baseline lamps in the engineering analysis of this rulemaking for the reasons that follow. The baseline lamp should be typical of *covered* lamps within a certain product class. The most common BR lamp is the 65W BR lamp, which remains on the market due to Federal exemptions. Because the 65W BR lamp is not covered in this rulemaking, it cannot be a baseline lamp. In addition, consumers purchasing the 65W BR lamp would not be affected by the amended standards proposed in this NOPR. Therefore, DOE would not be able to demonstrate additional energy savings for those consumers purchasing the 65W BR lamp even if it were able to select that lamp as a baseline lamp.

Although certain BR lamps are covered in this rulemaking, DOE predicts that the most typical lamp sold on the market in 2012 will continue to be the halogen PAR lamp. EISA 2007 required that all non-exempted BR lamps meet EPCA standards by January 1, 2008. Because these lamps are similar in efficacy and price to the halogen PAR, the most common reflector lamps meeting the EPCA standard in 2007, DOE is continuing to choose halogen PAR lamps as the baseline lamp for the NOPR.

NEMA commented that current PAR baseline lamps have higher efficacy than the lamps sold in 1992 (when EPACT 1992 prescribed IRL standards), due to optical improvements. (NEMA, No. 22 at p. 16) However, because DOE prefers that the baseline lamp be typical of lamps sold on the market today, DOE is maintaining the same 90W PAR baseline lamp and 75W PAR baseline lamp used

[23] *Id.*

[24] U.S. Department of Energy—Energy Efficiency and Renewable Energy Office of Building Research and Standards, *Technical Support Document: Energy Efficiency Standards for Consumer Products: Fluorescent Lamp Ballast Proposed Rule* (Jan. 2000). Available at: *http://www1.eere.energy.gov/buildings/appliance_standards/residential/gs_fluorescent_0100_r.html.*

in the March 2008 ANOPR. 73 FR 13620, 13648 (March 13, 2008). DOE now believes that the 50W PAR30 baseline lamp with a lifetime of 3,000 hours and an efficacy of 11.6 lm/W presented in the March 2008 ANOPR is not typical of lamps sold on the market today. 73 FR 13620, 13648 (March 13, 2008). Therefore, for this notice, DOE is choosing a 50W PAR30 lamp with an efficacy of 14.2 lm/W and a lifetime of 3,000 hours. Based on an examination of manufacturer product catalogs, DOE believes that this lamp is a higher-volume product than the baseline lamp presented in the March 2008 ANOPR. The lamp choice is consistent with advice DOE received from GE to use lamps from major manufacturers in the IRL analysis for modified-spectrum lamps. (Public Meeting Transcript, No. 21 at p. 170) For further detail on IRL baseline lamps, see chapter 5 of the TSD.

4. Lamp and Lamp-and-Ballast Designs

As described in the March 2008 ANOPR, in the engineering analysis, DOE considered only ''design options''—technology options used to improve lamp efficacy that were not eliminated in the screening analysis. 73 FR 13620, 13644 (March 13, 2008). DOE's selection of design options guided its selection of lamp and lamp-and-ballast designs and efficacy levels. For example, for GSFL, DOE noted groupings around the types of phosphor used and the wall thickness of those phosphors. Regarding IRL, DOE identified natural ''technology-based'' divisions in the market around the type of incandescent technology (*i.e.*, halogen or HIR) used. DOE also identified certain technology options and created model lamps to represent the efficacy those technology options could achieve.

As described in the March 2008 ANOPR, DOE also accounted for lumen output when DOE established lamp designs for its analyses. 73 FR 13620, 13648 (March 13, 2008). For the LCC analysis, DOE considered those lamps (or lamp-and-ballast systems) that: (1) Emit lumens equal to the lumen output of the baseline lamp or lamp-and-ballast system, or below that lamp by no more than 10 percent; and (2) result in energy savings. DOE took this approach in order to accurately characterize the cost-effectiveness of a particular efficacy level if a consumer makes an informed decision that maintains light output. However, as DOE recognizes that all consumers may not make such decisions, lamp or lamp-and-ballast designs that under-illuminate, over-illuminate, or do not result in energy savings are considered in the NIA.

a. General Service Fluorescent Lamps

As described in the March 2008 ANOPR, DOE used a systems approach for the fluorescent lamp analysis, because DOE recognizes that both lamps and ballasts determine a system's energy use and the overall system lumen output. 73 FR 13620, 13649 (March 13, 2008). This approach allows DOE to select a variety of lamp-and-ballast designs that meet a given efficacy level. Generally, DOE chose its potential design options by selecting commercially-available fluorescent lamps at higher efficacies than the baseline lamps. These higher efficacies are achieved through the design options described in the screening analysis. After selecting these higher-efficacy lamps, DOE selected lamp-and-ballast combinations for the LCC that both save energy and maintain comparable lumen output. For instances when the consumer is replacing only the lamp, DOE selected a reduced-wattage, higher-efficacy lamp for use on the existing ballast. For instances when the consumer is replacing both the lamp and the ballast, DOE was able to obtain energy savings and maintain comparable lumen output using a variety of lamp-and-ballast combinations.

In the March 2008 ANOPR, DOE stated that it was not able to identify any application restrictions on using reduced-wattage fluorescent lamps, so therefore, DOE included reduced-wattage lamps as design options in the ANOPR. 73 FR 13620, 13650 (March 13, 2008). NEMA responded that most manufacturers identify several application issues for these lamps. For example, NEMA stated that reduced-wattage T8 lamps cannot be used with certain rapid-start circuits, at temperatures below 60 degrees Fahrenheit (°F) (or 70 °F for the 25W lamp), in drafty locations, in air-handling fixtures, on low-power-factor ballasts, on dimming ballasts, or on an inverter-operated emergency lighting system, unless the equipment is specifically listed for use with the reduced-wattage lamp in question. (NEMA, No. 22 at p. 10) NEMA also stated that reduced-wattage T12 lamps cannot be used at temperatures below 60 °F, in drafty locations, on low-power-factor ballasts, on reduced-light-output ballasts, on dimming ballasts, or on inverter-operated emergency lighting systems unless the equipment is specifically listed for use with the reduced-wattage lamp in question. (NEMA, No. 22 at p. 11)

In response, DOE recognizes that reduced-wattage lamps cannot be used in certain applications and that consumers should not be subject to any decrease in utility and performance due to an amended energy conservation standard. However, because consumers have the opportunity to purchase at least one full-wattage T12 or T8 lamp at each efficacy level, consumer utility will not be reduced by amending the existing energy conservation standard.

There are many applications where reduced-wattage lamps are appropriate. Therefore, DOE is modeling reduced-wattage lamps in the engineering analysis. In the NIA, DOE did not shift all consumers to reduced-wattage lamps in response to an energy conservation standard, because reduced-wattage lamps cannot be used in certain applications. Specifically, the majority of residential consumers have low-power-factor ballasts not designed to operate 34W T12 lamps. These assumptions are displayed in the NIA market-share matrices described in chapter 10 of the TSD.

b. Incandescent Reflector Lamps

In the March 2008 ANOPR, DOE selected lamp designs and candidate standard levels (CSLs) by observing natural efficacy divisions in the marketplace that correspond to the use of technologies (*e.g.*, halogen capsules, HIR technology, and improved reflector coatings) to increase lamp efficacy. 73 FR 13620, 13650 (March 13, 2008). CSL1, as set forth in the March 2008 ANOPR, could be met with a halogen lamp using a silverized reflector coating. CSL2 could be met with a 3,000-hour halogen infrared (IR) lamp. CSL3 could be met with an improved 4,000-hour halogen infrared lamp. CSL3 could also be achieved by using design options like a silverized reflector coating with a halogen infrared burner, or improved filament placement and higher efficiency inert fill gases in conjunction with a halogen infrared burner.

At the public meeting and through written comments, NEMA proposed several changes to the lamp designs and efficacy levels DOE identified for the IRL engineering analysis. NEMA suggested that DOE should analyze four efficacy levels, beginning with one slightly above EPCA and ending with the max-tech candidate standard level analyzed in the March 2008 ANOPR. (NEMA, No. 22 at p. 17) However, the efficacies of the baseline lamps chosen in the engineering analysis are above the lowest NEMA-proposed efficacy level. Therefore, because NEMA's lowest proposed efficacy level would not raise the efficacies of the most common reflector lamps on the market today, DOE did not consider it in this NOPR.

NEMA commented that DOE should also consider in its NOPR an efficacy level that can be met with non-standard halogen or infrared halogen lamps. (NEMA, No. 22 at p. 18) This standard level would lie between the first efficacy level proposed by NEMA and the first candidate standard level (CSL1) proposed by DOE in the March 2008 ANOPR. 73 FR 13620, 13651 (March 13, 2008). To model the technologies that meet this efficacy level, DOE modeled an improved halogen lamp that uses xenon, a higher efficiency inert fill gas.

NEMA commented that DOE should not analyze CSL1 presented in the March 2008 ANOPR because that level is based on the silverized reflector coating, a patented technology.[25] (NEMA, No. 22 at pp. 16–17; Public Meeting Transcript, No. 21 at pp. 157–158) Other stakeholders commented that DOE should research when the patent on the silver technology expires, because the standard does not go into effect until 2012. (Joint Comment, No. 23 at p. 15) The Joint Comment stated that DOE should research viable alternatives that can be used to reach the first CSL if the silverized reflector coating is indeed patented. (Joint Comment, No. 23 at p. 15)

In response to these stakeholder comments, DOE researched the silverized reflector technology and found that the patent for that technology expires in December 2019.[26] Therefore, for the purpose of this rulemaking, DOE considers the silverized reflector coating a proprietary technology. As discussed during the Framework stage of this rulemaking, DOE only considers proprietary designs in its engineering analysis if there are other technology pathways to meet that efficacy level. DOE researched possible lamp designs for the March 2008 ANOPR's first CSL and found that a halogen lamp with a silverized reflector coating is the only improved halogen technology that can meet the March 2008 ANOPR CSL1. However, a slightly lower level can be achieved with an HIR lamp that has a 6,000-hour lifetime. Therefore, DOE is considering a slightly lower level that can be met by both long-life HIR lamp designs and silverized reflector coating lamp designs in the NOPR. In its analysis of this level, DOE considers both lamp designs as viable consumer options.

NEMA commented that DOE should lower CSL2, because longer life lamps would be in jeopardy of being eliminated from the marketplace. Because longer life products typically have lower efficacies, manufacturers may need to reduce lamp life to meet a particular efficacy level. (Public Meeting Transcript, No. 21 at pp. 177–178; NEMA, No. 22 at p. 16; Joint Comment, No. 23 at p. 15) Although increased lifetime reduces a lamp's efficacy, DOE believes that lifetime is a consumer economic issue rather than a utility issue. In addition, the IRL at each standard level can be manufactured with lifetimes equal to or greater than the lifetimes of the baseline lamp. Therefore, consumers who are purchasing the baseline lamp will continue to be able to purchase a lamp with a similar lifetime in the standards case. Finally, DOE has conducted an analysis to assess the impact of standards on longer lifetime lamps. Based on this analysis, documented in appendix 5D of the TSD, DOE is reasonably certain that even under the highest efficacy level analyzed in this NOPR, 6,000 hour lifetime lamps are technologically feasible. For all of these reasons, DOE maintained the lamp designs and efficacy level for CSL2 described in the March 2008 ANOPR.

Similar to its comments related to CSL1, NEMA commented that CSL3 is problematic because it is also based on the silverized reflector coating, a patented technology. (NEMA, No. 22 at p. 17; Public Meeting Transcript, No. 21 at pp. 157–158)

In its conversations with manufacturers and review of manufacturer catalogs, DOE found that CSL3 is achievable using technologies other than a silverized reflector coating. For example, other non-patented types of improved reflectors and higher-efficiency IR coatings can be used to reach this level. In fact, all major manufacturers produce two or more lamps that exceed this level, some of which are not dependent on the proprietary silverized reflector. Therefore, because there are alternate technology pathways to this level, DOE maintained the March 2008 ANOPR CSL3 as efficacy level 4 in the NOPR. This efficacy level is consistent with CSL4 proposed by NEMA in its comment. (NEMA, No. 22 at p. 17)

Finally, DOE conducted additional market research and discovered that IRL with efficacies significantly higher than the ANOPR CSL3 (or NOPR EL4) are being sold by one major manufacturer. These IRL are marketed as halogen infrared lamps with a silverized reflector, improved IR coating, and a lifetime of 4,200 hours. Therefore, in order to meet the requirement to analyze the highest technologically feasible level, for the NOPR, DOE has added a fifth efficacy level (EL5) based on these high-efficacy lamps. Although, to DOE's knowledge, there are no commercially-available IRL that do not use the patented silverized reflector and are equivalent in efficacy, DOE's research indicates that that are alternate, non-proprietary technology pathways to meet this efficacy level. In particular, DOE has extensively researched one particular advanced IR coating technology. Through interviews with manufacturers of this technology and through independent testing, DOE has preliminarily concluded that by using this advanced IR coating technology with a standard aluminum reflector, manufacturers can produce an IRL with an efficacy that exceeds EL5. For further detail on DOE's research on this technology, see appendix 5D of the TSD.

In summary, EL1 is based on an improved halogen lamp that uses xenon, a higher-efficiency inert fill gas. EL2 is based on a halogen infrared lamp with a lifetime of 6,000 hours; a halogen lamp using a silverized reflector coating could also meet this EL. EL3 is associated with a 3,000-hour halogen infrared lamp; this EL is more efficient than EL2 due to higher temperature operation of the filament. EL4 is based on a 4,000-hour improved halogen infrared lamp; improvements in the halogen infrared lamp could be made by using a double-ended halogen infrared burner, higher-efficiency inert fill gases, and efficient filament orientation. EL5 is based on a 4,200-hour halogen infrared lamps (even further improved); these further improvements include an improved reflector, IR coating, or filament design that produces higher-temperature operation (and may reduce lifetime to 3,000 hours).

5. Efficiency Levels

a. General Service Fluorescent Lamps

i. Revisions to ANOPR Efficiency Levels

For the March 2008 ANOPR, DOE developed CSLs for GSFL by dividing initial lumen output by the ANSI rated wattages of commercially-available lamps, resulting in rated lamp efficacies. In response to the potential GSFL efficacy levels presented in the March 2008 ANOPR, NEMA commented on several reasons why the association

[25] DOE notes that it would clearly be technologically feasible for manufacturers to adopt a product design that surpasses the levels specified in CSL1 (*e.g.*, using technologies that meet CSL2) and also avoids use of the proprietary technology in question. However, if DOE were to adopt CSL1, as presented in the March 2008 ANOPR, such manufacturers would be at a competitive disadvantage as compared to manufacturers who are able to access the patented technology.

[26] Zhao, Tianji *et al.*, ''Protected Coating for Energy Efficient Lamp,'' U.S. Patent 6,773,141 (August 10, 2004).

believes that the efficacy levels need to be revised. NEMA's comments regarding the efficacy levels considered in the March 2008 ANOPR can be divided into five categories: (1) The appropriateness of using ANSI rated wattages in the calculation of lumens per watt; (2) consideration of variability in production of GSFL; (3) manufacturing process limitations related to specialty products; (4) consideration of adjustments to photometry calibrations; and (5) the appropriateness of establishing efficacy levels to the nearest tenth of a lumen per watt. (NEMA, No. 22 at p. 13–14) In consideration of the above issues, NEMA suggested revised efficacy levels that could achieve the same results as the efficacy levels considered in the March 2008 ANOPR.

First, in support of lowering the March 2008 ANOPR efficacy levels, NEMA argued that ANSI rated wattages of GSFL are not necessarily representative of long-term reference watts. NEMA further stated that in many cases the actual lamp reference watts are greater than the ANSI designated value. (NEMA, No. 22 at p. 14) Second, NEMA commented on production variability and its impact on the resulting measured lamp efficacies. NEMA stated that DOE should not use nominal catalog initial lumen values when developing efficacy levels, as they do not reflect statistical lot-to-lot production variation. It also argued that as lamp lumens per watt is not a controlled process element in production or a product rating, larger tolerances may be required. NEMA further stated that lumens per watt is actually a calculation based on two primary process control elements: (1) Watts and (2) lumens. When practical production variation in lamp wattage (above ANSI-designated values) and lamp lumens (below catalog initial lumens) combine, the resulting variation in lumens per watt may be larger than expected. NEMA stated that DOE's proposed efficacy levels should be lowered to account for these tolerances. (NEMA, No. 22 at p. 14)

In consultation with the National Institute of Standards and Technology (NIST), DOE has investigated this issue thoroughly, and DOE agrees with NEMA on several points. By analyzing manufacturer compliance reports (submitted to DOE for existing GSFL energy conservation standards), DOE found that efficacies of lamps when reported for the purpose of compliance often vary from catalog-rated values. Specifically, DOE agrees that ANSI designated rated wattages may not be appropriate in calculating efficacy. In fact, the test procedures for GSFL incorporate a tolerance factor comparing measured lamp wattage to ANSI-rated wattage. DOE acknowledges that this tolerance factor could in fact significantly alter the measured efficacy of the lamps from the rated efficacy. In addition, DOE agrees that using rated lamp efficacy does not sufficiently account for lot-to-lot production variability. For this reason, to establish revised GSFL efficacy levels, DOE proposes to use lamp efficacy values submitted to DOE over the past 10 years for the purpose of compliance with existing energy conservation standards. Using compliance reports as a basis for efficacy standards should ensure that DOE is accurately characterizing the tested performance of GSFL, accounting for the measured wattage effects and wattage and lumen output variability as discussed above.

Further remarking on the effects of production variability, NEMA argued that it is inappropriate to use a small number of test samples to calculate a lumen-per-watt efficacy level. NEMA stated that its suggested levels incorporate a safety factor to take into account manufacturer process variations. (NEMA, No. 22 at p. 14) While DOE appreciates NEMA's input, it disagrees that the sample size is inappropriate. At NEMA's suggestion, a sample size of 21 lamps was originally established for reporting requirements in the 1997 test procedure rulemaking. 62 FR 29222, 29229 (May 29, 1997). The reported efficacy values are obtained by testing at least three lamps manufactured each month for at least 7 months out of a 12-month period. Upon receiving NEMA's comment, DOE consulted with NIST and has tentatively concluded that the minimum of 21 samples is sufficiently large sample size, assuming a normal distribution. In addition, by using the compliance report efficacies, DOE believes that it is accounting for statistical variations due to differences in production. The efficacy reported for compliance is related to the lower limit of the 95-percent confidence interval. This interval represents variation over the whole population of production, not only the sample size. 62 FR 29222, 29230 (May 29, 1997).

Third, NEMA commented that the proposed efficacy levels should be lowered to account for realistic production and manufacturing process limitations. NEMA argued that it may not be possible to apply the highest efficacy levels to some specialty products because they do not use high-speed production methods. (NEMA, No. 22 at p. 14) DOE is unaware of specialty products that meet the definition of GSFL and would be unable to meet the proposed standards. Therefore, DOE cannot appropriately quantify the reduction in efficacy level necessary if such situation in fact exists. DOE requests further comment and detail on this topic.

Fourth, NEMA claims that because the National Voluntary Laboratory Accreditation Program (NVLAP) has made adjustments to photometry calibrations since 1997, the lumens for some products have actually been reduced. These adjustments would thereby merit a reduction in DOE's GSFL efficacy levels. (NEMA, No. 22 at p. 14) In response, DOE consulted with NIST, which is unaware of any such adjustments in photometry calibrations since 1997. The lumen scale has not changed more than 0.2 percent as a result of changes to calibration systems. Furthermore, the formula used in the compliance reports contains a 2-percent de-rate factor to allow for testing variations. Therefore, DOE disagrees with NEMA's assertion that the efficacy levels should be further lowered to account for these adjustments.

Finally, NEMA maintained that if DOE uses lumens per watt as the efficacy level measurement, then the numbers should be rounded to the nearest whole number, rather than carried out to the tenths decimal place. In the March 2008 ANOPR, DOE considered efficacy levels that were specified to the nearest tenths lumen per watt. NEMA asserts that lamp testing and production variation does not allow for establishing minimum lumens per watt levels to the tenth place. (NEMA, No. 22 at p. 12) While DOE appreciates NEMA's comment, after consulting with NIST, DOE disagrees that lamp production variation would prohibit the regulation of GSFL to the nearest tenth decimal place of lumens per watt. If DOE were able to set minimum efficacy requirements to the nearest tenth of a decimal place, the higher-accuracy measurements and compliance could result in increased energy savings. However, in consideration of DOE's approach to establish efficacy levels and conduct subsequent analyses based on certification and compliance reports submitted by manufacturers, DOE now believes that maintaining the current rounding procedure (*i.e.*, to the nearest whole lumen per watt) is more appropriate. Because manufacturer compliance reports round numbers to the nearest lumen per watt, DOE believes that the data would not support establishment of an energy conservation standard for GSFL to the nearest tenth of a lumen per watt. Therefore, in this NOPR, DOE is proposing to establish efficacy levels as whole lumen per watt numbers.

DOE presents revised GSFL efficacy levels in section VI.A.1 of this NOPR.

ii. Four-Foot T5 Miniature Bipin Efficiency Levels

Because DOE proposes to cover 4-foot T5 miniature bipin lamps and 4-foot T5 miniature bipin HO lamps, DOE developed efficacy levels for these two product classes. In its review of manufacturer literature, DOE identified the most common 4-foot T5 miniature bipin standard output lamps on the market (which based on product catalogs, DOE believes accounts for the majority of the 4-foot T5 SO market). The first efficacy level for this product class is based on these lamps, which use 800-series phosphors and have a rated catalog efficacy (initial lamp lumens divided by ANSI rated wattage) of 104 lm/W. In its research, DOE also noted higher efficacy 4-foot T5 miniature bipin standard output lamps that use improved 800-series phosphors. Specifically, there is a reduced-wattage (26W) 4-foot T5 miniature bipin lamp (with a rated efficacy of 112 lm/w) and a full-wattage (28W) lamp (with a rated efficacy of 110 lm/w). EL2, the second efficacy level for this product class, is based on these higher-efficacy lamps. Therefore, DOE analyzed two efficacy levels for this product class. The first efficacy level prevents the introduction of less-efficacious halophosphor lamps on the market, while the second efficacy level raises the efficacy of the current highest volume 4-foot T5 miniature bipin lamps on the market. In order to account for manufacturer variation, DOE used the average reductions in efficacy values due to manufacturer variation calculated for the highest efficacy 4-foot T8 medium bipin lamps, and applied those same reductions to the 4-foot miniature bipin rated efficacy values.

For the 4-foot T5 miniature bipin HO product class, DOE found that higher-efficacy full-wattage lamps do not exist on the market today. DOE did identify a higher-efficacy reduced-wattage lamp for this product class. However, because reduced-wattage lamps have a limited utility, DOE is choosing to base its efficacy levels on full-wattage lamps. In this way, consumers are not forced to purchase a lamp with limited utility under energy conservation standards. Therefore, for this product class, DOE is analyzing one efficacy level, which prevents the introduction of less-efficacious halophosphor lamps on the market. For more information on GSFL efficacy levels, see chapter 5 of the TSD.

b. Incandescent Reflector Lamps

As wattage increases for incandescent lamps, efficacy generally increases. Therefore, so that the efficacy levels reflected the performance of these lamps, DOE proposed in the ANOPR that the efficacy requirement for IRL vary according to the following equation: $a*P^{0.27}$, where ''a'' is a constant specifying the technology level and ''P'' is the wattage of the lamp. 73 FR 13620, 13645 (March 13, 2008). At the public meeting, NEMA commented that the smooth form of the candidate standard levels for IRL was appropriate. (Public Meeting Transcript, No. 21 at pp. 100–101, 156) Several other stakeholders also commented that they support the continuous function for IRL. These stakeholders noted that continuous functions more closely follow theoretical equations predicting the level of efficacy possible for any given desired level of light output and thus maximize energy savings. (Joint Comment, No. 23 at p. 15) DOE agrees with these comments and is proposing to maintain the continuous function for IRL in the same equation form proposed in the ANOPR.

As described in section V.C.4.b, DOE is proposing five efficacy levels in this NOPR. EL1 is based on an improved halogen lamp that uses xenon, a higher-efficiency inert fill gas. EL2 is based on a halogen infrared lamp with a lifetime of 6,000 hours. A halogen lamp using a silverized reflector coating also meets this EL. EL3 is based on the 3,000-hour HIR lamp. EL4 is based on a 4,000-hour improved HIR lamp. EL5 is based on a 4,200-hour improved HIR lamp.

6. Engineering Analysis Results

a. General Service Fluorescent Lamps

In chapter 5 of the March 2008 ANOPR TSD, DOE presented lifetime, rated wattage, and rated efficacy results for all lamp-and-ballast designs. NEMA commented that the lifetime rating for the reduced-wattage 30W T8 lamp should be 20,000 hours instead of 18,000 hours. (NEMA, No. 22 at p. 18) DOE reviewed catalog data and agrees that 20,000 hours is the appropriate lifetime for the 30W T8 lamp. DOE also reviewed catalog data for other reduced-wattage lamps. DOE found several 25W T8 lamps that were introduced on the market after it completed the ANOPR GSFL engineering analysis. Therefore, DOE updated the 25W T8 reduced-wattage lamp to have a slightly higher lumen output and longer lifetime to reflect the more common 25W T8 lamps sold on the market today.

Through interviews with lamp manufacturers, DOE found that several of the rated wattages DOE used in its ANOPR for the 4-foot medium bipin product class were not accurate. For the NOPR, DOE updated the rated wattage of the nominally 40W T12 from 40 to 41 watts. DOE also updated the rated wattage of the 30W T8, 28W T8, and 25W T8 lamp from 30 to 30.4 watts, 28 to 28.4 watts, and 25 to 26.6 watts, respectively. Due to these updates (and because the rated wattage affects the rated lamp efficacy), two 40W T12 lamps and the 25W T8 lamp have lower efficiencies than as they were analyzed in the March 2008 ANOPR. For further detail associated with these revisions, see chapter 5 of the TSD.

In addition to updating lamp efficacy, DOE revised the 8-foot T12 high output engineering analysis to reflect the purchase of a magnetic ballast in both the base case and standards case. As discussed in section V.C.4.a of this notice, DOE recognizes that a typical 8-foot T12 high output system uses a magnetic ballast. In addition, as the 2000 ballast rule does not require that these systems be electronic, consumers will be able to purchase a magnetic 8-foot T12 high output system in the future.

DOE also created a separate residential engineering analysis. In this engineering analysis, DOE assumes that the most typical installed fluorescent system in a residential household is a 40W T12 magnetic system. However, DOE recognizes that T8 systems are gaining in market share in the residential market. Therefore, DOE assumes that the majority of fluorescent systems installed for new construction and renovation in the residential sector are T8 systems. DOE discusses this assumption further in section V.D and V.E, as it primarily affects the LCC and NIA.

In the March 2008 ANOPR, DOE considered using two low ballast factor (BF) ballasts for 4-foot T8s, a 0.75 BF and a 0.78 BF. ACEEE stated that manufacturers are now selling ballasts for 4-foot T8 lamps with a ballast factor between 0.68–0.7 and that DOE should consider this ballast in the engineering analysis. (Public Meeting Transcript, No. 21 at p. 262) After reviewing catalog data for fluorescent lamp ballasts, DOE decided to add a ballast with a 0.71 BF in its engineering analysis as a system option that attains energy savings while maintaining light output. By including this low-BF ballast, DOE is able to more thoroughly characterize all consumer purchase options in the LCC and NIA.

b. Incandescent Reflector Lamps

In the March 2008 ANOPR, DOE also presented engineering analysis results for IRL. NEMA generally agreed with the efficacy values in the table. (NEMA, No. 22 at p. 18) Thus, DOE is maintaining this approach with one exception. Specifically, DOE is revising the efficacy values it used for the 50W PAR30 baseline lamps and is creating several additional model lamps for the efficacy levels not analyzed in the March 2008 ANOPR. Because the revised baseline model exhibits a slightly different lumen package than the baseline model analyzed in the March 2008 ANOPR, DOE has created several additional model lamps in order to match the lumen package of the baseline lamp. For more information on the revised baseline model, see section V.C.3.b. For more information about lamp designs used in the IRL engineering analysis, see chapter 5 of the TSD.

7. Scaling to Product Classes Not Analyzed

As discussed above, DOE identified and selected certain product classes as ''representative'' product classes where DOE would concentrate its analytical effort. DOE chose these representative product classes primarily because of their high market volumes. The following section discusses how DOE scaled efficacy standards from those product classes it analyzed to those it did not.

a. General Service Fluorescent Lamps

In the engineering analysis for GSFL, DOE decided not to analyze the 2-foot U-shaped product class and the product classes with a CCT greater than 4,500K, due to the small market share of these classes. Instead, DOE is scaling the efficacy standards for the product classes analyzed to these product classes. The following sections discuss DOE's approaches to scaling to product classes not directly analyzed.

i. Correlated Color Temperature

Regarding the CCT product class division, DOE found in the March 2008 ANOPR that the reduction in efficacy between 4,100K and 6,500K lamps was between 4 percent and 7 percent. To avoid subjecting certain products to inappropriately high standards, DOE considered a single 7-percent reduction (from the efficacy levels for lamps with CCT less than or equal to 4,500K (low CCT)) for product classes greater than 4,500K (high CCT). 73 FR 13620, 13653 (March 13, 2008).

NEMA disagreed with DOE's use of a single 7-percent reduction for all GSFL lamps with a CCT greater than 4,500K. (NEMA, No. 22 at p. 18) NEMA submitted a written comment recommending an individualized reduction for each efficacy level and each product class for products with a CCT between 4,500K and 7,000K. NEMA's reductions ranged from 2.6 percent to 7.2 percent, depending on the efficacy level and product class. (NEMA, No. 26 at pp. 4, 6–7)

The Joint Comment also disagreed with the 7-percent reduction DOE employed. Looking at catalog data for the greater-than-4,500K product classes, the Joint Comment noted that the reduction in efficacy when moving from low-CCT to high-CCT lamps or from 4-foot MBP to 2-foot U-shaped lamps varies by efficacy level. For example, at CSL1 in the 4-foot medium bipin product class, the Joint Comment found that no reduction in the efficacy standard was necessary because high-CCT and 2-foot U-shaped T8 lamps are able to meet that level. At CSL3, the Joint Comment found a 5-percent reduction was appropriate; at CSL4 and CSL5, the Joint Comment found a 3-percent reduction was appropriate. Based on this data, the Joint Comment stated that the commenters would accept a 5-percent reduction for both the 2-foot U-shaped and greater-than-4,500K product classes. (Joint Comment, No. 23 at pp. 9–10)

Through an examination of the comments and a further inspection of manufacturer catalog data, DOE now recognizes that a single efficacy reduction of 7 percent for each efficacy level and each product class is not always appropriate when trying to establish efficacy levels for lamps with greater than 4,500K CCT. Therefore, for this NOPR, DOE proposes to establish a separate scaling factor for each EL and product class. DOE's intention in developing scaling factors for this NOPR was to establish high-CCT efficacy levels that mimic the same technological effects as the low-CCT efficacy levels. For example, if EL3 for the low-CCT 4-foot MBP product class eliminates all but the highest-efficacy, low-CCT T12 lamps, DOE established a high-CCT EL3 that attempted to eliminate all but the highest-efficacy, high-CCT, T12 lamps as well. Because the NEMA technical committee analyzed all efficacy levels for all product classes with a similar intention and because DOE found that this range is consistent with the range of reductions found in manufacturer literature, DOE proposes to adopt the percentage reduction for each EL suggested by NEMA. In order to establish efficacy levels for high CCT lamps, DOE then applied these percentage reductions to the efficacy levels (discussed in sectionV.C.5.a) for the representative product classes. For more information on the efficacy levels for product classes with a CCT greater than 4,500K, see chapter 5 of the TSD.

ii. U-Shaped Lamps

Regarding the 2-foot U-shaped product classes, in March 2008 ANOPR, DOE found that when comparing catalog efficacies of 2-foot U-shaped lamps to 4-foot MBP lamps, efficacy scaling factors varied depending on whether one was comparing T12 lamps or T8 lamps. Specifically, DOE had initially determined that a 3-percent reduction was appropriate for T8 lamps, and a 6-percent reduction was appropriate for T12 lamps. To avoid subjecting certain products to inappropriately high standards, DOE stated that it was considering to apply a single 6-percent reduction from the five 4-foot medium bipin efficacy levels to obtain five 2-foot U-shaped efficacy levels. 73 FR 13620, 13653 (March 13, 2008).

In response to the ANOPR, NEMA commented that only three ELs for the 2-foot U-shaped product class were appropriate. These ELs recommended by NEMA were based on the same technology options for the 4-foot medium bipin product class: (1) NEMA's EL1 would remove all halophosphor T12 lamps; (2) NEMA's EL2 would remove all 700-series T12 U-lamps; and (3) NEMA's EL3 would remove all T12 U-lamps. (NEMA, No. 22 at p. 15) Each EL recommended by NEMA represented an approximately 9-percent to 10-percent reduction from ELs in the 4-foot medium bipin product class. As discussed above, the Joint Comment recommended that DOE use a single 5-percent reduction when scaling from the 4-foot medium bipin product class to the 2-foot U-shaped product class. However, the Joint Comment also found that the reduction varied by CSL. (Joint Comment, No. 23 at pp. 9–10)

Similar to its analysis regarding scaling to high-CCT product classes, DOE recognizes that a single reduction in efficacy may not be appropriate for all efficacy levels for the U-shaped product classes. Therefore, similar to NEMA's suggestion, DOE is proposing a separate reduction for each efficacy level based on similar technology steps seen for the 4-foot medium bipin product class. However, after examining commercially-available product DOE believes that five, not three, efficacy levels are appropriate for the 2-foot U-shaped product class. DOE assessed manufacturer catalogs containing commercially-available U-shaped lamps to develop standard levels with a similar technology impact at each EL as 4-foot linear medium bipin lamps. DOE supplemented this analysis with compliance report data for U-shaped lamps to verify that the established efficacy levels coincide with the technological goals and actual performance of products on the market. For specific scaling factors for the proposed 2-foot U-shaped efficacy levels and a more detailed discussion of DOE's methodology, see chapter 5 of the TSD.

b. Incandescent Reflector Lamps

i. Modified-Spectrum IRL

At the ANOPR public meeting, DOE stated that the average reduction in efficacy of modified-spectrum lamps (as compared to standard spectrum lamps) was between 2 percent and 25 percent, with an average reduction of 15 percent. DOE acknowledged the range of spectrum modification and its effects on utility, and aimed to establish a standard that would not eliminate modified-spectrum lamps. Therefore, in the March 2008 ANOPR, DOE considered a minimum efficacy requirement for each modified-spectrum lamp that would be dependent on the testing of a equivalent standard-spectrum lamp. More specifically, the efficacy requirement for the modified-spectrum lamp would be determined on a per-lamp basis by measuring the lumen output of both the modified-spectrum lamp and the equivalent standard-spectrum reference lamp; manufacturers would then multiply the ratio of lumen outputs (*i.e.,* the lumen output of the modified-spectrum lamp divided by the lumen output of the standard-spectrum reference lamp) by the efficacy requirement for the standard-spectrum reference lamp to obtain the efficacy requirement for that modified-spectrum lamp. 73 FR 13620,13653 (March 13, 2008).

GE commented that this approach may be reasonable as long as DOE gave this reduction to true modified-spectrum lamps, rather than lamps marketed as having modified spectrums, but which in fact do not meet the requirements of that term. (Public Meeting Transcript, No. 21 at p. 168) NEMA commented that DOE's proposal for establishing an efficacy standard for modified-spectrum IRL is complicated, difficult to enforce, and non-verifiable. (NEMA, No. 22 at p. 19) In addition, NEMA expressed concern that the responsibility of establishing the efficacy for the equivalent standard-spectrum lamp would fall on the manufacturer. (Public Meeting Transcript, No. 21 at pp. 100–101) Also, the Joint Comment disagreed with an approach that would allow modified-spectrum technologies a variable reduction in efficacy (depending on their degree of spectrum modification and the method with which it is reached). (Joint Comment, No. 23 at p. 16) In response to those comments, DOE recognizes the drawbacks to the approach considered in the ANOPR and instead in the NOPR is proposing a single efficacy requirement (irrespective of the degree or method of spectrum modification) for each modified-spectrum IRL product class.

GE and NEMA suggested that the 25-percent reduction for A-line modified-spectrum lamps enacted by EISA 2007 standards for general service incandescent lamps (GSIL) and modified-spectrum GSIL may be appropriate for modified-spectrum IRL. (Public Meeting Transcript, No. 21 at pp. 169–170; NEMA, No. 22 at p. 19) The Joint Comment expressed an opposing viewpoint, arguing that the 25-percent reduction specified in EISA 2007 was based on a political compromise, not technical research. The Joint Comment also mentions that Ecos Consulting, on behalf of PG&E, tested a variety of modified-spectrum general service incandescent lamps. Their researchers estimated a total light output reduction of 11 to 18 percent due to the modified spectrum. (Joint Comment, No. 23 at p. 16)

DOE agrees with the Joint Comment that the reduction in efficacy for general service incandescent lamps used in EISA 2007 may not be appropriate for IRL. Instead, DOE based its reduction for the modified-spectrum product classes on independent testing and research of commercially-available modified-spectrum and standard-spectrum IRL.

Several stakeholders commented that the range of lumen reduction (2 percent to 29 percent) found among commercially-available modified-spectrum IRL may be attributable to lamps that do not meet the statutory definition of ''modified spectrum,'' which would make the stated average too high. (NEMA, No. 22 at p. 19; Public Meeting Transcript, No. 21 at pp. 164–167) These stakeholders suggested that DOE should only use lamps that meet the definition of ''modified spectrum'' when determining an appropriate scaling factor. (Public Meeting Transcript, No. 21 at p. 167–168) GE suggested that lamps sold by major manufacturers will meet the statutory definition of ''modified spectrum'' because NEMA manufacturers offered input into the legislative process that created this definition. (Public Meeting Transcript, No. 21 at p. 171)

In addition, the Joint Comment noted that when determining the modified-spectrum scaling factor, DOE should base its analysis on HIR IRL sources rather than conventional incandescent or conventional halogen IRL. The Joint Comment further stated that the spectral distribution of the HIR sources have reduced output in the red region of the spectrum compared to conventional incandescent lamp. The comment argued because this red region is the portion of the spectrum modified-spectrum lamps are often trying to suppress, a lower and more accurate scaling factor could be calculated by considering only HIR lamps. (Joint Comment, No. 23 at p. 16)

DOE agrees with stakeholders regarding the need to determine appropriate scaling factors and tested several modified-spectrum lamps from major manufacturers to determine whether they qualify as modified spectrum under the statutory definition. DOE only used the IRL that qualify as modified spectrum under the statutory definition to determine an appropriate scaling factor. In addition, DOE acknowledges that the spectral power distributions of incandescent (non-halogen), halogen, and HIR IRL are different over the electromagnetic spectrum. However, DOE does not believe that the reduced light output in the red region of the spectrum of HIR sources significantly affects the resulting scaling factor. This high wavelength red region of the spectrum is not weighted heavily when calculating the lumens emitted by the lamp. Therefore, any spectral differences in the infrared regions between the halogen IRL compared to the halogen infrared IRL would produce only minor differences in the reduction in efficacy for modified-spectrum lamps. Therefore, DOE tested both HIR and conventional halogen lamps in determining an appropriate scaling factor for modified spectrum.

However, as non-halogen (or conventional incandescent) IRL have significantly different radiation spectra over wavelengths contributing to the calculation of lumens (in general their light outputs are shifted toward lower wavelengths), it is likely that the resulting scaling factor based on these lamps would be significantly different than for halogen sources. Because non-halogen IRL (representing the IRL lamp types exempted from standards) are not regulated in this rulemaking, DOE believes that it would be inappropriate to include such lamps in its scaling factor analysis. Therefore, DOE considered only halogen and HIR IRL for the computation of the modified-spectrum IRL scaling factor.

To determine the scaling factor, DOE tested seven pairs (each pair consisting of one standard-spectrum lamp and one lamp marketed as modified-spectrum or a similar designation) of halogen IRL and one pair of HIR IRL made by major manufacturers. Though many of the lamps did not qualify as modified-spectrum under the statutory definition, for those that did qualify, DOE determined that the difference in light output and efficacy due to the modified-spectrum coating was 19 percent for both the halogen and IR halogen lamps. Therefore, DOE proposes to use a 19 percent reduction as the scaling factor for modified-spectrum IRL. For further details on scaling to modified-spectrum lamps, see chapter 5 and appendix 5C of the TSD.

ii. Lamp Diameter

As discussed in section V.A.2.c, in this NOPR, DOE has established separate product classes for IRL with a diameter of 2.5 inches or less based on their decreased efficacy associated with the unique utility that they provide (*e.g.*, ability of reduced diameter lamps to be installed in smaller fixtures). NEMA commented that a percentage reduction should be applied to the PAR30/PAR38 CSL so as not to eliminate PAR20 lamps (with diameters of 2.5 inches) at the highest CSLs set forth in the ANOPR. (Public Meeting Transcript, No. 21 at pp. 158–159) NEMA explained that the PAR20 lamp optical system is inherently less efficient than the PAR30 and PAR38 optical systems. In addition, it is difficult to implement the most efficient double-ended HIR burner in the PAR20 lamps. Therefore, NEMA suggests a reduction in the lumen per watt standards by 12 percent. (NEMA, No. 22 at pp. 17–18) In the Joint Comment, stakeholders stated that they were not opposed to a reduction in the efficacy standard as long as data supports manufacturer claims. (Joint Comment, No. 23 at p. 15–16)

DOE understands that PAR20 lamps are inherently less efficient than PAR30 and PAR38 lamps. To determine an appropriate scaling factor, DOE examined the inherent efficacy differences between the PAR20 lamp and its PAR30 or PAR38 counterpart by comparing catalog efficacy data of each lamp type from several lamp manufacturers. In general, DOE's analysis is consistent with NEMA's suggestion. Therefore, DOE proposes applying a 12-percent reduction from the efficacy requirement of the PAR30/PAR38 product class to determine the efficacy requirement for the PAR20 product class. For further details regarding the scaling to smaller lamp diameters, see chapter 5 of the TSD.

iii. Voltage

DOE also conducted an analysis to determine how to scale from the less than 125 volt product class to the greater or equal to 125 volt product class. NEMA commented that lamps rated at 130V are almost always used by customers to achieve "double life" by operating them at 120V, which results in performance below EPACT 1992 efficacy levels. (NEMA, No. 22 at p. 16) In consideration of the different test procedures for IRL rated at 130V than those rated at 120V, and by using equations from the *IESNA Lighting Handbook*,[27] DOE derived an efficacy scaling factor which would result in equivalent performance of both classes of IRL when operating under the same voltage conditions (as NEMA suggests they most often are). DOE determined that a higher standard for lamps equal to or greater than 125V would result in similar technological requirements and operational efficacies for lamps rated at all voltages. Using published manufacturer literature and the *IESNA Lighting Handbook*, DOE determined that there should be a 15-percent increase in the efficacy standard for lamps rated at 125V or greater. See chapter 5 of the TSD for details of the results and methodology used in the scaling analysis and other aspects of the engineering analysis.

D. Life-Cycle Cost and Payback Period Analyses

This section describes the LCC and payback period analyses and the spreadsheet model DOE used for analyzing the economic impacts of possible standards on individual consumers. Details of the spreadsheet model, and of all the inputs to the LCC and PBP analyses, are contained in chapter 8 and appendix 8A of the TSD. DOE conducted the LCC and PBP analyses using a spreadsheet model developed in Microsoft Excel. When combined with Crystal Ball (a commercially-available software program), the LCC and PBP model generates a Monte Carlo simulation[28] to perform the analysis by incorporating uncertainty and variability considerations.

The LCC analysis estimates the impact of a standard on consumers by calculating the net cost of a lamp (or lamp-and-ballast system) under a base-case scenario (in which no new energy conservation standard is in effect) and under a standards-case scenario (in which the proposed energy conservation regulation is applied). As detailed in the March 2008 ANOPR, the life-cycle cost of a particular lamp design is composed of the total installed cost (which includes manufacturer selling price, sales taxes, distribution chain mark-ups, and any installation cost), operating expenses (energy, repair, and maintenance costs), product lifetime, and discount rate. 73 FR 13620, 13659 (March 13, 2008). As noted in the March 2008 ANOPR, DOE also incorporated a residual value calculation to account for any remaining lifetime of lamps (or ballasts) at the end of the analysis period. 73 FR 13620, 13659 (March 13, 2008). The residual value is an estimate of the product's value to the consumer at the end of the life-cycle cost analysis period. In addition, this residual value must recognize that a lamp system continues to function beyond the end of the analysis period. DOE calculates the residual value by linearly prorating the product's initial cost consistent with the methodology described in the *Life-Cycle Costing Manual for the Federal Energy Management Program*.[29]

The payback period is the change in purchase expense due to an increased energy conservation standard, divided by the change in annual operating cost that results from the standard. Stated more simply, the payback period is the time period it takes to recoup the increased purchase cost (including installation) of a more-efficient product through energy savings. DOE expresses this period in years.

The Joint Comment stated that given the inherent uncertainty in the LCC methodology, DOE should recognize that LCC results within a certain range can be considered essentially equivalent. The Joint Comment emphasized that recognizing this uncertainty is especially important if other aspects of the analysis (*e.g.*, energy savings) show large differences for standard levels with LCC results that, given uncertainty in the analysis, are essentially the same. (Joint Comment, No. 23 at p. 22) DOE agrees that there are inherent sources of uncertainty in

[27] Rea, M. S., ed., *The IESNA Lighting Handbook: Reference and Application, 9th Edition*. New York: Illuminating Engineering Society of North America. IESNA (2000).

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

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

the results of the LCC analysis due to the need to forecast certain inputs (*e.g.*, future electricity prices). In addition, DOE recognizes that inputs such as sales tax, operating hours, and discount rates may introduce variability in LCC results. However, as explained below, DOE's analyses are structured so as to address such uncertainties. As stated earlier, to properly characterize the LCC results, DOE performed probability analyses via Monte Carlo simulations by utilizing Microsoft Excel in combination with Crystal Ball. The Monte Carlo approach allowed DOE to determine average LCC savings and payback periods, as well as the proportion of lamp installations achieving LCC savings or attaining certain payback values. To fully consider the range of LCC results that may occur due to a standard, DOE also performed several sensitivity analyses on inputs such as operating hours, electricity price forecasts, and product prices. Based on these analyses, DOE believes that it can characterize the LCC and PBP for these products with a reasonable degree of certainty. See the TSD appendix 8B for further details, where probable ranges of LCC results are presented.

Table V.2 summarizes the approach and data that DOE used to derive the inputs to the LCC and PBP calculations for the March 2008 ANOPR and the changes made for today's proposed rule. The following sections discuss these inputs and comments DOE received regarding its presentation of the LCC and PBP analyses in the March 2008 ANOPR, as well as DOE's responses thereto.

TABLE V.2—SUMMARY OF INPUTS AND KEY ASSUMPTIONS USED IN THE ANOPR AND NOPR LCC ANALYSES

Inputs	March 2008 ANOPR	Changes for the Proposed Rule
Consumer Product Price	Applied discounts to manufacturer catalog ("blue-book") pricing in order to represent low, medium, and high prices for all lamp categories. Discounts were also applied to develop a price for ballasts.	Used same methodology from March 2008 ANOPR to derive additional prices for new lamps and ballasts incorporated into the engineering analysis.
Sales Tax	Derived weighted-average tax values for each Census division and large State from data provided by the Sales Tax Clearinghouse.[1]	Updated the sales tax using the latest information from the Sales Tax Clearinghouse.[2]
Installation Cost	Derived costs using the RS Means Electrical Cost Data, 2007[3] to obtain average labor times for installation, as well as labor rates for electricians and helpers based on wage rates, benefits, and training costs.	IRL and GSFL: Updated lamp replacement and lamp and ballast replacement labor rates from 2006$ to 2007$. GSFL: Added 2.5 minutes of installation time to the new construction, major retrofit, and renovation events in the commercial and industrial sectors to capture the time needed to install luminaire disconnects.
Disposal Cost	Not included	GSFL: Included a recycling cost of 10 cents per linear foot in the commercial and industrial sectors. IRL: No change.
Annual Operating Hours	Determined operating hours by associating building-type-specific operating hours data with regional distributions of various building types using the 2002 U.S. Lighting Market Characterization[4] and the Energy Information Administration's (EIA) 2003 Commercial Building Energy Consumption Survey (CBECS),[5] 2001 Residential Energy Consumption Survey,[6] and 2002 Manufacturing Energy Consumption Survey.[7]	GSFL: Added residential GSFL to LCC analysis and used methodology developed in the March 2008 ANOPR to derive residential operating hours for GSFL based on data in the 2002 U.S. Lighting Market Characterization and the EIA's 2001 Residential Energy Consumption Survey. IRL: Removed industrial sector analysis due to the low prevalence of IRL in that sector.
Product Energy Consumption Rate.	Determined lamp input power (or lamp-and-ballast system input power for GSFL) based on published manufacturer literature. Used a linear fit of GSFL system power on several different ballasts with varying ballast factors in order to derive GSFL system power for all of the ballasts used in the analysis.	Updated 4-foot T8 lamp-and-ballast system input power based on additional published manufacturer literature. Developed new system input powers for 8-foot T12 HO systems, 4-foot T12 residential systems, and 4-foot T5 systems.
Electricity Prices	Price: Based on EIA's 2005 Form EIA–861 data Variability: Regional energy prices determined for 13 regions.	Price: Updated using EIA's 2006 Form EIA 861 data.[8] Variability: No change.
Electricity Price Trends	Forecasted with EIA's Annual Energy Outlook (*AEO) 2007*.[9]	Updated with EIA's *AEO2008*.[10]
Lifetime	Ballast lifetime based on average ballast life of 49,054 from 2000 Ballast Rule.[11] Lamp lifetime based on published manufacturer literature where available. DOE assumed a lamp operating time of 3 hours per start. Where manufacturer literature was not available, DOE derived lamp lifetimes as part of the engineering analysis.	Ballasts: No change in commercial and industrial sector. Developed separate ballast lifetime estimate for the residential sector. Residential GSFL: 4-foot medium bipin lamp lifetime is dependent on the fixture lifetime (*i.e.,* the fixture reaches end of life before the lamp reaches end of life.). Commercial and industrial GSFL: No change. IRL: No change.

TABLE V.2—SUMMARY OF INPUTS AND KEY ASSUMPTIONS USED IN THE ANOPR AND NOPR LCC ANALYSES—Continued

Inputs	March 2008 ANOPR	Changes for the Proposed Rule
Discount Rate	Residential: Approach based on the finance cost of raising funds to purchase lamps either through the financial cost of any debt incurred to purchase product or the opportunity cost of any equity used to purchase equipment, based on the Federal Reserve's Survey of Consumer Finances data [12] for 1989, 1992, 1995, 1998, 2001, and 2004. Commercial and industrial: Derived discount rates using the cost of capital of publicly-traded firms in the sectors that purchase lamps, based on data in the 2003 CBECS,[13] Damodaran Online,[14] Ibbotson's Associates,[15] the 2007 Value Line Investment survey,[16] Office of Management and Budget (OMB) Circular No. A–94,[17] 2008 State and local bond interest rates,[18] and the U.S. Bureau of Economic Analysis.[19]	DOE updated the commercial and industrial discount rates using the latest versions of the sources used in the March 2008 ANOPR.
Analysis Period	Based on the longest baseline lamp life in a product class divided by the annual operating hours of that lamp.	Commercial and industrial GSFL: No Change. Residential GSFL: Analysis period is based on the useful lifetime of the baseline lamp. IRL: No Change.
Lamp Purchasing Events	DOE assessed five events: Lamp failure, standards-induced retrofit, ballast failure (GSFL only), ballast retrofit (GSFL only), and new construction/renovation.	GSFL: DOE assumed that HO lamps used magnetic ballasts in the base case. DOE added lamp failure, ballast failure/fixture failure, and new construction events for 4-foot medium bipin systems in the residential sector, where DOE also assumed the usage of magnetic ballasts in the base case. IRL: No change.

[1] The four large States are New York, California, Texas, and Florida.

[2] Sales Tax Clearinghouse, Aggregate State Tax Rates (2008)(Last accessed May 30, 2008). Available at: *http://thestc.com/STrates.stm*. The May 30, 2008 material from this Web site is available in Docket # EE–2006–STD–0131. For more information, contact Brenda Edwards at (202) 586–2945.

[3] R. S. Means Company, Inc., 2007 RS Means Electrical Cost Data (2007).

[4] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Energy Conservation Program for Consumer Products: Final Report: U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate (2002). Available at: *http://www.eere.energy.gov/buildings/info/documents/pdfs/lmc_vol1_final.pdf*.

[5] U.S. Department of Energy, Energy Information Administration, Commercial Building Energy Consumption Survey: Micro-level data, file 2 Building Activities, Special Measures of Size, and Multi-building Facilities (2003). Available at: *http://www.eia.doe.gov/emeu/cbecs/public_use.html*.

[6] U.S. Department of Energy, Energy Information Administration, Residential Energy Consumption Survey: File 1: Housing Unit Characteristic (2006). Available at: *http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html.*

[7] U.S. Department of Energy, Energy Information Administration, Manufacturing Energy Consumption Survey, Table 1.4: Number of Establishments by First Use of Energy for All Purposes (Fuel and Nonfuel) (2002). Available at: *http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html.*

[8] U.S. Department of Energy, Energy Information Administration, Form EIA–861 for 2006 (2006). Available at: *http://www.eia.doe.gov/cneaf/electricity/page/eia861.html.*

[9] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2007 with Projections to 2030* (Feb. 2007). Available at: *http://www.eia.doe.gov/oiaf/aeo/index.html.*

[10] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2008 with Projections to 2030* (June 2008). Available at: *http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_3.xls*.

[11] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Building Research and Standards, Technical Support Document: Energy Efficiency Standards for Consumer Products: Fluorescent Lamps Ballast Final Rule (Sept. 2000). Available at: *http://www1.eere.energy.gov/buildings/appliance_standards/residential/gs_fluorescent_0100_r.html*.

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

[13] U.S. Department of Energy, Energy Information Administration, Commercial Building Energy Consumption Survey (2003). Available at: *http://www.eia.doe.gov/emeu/cbecs/*.

[14] Damodaran Online, *The Data Page: Historical Returns on Stocks, Bonds, and Bills—United States* (2006). Available at: *http://pages.stern.nyu.edu/adamodar*. (Last accessed Sept. 12, 2007.) The September 12, 2007 material from this Web site is available in Docket # EE–2006–STD–0131. For more information, contact Brenda Edwards at (202) 586–2945.

[15] Ibbotson's Associates, Stocks, Bonds, Bills, and Inflation, Valuation Edition, 2001 Yearbook (2001).

[16] Value Line, Value Line Investment Survey (2007). Available at: *http://www.valueline.com.*

[17] U.S. Office of Management and Budget, Circular No. A–94 Appendix C (2008). Available at: *http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html*.

[18] Federal Reserve Board, Statistics: Releases and Historical Data—Selected Interest Rates—State and Local Bonds (2008). Available at: *http://www.federalreserve.gov/releases/h15/data/Monthly/H15_SL_Y20.txt*.

[19] U.S. Department of Commerce, Bureau of Economic Analysis, Table 1.1.9 Implicit Price Deflators for Gross Domestic Product (2008). Available at: *http://www.bea.gov/national/nipaweb/SelectTable.asp?Selected=N.*

1. Consumer Product Price

As in the March 2008 ANOPR, DOE used a variety of sources to develop consumer equipment prices, including lamp and ballast prices in manufacturers' suggested retail price lists (''blue books''), State procurement contracts, large electrical supply distributors, hardware and home improvement stores, Internet retailers, and other similar sources. DOE then developed low, medium, and high prices based on its findings.

For the NOPR, DOE added several new lamps and ballasts to its analyses. Accordingly, DOE developed prices for 4-foot medium bipin GSFL systems in the residential sector, the 8-foot HO magnetic ballast, and commercially-available 4-foot T5 miniature bipin standard output and high-output lamps and ballasts using the same methodology applied in the March 2008 ANOPR. However, not all lamps assessed for this rulemaking are commercially available. In particular, DOE developed model halophosphor T5 standard-output and high-output lamps as baselines for these product classes. To establish prices for these baseline lamps, DOE calculated the price differential between a halophosphor 4-foot MBP lamp and the highest-efficacy 32W 4-foot MBP lamp. DOE then used this relationship to scale prices from the commercially-available T5 standard-output and high-output lamps to establish the halophosphor lamp prices.

DOE also developed a model IRL for EL1 based on the incorporation of xenon gas into the lamps. To determine the price of these lamps, DOE interviewed manufacturers and conducted its own research on the cost of xenon [30] to develop a manufacturer cost increase over the baseline lamp in a product class, and then applied a markup to represent consumer prices. See the engineering analysis in section V.C.4.b for further information on the model IRL lamp.

DOE also developed a price for the 6,000-hour HIR IRL for the NOPR. After reviewing data in manufacturer catalogs and interviewing manufacturers, DOE determined that the manufacturing costs for the 6,000-hour HIR lamp are the same as the manufacturing costs for the 3,000-hour HIR lamps that meet EL3. Therefore, for the NOPR, the commoditized retail prices for the long-life HIR lamps are the same as for the IRL that meet EL3.

Lastly, because DOE did not have manufacturer suggested retail price list data for the EL5 (HIR Plus) IRL, DOE used prices offered by Internet retailers to establish prices for these lamps. Specifically, DOE calculated individual retailers' discounts on blue book prices for EL4 (Improved HIR) lamps. DOE applied these same discounts to establish average blue book prices for EL5 lamps across all Internet retailers found to sell both EL4 and EL5 lamps. Using these approximate blue-book prices, DOE then followed the same methodology applied in the March 2008 ANOPR to establish low, medium and high lamp prices.

2. Sales Tax

As in the March 2008 ANOPR, DOE obtained State and local sales tax data from the Sales Tax Clearinghouse. (March 2008 ANOPR TSD chapter 7) The data represented weighted averages that include county and city rates. DOE used the data to compute population-weighted average tax values for each Census division and four large States (New York, California, Texas, and Florida). For the NOPR, DOE retained this methodology and used updated sales tax data from the Sales Tax Clearinghouse [31] and updated population estimates from the U.S. Census Bureau.[32]

3. Installation Costs

As detailed in the ANOPR, DOE considered the total installed cost of a lamp or lamp-and-ballast system to be the consumer product price (including sales taxes) plus the installation cost. 73 FR 13620, 13660 (March 13, 2008). For the commercial and industrial sectors, DOE assumed an installation cost that was the product of the average labor rate and the time needed to install a lamp or lamp and ballast. In the residential sector, DOE assumed that consumers must pay for the installation of a lamp and ballast system. Therefore, the installation cost assumed was the product of the average labor rate and the time needed to install the lamp and ballast system. However, DOE assumed that consumers would install their own replacement lamps and, thus, would incur no installation cost when replacing their own lamp.

DOE received multiple comments on the average labor rates DOE used in the March 2008 ANOPR: $65.35 per hour for an electrician and $42.40 per hour for an electrician's helper. (March 2008 ANOPR TSD chapter 8). DOE assumed that the lamp-and-ballast hourly labor rate is 50 percent of an electrician's rate and 50 percent of the helper's rate, for a total labor rate of $53.88 based on ''RS Means Electrical Cost Data, 2007'' (RS Means).[33] NEMA commented that $53.88 per hour is approximately 10 percent lower than the current labor rate including benefits, while the Joint Comment stated that $54 per hour for ballast change-outs is reasonable only for residential and small commercial customers, and is too high for large commercial customers, who will have a full-time electrician or non-electrician maintenance person on staff for installations. (NEMA, No. 22 at p. 22; Joint Comment, No. 23 at p. 10) ACEEE also commented that large companies may have electricians on staff and encouraged DOE to research labor rates for these workers. (Public Meeting Transcript, No. 21 at pp. 216–217)

DOE understands that there may be a range of labor rates in the market for installations and also clarifies that the March 2008 ANOPR labor rate of $53.88 per hour is for the installation of lamps and ballasts, not only ballasts, as stated in the Joint Comment. ACEEE and the Joint Comment requested that DOE lower the labor rate, while NEMA commented that DOE should raise the labor rate; none of the comments provided DOE with supporting references. DOE uses ''RS Means Electrical Cost Data, 2007,'' because labor costs in RS Means are based on labor union agreements and construction wages, as well as actual working conditions in 30 major U.S. cities. Productivity data in RS Means represents an extended period of observations. For this reason, DOE chose to retain for the NOPR the RS Means methodology used for the March 2008 ANOPR. Based on inflation estimates derived from consumer price index data from the U.S. Bureau of Labor Statistics, DOE estimated that this rate in 2007 dollars is $55.41 per hour. DOE also updated the lamp replacement labor rate to be $15.94 per hour in 2007 dollars.

In the March 2008 ANOPR, DOE used several installation times for lamps and ballasts in the commercial and industrial sector analyses, such as the lower bound installation time of 30 minutes for 2-lamp 4-foot medium bipin fixtures, and the upper bound installation time of 60 minutes for 2-lamp 8-foot recessed double contact high-output fixtures. (March 2008 ANOPR TSD chapter 8) These times were obtained from the 2000 Ballast Rule TSD.[34]

DOE received several comments addressing these installation times. GE commented that the 2005 National Electric Code requirements for disconnecting luminaires before they are serviced for lamp or ballast

[30] DOE used the information in the following article to obtain the price of xenon: Betzendahl, Richard, ''The Rare Gets More Rare: The Rare Gases Market Update,'' CryoGas International (June 2008) 26.

[31] Sales Tax Clearinghouse, ''Aggregate State Tax Rates'' (2007) (Last accessed May 30, 2008). Available at: *http://thestc.com/STrates.stm*. The May 30, 2008, material from this Web site is available in Docket #EE–2006–STD–0131. For more information, contact Brenda Edwards at (202) 586–2945.

[32] U.S. Census Bureau, ''Population Change: April 1, 2000 to July 1, 2007'' (July 2007). Available at: *http://www.census.gov/popest/states/files/NST-EST2007-popchg2000-2007.csv*.

[33] R. S. Means Company, Inc., *2007 RS Means Electrical Cost Data* (2007).

[34] U.S. Department of Energy, ''Appendix A: Engineering Analysis Support Documentation, 2000 Ballast Rule'' (2000) (Last accessed June 20, 2008). Available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/appendix_a.pdf*.

replacements and installing luminaire disconnects for new construction or major retrofits will necessitate additional labor time. (Public Meeting Transcript, No. 21 at pp. 218–219; NEMA, No. 22 at p. 22) NEMA recommended that DOE use an installation time of approximately 2 to 3 minutes for luminaire disconnects. Industrial Ecology commented on average installation times during the recent relamping of a school in Atlantic City, NJ, in which an electrician changed ballasts and lamps for 4-lamp and 2-lamp fixtures at the rate of approximately 3 fixtures per hour. (Public Meeting Transcript, No. 21 at p. 220)

DOE agrees that extra time will be needed when a luminaire disconnect must be installed. Because DOE has not received detailed data on other installation times apart from the ones used in the 2000 Ballast Rule, DOE revised the ANOPR installation times specifically to address the time added by the installation of luminaire disconnects. For the NOPR analysis, DOE added 2.5 minutes to the ANOPR installation times for new construction, major retrofits, and renovation, events in which DOE assumed that a luminaire disconnect must be installed. Additional details on installation costs are available in chapter 8 of the NOPR TSD.

4. Disposal Costs

DOE did not consider disposal costs in the March 2008 ANOPR. Industrial Ecology commented that recycling costs should be considered in the LCC analysis for GSFL and that such costs range from 5 cents to 10 cents per foot. (Public Meeting Transcript, No. 21 at p. 212) In response, DOE researched recycling costs for GSFL and found an average cost of 10 cents per linear foot.[35] DOE also explored the prevalence of recycling in the commercial, industrial, and residential sectors. A report released by the Association of Lighting and Mercury Recyclers in 2004 noted that approximately 30 percent of lamps used by businesses and 2 percent of lamps in the residential sector are recycled nationwide.[36] DOE considers the 30 percent commercial and industrial recycling rate to be significant and, thus, incorporates recycling costs into its main analysis. DOE applied a cost of 10 cents per linear foot in the commercial and industrial sectors every time a lamp is replaced during the LCC analysis period. Due to discounting, the inclusion of recycling costs affects the LCC savings of lamps with different lifetimes than the baseline lamps that they are compared to. The recycling cost also affects the residual value of lamps that operate beyond the end of the analysis period. In the Monte Carlo analysis, DOE assumes that commercial and industrial consumers pay recycling costs in approximately 30 percent of lamp failures. DOE does not expect the 2 percent residential recycling rate to affect the residential sector LCC substantially, however, and thus did not apply the recycling costs to this sector.

5. Annual Operating Hours

DOE developed annual operating hours for IRL and GSFL in the March 2008 ANOPR by combining building type-specific operating hours data in the 2002 U.S. Lighting Market Characterization (LMC)[37] with data in the 2003 Commercial Building Energy Consumption Survey (CBECS),[38] the 2001 Residential Energy Consumption Survey (RECS),[39] and the 2002 Manufacturing Energy Consumption Survey (MECS),[40] which describe the probability that a particular building type exists in a particular region. (March 2008 ANOPR TSD chapter 6) DOE received comments on three areas related to the operating hours used for the LCC analysis: (1) Sectors analyzed; (2) regional variations; and (3) building types. These comments are discussed below. For further details regarding the annual operating hours used in the analyses, see chapter 6 of the TSD.

a. Sectors Analyzed

In the March 2008 ANOPR, DOE analyzed GSFL in the commercial and industrial sectors; DOE did not analyze the usage of GSFL in the residential sector because it believed it was a relatively small portion of GSFL sales. The Joint Comment requested that DOE perform an LCC analysis of GSFL in the residential sector, because lamps in the residential sector are replaced infrequently due to lower operating hours compared to the commercial and industrial sectors. (Joint Comment, No. 23 at p. 10) Similarly, NEMA commented that DOE should assess GSFL in the residential sector, because certain ELs may eliminate T12 lamp types, requiring many residential consumers to install new lamp fixtures. (NEMA, No. 22 at p. 32)

In response, DOE assessed the installed stock of lamps using the LMC, which stated that approximately 25 percent of linear fluorescent lamps exist in the residential sector. DOE considers this proportion to be significant and, thus, supports the recommendation to perform a residential LCC analysis of GSFL. DOE developed residential operating hours for GSFL by using data in the 2002 LMC and the 2001 RECS. However, DOE only performed an LCC analysis of 4-foot medium bipin lamps in the residential sector, because marketing literature indicates that 8-foot single pin slimline lamps and 8-foot recessed double contact HO lamps are not prevalent in residential settings.

In the March 2008 ANOPR, DOE analyzed IRL in the commercial, residential, and industrial sectors. (March 2008 ANOPR TSD chapter 6) NEMA commented that IRL should be removed from the industrial sector LCC analysis because they are rarely used in industrial settings. The Joint Comment emphasized the importance of analyzing IRL in the residential sector due to lower operating hours and higher electricity prices for residences compared to prices in the commercial sector. (NEMA, No. 22 at p. 20; Joint Comment, No. 23 at p. 17)

The LMC indicates that less than 1 percent of IRL were found in the industrial sector. Based on this data, DOE agrees with both comments and has removed IRL from the industrial sector in terms of its analyses. Consistent with the March 2008 ANORP LCC analysis, DOE also continued to perform a residential sector LCC analysis of IRL for the NOPR.

b. Regional Variation

At the public meeting for the March 2008 ANOPR, the Alliance to Save

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[35] Environmental Health and Safety Online's fluorescent lights and lighting disposal and recycling Web page—Recycling Costs. Available at: *http://www.ehso.com/fluoresc.php* (Last accessed Dec. 8, 2008).

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

[37] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, ''U.S. Lighting Market Characterization. Volume I: National Lighting Inventory and Energy Consumption Estimate (2002).'' Available at: *http://www.netl.doe.gov/ssl/PDFs/lmc_vol1_final.pdf*.

[38] 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: *http://www.eia.doe.gov/emeu/cbecs/public_use.html*.

[39] U.S. Department of Energy, Energy Information Agency, ''Residential Energy Consumption Survey: File 1: Housing Unit Characteristic (2006).'' Available at: *http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html*.

[40] U.S. Department of Energy, Energy Information Agency, ''Manufacturing Energy Consumption Survey, Table 1.4: Number of Establishments by First Use of Energy for All Purposes (Fuel and Nonfuel) (2002).'' Available at: *http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html*.

Energy commented that the LMC, which DOE used during the LCC analysis, may underestimate energy usage in the residential sector because operating hours may vary regionally (*e.g.*, by latitude), even for the same building types. (Public Meeting Transcript, No. 21 at pp. 197–198) In contrast, the Northwest Power and Conservation Council responded that there was a variation of a tenth of an hour per day in operating hours between a study completed in Tacoma, Washington, and a study of California. Therefore, the Council suggested that differences in latitude and weather do not significantly affect operating hours. (Public Meeting Transcript, No. 21 at p. 199)

DOE found no conclusive evidence that would suggest that geographic location has a significant impact on operating hours for a given building type. However, DOE found evidence of regional differences in the proportions of different building types (*e.g.*, number of mobile homes versus number of multi-family dwellings) as the probable source of regional variation in operating hours.[41] As detailed in the March 2008 ANOPR, DOE captured this regional variation by using the RECS, CBECS, and MECS to determine the probability that a particular building type exists in a particular region. 73 FR 13620, 13654 (March 13, 2008). For this reason, DOE has not revised its analysis for the NOPR to specifically address latitude, weather, or other regional factors apart from building type proportions.

c. Building Type

NEMA requested a confirmation that DOE has included retail facilities in its consideration of operating hours, because retail facilities have more operating hours compared to other commercial facilities. (NEMA, No. 22 at p. 20) DOE is aware that different commercial building types have different average operating hours and, thus, considered a variety of commercial building types, including retail facilities, in its analysis. Operating hours were determined using the LMC study. DOE assessed the operating hours for retail facilities for the March 2008 ANOPR (ANOPR chapter 6 of the TSD) and retained the assessment of commercial retail facility operating hours for the NOPR analysis.

6. Product Energy Consumption Rate

As in the March 2008 ANOPR, DOE determined lamp input power (or lamp-and-ballast system input power for GSFL) based on published manufacturer literature. (March 2008 ANOPR TSD chapter 5) For GSFL, DOE assessed a variety of lamp-and-ballast combinations by establishing a correlation between ballast factor and system input power. This allowed DOE to derive GSFL system power (in watts) for all of the lamp and ballast combinations used in the analysis. The rated system power was then multiplied by the annual operating hours of the system to determine the annual energy consumption. DOE retained this methodology for this notice.

For this NOPR, DOE updated system input power ratings for certain lamp-and-ballast combinations, and developed new system-input powers for other lamp-and-ballast combinations not considered in the March 2008 ANOPR. Specifically, DOE obtained additional system power ratings for 4-foot T8 ballasts from recently released manufacturer literature and updated these system input power ratings for the NOPR. DOE also developed new system input power ratings for magnetic residential 4-foot T12 systems, magnetic 8-foot HO systems, 4-foot T5 miniature bipin systems, and 4-foot T5 miniature bipin HO systems.

7. Electricity Prices

DOE determined energy prices by deriving regional average prices for 13 geographic areas consisting of the nine U.S. Census divisions, with four large states (New York, Florida, Texas, and California) treated separately. The derivation of prices was based on data in EIA's Form EIA–861. DOE received three comments on the regional electricity prices that it used for the ANOPR LCC. PG&E commented that the California residential electricity price of 9.9 cents per kWh (ANOPR TSD chapter 8) was lower than what appears to be an average of 14 cents per kWh in the State. ACEEE and the Joint Comment recommended that DOE use EIA's publication ''Electric Power Monthly''—as a source of recent electricity prices instead of Form EIA–861. (Public Meeting Transcript, No. 21 at pp. 223–224; Joint Comment, No. 23 at p. 18)

In response, DOE notes that it uses Form EIA–861 for two reasons. First, it allows for the creation of regional average electricity prices weighted by the number of customers each electric utility serves. DOE prefers to use customer-weighted average electricity prices so that prices are not skewed by utilities serving small numbers of very large electricity consumers. Electricity sales are not well correlated with the number of consumers in the commercial sector, and the usage of customer-weighted averages more heavily weights the utilities that serve larger numbers of consumers. Second, ''Electric Power Monthly'' does not report customer-weighted prices. DOE appreciates the comments related to electricity prices, and for the NOPR analysis, DOE updated its electricity prices by using the latest version of Form EIA–861 (2006).[42] DOE notes that the latest Form's updated residential electricity price for California is 14.7 cents per kWh which is consistent with PG&E's assessment that the average residential electricity price in California is around 14 cents per kWh.

8. Electricity Price Trends

To project electricity prices to the end of the LCC analysis period in the March 2008 ANOPR, DOE used the reference, low-economic-growth, and high-economic-growth projections in EIA's *AEO2007*.[43] 73 FR 13620, 13660 (March 13, 2008). DOE received several comments on the resulting electricity price trends that it used in the LCC calculation. PG&E commented that DOE's forecasted electricity prices do not increase in real terms in the next 20 years, which the commenter argued is unrealistic. ACEEE and the Joint Comment both stated that DOE should use the most recent *AEO* forecasts along with a collection of other electricity price forecasts. (Public Meeting Transcript, No. 21 at pp. 224–225; Joint Comment, No. 23 at p. 18)

DOE supports the suggestion that it should use the most recent electricity price forecasts. DOE uses EIA's *AEO* because it is publicly available and has been widely reviewed. The latest *AEO* contains a table of comparisons to three other electricity forecasts; the only forecast that included prices (from Global Insight, Inc.) showed electricity prices very similar to the prices in the *AEO2008* reference case. Also, a conversion of the *AEO2008* forecast into real dollars reveals that *AEO*'s forecasted electricity prices do increase in real terms. For these reasons, DOE chose to continue using the *AEO* and

[41] E. Vine, D. Fielding, ''An Evaluation of Residential CFL Hours-of-Use Methodologies and Estimates: Recommendations for Evaluators and Program Managers,'' *Energy and Buildings* 38 (2006), 1388–1394.

[42] Energy Information Administration, *Form EIA–861 Final Data File for 2006* (2006) (Last accessed June 20, 2008). Available at: *http://www.eia.doe.gov/cneaf/electricity/page/eia861.html.*

[43] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2007 with Projections to 2030* (Feb. 2007). Available at: *http://www.eia.doe.gov/oiaf/archive/aeo07/index.html.*

the reference case in *AEO2008*.[44] DOE also presents LCC and PBP results for the low-economic-growth and high-economic-growth scenarios from *AEO2008* in appendix 8B of the TSD.

9. Lifetime

a. Ballast Lifetime

In chapter 8 of the March 2008 ANOPR TSD, DOE stated that it used 49,054 hours as the estimated ballast lifetime based on findings in the 2000 Ballast Rule. The Joint Comment suggested three reasons why ballast lifetimes are actually longer than the lifetime used in the 2000 Ballast Rule. The Joint Comment stated that, on average, ballasts operate below their life rating temperature. In addition, manufacturer estimates exceed the DOE lifetime even at rated conditions. The commenter also argued that market data of historical shipments of ballasts sold to new construction versus retrofit and replacement suggest that the average ballast life is longer than suggested. The Joint Comment contends that, in addition to considering the above points generally, DOE should specifically study these shipments to establish ballast lifetime. (Joint Comment, No. 23 at pp. 7–9)

Based on the Joint Comment's suggestions, DOE investigated several different ways of measuring a ballast's useful lifetime in commercial and residential buildings. DOE does not believe that using the rated temperature of ballasts is an appropriate way to measure a ballast's lifetime. For example, a building renovation or a lighting retrofit may cause buildings or homeowners to replace a ballast before it fails. DOE also believes that examining historical sales data of ballasts sold to new construction versus replacement and retrofit to estimate ballast lifetime would involve too many assumptions to provide a useful measure of lifetime. For example, DOE would need to estimate an appropriate distribution of ballast lifetimes in the field because ballasts are replaced at various points in their useful life due to different operating hours, failure rates, and time periods between initial building construction and the first lighting retrofit.

In its investigation of ballast lifetime, DOE encountered several studies that establish the ''measure life'' (*i.e.,* the true service life of a ballast in the field) of ballasts in both the commercial and residential sectors. One study comparing the results of several ''measure life'' reports found that the average ballast lifetime after a retrofit in the commercial sector is 13 years, and the average ballast lifetime after new construction is 15 years.[45] Using DOE's estimate of 49,054 hours and average operating hours for GSFL in the commercial sector, the lifetime of an average ballast is approximately 14.2 years. Because this lifetime is consistent with several measure life reports, DOE maintains the same ballast lifetime of 49,054 hours in its NOPR analysis. DOE also found in a separate measure life report that the average fixture and ballast in the residential sector lasts for 15 years. Therefore, in its residential sector analysis for GSFL, DOE established 15 years as the average ballast lifetime in the residential sector,[46] and an average annual operating lifetime of 789 hours. The ballast's average hours of operation over its service lifetime is therefore 11,835 hours in the residential sector.

b. Lamp Lifetime

When possible, DOE used manufacturer literature to measure lamp lifetimes, as in the March 2008 ANOPR. 73 FR 13620, 13662 (March 13, 2008). When published manufacturer literature was not available (as for some IRL), DOE derived lamp lifetimes as part of the engineering analysis (section V.C.4.b). DOE based its calculations of GSFL lifetime for the base and standards cases on lamp operating times of 3 hours per start in the March 2008 ANOPR LCC analysis. 73 FR 13620, 13662 (March 13, 2008). In comments, NEMA supported the 3 hours per start operating time for both the base and standards cases, but also argued that while lamps are started every 12 hours in commercial and industrial applications, the increasing use of occupancy sensors is leading to shorter start cycles. (NEMA, No. 22 at p. 23) DOE did not receive any other comments about using a GSFL operating time of 3 hours per start. Therefore, DOE retained the assumption of 3 hours per start in the NOPR LCC analysis for both the base and standards cases. In addition, DOE researched the impact of occupancy sensors on start cycle lengths. However, DOE was unable to obtain significant information with which it could quantify this effect.

As in the March 2008 ANOPR, DOE also considered in the NOPR analysis the impact of group re-lamping practices on GSFL lifetime in the commercial and industrial sectors. 73 FR 13620, 13662 (March 13, 2008). DOE assumed that a lamp subject to group re-lamping operates for 75 percent of its rated lifetime, an estimate obtained from the 2000 Ballast Rule.[47] By considering lamp rated lifetimes and the prevalence of group versus spot re-lamping practices, DOE derived an average lifetime for a GSFL. This ranged from 91 percent of rated lifetime for 8-foot single pin slimline lamps to 94 percent of rated lifetime for 4-foot medium bipin lamps. See chapter 8 of the TSD for further details.

As stated above, DOE is using 15 years as the estimated fixture and ballast lifetime in the residential sector for purposes of its analyses. If one calculates the lifetime of the baseline GSFL lamp in the residential sector by dividing the life in hours by the average operating hours of a GSFL in the residential sector (789 hours), one finds that the baseline lamp should live for 19 years. Because the lifetime of the baseline lamp is longer than the average lifetime of a fixture and ballast, DOE assumes that the ballast or fixture lifetime limits the lifetime of an average lamp in the residential sector. DOE is aware that there are certain rooms in residential buildings where GSFL are operated for much longer than 789 hours per year; in particular, GSFL are operated for approximately 1,210 hours per year in kitchens of single-family detached households. Therefore, DOE has conducted the residential sector analysis under average operating hours and high operating hours. Under average operating hours (789 hours per year), DOE assumes that lamp lifetime of the baseline-case and standards-case lamps is limited to 11,835 hours or 15 years, due to a ballast or fixture failure. Thus, in this situation, the lamp failure event does not occur; only the ballast failure event occurs. See section V.D.14 for a description of lamp purchase events.

DOE recognizes that although some consumers do not experience a lamp failure in the residential sector, consumers whose operating hours yield a lamp lifetime that is shorter than that of the fixture or ballast do need to replace their lamp occasionally. DOE

[44] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2008 with Projections to 2030* (June 2008). Available at: *http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_3.xls.*

[45] GDS Associates, Inc., Engineers and Consultants, *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures* (The New England State Program Working Group) (2007).

[46] Economic Research Associates, Inc., and Quantec, LLC., *Revised/Updated EULs Based on Retention and Persistence Studies Results* (Southern California Edison) (2005).

[47] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, ''Energy Conservation Program for Consumer Products: Technical Support Document: Energy Efficiency Standards for Consumer Products: Fluorescent Lamp Ballast Proposed Rule: Appendix A'' (Jan. 2000) A–19.

assumes the shortest lifetime of the baseline lamp, using the highest operating hours for GSFL in the LMC of 1,210 hours per year (as in kitchens), is approximately 12.5 years. When a baseline lamp is replaced at 12.5 years, the fixture and ballast have another 2.5 years of life remaining. DOE assumes that when fixtures or ballasts are discarded, their associated lamps are also discarded at the same time. Therefore, for GSFL in the residential sector, the longest useful life of the baseline replacement lamp would be 2.5 years or 1,972 hours. At the end of this lifetime, the ballast and fixture are replaced. Therefore, for the lamp replacement event for a GSFL in the residential sector in a high operating hours scenario (1,210 hours per year), the lifetime of the baseline lamp is assumed to be 1,972 hours or 2.5 years, and DOE assumes that the ballast failure event does not occur. DOE requests comment on the typical service life of a GSFL in the residential sector.

10. Discount Rates

In the March 2008 ANOPR, DOE derived residential discount rates by identifying all possible debt or asset classes that might be used to purchase replacement products, including household assets that might be affected indirectly. 73 FR 13620, 13663 (March 13, 2008). DOE estimated the average shares of the various debt and equity classes in the average U.S. household equity and debt portfolios using data from the SCFs from 1989 to 2004. DOE used the mean share of each class across the six sample years as a basis for estimating the effective financing rate for replacement equipment. DOE estimated interest or return rates associated with each type of equity and debt using SCF data and other sources. The mean real effective rate across the classes of household debt and equity, weighted by the shares of each class, is 5.6 percent.

For the commercial sector and industrial sector, DOE derived the discount rate from the cost of capital of publicly-traded firms in the sectors that purchase lamps. To obtain an average discount rate value for the commercial sector, DOE used data from CBECS 2003, which provides market-share data by type of owner. Weighting each ownership type by its market share, DOE estimated the average discount rate for the commercial sector to be 6.2 percent. Similarly, the industrial sector discount rate was derived to be 7.5 percent. 73 FR 13620, 13663 (March 13, 2008).

The Joint Comment stated that, in the past, NRDC has argued that a 2 to 3 percent real discount rate should be used in the LCC. (Joint Comment, No. 23 at p. 22) It also stated that ACEEE and others have supported the weighted average cost of capital approach. In general, the Joint Comment stated that if DOE continues with using the weighted cost of capital approach, the agency should make sure its calculations are updated, as current economic conditions will influence agency estimates for discount rates over the analysis period. (Joint Comment, No. 23 at p. 22) In consideration of the above comments (and absent any evidence to the contrary), DOE agrees with ACEEE and others in the Joint Comment that the weighted average cost of capital approach described above is the most accurate way of establishing an appropriate consumer discount rate for the LCC analysis. For this NOPR, DOE was not able to use the most up-to-date information to update the residential discount rate, because the 2007 SCF survey was not available at the time of publication. However, because the rates for various forms of credit carried by households in these years were established over a range of time, DOE believes they are representative of rates that may be in effect in 2012. DOE is not aware of any other nationally representative data source that provides interest rates from a statistically valid sample. Therefore, DOE continued to use the above approach and results for today's proposed rule. According to the Federal Reserve Board Web site, the 2007 SCF survey may be available in the first quarter of 2009.[48] Contingent on this data's release in a timely manner, DOE will attempt to incorporate the 2007 SCF survey in the final rule of this rulemaking.

Despite the limitations associated with its residential analysis, DOE was able to update certain sources used to compute the commercial and industrial sector discount rates. Specifically, DOE applied the 2008 Damodaran Online Data, the 2008 implicit price deflators from the U.S. Department of Commerce, the 2007 Value Line Investment Survey data, information from the 2008 OMB Circular No. A–94, and 2008 State and local bond interest rates. However, DOE continued to use data from CBECS 2003, which provides market-share data by type of owner to obtain an average discount rate value for the commercial sector. DOE is not aware of any other nationally representative data source that provides market-share data by type of owner and, therefore, is continuing to use this source of data in today's proposed rule. DOE computed the new discount rates to be 7.0 percent in the commercial sector and 7.6 percent in the industrial sector. For further details on discount rates, see chapter 8 and appendix 8C of the TSD.

11. Analysis Period

The analysis period is the span of time over which the LCC is calculated. For the March 2008 ANOPR, DOE used the longest baseline lamp life in a product class divided by the annual operating hours of that lamp as the analysis period. 73 FR 13620, 13663 (March 13, 2008). During Monte Carlo simulations for the LCC analysis, DOE selected the analysis period based on the longest baseline lamp life divided by the annual operating hours chosen by Crystal Ball. For the NOPR analysis, DOE retained this methodology for IRL and GSFL in the commercial and industrial sectors. However, for GSFL in the residential sector, the analysis period is based on the useful life of the baseline lamp for a specific event. Specifically, for the lamp replacement event, the analysis period is 2.5 years, and for the lamp and ballast replacement and new construction event, the analysis period is 15 years. DOE requests comment on the analysis period used for the residential sector analysis. See section V.D.9.a of this notice for more information on the useful life of the baseline lamp in all residential sector purchase events.

12. Effective Date

For purposes of DOE's analyses, the effective date is the date when a new standard becomes operative. DOE intends to publish the final rule for this rulemaking in June 2009. 73 FR 13620, 13663 (March 13, 2008). In accordance with sections 325(i)(3) and (i)(5) of EPCA, the effective date of any new or amended energy conservation standard for these lamps shall be 3 years after the final rule is published, which would be June 2012 for this rulemaking. (42 U.S.C. 6295(i)(3) and (i)(5)) DOE performed its LCC analysis based upon an assumption that each consumer would purchase a new product in the year that the standard takes effect.

13. Payback Period Inputs

The payback period (PBP) is the amount of time a consumer needs to recover the assumed additional costs of a more-efficient product through lower operating costs. As in the March 2008 ANOPR, DOE used a "simple" PBP for the NOPR, because the PBP does not take into account other changes in operating expenses over time or the time value of money. 73 FR 13620, 13663

[48] *http://www.federalreserve.gov/PUBS/oss/oss2/2007/scf2007home_modify.html.*

(March 13, 2008). As inputs to the PBP analysis, DOE used the total installed cost of the product to the consumer for each efficacy level, as well as the first year annual operating costs for each efficacy level. The calculation requires the same inputs as the LCC, except for energy price trends and discount rates; only energy prices for the year the standard takes effect (2012 in this case) are needed. 73 FR 13620, 13663 (March 13, 2008).

14. Lamp Purchase Events

In the March 2008 ANOPR, DOE described five types of events that would prompt a consumer to purchase a lamp. 73 FR 13620, 13664 (March 13, 2008). These events are described below along with changes for the NOPR analysis. Of particular note, DOE conducted a number of new analyses for the NOPR which assessed lamp failure, ballast failure, and new construction events for residential sector GSFL. In addition, though described primarily in the context of GSFL, lamp purchase events can be applied to IRL as well. However, considering that IRL are generally not used with a ballast the only lamp purchase events applicable are lamp failure (event I) and new construction and renovation (event V).

- *Lamp Failure* (Event I): This event reflects a scenario in which a lamp has failed (spot relamping) or is about to fail (group re-lamping). In the base case, identical lamps are installed as replacements. In the standards case, the consumer installs a standards-compliant lamp that is compatible with the existing ballast. When a standards-compliant lamp for that ballast is not available, the consumer purchases a new lamp and ballast. For the NOPR, DOE added a residential sector GSFL lamp failure event.
- *Standards-Induced Retrofit* (Event II): This event occurs when a consumer realizes that its T12 lamp will fail in the near future and installs a standards-compliant lamp and ballast. In the base case, the consumer would have installed only a new lamp. This event applies only to T12 commercial and industrial users because there are certain lamp standard levels that a T12 cannot meet. This event does not apply to T12 residential users because these users would not proactively replace their T12 system before the T12 lamp fails.
- *Ballast Failure* (Event III): In the March 2008 ANOPR, DOE assumed that failed ballasts would be replaced with electronic ballasts because standards set by the 2000 Ballast Rule and EPACT 2005 ban the sale of magnetic 4-foot medium bipin and 8-foot single pin slimline ballasts beginning in 2010. 73 FR 13620, 13664 (March 13, 2008). NEMA commented that the 2000 Ballast Rule allows the continued sale of residential magnetic ballasts as well as magnetic cold-temperature ballasts, which operate a large portion of the installed base of T12 recessed double contact high-output lamps. (NEMA, No. 22 at p. 20) In response, DOE has assumed that failed magnetic HO ballasts would be replaced with magnetic ballasts in the base case for the NOPR analysis. DOE also assumed that magnetic ballasts would be purchased in the event of a ballast or fixture failure in the residential sector base case for the NOPR analysis because residential systems are commonly T12 magnetic systems currently. In addition, standards established in the 2000 Ballast Rule and the Energy Policy Act of 2005 (EPACT 2005, Pub. L. 109–58) will allow magnetic ballasts to continue to be sold in the residential sector after 2010. See the engineering analysis (section V.C) for further details.
- *Ballast Retrofit* (Event IV): This event applies only to T12 users because, according to industry experts, the majority of ballast retrofits occur for consumers with T12 systems. Consumers retrofitting their ballasts commonly do so to save energy, and T8 systems are generally more efficacious than T12 systems.
- *New Construction and Renovation* (Event V): This event encompasses all fixture installations where the lighting design will be completely new or can be completely changed. The scenario applies only to baseline lamps that are usually used in new construction and renovation (4-foot T8 lamps, 4-foot T12 lamps in the residential sector, 8-foot single pin slimline T8 lamps, and 8-foot recessed double contact HO T12 lamps). For the NOPR analysis, DOE assumed that 4-foot T8 lamps with electronic ballasts would be chosen during the new construction and renovation event for the 4-foot T12 residential baseline.

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

1. General

DOE's NIA assesses 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 standards at specific efficacy levels.

DOE uses the NIA spreadsheets to calculate energy savings and NPV based on the annual energy consumption and total installed cost data employed in the LCC analysis. DOE forecasts the energy savings, energy cost savings, equipment costs, and NPV for each product class from 2012 through 2042. The forecasts provide annual and cumulative values for all four output parameters. DOE also examines impact sensitivities by analyzing various lamp shipment scenarios (such as Roll-up and Shift).

DOE develops a base-case forecast for each analyzed lamp type which characterizes energy use and consumer costs (lamp purchase and operation) in the absence of new or revised energy conservation standards. To evaluate the impacts of such standards on these lamps, DOE compares the estimated base-case projection with projections characterizing the market if DOE did promulgate new or amended standards (*i.e.*, the standards case). In characterizing the base and standards cases, DOE considers historical shipments, the mix of efficacies sold in the absence of any new standards, and how that mix might change over time.

Inputs and issues associated with the NIA are discussed immediately below.

a. Overview of NIA Changes in This Notice

Based on the comments it received on the March 2008 ANOPR, DOE made a number of changes to the NIA. Table V.3 summarizes the approach and data DOE used to derive the inputs to the NES and NPV analyses for the March 2008 ANOPR, as well as the changes it made for this notice. Following the table, DOE details those inputs and the changes, and summarizes and responds to each of the NIA-related comments it received. See TSD chapters 10 and 11 for further details.

TABLE V.3—APPROACH AND DATA USED TO DERIVE THE INPUTS TO THE NATIONAL ENERGY SAVINGS AND NET PRESENT VALUE ANALYSES

Inputs	2008 ANOPR description	Changes for the proposed rule
Shipments	Annual shipments from shipments model	See Table V.4 and Table V.5.

TABLE V.3—APPROACH AND DATA USED TO DERIVE THE INPUTS TO THE NATIONAL ENERGY SAVINGS AND NET PRESENT VALUE ANALYSES—Continued

Inputs	2008 ANOPR description	Changes for the proposed rule
Stock of lamps	Established based on the projected 2011 lamp stock, the service life of lamps and/or ballasts, and the annual shipments. The 2011 stock is based on historical shipments and projected shipments from 2006 to 2011. (See ANOPR TSD chapter 10, shipments analysis.).	Established based on 2005 lamp stock, rather than 2011. Considered market penetration of emerging technologies. See Table V.4 and Table V.5 for additional detail.
Effective date of standard	2012	No change.
Analysis period	2012 to 2042	No change.
Unit energy consumption (kWh/yr).	Established in the energy-use characterization, ANOPR TSD chapter 6, by lamp or lamp-and-ballast design and sector.	No change.
Total installed cost	Established in the product price determination, ANOPR TSD chapter 7 and the LCC analysis, ANOPR chapter 8, by lamp-and-ballast designs.	Added costs of retrofit kit and labor for replacing a 8-foot SP slimline system with two 4-foot MBP systems.
Electricity price forecast	*AEO2007* forecasts (to 2030) and extrapolation for beyond 2030. (See ANOPR TSD chapter 8.).	Updated for *AEO2008*.
Energy site-to-source conversion.	Conversion varies yearly and is generated by *AEO2007* forecasts (to 2030) of electricity generation and electricity-related losses. Conversion factors for beyond 2030 are extrapolated.	Conversion varies yearly and is now generated by DOE/EIA's NEMS program (a time-series conversion factor; includes electric generation, transmission, and distribution losses). Conversion factors for beyond 2030 are held constant.
HVAC interaction savings	6.25 percent of total energy savings in the commercial sector.	No change.
Rebound effect	1 percent of total energy savings in the commercial and industrial sectors. 8.5 percent of total energy savings in the residential sector.	No change.
Discount rate	3 and 7 percent real	No change.
Present year	Future costs and savings are discounted to 2007	No change.

2. Shipments Analysis

Lamp shipments are an important input to the NIA. In the March 2008 ANOPR, DOE followed a four-step approach to forecast shipments for GSFL and IRL. 73 FR 13620, 13668 (March 13, 2008). First, DOE used NEMA's historical shipment data from 2001 to 2005 to estimate total historical (NEMA members and non-NEMA members) shipments of each analyzed lamp type in the commercial, industrial, and residential sectors. Second, using these historical shipments, DOE linearly extrapolated shipments to 2011. Then, based on average service lifetimes, DOE estimated a stock of lamps in 2011 for each lamp type. Next, DOE forecasted lamp (and ballast for GSFL) shipments from 2012 to 2042 (the NIA analysis period) based on four market events: (1) New construction; (2) ballast failure (GSFL only); (3) lamp replacement; and (4) standards-induced retrofit (for the standards case). Lastly, because these shipments depend on lamp and lamp-system properties (*e.g.*, lifetime and lumen output), DOE developed base-case and standards-case market-share matrices. These matrices determine the forecasted technology mixes in the lamp stock and shipments.

Table V.4 and Table V.5 summarize the approach and data DOE used for GSFL and IRL, respectively, to derive the inputs to the shipments analysis for the March 2008 ANOPR, as well as the changes DOE made for the NOPR. A discussion of the inputs and the changes follows.

TABLE V.4—APPROACH AND DATA USED TO DERIVE THE INPUTS TO GSFL SHIPMENTS ANALYSIS

Inputs	2008 ANOPR description	Changes for the proposed rule
Historical shipments	2001–2005 shipment data provided publicly by NEMA. Assumed NEMA data represented 90 percent of GSFL shipments.	Calibrated 2006–2007 forecasted shipments based on confidential historical shipment data NEMA provided for those years.
Lamp inventory	Calculated lamp inventory in 2011 by linearly projecting NEMA's 2001–2005 historical shipment data. Then used growth and shipment assumptions to establish lamp inventory from 2012 to 2042.	Did not use linear projections; calculated stock in 2005. Then used growth, emerging technologies, and shipment assumptions to establish lamp inventory from 2006 to 2042.
Growth	Shipment growth driven by lumen demand. Lumen demand projected from historical CBECS commercial floor space growth.	Based commercial and residential growth on *AEO2008* estimates for future floor space growth. For the residential sector, modeled variations in number of lamps per new home. For the industrial sector, projected floor space growth using MECS.
T5 lamps	Not included	Shipments modeled by assuming T5 lamps used in new construction and in conversions from 4-foot medium bipin, 8-foot SP slimline, and 8-foot RDC HO.

TABLE V.4—APPROACH AND DATA USED TO DERIVE THE INPUTS TO GSFL SHIPMENTS ANALYSIS—Continued

Inputs	2008 ANOPR description	Changes for the proposed rule
T12 ballasts	Assumed no T12 magnetic ballasts shipped after 2009 for 8-foot SP slimline and 4-foot MBP lamps. Did not consider T12 electronic ballasts for 8-foot SP slimline and 4-foot MBP lamps.	Assumed no T12 magnetic ballasts shipped after 2010 for commercial 4-foot MBP and 8-foot SP slimline. Also assumed 4-foot MBP and 8-foot SP slimline electronic T12 ballasts shipped through 2042. For 8-foot T12 RDC HO and residential 4-foot T12 MBP, assumed magnetic ballasts are shipped through 2042.
Sectors analyzed	Commercial and industrial	Included residential sector in analysis.
Base-case emerging technologies.	None included	Developed two base-case scenarios, one of which modeled the market penetration of LEDs based on projected payback period.
Market share matrices	Developed product distributions based on interviews and catalog data.	Revised product distributions based on comments, subsequent interviews, and further catalog research.
Standards case scenarios	Shift and Roll-up scenarios analyzed. Assumed all consumers will attempt to maintain lumen output by either moving to lower ballast factors or reduced-wattage lamps in the standards case.	Revised the Shift and Roll-up scenarios. Developed a standards-case scenario (Market Segment-Based Lighting Expertise scenario) to characterize consumers who, based on lighting expertise, will not migrate to lower ballast factors or reduced-wattage lamps to maintain lumen output.

TABLE V.5—APPROACH AND DATA USED TO DERIVE THE INPUTS TO IRL SHIPMENTS ANALYSIS

Inputs	2008 ANOPR description	Changes for the proposed rule
Historical shipments	2001–2005 shipment data provided publicly by NEMA. Assumed NEMA data represented 85 percent of IRL shipments.	Calibrated 2006–2007 projected shipments based on confidential historical shipment data NEMA provided for those years.
Lamp inventory	Calculated stock in 2011 by linearly projecting NEMA's 2001–2005 historical shipment data. Then used growth assumptions to establish lamp inventory from 2012 to 2042.	Did not use linear projections; calculated stock in 2005. Then used growth and emerging technologies assumptions to establish lamp inventory from 2006 to 2042.
Growth	Shipment growth driven by socket growth. Socket growth projected from historical CBECS commercial floor space and RECS residential building growth.	Based growth on *AEO2008* estimates for future commercial floor space and residential buildings. Also accounted for trend of increasing sockets per home.
Sectors analyzed	Commercial and residential	No change.
Base case reflector compact fluorescent lamps (R–CFL) and emerging technologies.	Assumed 0 percent stock penetration in 2012 and 50 percent stock penetration in 2042.	Developed two base-case scenarios modeling the market penetration of LED, CMH, and R–CFL based on projected payback period.
Market share matrices	Considered mix of technologies consumers select in the base case and standards case, as well as each of the scenarios analyzed.	Revised market-share matrices to reflect its changes in the scenarios analyzed and engineering analyses.
Standards-case scenarios	Modeled the Roll-up scenario. Analyzed two standards-case sensitivity scenarios: One modeling consumer movement to exempted BR lamps and another modeling a 10 percent increase in lumen output. Did not consider additional migration to R–CFL in the standards case.	Modeled both Roll-up and Shift scenarios. Revised BR lamp sensitivity scenario, creating two new standards-case scenarios also accounting for additional migration to R–CFL: "Product Substitution" and "No Product Substitution."

a. Lamp Inventory

In the March 2008 ANOPR, DOE linearly extrapolated NEMA's historical lamp shipments from 2005 to 2011 to establish a 2011 installed stock of GSFL and IRL using each lamp's average service lifetime. In its written comments, NEMA argued that DOE's linear extrapolation approach does not account for market dynamics and is vulnerable to certain temporal biases inherent in NEMA's historical data. For example, if a new product was introduced and rapidly gained market share during this historical shipment period, a linear extrapolation based on this data could exaggerate the growth rate of this product in future years. Likewise, any new products introduced would be excluded from the future results. For example, Philips noted at the public meeting that because DOE extrapolated shipment data from 2001 to 2005 to establish its lamp stocks, it may have discounted migration to T5 lamps, which have only started to grow in the last couple of years. Thus, the commenter argued that DOE may have overstated the 2011 stock of some types of lamps (*e.g.*, T8 lamps), while understating others (*e.g.*, T5 lamps). (NEMA, No. 22 at pp. 23–25, 31; Public Meeting Transcript, No. 21 at p. 246)

On the other hand, NEMA suggested that a linear extrapolation is sometimes appropriate for lamps with small and stable market shares, such as 8-foot T8 recessed double contact HO lamps. However, for large and variable product classes, NEMA urged DOE to model lamp types against specific economic factors and technical relationships. (NEMA, No. 22 at p. 24)

DOE agrees that a linear extrapolation may generally be too limited in its application, and that lamp shipment forecasts from 2006 to 2011 should incorporate both market dynamics and macroeconomic factors. Therefore, DOE is no longer using a linear extrapolation from historical data. Instead, for this NOPR, DOE calculated an installed stock of lamps in 2005 and applied growth, replacement rate, and emerging technologies assumptions to develop shipments estimates from 2006 to 2042. In addition, DOE received confidential shipment information from NEMA for 2006 and 2007, and, when possible, calibrated the shipments model to match that information. The assumptions used to develop shipment forecasts are discussed in the following sections.

b. Shipments Growth

To develop the shipments models for both GSFL and IRL, DOE applied several growth rate assumptions. In the March 2008 ANOPR, DOE modeled GSFL shipments from 2012 to 2042 by projecting lumen growth based on lumen demand serviced by each lamp type in the commercial and industrial sectors. For IRL, DOE projected shipments through 2042 based on growth in the number of sockets using IRL in the commercial and residential sectors. DOE based forecasted lumen and socket growth for GSFL and IRL on historical residential building growth from RECS and historical commercial and industrial floor space growth from CBECS and MECS.

DOE received a number of comments in response to its growth rate methodology. The majority of these comments fell into three categories: (1) The limits of basing lamp stock growth on historical floor space growth; (2) the increasing number of lamps per household; and (3) the wider spacing of more-efficient light fixtures. Below is a discussion of those comments. For further details regarding GSFL and IRL growth rate assumptions, see TSD chapter 10.

i. Floor Space and Building Growth

NEMA stated that the commercial and residential growth rates DOE used in the March 2008 ANOPR (based on total floor space from CBECS in RECS) have likely led to an overstatement of lamp shipments and stock, given the deteriorating economy. (NEMA, No. 22 at pp. 23–24) DOE understands NEMA's concerns and no longer establishes its commercial and residential growth from historical floor space growth. Instead, for this NOPR, DOE modeled commercial floor space and residential buildings growth based on *AEO2008*, which estimates year-to-year commercial floor space and residential building growth. Because *AEO2008* takes into account future trends in economic growth, DOE was able to incorporate forecasts of macroeconomic conditions in its growth forecast. However, because *AEO* does not provide industrial floor space forecasts, DOE used historical MECS floor space values to establish a growth rate for the industrial sector.

ii. Lamps per Household

The Joint Comment stated that DOE's growth forecasts omitted an important factor driving IRL sales: a trend toward an increasing number of recessed fixtures per home in new construction and existing home renovation. Because this trend is excluded from DOE's analysis, which assumed growth based on floor space growth, the Joint Comment argued that IRL shipments are likely understated. NEMA also stated that it has seen a trend toward increasing light points per home. To address this development, the Joint Comment recommended DOE obtain additional data on sales trends of these lamps and not assume recessed socket growth was directly proportional to floor space growth. The Joint Comment, PG&E, and ACEEE cited several studies supporting this claim. (Joint Comment, No. 23 at p. 17; Public Meeting Transcript, No. 21 at pp. 287–288; NEMA, No. 22 at p. 31)

DOE agrees with the Joint Comment that the increasing popularity of recessed fixtures in new homes will drive IRL sales growth faster in the residential sector. New homes are likely to install more IRL than those installed in older homes, and older homes may be renovated to include more recessed cans and, thus, more reflector lamps. Therefore, DOE conducted an analysis that estimated the average number of recessed cans in homes between 2005 and 2042. Using California data [49] on recessed cans per home broken out by home age, DOE assumed new homes constructed after 2005 would install the same number of recessed cans as homes constructed between 2001 and 2005. DOE also assumed that half of the homes constructed before 2001 would be renovated by 2042 to have an equal number of recessed cans as newly constructed homes. DOE estimated the distribution of homes by age using U.S. Census data [50] on new building starts in the residential sector. DOE estimated new construction and the number of future homes constructed in each year from *AEO2008*. Using this data, DOE estimated that the average number of recessed cans per home in 2005 was 4.82, and the average number of recessed cans per home in 2042 will be 8.52. As noted above, DOE also agrees with NEMA that growth rates should include forecasts of economic conditions. Therefore, to estimate the growth rate in each year, DOE multiplied the number of recessed cans in homes by the projected stock of homes according to *AEO2008*. Combining these two sources, DOE predicts an average growth rate of sockets of 2.6 percent between 2006 and 2042, compared to the 1.6 percent DOE estimated in the March 2008 ANOPR.

DOE estimated the GSFL growth rate in the residential sector using a methodology similar to that which it employed for IRL in the residential sector. Instead of using the number of recessed cans per home by home age, DOE used the number of T8 and T12 lamps by home age. Again, DOE assumed that the same number of T8 and T12 lamps per home would be installed in new homes as those installed between 2001 and 2005, and that half of homes built before 2001 would be renovated by 2042 to have the same number of T8 and T12 lamps as newly constructed homes. DOE estimated that the average number of T8 and T12 lamps per home in 2005 was 4.5, and the average number in 2042 will be 4.7. Combining this growth estimate with *AEO2008*'s projected growth in the residential home stock yields an average growth rate of 1 percent between 2006 and 2042 for GSFL in the residential sector. Compared to IRL, the lower GSFL growth rate reflects the lower growth rate of T8 and T12 lamps per home versus recessed cans. (In the March 2008 ANOPR, DOE did not consider the residential sector for GSFL.)

iii. Wider Spacing of More-Efficient Fixtures

In its written comments, NEMA suggested that DOE should assume a slower growth rate in the commercial building IRL socket base to account for wider spacing of lighting fixtures and/or greater use of high-output systems. (NEMA, No. 22 at p. 31) While DOE appreciates NEMA's comment, it was unable to find (and the commenter did not provide) any information related to wider spacing between fixtures, and, therefore, DOE did not change growth estimates to account for this potential effect.

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[49] RLW Analytics, Inc., ''California Statewide Residential Lighting and Appliance Efficiency Saturation Survey'' (August 2005) (Last accessed on Sept. 29, 2008). Available at: *http://www.calresest.com/docs/2005CLASSREPORT.pdf.*

[50] U.S. Census Bureau, Manufacturing and Construction Division, ''New Privately Owned Housing Unit Starts'' (2008) (Last accessed on Sept. 29, 2008). Available at: *http://www.census.gov/const/startsan.pdf.*

c. Base-Case Scenarios: Emerging Technologies and Existing Technologies

In the March 2008 ANOPR, DOE estimated that by 2042 R–CFL and emerging technologies, (*e.g.*, such as LED lamps, and ceramic metal halide (CMH) lamps) would compose 50 percent of IRL sockets in the installed base. 73 FR 13620, 13670 (March 13, 2008). For IRL, DOE accounted for the impact of emerging technologies by deducting their market share in each year over the analysis period from the installed base of lamps, effectively reducing the size of the market affected by the standards proposed in this rulemaking. In the March 2008 ANOPR, DOE did not account for any penetration of emerging technologies into the GSFL market, and requested comment on if and how it should incorporate their effects into its analyses.

DOE received several comments on its consideration of emerging technologies. NEMA argued that the performance improvements of CMH will drive the technology's market penetration into the GSFL market. NEMA also asserted that LED lamps could displace GSFL shipments to some extent by 2042. (NEMA, No. 22 at pp. 24–26) As for emerging technologies in the IRL market, NEMA commented that LED lamps could also displace shipments of IRL to some extent by 2042, particularly in the residential sector. NEMA stated that the shift from halogen IRL to CMH is already occurring in the retail market. Industrial Ecology stated that an integrated PAR CMH lamp would be expected to replace other IRL PAR lamps in the commercial retail market. (NEMA, No. 22 at pp. 24–26; Public Meeting Transcript, No. 21 at pp. 307–309) NEMA argued that these emerging technologies will significantly affect future lamp shipments and reduce the NPV results of standards for both GSFL and IRL. To more accurately forecast the impact of emerging technologies, NEMA suggested that DOE should examine historical price and performance points of R–CFL, as well as product cycles for other advanced technology equipment. (NEMA, No. 22 at pp. 24–26) Industrial Ecology suggested that DOE should use semiconductor industry data to assess the manufacturing capacity for solid state lamps. (Public Meeting Transcript, No. 21 at p. 311–312)

DOE agrees that emerging technologies could penetrate GSFL and IRL markets and significantly affect shipment forecasts and NIA results. Therefore, for the NOPR, DOE has revised its analysis of emerging technologies within the IRL market and now accounts for emerging technologies within the GSFL market as well. These emerging technologies already are, or eventually will likely be, significantly more efficacious and longer lasting than the lamps they replace. However, to calculate the energy savings and NPV benefits due to the penetration of an emerging technology, DOE must accurately forecast the anticipated price and performance points of the individual technologies—a difficult and highly speculative task. Forecasts related to emerging technologies are inherently uncertain because they depend upon assumptions about future price, efficacy, and utility, none of which can be verified. Therefore, for the NOPR, DOE has chosen to analyze *two* base-case scenarios for both GSFL and IRL: (1) Existing Technologies, and (2) Emerging Technologies. DOE believes evaluating two base-case scenarios more completely characterizes the inherent uncertainty of the market penetration of the technologies and the consequent impact on NPV and NES. Incorporating emerging technologies in the base case does not affect the relative benefits of each TSL and prevents uncertain projections of market share, price, or performance from obscuring the benefits derived from more-efficient GSFL and IRL alone.

For these base-case scenarios, DOE estimated the market penetration of three specific technologies into the projected installed stock: (1) LED lamps; (2) CMH lamps; and (3) reflector CFL. In general, the Existing Technologies scenario only considers the market penetration of technologies that are currently readily available and have reached maturation in terms of price and efficacy. Specifically, DOE considers R–CFL in the Existing Technologies scenario within the IRL market. For GSFL, no technologies other than those covered by this rulemaking were analyzed in the Existing Technologies scenario. (DOE considers the migration to T5 lamps, a covered product, separately, as discussed in section V.E.2.d.)

In the Emerging Technologies scenario, DOE attempts to forecast the market penetration of mature technologies *and* those technologies that are still undergoing significant changes in price and efficacy. Specifically, DOE considered the market penetration of R–CFL, LED lamps, and CMH lamps in the Emerging Technologies scenario.

DOE generally followed a 5-step process for each scenario to estimate the market penetration of the analyzed technologies and account for their impact on NES and NPV. (Sector- and technology-specific aspects of DOE's methodology are described below and in TSD chapter 10.)

First, DOE developed price, performance, and efficacy forecasts for each of the analyzed technologies. DOE's methodology in generating these forecasts for each analyzed technology is described below. Second, using those estimates, DOE calculated the payback period (PBP) of each technology in the relevant sector using the difference between its purchase price, annual electricity cost, and annual lamp replacement cost relative to the lamp it replaces. (See TSD chapter 10 for further details.) Third, DOE used a relationship between PBP and market penetration to predict the market penetration of each technology in the relevant sector in every year from 2006 to 2042. Generally, lower PBP of a given lamp technology results in a greater predicted market penetration of that technology. DOE used a 5-year average of the market penetrations predicted by the relationship as its final market penetration. The 5-year average represents the time DOE assumed it takes products with lower PBPs to penetrate the market. Fourth, when necessary, DOE applied a scaling factor to the predicted market penetration to account for observed market trends. Fifth, DOE reduced the projected installed stock of covered products in each year by the value that corresponded to the highest level of market penetration achieved in each year by one of the analyzed technologies. Thus, the inclusion of R–CFL and other lamps using emerging technologies in the base case have the effect of lowering the energy savings of a potential new standard. For those covered lamps remaining, the cost-effectiveness of LCC savings and, thus, the relative cost effectiveness of each TSL is not affected.

Because the lamps employing emerging technologies are beyond the scope of the rulemaking, they are not considered design options to improving IRL or GSFL efficacy, but rather they may substitutes for the lamps covered in this rulemaking. In the Emerging Technologies base case, DOE uses its prices projections effectively as inputs into its shipments forecasts of its covered products, rather than forecasts of shipments of lamps employing the emerging technologies themselves. In this way, the price projections of the analyzed lamps using emerging technologies indirectly affect the NPV of the present rulemaking, despite not being a direct input into equipment prices. As stated previously, to acknowledge the uncertainty of price forecasts for lamps using emerging technologies, DOE models two base-case scenarios.

i. General Service Fluorescent Lamps

For the Existing Technologies scenario, DOE believes that no mature technologies in the current market show the potential to significantly penetrate the GSFL market. (T5 lamps, previously considered an emerging technology, are now a covered product class.) Therefore, for the Existing Technologies scenario, DOE considered only the fluorescent technologies already covered by this rulemaking. Thus, except for the addition of T5 lamps, the Existing Technologies base case in this NOPR is the same as the base case in the March 2008 ANOPR.

In the GSFL Emerging Technology scenario, however, DOE separately considered the potential market penetration of two technologies: (1) LEDs (into the commercial, residential, and industrial sectors); and (2) CMH (into the commercial and industrial sectors).

For its analysis of LED market penetration, DOE found a commercially-available retrofit kit that included a LED replacement for a 4-foot medium bipin system. DOE used the retrofit kit as a current baseline from which to project future cost, efficacy, and price points. DOE interviewed an integrated circuit manufacturer to develop cost estimates for LED driver circuits. For cost estimates of other components, DOE used prices of existing LED products already on the market, which it modified in accordance with cost data and efficacy projections from DOE's Solid State Lighting Multi-Year Program Plan.[51] Lastly, using markup based on currently-available LED lamps, DOE was able to develop price and efficacy projections for the LED luminaire in the retrofit kit.[52] Following the 5-step process described above, DOE calculated a 41 percent market penetration rate of LED lamps into the 4-foot GSFL commercial sector by 2042. DOE assumed LED lamps penetrated only the new construction, renovation, and fixture replacement markets because these lamps would require their own specific fixtures. In the residential sector, the LED option did not have a low enough payback period to result in any market penetration.

DOE also analyzed the potential penetration of CMH into the GSFL market. DOE first estimated current CMH prices using a methodology similar to the methodology it used to estimate GSFL and IRL prices, as described in the product price determination. (See TSD chapter 7.) Industry experts informed DOE that CMH efficacies and lifetimes would increase over the next several years while prices would remain constant. Applying these lifetime and efficacy projections DOE compared CMH replacements to GSFL systems. As a result, DOE assumed no market penetration of CMH because it found that T5 lamp systems (standard output and high output) would always be less costly and more efficacious than projected CMH replacements. Given this information, DOE believes that it is likely that migration to CMH (from the GSFL market) will be dominated by the migration to standard-output and high-output T5 lamps.

ii. Incandescent Reflector Lamps

As with GSFL, DOE considered two base case scenarios for IRL: Existing Technologies and Emerging Technologies. Because DOE believes that R–CFL is a mature technology with relatively stable price points and efficacies, DOE considered R–CFL penetration into the residential market in the Existing Technologies scenario. In contrast, for the Emerging Technologies scenario, DOE considered the market penetration of R–CFL, LED, and CMH lamps in both the residential and commercial sectors. DOE separately calculated the penetration of each technology into the IRL stock by using the 5-step process described above.

For R–CFL, DOE developed price forecasts based on historical pricing trends of CFL and R–CFL, using a methodology similar to the methodology DOE used to estimate GSFL and IRL prices, as described in the product price determination. (See TSD chapter 7.) DOE assumed no future change in efficacy. Using this data, DOE found the market penetration predicted by the PBP relationship. However, PG&E argued that R–CFL are not always suitable substitutes for IRL because they lack dimming capabilities and their beam width is too broad. (Public Meeting Transcript, No. 21 at pp. 289, 321) Industrial Ecology commented that dimmable R–CFL do in fact exist, while PG&E noted that these lamps have little market share. (Public Meeting Transcript, No. 21 at pp. 291, 321) DOE agrees that R–CFL may not always be appropriate substitutes for IRL, due to differences in form factor, beam spread, color quality, size and dimming capability. DOE observed that the actual market penetration of CFL replacements for A-line incandescent lamps thus far has been approximately 40 percent of the penetration predicted by the PBP-penetration relationship. Therefore, DOE applied these same scaling-factor reductions of 40 percent and 36 percent in calculating the market penetration of R–CFL into the IRL market for the residential and commercial sectors, respectively.

For LED and CMH lamps in the IRL market, DOE developed price and efficacy forecasts using a methodology similar to the one described above for GSFL. DOE did not apply the scaling factor reduction to the predicted LED and CMH market penetration rates that it used for the R–CFL analysis. DOE believes the substitutability problems that arise when R–CFL replace IRL do not apply when LED and CMH replace IRL.

By the methodology described, DOE arrived at market penetration values (and market size reductions) for each base-case scenario. For the Existing Technology scenario, 2042 R–CFL penetration reached 38 percent in the residential sector and 20 percent in the commercial sector. (This was the highest market penetration because it was the only technology analyzed for the scenario.) For the Emerging Technology scenario, LED reached the highest market penetration of any analyzed technology in both the residential sector and the commercial sector. DOE's analysis found LED lamps could penetrate 40 percent and 82 percent of the IRL installed stock by 2042 in the residential and commercial sector, respectively. DOE's results support a comment by Industrial Ecology stating that emerging technologies will enter the commercial market first. (Public Meeting Transcript, No. 21 at p. 308) This effect occurs because there are higher installation and operating costs in the commercial sector relative to the residential sector, resulting in lower PBPs and faster migration to emerging technologies. Again, DOE used these results to effectively reduce the size of the IRL market for its analysis.

d. Fluorescent Market Sectors Analyzed

In the March 2008 ANOPR, DOE modeled both the commercial and industrial market sectors to generate GSFL shipments forecasts. DOE received several comments on its decision not to model the residential sector.

[51] *Multi-Year Program Plan FY'09 to FY'14: Solid-State Lighting Research and Development* (March 2008). Available at: *http://www.netl.doe.gov/ssl/PDFs/SSLMYPP2008_web.pdf*.

[52] Because they are based on an existing LED retrofit kit, DOE's projections did not consider innovations in form factor on OLED tyechnology which could improve the possible payback period for solid-state lighting technologies.

GE commented that DOE should model the residential sector because it makes substantial use of less-efficacious T12 lamps, which could be effectively eliminated by new standards. GE estimated that by 2012, roughly 20 percent of GSFL shipments will be T12 lamps, and more than half of those will go to residential consumers. PG&E stated that California codes only recently required higher-efficacy lamps in new construction; therefore, 4-foot T12 lamps with magnetic ballasts remain a large part of the residential installed stock. (Public Meeting Transcript, No. 21 at pp. 276–279)

The Joint Comment asserted that a separate analysis for the residential sector is unnecessary; however, the Joint Comment recommended that residential applications should be accounted for in DOE's LCC analysis based on the proportion of lamp sales, operating hours, and electric rates. The Joint Comment stated DOE should use caution in apportioning all sales through do-it-yourself (DIY) stores, such as Home Depot and Lowe's, to the residential sector. (Joint Comment, No. 23 at p. 10) PG&E and NEMA commented that approximately 20 percent of DIY business is commercial. (NEMA, No. 22 at p. 30; Public Meeting Transcript, No. 21 at p. 290)

DOE agrees that it should model the residential sector to more accurately capture overall consumer behavior and the market impact of standards. DOE calculated the initial residential stock of 4-foot medium bipin T12 lamps using the lamps sold through the DIY distribution chain, which accounted for approximately 25 percent of NEMA's historical shipments. Next, DOE assumed 20 percent of those DIY sales went to small commercial consumers, with the remaining 80 percent apportioned to the residential sector. As a result, DOE assumed 20 percent of all 4-foot medium bipin shipments went to the residential sector and all of those were T12 lamps.

From those shipments, DOE calculated the residential installed stock and then modeled new construction, renovation, and fixture/ballast replacement in the same manner described in section 0. DOE assumed that in the base case, a portion of consumers will continue to purchase 4-foot T12 magnetic systems, while the remaining consumers will choose to purchase higher-efficacy 4-foot T8 and 4-foot T12 electronic systems. Overall, the number of 4-foot T12 systems installed in the residential sectors is relatively constant over the analysis period. For more details regarding DOE's assumptions in the residential sector, please see chapter 10 of the TSD.

e. GSFL Product Migration

DOE received many comments on its assumptions characterizing how consumers will migrate among different GSFL products. These comments were primarily focused on the movement away from T12 systems and the migration toward T5 systems, topics discussed in detail below.

i. Ballast Rule Effective Start Date

NEMA commented that the 2000 Ballast Rule does not ban T12 magnetic ballasts in the commercial sector until June 2010. This means these ballasts will be available through the end of 2010, and not 2009 as DOE's model had assumed, because some T12s will remain in the distribution chain for a period of months after the rule takes effect. Therefore, NEMA argued, DOE should expect T12 lamps to continue to be shipped beyond 2022, the year DOE projected the lamps will phase out. (NEMA, No. 22 at p. 25, 28) DOE agrees with NEMA that commercial sector magnetic ballasts will continue to be available through 2010 and has revised its model accordingly to better reflect the timing of the 2000 Ballast Rule's effective start date of amended standards. According to the revised model, DOE estimates that the majority of banned magnetic T12 ballasts will be eliminated from the installed stock by 2025. However, as discussed below, the inclusion of T12 electronic ballasts results in T12 lamps being shipped throughout the analysis period.

ii. Four-Foot Medium Bipin T12 Lamp Replacements

In the March 2008 ANOPR, DOE assumed that 100 percent of 4-foot T12 systems would be replaced by 4-foot T8 systems upon ballast failure. This assumption was made in consideration of the 2000 Ballast Rule, which effectively banned most 4-foot T12 medium bipin magnetic ballasts. 10 CFR part 430.32(m)(5) DOE received several comments related to this assumption and the implications for DOE's GSFL shipments analysis.

Stakeholders generally agreed that DOE's base-case assumption was too optimistic in terms of the migration from 4-foot T12 to 4-foot T8 systems. The comments provided two reasons why consumers would be expected to maintain T12 electronic ballasts and not migrate to T8 lamps. First, because the installed stock is dominated by T12 lamps, it is unlikely all consumers would switch to T8 lamps upon repurchase, especially when spot re-ballasting. Some commercial sector consumers would be expected to use another T12 lamp and ballast to maintain visual consistency with other lamps in a room. Second, the Joint Comment noted that residential low-power-factor ballasts are not subject to the 2000 Ballast Rule, meaning legal ballasts compatible with T12 lamps will continue to exist. 10 CFR part 430.32(m)(7)(iii). Similarly, Osram Sylvania made the same point and commented that 4-foot T12 medium bipin magnetic ballast systems are common in the residential sector. Osram Sylvania added that some fixtures include electronic ballasts and are marketed as being capable of operating T12 lamps, which could perpetuate T12 usage. NEMA added that cold temperature ballasts for 8-foot T12 RDC high output lamps are still allowed under the rule as well. (Public Meeting Transcript, No. 21 at pp. 248–251, 276, 281; NEMA, No. at pp. 25, 28; Joint Comment, No. 23 at p. 7)

The stakeholders did differ slightly on the appropriate replacement rates that DOE should assume. The Joint Comment recommended DOE assume 5 to 10 percent of the commercial market and a higher proportion of the residential market will purchase T12 lamp and ballast systems upon ballast failure, with the remainder migrating to T8 systems. (Joint Comment, No. 23 at p. 7) GE estimated that about 20 percent of the currently installed base of T12 lamps will be replaced by T12 lamps, while the other 80 percent will migrate to T8 lamps. (Public Meeting Transcript, No. 21 at pp. 250–252) NEMA suggested that DOE should assume that in 2022, T12 lamps will compose at least 10 percent of the 4-foot lamp market, 40 percent of the 8-foot single pin slimline market, and over 90 percent of the RDC HO market. (NEMA, No. 22 at p. 28)

After careful consideration of these comments, DOE has decided to modify its assumption regarding the rate of migration from T12 to T8 lamps. Accordingly, DOE is using NEMA's estimates to recalibrate its shipment forecasts. DOE now agrees that not all 4-foot T12 lamps would be replaced by T8 systems upon ballast failure. Thus, for this NOPR, DOE assumed 90 percent (down from 100 percent) of 4-foot T12 systems will be replaced with T8 systems and 10 percent with T12 systems. According to DOE's estimates in 2022, T12 lamps will comprise nearly 20 percent of the 4-foot medium bipin market, 25 percent of the 8-foot single pin slimline market, and 93 percent of the 8-foot recessed double contact HO market. (See TSD chapter 10.) DOE notes that these estimates do not exactly align with NEMA's suggestions, because they incorporate several other phenomena in addition to the migration to T12 electronic systems (*e.g.*, growth rate, emerging technologies, T5 penetration, 8-foot SP slimline to 4-foot MBP conversions).

iii. Eight-Foot Single Pin Slimline T12 Lamp Replacements

For its shipments forecasts in the March 2008 ANOPR, DOE assumed that 90 percent of the 8-foot T12 single pin systems would be replaced with two 4-foot T8 systems, and 10 percent would be replaced by 8-foot single pin T8 systems. In its written comments, NEMA generally agreed with DOE's assumption but provided slightly different replacement rate: NEMA suggested that DOE should assume 80 percent of the 8-foot T12 single pin lamps would be replaced by two 4-foot T8 lamps and 20 percent by 8-foot T8 lamps. (NEMA, No. 22 at p. 28) ACEEE and the Joint Comment argued that DOE's assumption that 90 percent of the 8-foot market would switch to 4-foot lamps is much too high, particularly because the current stock is dominated by T12. The Joint Comment also stated that DOE should include some electronic T12 system ballast purchases, as in the case of 4-foot T12 lamps. (Public Meeting Transcript, No. 21 at pp. 254–255; Joint Comment, No. 23 at p. 7)

Based on its consideration of the above comments, DOE revised its estimated conversion rates for 8-foot single pin slimline systems in this NOPR. In line with the Joint Comment and NEMA's recommendations, DOE lowered its conversion rates to 4-foot MBP systems. In addition, consistent with NEMA's suggestion, DOE has included a conversion to electronic 8-foot T12 SP slimline systems. DOE now assumes 80 percent of the 8-foot T12 single pin lamps would be replaced by two 4-foot MBP T8 systems, with the remaining 20 percent split evenly between 8-foot T8 and electronic 8-foot T12 SP slimline systems.

iv. Four-Foot T5 Lamps

In the March 2008 ANOPR, DOE did not analyze 4-foot miniature bipin T5 standard output (SO) and high output (HO) lamps as covered product classes. As discussed in section A.1.b above, for this NOPR, DOE is proposing to cover both T5 SO and T5 HO lamps as additional, distinct product classes. The following describes the methodology DOE used to generate shipments of these lamps.

To establish the 2005 installed stock of T5 lamps, DOE first estimated 2001-to-2005 shipments based on assumptions derived from its market research and supported by manufacturer interviews. Market literature indicated that T5 lamps represented 2 percent of the 2004 GSFL market, a figure DOE assumed for its analysis. DOE's research also indicated that the combined market share of T5 SO and HO lamps was growing as a percentage of the overall GSFL market. Additionally, in interviews, manufacturers provided insight on the proportions of T5 lamp sales that are standard output and high output. Using these assumptions, DOE generated historical shipment estimates for 2001 to 2005, which it used to calculate the initial stock of SO and HO lamps in the same manner it does for all other GSFL product classes. Finally, DOE received confidential aggregated (both SO and HO) T5 lamp shipment data from NEMA for 2001 to 2007. DOE used this data to validate its installed stock estimates.

In general, after establishing the 2005 T5 SO and HO installed stocks, DOE modeled shipment growth based on a migration from other product classes. For T5 SO lamps specifically, DOE's research indicated that shipment growth of these lamps is primarily driven by a migration from the 4-foot MBP market. In addition, because 4-foot T5 MiniBP SO systems require a different fixture than 4-foot MBP systems, T5 systems would be unlikely to penetrate the ballast-only replacement market. Therefore, to establish T5 standard output shipments, DOE allotted a portion of the 4-foot MBP fixture replacement, renovation, and new construction markets to 4-foot T5 MiniBP systems. To do this, DOE first calculated the size of this potential market for new T5 SO systems in each year. DOE then determined the portion of this market that would actually be serviced by T5 SO lamps by calculating the share that resulted in T5 shipments consistent with 2006 and 2007 historical data. DOE held the resulting percentage (approximately 12.5 percent) constant throughout the analysis period. As a result of the inclusion of 4-foot T5 MiniBP lamps eroding part of the 4-foot MBP market, estimates of total 4-foot MBP lamp shipments are lower in the NOPR than in the ANOPR. Using this methodology, in the base case Emerging Technologies scenario, DOE forecasts T5 SO shipments of 15.0 million in 2008, 24.2 million in 2012, and 47.4 million in 2025 (56.2 million in 2025 in the base-case Existing Technologies scenario).[53]

For T5 HO lamps, after establishing the installed stock in 2005 in the same manner as with T5 SO lamps, DOE developed 4-foot T5 MiniBP HO lamp shipments by modeling a migration from two different lighting markets. Marketing literature indicated, similar to 8-foot RDC HO systems, a large portion of 4-foot MiniBP T5 HO systems serve high-bay (ceilings higher than 20-feet high) applications due to their highly-concentrated light output. Historical shipment data for 8-foot RDC HO lamps showed substantial declines in 2006 and 2007, indicating T5 HO lamps may be rapidly displacing them. In addition, DOE's research indicated that a significant portion of 4-foot T5 HO growth can be attributed to a penetration into the high intensity discharge (HID) lamp high-bay and low-bay markets. Therefore, to calculate the growth in 4-foot MiniBP T5 HO lamp shipments, DOE assumed that these systems were penetrating both the 8-foot RDC HO and HID markets. Similar to its analysis for T5 SO systems, DOE established that the fixture replacement, renovation, and new construction market segments represent the available market for T5 HO systems. DOE obtained HID shipment data from the 2004 HID determination,[54] from which DOE calculated the total lumens servicing low-bay and high-bay applications. Then, consistent with historical T5 and 8-foot RDC HO shipments, DOE assumed T5 HO would fully penetrate the 8-foot RDC HO new construction, renovation, and fixture replacement markets, as well as the HID new construction and renovation market. Using this methodology, DOE forecasts T5 HO shipments of 14.0 million in 2008, 23.6 million in 2012, and 46.1 million in 2025.

For further details on shipment forecasts of 4-foot T5 lamps, see chapter 10 of the TSD. DOE seeks public comment on its analysis of the 4-foot T5 SO and HO markets, as well as its shipment results.

[53] As discussed earlier, DOE models two base-case shipment scenarios: Existing Technologies and Emerging Technologies. Because the Emerging Technologies scenario models the potential substitution of GSFL systems with lamps that incorporate emerging technologies (such as LED), the Emerging Technologies scenario generally results in fewer shipments of GSFL. However, based on price and technology advancement projections, DOE estimated that these emerging technologies will not likely significantly penetrate the GSFL market until after 2012.

[54] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, ''Energy Conservation Program for Commercial and Industrial Equipment: High-Intensity Discharge Lamps Analysis of Potential Energy Savings'' (Dec. 2004). Available at: *http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/hid_energy_savings_report.pdf*.

3. Base-Case Market-Share Matrices

DOE's market-share matrices are another important input into the shipments analysis and NIA. Within each product class, DOE considers the mix of technologies from which consumers can choose. These choices are represented in market-share matrices, which apportion market share for lamp stocks (in 2012) or lamp shipments (after 2012). Because shipments depend on lamp lifetime and system lumen output assumptions, among other inputs, DOE allocated market shares to each of the lamp technologies for the base case and standards case. The matrices enable the shipment model to capture a migration to different lamps, or, for GSFL, lamp-and-ballast designs, over time in both the base and standards cases. Issues related to these market-share matrices are discussed below.

a. General Service Fluorescent Lamps

A ballast factor measures the actual lumen output of a lamp-and-ballast system relative to a reference system. A lower ballast factor will, all else equal, lead to lower lumen output, and proportionally less energy consumption than the reference system. ACEEE commented that the ballast factor of 0.75 that DOE used in the market matrices is fairly uncommon and that manufacturers are now marketing lower ballast factors, including 0.7, 0.69, and 0.68. Therefore, ACEEE expects a bigger jump from normal to low ballast factor than the 0.78–0.75 jump that DOE assumes in its market-share matrices presented in the ANOPR. The Joint Comment noted that 0.71 represents the mid-point of very low ballast factors on the market. (Public Meeting Transcript, No. 21 at pp. 262–263; Joint Comment, No. 21 at p. 10) Consistent with changes incorporated in the engineering analysis, DOE incorporated a 0.71 ballast factor ballast option in the NIA. In sum, DOE attempts to match as closely as possible the lumen output of the retiring system and the replacement system. To the extent that a lower ballast factor can achieve the appropriate lumen output, it is incorporated into the technology choices facing consumers.

Regarding the base-case 4-foot T8 medium bipin market-share matrix, Industrial Ecology commented that DOE was incorrect to assume 0 percent market share for the 25W lamp in 2012. Because thousands of these lamps are being sold in 2008, that estimate should be much greater than zero. (Public Meeting Transcript, No. 21 at p. 261) The Joint Comment stated that 30W lamps are being displaced by 25W and 28W options. Therefore, DOE's 30W market share assumptions—4 percent in 2012 and 15 percent in 2042—are too large. The Joint Comment suggested that DOE should substantially reduce the market share of 30W lamps and split those sales between 25W and 28W lamps. (Joint Comment, No. 23 at p. 10)

NEMA commented on the same market-share matrix, stating that the market share for T8 lamps in the 2042 base case should be less than 30 percent for 32W lamps and greater than 30 percent for 25W lamps, with the rest of the market composed of 28W and 30W lamps. (NEMA, No. 22 at p. 28)

DOE considered the submitted comments and modified its base-case 4-foot T8 medium bipin market-share matrix accordingly. Based on a confidential NEMA survey of market shares of 4-foot medium bipin lamps, in 2012, DOE allocated 4 percent, 4 percent, and 2 percent of the 4-foot T8 market share to 25W, 28W, and 30W lamps, respectively, for the revised NOPR base-case market-share matrices. In 2042, DOE allocated 32 percent, 27 percent, and 14 percent market to 25W, 28W, and 30W lamps, respectively. See chapter 10 of the NOPR TSD for the full market-share matrices in 2012 and 2042.

b. Incandescent Reflector Lamps

In the March 2008 ANOPR, DOE presented market-share matrices for both residential and commercial IRL. For the commercial sector, the base-case IRL market-share matrix apportioned market share of the stock to only halogen and the standard HIR (currently EL2) lamps. Although DOE received no comments from stakeholders, DOE modified these matrices for the NOPR to reflect changes made in the engineering analysis. For the NOPR, the base case market-share matrix for commercial IRL now allocates market share to all currently commercially-available lamp technologies, including improved halogen, long-life HIR, and the silverized reflector technology. DOE believes this revised distribution better reflects product availability and consumer purchasing trends because they include all covered lamp technologies currently being sold.

4. GSFL Standards-Case Shipment Scenarios and Forecasts

In the March 2008 ANOPR, DOE modified its base-case market-share matrices to account for two standards-case scenarios and to generate shipment forecasts. DOE considered a Roll-up scenario and a Shift scenario, described below. DOE also introduced voluntary standards-induced retrofits in the standards case. DOE received several comments on the scenarios it analyzed and its rate of voluntary retrofits. In response to those and related comments, DOE is modifying its Shift and Roll-up scenarios and introducing new standards-case scenarios. These scenarios are discussed in detail below and in TSD chapter 10.

a. Shift/Roll-Up Scenarios

In the March 2008 ANOPR, DOE modeled lower-bound and upper-bound energy conservation scenarios for the GSFL standards-case NIA to characterize the range of energy savings that may result from standards. 73 FR 13620, 13671 (March 13, 2008). In the standards-case NIA for GSFL and commercial IRL, DOE first modeled a lower-bound energy conservation scenario called the Roll-up scenario. 73 FR 13620, 13671 (March 13, 2008). This scenario assumes that consumers owning lamps or systems that do not meet the new standards will "roll up" to the lowest first-cost option available (preserving lumen output if possible) when purchasing standards-compliant lamps. (March 2008 ANOPR TSD chapter 9) The Roll-up scenario also assumes that consumers already owning standards-compliant lamps or systems will continue to purchase those lamps or systems.

DOE also modeled a Shift scenario in the March 2008 ANOPR for the GSFL NIA, in which DOE assumed that consumers are driven by both lamps cost and energy savings. In this case, consumers may purchase a variety of lamps or systems that are more efficacious than their base case systems. (73 FR 13620, 13671 (March 13, 2008); March 2008 ANOPR TSD chapter 9) Specifically, consumers who purchase products in the base case at above-minimum standard levels will "shift up" to even higher efficacy standard levels in the Shift scenario. DOE used this scenario to illustrate upper-bound energy savings.

The Joint Comment argued that both the Roll-up and Shift scenarios understate standards-case energy savings, but the Roll-up scenario is more unrealistic because standards change the relative economics of more-efficient products. (Joint Comment, No. 23 at p. 11) In other words, standards would eliminate the least-efficacious lamps (which usually have the lowest first costs), thereby reducing the cost premium of high-efficacy lamps relative to the lowest first-cost available lamp. According to the commenter, that would encourage some consumers to purchase lamps above the standards. The Joint Comment also argued that new standards would encourage manufacturers to promote more efficacious products, a market dynamic not sufficiently captured by either scenario. (Joint Comment, No. 23 at p. 11)

The Joint Comment further stated that the Shift scenario reflects a more realistic consumer response to standards than the Roll-up scenario. Historically, for example, some consumers have purchased systems that are more efficacious than minimum standards. Still, the Joint Comment argued, the Shift scenario does not fully capture the spread of efficiencies in a standards-compliant market and fails to characterize manufacturer efforts to hasten development of more-efficient lamps and systems. The Joint Comment argued that DOE's scenarios should anticipate voluntary programs and manufacturer interest in establishing more-efficient product lines in the standards case. (Joint Comment, No. 23 at pp. 11, 22)

Regarding the comment about the relative economics of lamp purchases, DOE agrees that the relative first-costs change in the standards case (*i.e.*, the up-front cost differential between the least-cost, standards-compliant lamp and a more-efficient lamp) is less than in the base case. This effect is one of the reasons DOE models a Shift scenario. Still, DOE does not believe that this effect implies that the Shift scenario is necessarily more viable than the Roll-up scenario. Although the relative up-front economics change between cost and efficacy, they may not change between cost and income, meaning some consumers—particularly those not concerned about energy savings—may focus on the absolute costs at the time of purchase. A consumer's lighting budget, for example, will not necessarily increase simply because there is a smaller cost premium for a more-efficacious lamp. In sum, DOE cannot be certain which scenario is more likely, and, thus, continues to model both scenarios.

However, DOE agrees that revisions to the Shift scenario may better capture the spread of efficiencies in the market. Therefore, DOE revised its Shift scenario for the NOPR to more closely retain the existing (baseline) efficacy distribution in the standards case. (See TSD chapter 11 for the revised Shift scenario efficacy distribution results.) However, as the standard becomes more stringent, DOE has maintained its approach of incrementally accumulating market share of the lamp stock at TSL5 and not projecting some to move beyond what now characterizes the maximum technologically feasible standard level (''max-tech''). It is not possible for DOE to model a spread of efficiencies above max-tech levels. DOE has interviewed manufacturers and concluded it cannot reasonably predict future price and performance points of technologies yet to be developed for the market. DOE seeks comment and supporting data on whether the Roll-up or Shift scenario is more appropriate.

b. Lighting Expertise Scenarios

In its written comments, NEMA stated that it considers the Shift scenario implausible because the scenario assumes consumers will ''aggressively'' migrate to lower-ballast-factor ballasts. NEMA strongly disagreed with DOE's assumption that more-stringent efficacy standards are significantly correlated with lower GSFL ballast factors (particularly at CSLs 3, 4, and 5), and NEMA argued that it had seen no direct and demonstrated causal relationship between them in its experience. Further, NEMA argued that there is no proven correlation between new potential GSFL standards and the future mix of ballast factor values that will occur; therefore, NEMA reasoned that DOE should not apply such a correlation in its standards-case market-share matrices. NEMA also commented that new standards-compliant GSFL and their ballasts would have to be interoperable across manufacturers and with a wide range of existing ballasts and luminaires. Therefore, more-stringent efficacy standards would mostly yield greater lumen output, rather than decreasing lamp wattage. As such, NEMA argued, DOE has overreached in building a case for standards set at higher efficacy levels by inappropriately and arbitrarily assuming a strong correlation between increasing efficacy and decreasing ballast factor views. (NEMA, No. 22 at p. 26, 27)

NEMA also commented that the most direct way to use the efficacy improvements imposed by the standards is to use fewer luminaires to attain the same delivered light level on the work surface while reducing the total wattage. However, NEMA maintains that this is not a practical possibility because, even for new construction or major renovation projects, the spacing of luminaires is dictated by a building and ceiling system grid. Thus, there is no opportunity to take advantage of additional lumens that might result from standards by re-spacing existing luminaires, which must continue to operate on high-volume ballast designs. (NEMA, No. 22 at p. 26) Based on these arguments, NEMA strongly asserted that moving beyond CSL1 and CSL2 for a lamp-only rulemaking is ill-advised. (NEMA, No. 22 at p. 26, 27)

DOE has carefully considered NEMA's comments on DOE's assumption of a general trend toward lower-BF ballasts over the analysis period. In response, DOE undertook an extensive literature review and analysis—discussed below—to better characterize the likelihood of consumers migrating to lower-BF ballast systems if higher efficacy standards are required. DOE assessed the lighting expertise of groups of consumers, described below, who make lighting purchase decisions. DOE assumes that consumers with ''high'' lighting expertise will be sufficiently educated about ballast factors and lamp efficacy to migrate to lower-ballast-factor ballasts when lower wattage lamps are not available in the standards case. That is, these consumers will seek to maintain light output in the replacement purchase.

To analyze this issue, DOE first characterized the lighting market supply chain in the commercial and residential sectors and identified the decision makers within each one (*e.g.*, contractors, homeowners). DOE broke down each sector by the principal events that prompt lamp purchases: (1) Ballast failure; (2) retrofit; (3) fixture replacement; (4) renovation; and (5) new construction. DOE assigned probabilities reflecting each decision maker's likelihood of making the lighting purchase decision given the purchase event. For example, in purchase events driven by new construction, DOE assumed lighting designers, architects, and electrical engineers make 70 percent of the decisions, owners make 20 percent, and electrical contractors make the remaining 10 percent. DOE then analyzed the likelihood of each decision maker choosing to run a lamp on a lower BF ballast if forced by standards to purchase a more-efficacious lamp. DOE described that likelihood with a probability that was based on the technical expertise and motivation of the decision maker. Within each purchase event, DOE multiplied the likelihood of each market actor making the decision by the likelihood of that actor choosing a lower-BF ballast. In this way, DOE derived an estimate for the likelihood of a lower-BF ballast being selected for each event in each sector in the standards case.

DOE assumed the commercial and industrial sectors behave similarly with respect to ballast factor choices, and no distinction was made between them in this analysis. Additionally, decision makers in the large-commercial sector can be different agents making different decisions than those in the small-commercial sector. In the market segments (purchase events) where DOE found consumer behavior to be substantially different between these subsectors, DOE weighted the relative impact of each subsector when characterizing the overall commercial market. Table V.6 presents the results of DOE's analysis for the commercial and residential sectors. The values depict the probability that lamps purchased in each event will be matched with lower-ballast-factor ballasts, if necessary, to maintain lumen output. For example, 78 percent of lamps purchased in new construction in the commercial sector will be paired with lower-ballast-factor ballasts, if no reduced-wattage lamps are available in the standards case,

TABLE V.6—MARKET SEGMENT-BASED LIKELIHOOD OF HIGH LIGHTING EXPERTISE

Lamp purchase event	Probability	
	Commercial (in percent)	Residential (in percent)
Renovation	69	48
New Construction	78	61
Retrofit	92	0
Ballast Replacement	8	0
Fixture Replacement	34	0

In light of NEMA's comments and DOE's analysis, DOE used these results to add a second set of standards-case scenarios to characterize ballast factor migration in the GSFL NIA. DOE now also analyzes a High Lighting Expertise scenario and a Market Segment-Based Lighting Expertise scenario. These scenarios characterize consumers' decisions (or lack thereof) when purchasing a more-efficient lamp to either maintain previous lumen output or accept higher lighting levels. For its part, the High Lighting Expertise scenario uses the same methodology as DOE used in the ANOPR. The High Lighting Expertise scenario generally characterizes more sophisticated lighting decisions in which consistent lighting levels and/or energy savings play a determining role in consumer behavior. In this scenario, consumers are more likely to choose a lower-ballast-factor ballast to pair with higher-efficacy lamps. Conversely, in the Market Segment-Based scenario, DOE assumed consumers often accept higher lighting levels as a consequence of higher-efficacy lamps. As a consequence, these consumers do not achieve the same energy savings as would be possible by migrating to lower-ballast-factor ballasts. DOE used this analysis, and the results shown in Table V.6, to characterize the Market Segment-Based expertise scenario. On the other hand, in the High Lighting Expertise scenario, DOE assumes all consumers (100 percent) migrate to lower-ballast-factor ballasts when appropriate. Please see TSD appendix 10B for more details.

c. Voluntary Retrofits

In the March 2008 ANOPR, DOE assumed that more-stringent efficacy standards would lead to higher T12 lamp prices, and, in turn, higher rates of voluntary retrofits from T12 to more-efficacious T8 lamps. For example, DOE assumed that CSL1 would drive an additional 10 percent of the T12 market to voluntarily migrate to T8 lamps, that CSL2 would drive an additional 20 percent, that CSL3 would drive an additional 30 percent, and so on. These commercial standards-induced retrofits involve consumers voluntarily discarding their functioning T12 ballasts, and purchasing new T8 ballasts in the standards case. In contrast, in the base case, these consumers would have utilized the entirety of their T12 ballast lifetime.

At the public meeting, ACEEE agreed with DOE's assumption that standards will accelerate voluntary retrofits, but argued that DOE's retrofit rate was too aggressive. ACEEE specifically stated that the 50-percent retrofit rate per year at CSL5 was too high and suggested a rate of roughly half that level. (Public Meeting Transcript, No. 21 at p. 282) GE agreed that DOE's retrofit rates were too high, suggesting that 10 percent at CSL1 is an appropriate starting point, but 25 percent should probably be the maximum assumed retrofit rate at CSL5. Using those rates as the minimum and maximum, GE said DOE could scale the rate for the other CSLs. (Public Meeting Transcript, No. 21 at pp. 282–283) In its written comments, NEMA similarly stated that DOE's conversion rate for consumers voluntarily retrofitting from T12 to T8 systems is likely overstated. NEMA suggested that DOE should use a voluntary retrofit rate of 20 to 25 percent for CSL5 and recommended that other rates be adjusted based on that percentage. (NEMA, No. 22 at p. 28)

At the public meeting, Philips also commented that it would expect utilities to be more aggressive with their rebate programs in the standards case than they would be in the base case. PG&E stated that voluntary retrofits are driven by many factors, including attention to global climate change, increased product availability, and other factors, not necessarily utility rebate programs. (Public Meeting Transcript, No. 21 at pp. 273–275)

DOE considered these comments and maintains that these standards-induced retrofits are a likely phenomenon and important to model in the NIA. DOE agrees that its initial retrofit assumptions were likely too high, particularly for the higher efficacy levels. For the NOPR, consistent with comments received, in the commercial sector DOE continued to assume that EL1 would drive an additional 10 percent of the T12 market per year to voluntary retrofit to T8 lamps. DOE also assumed a 25-percent retrofit rate at EL4 and EL5, levels at which all T12 lamps are effectively eliminated from the market. For TSL1, TSL2, and TSL3, DOE changed the standards-induced retrofit rates to 10 percent, 15 percent, and 20 percent, respectively.

Similar to DOE's approach in the commercial sector, DOE also included increased migration of residential consumers from 4-foot medium bipin T12 systems to T8 systems. As discussed in chapter 10 of TSD, DOE assumed in the base case that residential consumers replacing their T12 fixture (either due to fixture failure or ballast failure) would purchase another T12 system. In contrast, in the commercial sector, DOE assumes 90 percent of 4-foot MBP consumer replace their T12 ballasts with T8 ballast upon fixture or ballast failure in the base case. In addition, while in the commercial sector DOE assumed, under amended energy conservation standards, some consumers would retrofit their working T12 ballast systems before end of ballast life, DOE assumed residential