DEPARTMENT OF ENERGY

10 CFR Part 430

[Docket No. 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: Advance notice of proposed rulemaking.

SUMMARY: The Energy Policy and Conservation Act authorizes the Department of Energy (DOE) to establish energy conservation standards for various consumer products and commercial and industrial equipment, including general service fluorescent lamps and incandescent reflector lamps, for which DOE determines that energy conservation standards would be technologically feasible and economically justified, and would result in significant energy savings. In this advance notice of proposed rulemaking (ANOPR), DOE is considering amendment of existing energy conservation standards for general service fluorescent lamps and incandescent reflector lamps, and it is also considering whether standards should apply to additional general service fluorescent lamps. In addition, this ANOPR considers various amendments to lighting-related definitions DOE previously developed and incorporated into the CFR.

DATES: DOE held a public meeting in Washington, DC, that began on March 10, 2008. The agenda for the public meeting covered first the concurrent test procedure rulemaking for general service fluorescent, incandescent reflector, and general service incandescent lamps (see proposal in today's **Federal Register**), and then this energy conservation standards rulemaking for these lighting products.

DOE began accepting comments, data, and information regarding the ANOPR at the public meeting and will continue to accept comments until, but no later than April 14, 2008. See section V, ''Public Participation,'' of this ANOPR for details.

ADDRESSES: The public meeting was held at the U.S. Department of Energy, Forrestal Building, Room 8E–089, 1000 Independence Avenue, SW., Washington, DC 20585–0121.

Any comments submitted must identify the ANOPR for Lighting Standards, and provide the docket number EE–2006–STD–0131 and/or Regulatory Information Number (RIN) 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–0131 and/or RIN number 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, 6th Floor, 950 L'Enfant Plaza, SW., 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 V 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, 6th Floor, 950 L'Enfant Plaza, SW., Washington, DC 20024, (202) 586–2945, between 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Please call Ms. Brenda Edwards at (202) 586–2945 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.*

Ms. Francine Pinto or Mr. Eric Stas, 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. Telephone: (202) 586–9507. E-mail: *Francine.Pinto@hq.doe.gov or Eric.Stas@hq.doe.gov.*

For information on how to submit or review public comments and on how to participate in the public meeting, 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

AEO Annual Energy Outlook
ANOPR advance notice of proposed rulemaking
ANSI American National Standards Institute
BEF ballast efficacy factor
BF ballast factor
BR bulged reflector (reflector lamp shape)
CBECS Commercial Buildings Energy Consumption Survey
CCT correlated color temperature
CEC California Energy Commission
CEE Consortium for Energy Efficiency
CFR Code of Federal Regulations
CFL compact fluorescent lamp
CIE International Commission on Illumination
CO_2 carbon dioxide
CRI color rendering index
CSL candidate standard level
DOE U.S. Department of Energy
E26 Medium screw-base (incandescent lamp base type)
EIA Energy Information Administration
EISA 2007 Energy Independence and Security Act of 2007
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
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
I–O input-output
IR Infrared
IRL incandescent reflector lamp
K degrees Kelvin
LCC life-cycle cost
Lm lumens
LMC U.S. Lighting Market Characterization Volume I
Lm/W lumens per watt
MECS Manufacturer Energy Consumption Survey (MECS)
MIA Manufacturer Impact Analysis
NAICS North American Industry Classification System
NEEP Northeast Energy Efficiency Partnership
NEMA National Electrical Manufacturers Association
NEMS National Energy Modeling System
NES national energy savings
NIA National Impact Analysis
NOPR notice of proposed rulemaking
NO_X nitrogen oxides
NPV net present value
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
R reflector (reflector lamp shape)
RECS Residential Energy Consumption Survey
SBA Small Business Administration
SO_2 sulfur dioxide
T5, T8, T10, T12 tubular fluorescent lamps, diameters of 0.625, 1, 1.25 or 1.5 inches, respectively
TSD technical support document
TSL trial standard level
U.S.C. United States Code
UV ultraviolet
V volts
W watts

I. Introduction

This advance notice of proposed rulemaking (ANOPR) serves two primary purposes: (1) Providing a preliminary determination regarding additional general service fluorescent lamps (GSFL) that DOE is considering for coverage and standards; and (2) initiating rulemaking to consider amending DOE's energy conservation standards related to coverage of GSFL and incandescent reflector lamps (IRL). The ANOPR is intended to help DOE satisfy two statutory directives, namely to make a preliminary determination representing the Secretary's initial assessment of additional GSFL to consider for energy conservation standards under section 325(i)(5) of the Energy Policy and Conservation Act (hereinafter ''EPCA'') (42 U.S.C. 6295(i)(5)), and to conduct an energy conservation standards rulemaking for general service fluorescent lamps and incandescent reflector lamps under Section 325(i)(3) of EPCA (42 U.S.C. 6295(i)(3)). Because the preliminary determination for certain additional lamps is positive, DOE is including such lamps in the ANOPR analyses for standard-setting purposes.

DOE welcomes comment on any relevant issue related to this ANOPR. However, throughout this **Federal Register** notice, DOE identifies specific areas and issues on which it specifically invites comment. These critical issues are summarized in section V.E of this notice.

A. Purpose of the Advance Notice of Proposed Rulemaking

The purpose of the ANOPR is to provide interested parties with an opportunity to comment on:

1. The preliminary determination of additional GSFL being considered for energy conservation standards;

2. The product classes DOE is planning to analyze in this rulemaking;

3. The analytical framework, methodology, inputs, and models (e.g., life-cycle cost (LCC) and national impact analysis (NIA) spreadsheets) that DOE developed to evaluate energy conservation standards for GSFL and IRL (collectively referred to in this ANOPR as the ''two categories of lamps'');

4. The analyses conducted for the ANOPR, including the preliminary results for the engineering analysis, product price determination, LCC and payback period (PBP) analysis, and NIA. These analyses are summarized in this ANOPR and presented in detail in the ANOPR technical support document (TSD), Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps,[1] published in tandem with this ANOPR; and

5. The candidate standard levels (CSLs) that DOE developed for the ANOPR.

B. Authority

Title III of EPCA (42 U.S.C. 6291 et seq.) sets forth a variety of provisions designed to improve energy efficiency. Part B of Title III (42 U.S.C. 6291–6309) established the ''Energy Conservation Program for Consumer Products Other Than Automobiles,'' which includes major household appliances. Subsequent amendments expanded Title III of EPCA to include additional consumer products and certain commercial and industrial equipment, including certain fluorescent and incandescent lamps—the products that are the focus of this document. In particular, amendments to EPCA in the Energy Policy Act of 1992 (EPACT 1992), P.L. 102–486, established energy conservation standards for certain classes of GSFL and IRL, and authorized DOE to amend these standards if such amendments were warranted. (42 U.S.C. 6291(1), 6295(i)(1) and (3)–(4)) The same EPACT 1992 amendments to EPCA also authorized DOE to adopt standards for additional GSFL and general service incandescent lamps (GSIL), if such additional standards were warranted. (42 U.S.C. 6295(i)(5)) Subsequent amendments to EPCA in the Energy Independence and Security Act of 2007 (EISA 2007), P.L. 110–140, amended the existing energy conservation standards for IRL and removed DOE's authority under 42 U.S.C. 6295(i)(5) to adopt standards for additional GSIL.

Before DOE establishes any new or amended energy conservation standards, it must first solicit public comments on a proposed standard. EPCA, as amended, specifies that any new or amended energy conservation standard that DOE prescribes for consumer products shall be designed to ''achieve the maximum improvement in energy efficiency * * * which the Secretary [of Energy] determines is technologically feasible and economically justified.'' (42 U.S.C. 6295(o)(2)(A)) Moreover, EPCA states that the Secretary of Energy (the Secretary) may not establish an amended standard if such standard would not result in ''significant conservation of energy,'' or ''is not technologically feasible or economically justified.'' (42 U.S.C. 6295(o)(3)(B)) To determine whether a proposed standard is economically justified, DOE must, after receiving comments on the proposed standard, determine whether the benefits of the standard exceed its burdens to the greatest extent practicable, weighing the following seven statutory factors:

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

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

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

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

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

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

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

C. Summary of Proposed Coverage for Lamps

DOE's regulations currently set energy efficiency standards for certain classes of general service fluorescent lamps and incandescent reflector lamps. 10 CFR 430.32(n). However, section 325(i)(5) of EPCA directs the Secretary of Energy to consider whether the standards in effect for GSFL should be amended so as to apply to ''additional general service fluorescent lamps.'' (42 U.S.C. 6295(i)(5)). Accordingly, in section II of this notice, DOE presents its preliminary determination regarding additional lamps that may be considered as part of the standards rulemaking. Section II provides a summary of DOE's authority under EPCA to consider additional lamps for coverage. In addition, because the preliminary determination was positive, section II also presents, by lamp type, the additional lamps for which DOE intends to consider setting standards.

[1] To view the technical support document for this rulemaking, visit DOE's website at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps.html.*

D. Overview of the Analyses Performed

As noted above, EPCA authorizes DOE to consider establishing or amending energy conservation standards for various consumer products and commercial and industrial equipment, including the two categories of lamps that are the subject of this ANOPR. For each of these products, DOE conducted key technical analyses for this ANOPR in the following areas: (1) Engineering; (2) energy-use characterization; (3) product price determination; (4) LCC and PBP analyses; and (5) NIA. DOE performed a separate set of the requisite analyses for each of the two categories of lamps examined in this rulemaking. This ANOPR presents the methodology and results of each of these analyses (first an overview, followed by a more in-depth discussion).

For each type of analysis, Table I.1 identifies the sections in this document that summarize the methodologies, key inputs, and assumptions for the analysis. In addition, DOE conducted several other analyses that either support the five analyses discussed above or are preliminary analyses that will be expanded upon during the NOPR stage of this rulemaking. These analyses include the market and technology assessment, a screening analysis which contributes to the engineering analysis, and the shipments analysis which contributes to the national impacts analysis. In addition to these analyses, DOE has begun some preliminary work on the life-cycle cost subgroup analysis, manufacturer impact analysis, utility impact analysis, employment impact analysis, environmental assessment analysis, and the regulatory impact analysis for the ANOPR. These analyses will be expanded upon during the NOPR stage of this rulemaking.

DOE consulted with interested parties as part of its process for conducting all of the analyses for the ANOPR and invites further input from the public on these topics. While obtaining such input is the primary purpose of this stage of the rulemaking, this notice also contains a synopsis of the preliminary analytical results. (The TSD contains a complete set of results.) The purpose of publishing these preliminary results in this notice is to: (1) Facilitate public comment on DOE's analytical methodology; (2) illustrate the level of detail found in the TSD; and (3) invite comment on the structure and the presentation of those results. The preliminary analytical results presented in the ANOPR are subject to revision following review and input from the public.

TABLE I.—1 KEY TECHNICAL ANALYSES CONDUCTED FOR THE ANOPR

Analysis area	Methodology	Key inputs [2]	Key assumptions	ANOPR section and TSD chapter
Engineering Analysis	Design option analysis to establish lamp and lamp-and-ballast designs at each CSL.	Published catalog data on performance values such as operating life, rated power, efficacy, and light output.	Analysis can be extended to product classes and efficiency levels for which DOE did not conduct analysis; ballast system power varies linearly by ballast factor.	Section III.C and TSD Chapter 5.
Energy-Use Characterization.	Multiply lamp power, or lamp-and-ballast system power, by annual operating hours.	Annual operating hours by lamp type; lamp, or lamp and ballast, energy consumption. Energy Information Administration (EIA) 2001, 2002, and 2003 survey data and 2002 U.S. Lighting Market Characterization Study Vol. I.	Data sources are indicative of current lighting use.	Section III.D and TSD Chapter 6.
Product Price Determination.	Mark up manufacturer price schedules to develop low, medium, and high end-user retail prices.	Manufacturer price schedules. Publicly available discount schedules from State procurement contracts and other users.	Future pricing for more efficacious products will reflect discounts used with today's commodity products.	Section III.E and TSD Chapter 7.
Life-cycle Cost and Payback Period Analyses.	Use Monte Carlo simulation in combination with inputs that are characterized with probability distributions to establish a distribution of consumer economic impacts (i.e., LCC savings and PBP); capture variability in annual energy use; correlate electricity prices with building samples to capture regional and sector-specific variability; use residual value to account for any remaining life of a lamp at the end of the analysis period; report LCC savings by event type and CSL.	Lamp and ballast installation costs; annual energy consumption; electricity prices and future trends; product lifetimes; discount rates; consumer "lamp purchasing events" that cause purchase of a new lamp / system; building samples based on the EIA's Commercial Building Energy Consumption Survey (CBECS), EIA's Residential Energy Consumption Survey (RECS), and EIA's Manufacturing Energy Consumption Survey (MECS) and the U.S. Lighting Market Characterization Vol. I (LMC).	AEO 2007 basis for energy price forecasts and EIA 2005 basis for distribution of electricity prices; average discount rate is 5.6% for the residential sector, 6.2% for the commercial sector, and 7.5% for the industrial sector.	Section III.G and TSD Chapter 8.

TABLE I.—1 KEY TECHNICAL ANALYSES CONDUCTED FOR THE ANOPR—Continued

Analysis area	Methodology	Key inputs [2]	Key assumptions	ANOPR section and TSD chapter
National Impact Analysis and Shipment Analysis.	Forecasts of national GSFL and IRL costs and energy consumption; forecast shipments through the use of a stock accounting model. DOE used the lamp purchase events to divide the market into segments—new construction, replacements, and early retrofit (only for GSFL); use multiple scenarios to forecast the technology mix of lamps (and ballasts) sold at each CSL.	Historical and forecasted annual shipments; lamp stock; total installed product costs; unit annual energy consumptions; AEO2007 energy price forecasts; site-to-source conversion factors for electricity; discount rate; HVAC interaction, and rebound effect.	Annual shipments; forecasted base-case and standards-case efficacy improvements based on market-share matrices and historical trends; AEO2007 basis for site-to-source conversion factors; discount rates are 3 percent and 7 percent real; future costs discounted to present year (2007).	Sections III.H and III.I; TSD Chapters 9 and 10.

1. Engineering Analysis and Product Price Determination

DOE uses the engineering analysis and product price determination together to characterize the relationship between the end-user (consumer) price and the efficiency of the product DOE evaluates for standards. The relationship between the efficiency of a product and the price of that product is essential in determining the relative cost of a more efficient product over its lifetime (i.e., the purchase price of the product plus maintenance and operating costs) as compared to a less efficient product. This calculation is necessary to determine whether individual consumers and the nation will benefit under an efficiency standard. DOE's approach to these analyses is explained briefly below.

The engineering analysis identifies the representative baseline lamps, or lamp-and-ballast combinations, that DOE will evaluate in the engineering analysis. The term ''baseline'' refers to a lamp (or lamp-and-ballast system) that has features and technologies typically found in equipment currently offered for sale and is representative of the characteristics of products in a given product class; for products which are already subject to an energy efficiency standard, the baseline unit is typically one which just meets the current regulatory requirement.

DOE based the product price determination for lamps and ballasts on marked-up manufacturer price schedules, developing low, medium, and high end-user retail prices. Section III.C and Chapter 5 of the TSD discuss the engineering analysis, and section III.E and Chapter 7 of the TSD discuss the product price determination in further detail.

2. Energy-Use Characterization

The energy-use characterization provides estimates of annual energy use for the two categories of lamps which are the subject of the present rulemaking. DOE uses these estimates in the LCC and PBP analyses, as well as the NIA. To develop annual energy use estimates, DOE multiplied annual usage (in hours per year) by the system power estimates (in watts). In order to obtain the inputs for these calculations, DOE took the following steps. DOE developed the system power estimates in the engineering analysis. To derive annual energy usage, DOE used data published in the U.S. Lighting Market Characterization: Volume I (LMC) [3], the Residential Energy Consumption Survey (RECS) [4], the Commercial Building Energy Consumption Survey (CBECS) [5], and the Manufacturer Energy Consumption Survey (MECS) [6]. More detail on the calculation of operating hours is available in section III.D.1 of this notice, and Chapter 6 of the TSD.

3. Life-Cycle Cost and Payback Period Analyses

The LCC and PBP analyses determine the economic impact of potential standards on individual consumers. The LCC is the total consumer expense for a product over the life of the product (i.e., purchase price plus maintenance and operating costs). The LCC analysis compares the LCC of products and equipment designed to meet possible energy conservation standards with the LCC of the products and equipment likely to be installed in the absence of standards.

The PBP represents the number of years required to recover the increase in purchase price (including installation cost) of a more-efficient product through savings in the operating cost of the product. The PBP is calculated by dividing the change in total installed cost due to increased efficacy by the change in annual operating cost from increased efficacy. More detail on the calculation of LCC and PBP is available in section III.G of this notice and Chapter 8 of the TSD.

4. National Impact Analysis

The NIA estimates the national energy savings (NES) and the net present value (NPV) of total customer costs and savings expected to result to the nation from new standards at specific efficiency levels. Stated another way, in the NIA, DOE calculates NES and NPV for any given potential standard level for each of the two categories of lamps as the difference between a base-case forecast (i.e., without new standards) and the standards-case forecast (i.e., with new standards). To start, DOE determines national annual energy consumption by multiplying the

[2] The data sources cited in this table were the most current available at the time DOE prepared this ANOPR. In the future, should more up-to-date sources become available, DOE will incorporate those more up-to-date sources into its analysis.

[3] 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: *www.eere.energy.gov/buildings/info/documents/pdfs/lmc_vol1_final.pdf.*

[4] 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.*

[5] 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.*

[6] 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.*

number of units in use which are expected to be purchased after the standard takes effect by their average unit energy consumption. Using that input, the NES is calculated as the sum of the cumulative annual energy savings over the analysis period (2012–2042).[7] The national NPV is then calculated from the discounted net savings each year for the products purchased over that same analysis period. The NPV sums the discounted net savings each year, consisting of the difference between the savings in total operating costs and increases in total installed costs. More detail on the NIA is available in sections III.H and III.I of this notice and Chapters 9 and 10 of the TSD.

E. Background

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

As noted above, EPCA established energy conservation standards for GSFL, requiring that certain fluorescent lamps meet prescribed minimum efficacy levels and minimum color rendering index (CRI) levels. EPCA also established efficacy standards for certain IRL. (42 U.S.C. 6295(i)(1)) For both categories of lamps, EPCA requires that DOE conduct two cycles of rulemakings to determine whether the standards should be amended. (42 U.S.C. 6295(i)(3)–(4)) In addition, EPCA provides that within 24 months after U.S. Federal Trade Commission (FTC) labeling requirements become effective for GSFL and GSIL, DOE must initiate a rulemaking to determine if the standards in effect for fluorescent and incandescent lamps should be amended so that they would be applicable to additional general service fluorescent lamps. (42 U.S.C. 6295(i)(5)) Within 18 months of initiating the rulemaking, EPCA further requires DOE to publish a final rule containing such amendment, if any. (42 U.S.C. 6295(i)(5)) The FTC published a final rule establishing labeling requirements for covered lamps on May 13, 1994, with an effective date of May 15, 1995. 59 FR 25176.

In this rulemaking, DOE is addressing two statutory directives under 42 U.S.C. 6295(i). First, DOE is reviewing and deciding whether to amend EPCA's prescribed energy conservation standards for GSFL and IRL. (42 U.S.C. 6295(i)(3)) Second, DOE is reviewing whether energy conservation standards should be made applicable to additional GSFL. (42 U.S.C. 6295(i)(5))

To initiate the current energy conservation standards rulemaking, on May 31, 2006, DOE published on its Web site the Rulemaking Framework Document for General Service Fluorescent Lamps, Incandescent Reflector Lamps, and General Service Incandescent Lamps[8] (''Framework Document''), which describes the procedural and analytical approaches it anticipated using to evaluate potential energy conservation standards for these products.[9] DOE published a notice to announce the availability of the Framework Document, to schedule a public meeting on the planned analytical framework for this rulemaking (hereafter, ''Public Meeting''), and to invite written comments concerning this analytical framework. The title of that **Federal Register** notice published on May 31, 2006 is ''Energy Conservation Standards for General Service Fluorescent Lamps, Incandescent Reflector Lamps, and General Service Incandescent Lamps: Notice of Public Meeting and Availability of the Framework Document,''[10]—71 FR 30834.

A Public Meeting was held on June 15, 2006, whose purpose was to discuss the analyses and issues identified in various sections of the Framework Document. At the Public Meeting, DOE described the different analyses it would conduct, such as the LCC and PBP analyses, the methods it planned to employ when conducting them, and the relationship among the various analyses.[11] Manufacturers, trade associations, environmental advocates, and other interested parties attended the Public Meeting. Issues discussed included: (1) The rulemaking's scope of coverage and definition of exclusions; (2) the development of product classes; (3) lamp-life variation; (4) selection of representative lamps for analysis and baseline models; (5) appropriate methods and sources for developing end-user price estimates; (6) test procedures; (7) the methodology for developing shipment estimates; (8) the need for systems analysis for GSFL (i.e., analyzing a lamp and a ballast in some scenarios); (9) the impact of higher efficacy lamps on building space conditioning loads; and (10) the use of average electricity rates. Comments submitted during the Framework Document comment period elaborated upon these major issues raised at the June 2006 Public Meeting. DOE worked with its contractors to address these issues in the ANOPR analyses.

Comments received in response to the Framework Document helped identify further issues involved in this rulemaking, and such input contributed to the overall analytical process. This document summarizes the comments DOE has received to date, each with a parenthetical reference at the end citing the location of the item in the docket for this rulemaking (i.e., the public record).

2. Energy Independence and Security Act of 2007

On December 19, 2007, during the ANOPR phase of this rulemaking, the Energy Independence and Security Act of 2007 was signed into law. In relevant parts, EISA 2007 amends various EPCA provisions regarding GSFL, IRL, and GSIL, and considerably changes the scope of this rulemaking and the structure of DOE's ANOPR analyses. Accordingly, DOE has incorporated these changes in both the preliminary determination and energy conservation standards analyses contained in this ANOPR. DOE notes that the relevant amendments in EISA 2007 are effective on the date prescribed by the legislation, not on the effective date of this rulemaking.

As stated earlier, in May 2006 DOE published a Framework Document outlining the procedural and analytical approaches it anticipated using for this rulemaking. In addition, DOE received both written and oral comments in response to the Framework Document. Due to the recent amendments to EPCA in EISA 2007, the scope of coverage and analytical approach presented in this ANOPR by necessity differs from that which was previously outlined in the Framework Document. In addition, given these latest legislative amendments, numerous comments submitted no longer hold relevance to this rulemaking and, therefore, are not addressed in this ANOPR. The following section summarizes various sections of EISA 2007 relevant to this rulemaking and discusses their effect on the preliminary determination and

[7] DOE uses 31 years as the time period of analysis for its NES calculations in many of its rulemakings, in order to enable stakeholders to understand the relative magnitude of energy savings potentials of the various products and standard levels being considered.

[8] 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.*

[9] At the time of publication of the Framework Document, EPCA gave DOE authority to consider energy conservation standards for additional GSIL under 42 U.S.C. 6295(i)(5). However, subsequent amendments to EPCA in EISA 2007 removed that authority.

[10] This rulemaking notice is available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps.html.*

[11] PDF copies of the slides and other material associated with the public meeting are available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/lamps_meeting_061506.html.*

ANOPR analyses contained in this notice.

a. General Service Fluorescent Lamps

Regarding GSFL, section 316(b) of EISA 2007 amends section 321(30)(B)(viii) of EPCA (42 U.S.C. 6291(30)(B)(viii)) by modifying the definition of ''general service fluorescent lamp'' so as to exclude lamps with a CRI of 87 or greater (as compared to the previous exclusion for lamps with a CRI of 82 or greater). This amendment effectively changes the scope of coverage of energy conservation standards for GSFL to now include additional fluorescent lamps with a CRI rating from 82 up to 87. The ANOPR analyses reflect this change in scope of coverage by analyzing lamp designs with CRI ratings up through 86 and also by accounting for the national impacts due to the regulation of this full range of GSFL.

In addition, section 322(b) of EISA 2007 amends section 325(i) of EPCA (42 U.S.C. 6295(i)) by moving the table of efficacy requirements for fluorescent lamps from section 325(i)(1)(A) to section 325(i)(1)(B). However, every aspect of the table is identical to the previous standard as enacted by EPACT 1992, including the product groupings, and the minimum efficacy and CRI requirements.[12] Therefore, the amendment in section 322(b) of EISA 2007 results in no substantive change in DOE's approach toward GSFL. Furthermore, the legislation does not modify the authority to consider extending coverage to additional GSFL under section 325(i)(5) of EPCA (42 U.S.C. 6295(i)(5)).

b. General Service Incandescent Lamps

Regarding GSIL, section 321(a)(1) of EISA 2007 amends section 321(30) of EPCA (42 U.S.C. 6291(30)) by deleting the existing definition and inserting a new definition for ''general service incandescent lamp.'' In the context of redefining ''general service incandescent lamp,'' this section also introduces new definitions for several lighting-related terms, some of which were previously defined by DOE in the CFR. Definitions contained in section 321(a)(1) of EISA 2007 relevant to this rulemaking include the following terms: (1) ''Modified spectrum;'' (2) ''rough service lamp;'' (3) ''vibration service lamp;'' and (4) ''colored incandescent lamp.'' The effect that the incorporation of these definitions has on this rulemaking will be discussed in section I.E.2.c of this notice.

In addition, section 321(a)(3) amends section 325 of EPCA (42 U.S.C. 6295) by prescribing separate energy conservation standards and minimum rated lifetimes for general service incandescent lamps and modified spectrum general service incandescent lamps, with effective dates ranging from January 1, 2012 to January 1, 2014. In addition, this section also directs DOE to conduct two future standards rulemakings to review and possibly amend the standards. Furthermore, although EPACT 1992 gave DOE authority under 42 U.S.C. 6295(i)(5) to consider additional general service incandescent lamps for energy conservation standards coverage, section 321(a)(3) of EISA 2007 amends section 325(i)(5) of EPCA and removes this provision. Accordingly, DOE has terminated its preliminary determination regarding the expansion of scope to additional GSIL. In addition, as EISA 2007 prescribed energy conservation standards for GSIL, this ANOPR does present any analyses or candidate standard levels related to GSIL.

c. Incandescent Reflector Lamps

Regarding IRL, section 322(a)(1) of EISA 2007 amends section 321(30)(C)(ii) of EPCA (42 U.S.C. 6291(30)(C)(ii)) by modifying the portion of the definition of ''incandescent lamp'' which is applicable to reflector lamps so as to expand that definition to include lamps with a diameter between 2.25 and 2.75 inches, as well as BPAR-, ER-, and BR-shaped lamps. In addition, section 322(a)(2) of EISA 2007 adds new statutory definitions for a BPAR incandescent reflector lamp, a BR incandescent reflector lamp, and an ER incandescent reflector lamp. These new statutory definitions supersede the existing CFR definitions for ''ER incandescent reflector lamp'' and ''BR incandescent reflector lamp'' that were developed by DOE (62 FR 29221 (May 29, 1997)), and thereby remove DOE's authority to amend these definitions.

In addition, section 322(b) of EISA 2007 amends section 325(i) of EPCA (42 U.S.C. 6295(i)) by moving the table of minimum average lamp efficacy requirements for IRL from section 325(i)(1)(A) to section 325(i)(1)(B). However, as noted above for GSFL, every aspect of this table of IRL efficacy requirements is identical to the previous standard as enacted by EPACT 1992. Section 322(b) also amends EPCA to incorporate several new exemptions to the IRL standards in a newly-adopted section 325(i)(1)(C) of EPCA. These exemptions are as follows: (1) Lamps rated at 50 watts or less that are ER30, BR30, BR40, and ER40; (2) lamps rated at 65 watts that are BR30, BR40, or ER40 lamps; and (3) R20 incandescent reflector lamps rated 45 watts or less. DOE notes that the expanded scope of IRL, as presented in EISA 2007, is consistent the proposal contained in a joint comment submitted by the American Council for an Energy Efficient Economy (ACEEE) and the National Electrical Manufacturers Association (NEMA) regarding this rulemaking. (ACEEE and NEMA, No. 14 at pp. 3–8) The effective date of energy conservation standards for BPAR, ER, and BR shaped lamps as prescribed by EISA 2007 is January 1, 2008. The effective date of standards for smaller diameter IRL as prescribed by EISA 2007 (i.e., diameter of more than 2.25 inches, but not more than 2.75 inches) is the later of January 1, 2008 or 180 days after the date of enactment of EISA 2007. Given that EISA 2007 was enacted on December 19, 2007, the effective date of these standards for smaller diameter IRL is June 16, 2008. In both of these cases, the EISA 2007 standards come into effect well before an amended IRL standard (as would be prescribed by this rulemaking) would come into effect. DOE's draft ANOPR analyses were modified to account for this expanded scope of IRL coverage by selecting IRL baselines which DOE expects to be the least efficacious covered lamp design that would comply with the amended standard. In addition, DOE updated its IRL shipment forecasts in response to EISA 2007 to account for both the expansion of scope for Federally-regulated reflector lamps and the exemptions to the standards.

In addition, it is also important to note that, as previously discussed, EISA 2007 introduced statutory definitions for ''rough service lamp,'' ''vibration service lamp,'' and ''colored incandescent lamp,''—lamp types which are explicitly excluded from the definition of ''incandescent reflector lamp,'' as contained in the referenced definition of ''incandescent lamp.'' DOE had previously developed and adopted into the CFR definitions for these three terms in the context of IRL; however, as previously mentioned, these DOE definitions are now superseded by the statutory definitions in EISA 2007. As these terms are used to define that portion of the definition of ''incandescent lamp'' that corresponds to the definition of ''incandescent reflector lamp,'' any amendments to these terms affect the scope of energy

[12] These CRI requirements reflect minimum CRI standards for covered fluorescent lamps. These minimum requirements are not affected by the exclusion in the definition of ''general service fluorescent lamp'' for lamps with a CRI of 87 or greater, as amended by EISA 2007.

conservation standards coverage of IRL. In examining the new definitions for ''rough service lamp'' and ''vibration service lamp,'' DOE recognizes that they differ from the earlier CFR definitions DOE had adopted. In response to the changes to these definitions, DOE attempted to account for these changes in the ANOPR analyses. Similarly, the new EISA 2007 definition for ''colored incandescent lamp'' effectively expands the scope of coverage for IRL. That is, IRL containing five percent or more of neodymium content and plant light IRL are now subject to energy conservation standards. DOE accounts for this expanded coverage of IRL by creating a separate product class for these lamps, termed ''modified spectrum lamps.'' This decision to treat modified spectrum lamps separately is consistent with the approach taken in EISA 2007 with respect to GSIL.

Finally, although EPACT 1992 gave DOE authority under U.S.C. 6295(i)(5) to consider additional general service incandescent lamps (which included IRL) for energy conservation standards coverage, section 321(a)(3) of EISA 2007 has amended section 325(i)(5) of EPCA to remove this provision. Accordingly, DOE has terminated its preliminary determination regarding the expansion of scope to additional GSIL and IRL. However, as discussed above, in the ANOPR analyses, DOE accounts for the new scope of coverage for IRL for purposes that remain relevant to this rulemaking (i.e., considering amended efficacy standards for all covered IRL).

d. Off Mode and Standby Mode Energy Consumption

In addition to the specific relevant actions described above, EISA 2007 also places various requirements on all covered products. Of particular note here, section 310(3) of EISA 2007 amends section 325 of EPCA (42 U.S.C. 6295) by mandating that any final rule establishing or revising a standard for a covered product that is adopted after July 1, 2010 shall incorporate standby mode and off mode energy use into the standard, if feasible. DOE notes that final rule for this energy conservation standards rulemaking on fluorescent and incandescent lamps is scheduled for publication by June 2009. In addition, after careful review, DOE has preliminarily determined that for the GSFL and IRL which are the subjects of this rulemaking, current technologies for these products do not employ 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''[13] applicable to both GSFL and IRL, the lamp must be entirely disconnected from the main power source (i.e., the lamp is switched off) in order not to provide any active mode function (i.e., emit light), thereby meeting the second provision in the definition of ''off mode.'' However, if the lamp is disconnected from the main power source, the lamp clearly does not satisfy the requirements of operating in off mode. In addition, DOE believes that all covered products that meet the definitions of ''GSFL'' and ''IRL'' are single-function products and do not offer any secondary user-oriented or protective functions. Therefore, DOE has tentatively concluded that it is not feasible to incorporate off mode or standby mode energy use into the energy conservation standards for GSFL and IRL. DOE welcomes comment on its understanding of off mode and standby mode energy consumption for the products addressed by this rulemaking.

3. Test Procedures

DOE test procedures outline the method by which manufacturers must determine the efficiency of their products and equipment, and thereby assess and certify compliance with the energy conservation standards adopted pursuant to EPCA. DOE established test procedures for fluorescent and incandescent lamps in a final rule published in the **Federal Register** on May 29, 1997 (hereafter ''1997 Test Procedure Final Rule''). 62 FR 29222 (adopting 10 CFR part 430, Subpart B, Appendix R[14]). In addition, the test procedures incorporate by reference American National Standards Institute (ANSI), Illuminating Engineering Society of North America (IESNA), and International Commission on Illumination (CIE) standards to measure lamp efficacy and CRI. In their totality, the DOE test procedures provide detailed instructions for measuring the performance of GSFL and IRL and certain performance attributes of GSIL.

The National Electrical Manufacturers Association (NEMA) submitted a comment identifying what it perceived to be problems with several of the industry standards incorporated in DOE's test procedures. Specifically, NEMA stated that many of the standards referenced in the test procedures are outdated, have been replaced, or are no longer available. (NEMA, No. 12 at pp. 2–4)[15]

Prompted by the NEMA comment, DOE reviewed the DOE test procedures for GSFL, IRL, and GSIL, and DOE has tentatively concluded that they should be revised because many of industry standards cited in the test procedures are out of date, are not available for purchase, or are no longer maintained. Therefore, DOE has initiated a test procedure rulemaking, in parallel with this energy conservation standards rulemaking, to review and revise the test procedures for these three categories of lamps—GSFL, IRL and GSIL (even though GSIL is no longer part of this ANOPR). To this end, DOE is publishing a notice of proposed rulemaking (NOPR) in today's **Federal Register** that proposes to amend the lighting test procedures. The following briefly summarizes the major points in the test procedures NOPR; however, for a complete discussion on these and other points, please consult the NOPR.

In the test procedure NOPR, DOE is proposing primarily to update the references to outdated industry standards for fluorescent and incandescent lamps. DOE believes this update is necessary in order to ensure that stakeholders and testing laboratories are able to follow DOE's test procedures, which require obtaining and using several industry standards incorporated by reference. DOE believes that the proposed test procedure amendments would not impact the measured efficacy of a lamp.

In the test procedure NOPR, DOE is also proposing a few definitional and procedural modifications to accommodate technological migrations in the GSFL market and approaches DOE is considering in this energy

[13] In amending 42 U.S.C. 6295(gg)(1)(a)(i), (ii), and (iii), EISA 2007 defines ''active mode,'' ''off mode,'' and ''standby mode'' as follows: '' The term 'active mode' means the condition in which an energy-using product—(I) is connected to a main power source; (II) has been activated; and (III) provides 1 or more main functions.'' ''The term 'off mode' means the condition in which an energy-using product—(I) is connected to a main power source; and (II) is not providing any stand-by or active mode function.'' ''The term 'standby mode' means the condition in which an energy-using product—(I) is connected to a main power source; and (II) offers 1 or more of the following user-oriented or protective functions: (aa) To facilitate the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer. (bb) Continuous functions including information or status displays (including clocks) or sensor-based functions.''

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

[15] A notation in the form ''NEMA, No. 12 at pp. 2–4'' 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) by the National Electrical Manufacturers Association (NEMA), (2) in document number 12 in the docket of this rulemaking, and (3) appearing on pages 2 through 4.

conservation standards rulemaking. Specifically, DOE is proposing to mandate that GSFL testing continue to be conducted on low-frequency ballasts whenever possible. By maintaining fluorescent lamp testing on low-frequency ballasts when possible, DOE's proposed updates to more current ANSI standards would not alter the measured efficacy of fluorescent lamps and maintain consistent testing across manufacturers. In addition, DOE is proposing amendments related to the calculation of ''lamp efficacy'' for GSFL. Presently, manufacturers are directed to report efficacies to differing degrees of accuracy for fluorescent and incandescent lamps. For example, fluorescent lamp efficacies are rounded off to the nearest whole number, while incandescent lamp efficacies are reported to the tenths decimal place. DOE is proposing to revise the reporting requirements for GSFL, such that all covered lamp efficacies are reported with an accuracy to the tenths decimal place. DOE believes that such change would not only promote consistency among the various lamp categories, but also would coincide with the significant digits presented in the EPCA efficacy standard. In addition DOE found that in order to have standard levels for GSFL that are best able to maximize energy savings, it must utilize the tenths decimal place in its energy conservation standards analysis.

DOE is also proposing in the test procedure NOPR to adopt a testing and calculation method for measuring the correlated color temperature (CCT) of fluorescent and incandescent lamps, a provision that is not currently contained in the test procedure. DOE is considering using CCT to differentiate between product classes for GSFL, and DOE notes that the definitions of ''colored fluorescent lamp'' and ''colored incandescent lamp'' both incorporate CCT ranges, which, in part, determine whether lamps are subject to regulation.

The test procedure NOPR also recognizes that DOE is considering the possibility of extending coverage to certain additional GSFL (see section II of this notice). In addition, the test procedure NOPR recognizes and accounts for the fact that EISA 2007 has extended statutorily-prescribed energy conservation standards to specified types of GSIL. Thus, the NOPR informs the public that DOE intends to amend the test procedures to accommodate these additional lamps, and to provide appropriate test methods, should DOE adopt standards for them.

Overall, and as stated in the NOPR, DOE believes that most of the proposed revisions to the test procedures would not significantly change the reported efficacy of covered lamps or result in a significant increase in testing burden. For any that do have an appreciable impact on the reported efficacy, DOE is proposing to delay the effectiveness of such test procedure revision until the effective date of any new energy conservation standard for these products.

DOE held a public meeting to discuss both the test procedure NOPR and energy conservation standards ANOPR for fluorescent and incandescent lamps. DOE intends to issue a final rule for the lamps test procedure prior to issuing the NOPR for the energy conservation standards rulemaking.

II. Consideration Regarding the Scope of Energy Conservation Standards Coverage

A. Introduction

As noted previously, section 325(i)(5) requires DOE to consider whether to adopt energy efficiency standards for additional GSFL beyond those already covered by the statutorily-prescribed standard. (42 U.S.C. 6295(i)(5)) More specifically, EPCA directs that the Secretary ''shall 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] * * * '' *Id.* Pursuant to this mandate and as explained in this section of the notice, DOE has made a preliminary determination that expanded coverage would be appropriate. The public is invited to review and comment on the initial findings and analyses, as set forth below, regarding which additional fluorescent lamps should be evaluated for possible coverage by energy conservation standards.

Furthermore, DOE was urged to make this preliminary determination by comments received at the Public Meeting. For example, the Appliance Standards Awareness Project (ASAP) recommended that DOE should permit the public to comment on consideration of the scope of additional product coverage, and that DOE should define that scope of coverage early in the rulemaking process in order to prevent any scheduling delays. (Public Meeting Transcript, No. 4.5 at pp. 34–36) DOE agrees with the ASAP comment, and consequently, this notice provides the public with the opportunity to submit comments regarding DOE's preliminary determination.

Below, DOE discusses the range of additional lamps that EPCA authorizes DOE to consider. Then, DOE identifies those additional GSFL that it believes warrant further consideration for possible energy conservation standards, and why. DOE requests comment on these subjects. After consideration of these comments, DOE may propose additional lamps to be covered, along with proposed standard levels for these lamps, during the NOPR stage of this standards rulemaking. After further public comment, DOE will publish a final rule which includes its final decision regarding coverage of additional lamps (and applicable standards levels, as appropriate).

In addition, the following sections also discuss modifications of various existing lighting-related definitions DOE developed and incorporated into the CFR. These modifications reflect market migrations or changes in industry standards and often have the effect of increasing or decreasing DOE's scope of energy conservation standards coverage.

B. Additional General Service Fluorescent Lamps Being Considered Under EPCA Section 325(i)(5)

1. Scope

Prior to embarking on a discussion of additional coverage of general service fluorescent lamps, it is first necessary to explain the extent of coverage under the present standard. Section 325(i)(1) of EPCA established energy conservation standards for certain 4-foot medium bipin lamps, 2-foot U-shaped lamps, 8-foot recessed double contact high output lamps, and 8-foot single pin slimline lamps. (42 U.S.C. 6295(i)(1)) The relevant standard levels for the products can be found in DOE's regulations at 10 CFR 430.32(n).

As the next step in this inquiry, DOE notes that section 325(i)(5) of EPCA directs DOE to determine if the standards in effect should be amended so as to apply to ''additional general service fluorescent [lamps] * * *'' (42 U.S.C. 6295(i)(5)) There are currently a wide variety of fluorescent lamps being used in broad, general service lighting applications [16] that are not covered by

[16] A key provision in the statutory definitions of ''general service fluorescent lamp'' is that the lamp must satisfy ''the majority of fluorescent applications.'' (42 U.S.C. 6291(B)) DOE interprets these phrases to mean that these lamps have broad utility in various fluorescent or lighting applications. In general, these lamps will not represent products used solely in niche applications (such as those specifically excluded in the definition of ''general service fluorescent lamp''), but rather will represent products that often fulfill general illumination purposes (casting light over a broad area), such as in the following common locations: Office space, warehouses, call centers, schools, health care, government buildings, residential housing, and retail stores.

existing energy conservation standards. Accordingly, these lamps are potential candidates for expanded coverage pursuant to 42 U.S.C. 6295(i)(5).

In addition, DOE received a joint comment from several stakeholders (hereafter referred to as ''Joint Comment'') concerning the extent of DOE's authority to expand coverage of its energy conservation standard for lighting products. The Joint Comment was submitted by the Alliance to Save Energy, ACEEE, ASAP, Natural Resources Defense Council, Northeast Energy Efficiency Partnerships, Northwest Power and Conservation Council, and PG&E (Pacific Gas and Electric). Given the stakeholders involved, it should be noted that the Joint Comment reflects views of both energy efficiency advocates and utilities.

The Joint Comment asserted that section 325(i)(5) of EPCA authorizes DOE to adopt standards for any fluorescent lamp not currently covered by standards so long as standards for that lamp would be technologically feasible, economically justified, and would achieve significant energy savings. The comment seems to argue that in implementing section 325(i)(5), DOE should interpret its mandate broadly to include any GSFL that meet these statutory criteria. (Joint Comment, No. 9 at pp. 1–2; Public Meeting Transcript, No. 4.5, pp. 38–39, and 45)

Given that EPCA's statutory definitions of ''general service fluorescent lamp'' contains a number of express exclusions for certain categories of fluorescent lamps, DOE finds no basis in the language of EPCA to support commenters' assertions that the agency's authority to act under section 325(i)(5) of EPCA is unlimited. As discussed below, DOE believes section 325(i)(5) covers additional GSFL that are not one of the enumerated specialized products that EPCA excludes from coverage (see 42 U.S.C. 6291(30)(B)). 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 non-general 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)) Both key elements of this definition—i.e., that the lamps can satisfy the majority of lighting applications and the exclusion of certain specialized fluorescent lamps—are consistent with the mandate of section 325(i)(5) that DOE consider and adopt standards for GSFL that currently are not covered by standards. That would allow DOE to cover a broad range of additional products used and viewed as general service fluorescent lamps.

In determining which GSFL would be suitable for consideration under 42 U.S.C. 6295(i)(5), DOE limited its inquiry to those fluorescent lamps with generic physical and operational features closely matching the IESNA's widely accepted definition of ''fluorescent lamp,'' as contained in ''The IESNA Lighting Handbook: Reference and Application,'' Ninth Edition, 2000, p. G–14.[17] Because only lamps with these features are commonly understood to be fluorescent or general service fluorescent lamps, DOE would apply standards to only such fluorescent lamps, provided that such lamps are not expressly excluded under 42 U.S.C. 6291(30)(B).

In summary, in considering whether to amend the standards in effect for fluorescent lamps to apply to ''additional'' GSFL under section 325(i)(5) of EPCA, DOE has considered all lamps that meet the general description of a ''fluorescent lamp'' in the introductory language of 42 U.S.C. 6291(30)(A), that can be used to satisfy the majority of fluorescent lighting applications, for which EPCA does not prescribe standards, and that are not within the exclusions specified in 42 U.S.C. 6291(30)(B).

2. Rationale for Coverage

In considering which additional GSFL to cover, DOE considered lamps other than those specifically excluded. Among the lamps considered, DOE used potential energy savings of the lamps as the primary criterion in considering preliminarily which should be covered by the standards program. After selecting the lamps for consideration, DOE then conducted a preliminary assessment of whether a standard on those lamps would have the potential to meet the two remaining criteria for prescribing new or amended standards—i.e., being technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) In the ANOPR (as described in section III below) and NOPR, each lamp selected for coverage would then be the subject of a more comprehensive analysis to determine if there is a reasonable likelihood that standards are justified.

DOE assessed the potential to achieve significant energy savings by extending coverage to particular lamps from market-share estimates and from potential incremental energy savings that could result from more-efficacious lamp designs. DOE has quantitative shipment or market share information for certain lamps, such as 8-foot T8 single pin slimline lamps, which it considered and cites in this notice. However, DOE has little to no information on shipments or market share for other lamp types which DOE is considering, such as 8-foot very high output (VHO) fluorescent lamps. In the absence of data, DOE has relied on qualitative assessments of market share (based on discussions with lighting industry experts) to gauge the potential for significant energy savings. DOE invites the public to present further shipment or market share data relevant to consideration of coverage for additional lamps.

In addition, DOE assessed the potential to achieve significant energy savings for particular lamps by considering whether these lamps serve as potential substitutes to other regulated lamps. By leaving potential substitutes unregulated, DOE risks that regulating one lamp shape may lead to rapid increased sales of other, unregulated substitutable shapes. This shift of installed stock towards unregulated lamps may result in decreased energy savings, or even the possibility of increased energy use, from energy conservation standards on regulated lamps. In order to avoid this consequence, DOE plans to consider coverage of GSFL lamps that are potential substitutes for any lamps that have high energy savings potential and are likely to be regulated. Though the shipments of these substitute lamps may not currently be high-volume, DOE believes that if the lamps are left unregulated, the shipments have the potential to grow in market share. As long as efficacy improvements are technologically feasible, coverage of these additional substitute lamps has the potential to not only provide energy

[17] The definition of fluorescent lamp in the IESNA handbook is a ''low-pressure mercury electric-discharge lamp in which a fluorescing coating (phosphor) transforms some of the UV energy generated by the discharge into light.''

savings in their own right, but to also prevent potentially significant losses in energy savings through substitution effect.

In addition to independently conducting its preliminary determination analysis, DOE considered comments on the additional GSFL it should cover. The following subsections provide a discussion of the GSFL being considered and not considered as expanded coverage, a summary of comments relating to the preliminary determination, and DOE's response to these comments. DOE invites comment on the rationale for coverage presented in this preliminary determination. DOE also invites comment on the scope of coverage defined in this preliminary determination.

In addition, the following sections also discuss modifications to various existing lighting-related definitions DOE developed and incorporated into the CFR, which would have the effect of increasing the scope of coverage under applicable energy conservation standards. The new and amended definitions under consideration are discussed and presented in section II.C.

3. Analysis of Individual General Service Fluorescent Lamps

Current DOE regulations set standards for the following types of fluorescent lamps: (1) 4-foot, medium bipin, straight-shaped lamps, rated wattage ≥ 28W; (2) 2-foot, medium bipin, U-shaped lamps, rated wattage of ≥ 28W; (3) 8-foot, recessed double contact, rapid start, high output lamps, 0.800 nominal amperes (as defined in ANSI C78.1–1991); and (4) 8-foot, single pin, instant start, slimline lamps, rated wattage of ≥ 52 (as defined in ANSI C78.3–1991). Based on an investigation of available products in manufacturer catalogs, DOE identified various, currently-unregulated general service fluorescent lamps that could be considered for additional coverage under section 325(i)(5) of EPCA, while maintaining the exclusions specified in the definition of ''general service fluorescent lamp.'' These lamps are as follows:

- 4-foot, medium bipin, straight-shaped lamps, rated wattage of < 28W;
- 2-foot, medium bipin, U-shaped lamps, rated wattage of < 28W;
- Additional 8-foot, recessed double contact, rapid start, high output lamps;
- Additional 8-foot single pin, instant start, slimline lamps;
- Very High Output (VHO) straight-shaped lamps;
- T5 miniature bipin straight-shaped lamps;
- Additional straight-shaped and U-shaped lamps, other than those listed above (e.g., alternate lengths, diameters, or bases); and
- Additional fluorescent lamps with alternate shapes (e.g., circline, pin-based CFL).

The following section discusses DOE's rationale for considering or not considering expansion of coverage to the above-listed lamps. In addition, in section II.C, DOE considers revisions to the definitions of ''rated wattage'' and ''colored fluorescent lamp'' which may further affect DOE's scope of energy conservations standards coverage.

DOE is considering extension of the standard's coverage to certain 4-foot, medium bipin, GSFL to which standards do not currently apply. Presently, DOE's regulations do not cover or set standards for any 4-foot medium bipin lamp with a wattage less than 28W. As part of this preliminary determination, DOE is considering extension of coverage to 4-foot, medium bipin, straight-shaped fluorescent lamps with wattages between 25W and 28W. DOE understands that 25W, 4-foot medium bipin, T12 fluorescent lamps are manufactured and used primarily in the residential sector for general purpose illumination applications, providing additional opportunity for energy savings. Although DOE received no quantitative shipment information on the market share of these wattages of 4-foot medium bipin lamps, DOE has found that manufacturers currently market and sell 25W, 4-foot medium bipin, T8 fluorescent lamps as replacements for higher-wattage, 4-foot medium bipin, T8 fluorescent lamps. As discussed earlier, by expanding standards coverage to substitute lamps of currently regulated lamps, DOE mitigates the risk of 25W lamps becoming a potential loophole (that decreases energy savings) to the current and pending amended standards on 4-foot medium bipin lamps.

For these reasons, DOE believes that 25W 4-foot medium bipin lamps (both T8 and T12) are suitable candidates to be considered for coverage under this rulemaking. In addition, as the technology and incremental costs associated with increased efficiency of 25W lamps are similar to their already regulated 28W counterparts, DOE has tentatively concluded that standards on these lamps have the potential to meet the statutory criteria of being technologically feasible and economically justified. Therefore, in this ANOPR, DOE analyzes these lamps as part of the 4-foot medium bipin product class in the life-cycle cost (LCC) and national impact analysis (NIA) (sections III.G and III.I, respectively). DOE invites comment on this potential expansion of coverage to 4-foot medium bipin lamps with wattages greater than or equal to 25W, including whether T12 lamps (commonly referred to as ''residential straight-shaped lamps'') should be covered.

Similar to 4-foot medium bipin lamps, DOE's current regulations do not cover or set standards for any 2-foot U-shaped lamp with a wattage less than 28W. In its research of available product in manufacturer catalogs, DOE found no commercially-available 2-foot U-shaped GSFL with wattages less than 28W. Therefore, DOE believes that the current standards cover the majority of the U-shaped general service lighting products available in the market today. Consequently, DOE's preliminary assessment is that lowering the minimum wattage threshold of U-shaped lamps will most likely not result in significant additional energy savings. For this reason, DOE is not considering expanded coverage of 2-foot, medium bipin, U-shaped lamps in this preliminary determination.

In this preliminary determination, DOE is considering extension of the standard's coverage to certain 8-foot, recessed double contact, rapid start, high output fluorescent lamps to which energy conservation standards do not currently apply. DOE's definition of ''fluorescent lamp,'' adopted in accordance with EPCA, includes only those 8-foot recessed double contact HO lamps with 0.800 nominal amperes and which are listed in ANSI Standard C78.1–1991. 10 CFR 430.2. Due to the ampere specification in the definition, the current standards applicable to GSFL (10 CFR 430.32(n)(1)), cover 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). ACEEE and Osram Sylvania (hereafter ''Osram'') commented that DOE should cover T8, 8-foot lamps. (Public Meeting Transcript, No. 4.5 at p. 59) According to Osram, T8, 8-foot recessed double contact HO lamps are currently available, and are replacing the older T12 technology. Osram stated its belief that this trend will continue. (Osram, No. 15 at p. 5)

Furthermore, DOE is aware that T8, 8-foot lamps are substitutes for T12, 8-foot lamps. As discussed earlier, by not regulating substitutes (e.g., T8, 8-foot recessed double contact HO lamps) of regulated lamps (e.g., T12, 8-foot recessed double contact HO lamps), DOE risks losing the potential energy savings of the current energy conservation standards for T12, 8-foot lamps, as well as any revised standard that may be adopted pursuant to this rulemaking. In addition, because T8, 8-foot recessed double contact HO lamps are predicted to replace the T12 market, the shipments of T8 lamps may increase considerably.

For the reasons above, DOE believes that regulating T8, 8-foot recessed double contact HO lamps has the potential to achieve significant energy savings. DOE analyzes these T8 lamps as part of the 8-foot recessed double contact HO product class in the NIA. From this analysis, DOE estimates that the energy savings achieved due to regulation of T8, 8-foot recessed double contact HO lamps could be as high as 0.30 quads over the analysis period. (See section III.I of this notice.)

In addition, in this preliminary determination, DOE tentatively plans to expand its coverage of 8-foot recessed double contact, rapid start, high output fluorescent lamps to those not listed in ANSI Standard C78.1–1991. As discussed in the fluorescent and incandescent lamps test procedure NOPR published in today's **Federal Register**, many of the ANSI standards currently referenced in DOE regulations (e.g., ANSI Standard C78.1–1991) are outdated. DOE understands that as the fluorescent lamp market moves forward and evolves, new 8-foot recessed double contact, rapid start, high output lamps (with 0.800 nominal amperes or other currents) may be introduced into the market. As these lamps would not be listed in the 1991 ANSI standard, they would not be covered under paragraph (3) of the definition of fluorescent lamp, and, therefore, would not be subject to current energy conservation standards. However, DOE understands that though these newly introduced lamps might have different wattages than those listed in ANSI Standard C78.1–1991, they serve as replacements and substitutes for the regulated 8-foot recessed double contact high output lamps. As discussed earlier, by leaving these potential substitute lamps unregulated, DOE risks not achieving the maximum energy savings from its established energy conservation standards.

Given the potential energy savings, in this preliminary determination, DOE is considering extension of coverage to T8, 8-foot recessed double contact HO lamps, thereby adding lamps previously restricted by the 0.800 nominal ampere limitation. In addition, DOE is considering extension of coverage to 8-foot recessed double contact HO lamps not listed in ANSI Standard C78.1–1991. As the technologies of T8, 8-foot recessed double contact HO lamps and the 8-foot recessed double contact HO lamps not listed in ANSI Standard C78.1–1991 are similar to the technologies of their already-regulated T12 counterparts, DOE has tentatively concluded that standards on these lamps have the potential to meet the statutory criterion of being technologically feasible. With regards to the statutory criterion of being economically justified, DOE analyzes T8, 8-foot recessed double contact HO lamps in the LCC analysis and NIA. Preliminary results show that regulation of these lamps would be expected to achieve LCC savings up to $3.15 (discounted at 6.2 percent) per lamp system and net present value (NPV) up to $0.73 billion to the nation (discounted at 3 percent) over the analysis period. Also, 8-foot recessed double contact HO lamps not listed in ANSI Standard C78.1–1991 should incur similar economic effects as their already-covered counterparts. Therefore, for the purpose of this preliminary determination, DOE has tentatively concluded that energy conservation standards on these lamps have the potential of being economically justified.

Similar to 8-foot recessed double contact HO lamps, in this preliminary determination, DOE is considering extension of the standard's coverage to certain 8-foot, single pin, instant start, slimline lamps to which energy conservation standards do not currently apply. DOE's definition of ''fluorescent lamp,'' adopted in accordance with EPCA, includes only those 8-foot, single pin, instant start, slimline lamps, with a rated wattage greater than or equal to 52W and listed in ANSI Standard C78.3–1991. 10 CFR 430.2. Under this definition, because they are not listed in ANSI Standard C78.3–1991, no T8, 8-foot single pin slimline lamps would be subject to energy conservation standards. However, as indicated by their inclusion in the updated ANSI Standard C78.81–2005, DOE understands that since the publication of ANSI Standard C78.3–1991, T8, 8-foot single pin slimline lamps have penetrated the GSFL market. Shipment information submitted by NEMA indicates that T8 lamps comprise approximately 15 percent of the total 8-foot single pin slimline market. (NEMA, No. 12 at p. 2) In addition, ACEEE and Osram commented that DOE should cover T8, 8-foot single pin slimline lamps. (Public Meeting Transcript, No. 4.5 at p. 59) For similar reasons as discussed with regard to T8, 8-foot recessed double contact HO lamps, DOE believes that the regulation of T8, 8-foot single pin slimline lamps has the potential to achieve significant energy savings. DOE analyzes these T8 lamps as part of the 8-foot single pin slimline product class in the NIA. From this analysis, the energy savings achieved due to the regulation of T8, 8-foot single pin slimline lamps would be expected to be as high as 0.25 quads over the analysis period (i.e., from the year 2012 to 2042). (See section III.I of this notice.)

As such, in this preliminary determination, DOE is considering expanding the standards' scope of coverage of 8-foot single pin slimline lamps with a rated wattage greater than or equal to 52W to those not listed in ANSI Standard C78.3–1991. This would include T8 lamps and any additional 8-foot single pin slimline lamps that might be introduced into the fluorescent lamp market in the future. As 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 T12 counterparts, DOE has tentatively concluded that standards on these lamps have the potential to meet the statutory criterion of being technologically feasible. With regards to the statutory criterion of being economically justified, DOE analyzes T8, 8-foot single pin slimline lamps in the LCC analysis and NIA. Preliminary results show that regulation of these lamps has the potential to achieve LCC savings up to $8.27 per lamp system (discounted at 6.2 percent) and NPV of $1.15 billion to the nation (discounted at 3 percent) over the analysis period (i.e., from the year 2012 to 2042). Also, 8-foot single pin slimline lamps not listed in ANSI Standard C78.1–1991 would be expected to incur similar economic effects as their already covered counterparts. Therefore, for the purpose of this preliminary determination, DOE has tentatively concluded that energy conservation standards for these lamps have the potential to be economically justified.

DOE also observed that some 8-foot, single pin, slimline lamps with wattages below 52W are available on the market today. These include 51W and 50W versions. However, DOE notes that published catalogs offered very few models at these wattages. Also, DOE believes that these lower-wattage slimline lamps are used for niche applications and would likely not be used as a substitute for higher-wattage versions. In particular, these lamps offer different lumen packages from their higher-wattage counterparts and are not currently marketed as substitutes. Consequently, DOE believes that the market share of such lamps is and will remain relatively small, thereby making the potential energy savings that would be achieved from their regulation small as well. Therefore, DOE has tentatively decided not to extend coverage of the energy conservation standards to T8, 8-foot single pin slimline lamps with wattages below 52W. DOE requests comment on this approach.

In this preliminary determination, DOE also considered whether or not to expand coverage to include very high output (VHO) fluorescent lamps. Philips Lighting (hereafter ''Philips'') commented that DOE should set standards for VHO, T12 fluorescent lamps, asserting that these lamps consume a large amount of energy. (Philips, No. 5 at p. 1) DOE research involving review of manufacturer catalog data corroborated the Philips comment, as common VHO fluorescent lamps can have rated wattages ranging from 115W to 215W, while corresponding HO lamps have rated wattages ranging from 60W to 110W. However, in considering the Philips comment, DOE learned from discussions with manufacturers that many VHO lamps are used in outdoor applications, such as parking lot or other area illumination, where high-intensity discharge (HID) lamps are rapidly gaining market share. Research also indicated that shipments of VHO, T12 lamps have been and are continuing to decline rapidly. Overall, DOE understands that these lamps constitute a very low-volume share of the relevant market, and these products will likely further decrease in terms of market share. As such, although these lamps may individually have a per-lamp energy savings potential larger than that of a typical GSFL, DOE believes that the total energy savings from regulating these lamps would be small and decreasing as that these lamps are naturally disappearing from the market in the absence of regulation. Therefore, DOE does not plan to extend coverage of the energy conservation standard to VHO lamps.

DOE also considered whether to include T5 fluorescent lamps in its expansion of energy conservation standards coverage. At the Public Meeting on the Framework Document, ACEEE and PG&E commented that DOE should cover T5 lamps. (Public Meeting Transcript, No. 4.5 at pp. 39 and 59) However, ACEEE and PG&E did not provide a rationale for consideration of these lamps, and DOE did not receive any written comments recommending that it consider T5 lamps for coverage. To further investigate this issue, DOE evaluated the market and typical applications for T5 lamps, and has tentatively decided to not extend coverage to T5 lamps, for the reasons that follow.

DOE found that T5 systems are used in a wide variety of indoor general illumination applications where T8 and T12 systems could also be used. However, DOE understands that T5 systems are always operated with higher-efficiency, high-frequency electronic ballasts (versus lower-efficiency, low-frequency ballasts). In addition, it was found that these lamps tend to have higher efficacies and that the systems tend to have lower energy consumption than the corresponding T8 and T12 lamps and systems. Therefore, DOE believes that the regulation of T5 lamps may not have the potential for significant per-unit energy savings. In addition, DOE understands that the current GSFL market share of T5 lamps is relatively small, representing low total energy savings potential. DOE also notes that T5 systems tend to be higher in cost than T8 or T12 systems. Thus, DOE believes 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.[18] To the contrary, not regulating T5 lamps could provide market incentives for and result in energy savings by encouraging greater end-user use of highly efficacious T5 lamps. For the above stated reasons, DOE does not plan to extend the standards' coverage to T5 lamps. DOE solicits further comment on whether it should extend coverage to T5 lamps, as well as the rationale for doing so.

Furthermore, DOE does not intend to extend coverage to fluorescent lamps that have alternate lengths, diameters, bases, or shapes (or a combination thereof) than the lamps discussed in the preceding section. DOE believes that the lamps currently covered and the additional lamps described above that DOE is considering for coverage (i.e., ones which have lengths and bases the same as those currently regulated) represent the significant majority of the market for GSFL, and, thus, the bulk of potential energy savings. Furthermore, DOE believes that there is limited potential for lamps with miscellaneous lengths and bases to grow in market share, given the constraint of fixture lengths and socket compatibility. DOE requests comment on this approach.

In summary, the following list represents the ''additional general service fluorescent lamps'' which DOE is considering for expanded coverage under the energy conservation standards:

- 4-foot, medium bipin lamps with wattages ≥ 25 and < 28;
- 8-foot recessed double contact, rapid start, HO lamps not 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.

C. Amended Definitions

As part of the examination of the scope of coverage of GSFL, DOE is considering amendments to existing DOE-adopted definitions in order to more clearly and accurately define the scope of GSFL and IRL. The following section describes these planned amendments and requests comment.

1. ''Rated Wattage''

One element of EPCA's definitions for ''fluorescent lamp'' and ''incandescent reflector lamp'' is a lamp's ''rated wattage,'' which helps to delineate the lamps for which the statute set prescriptive standards. (42 U.S.C. 6291(30)(A), (C)(ii) and (F)). For example, the definition of ''fluorescent lamp'' includes certain 4-foot medium bipin lamps with ''a rated wattage of 28 or more'' (42 U.S.C. 6291(30)(A)(i)), and EPCA prescribes standards for these particular lamps (42 U.S.C. 6295(i)(1)(B)). In addition, EISA 2007 prescribed energy conservation standards for general service incandescent lamps that require lamps of particular lumen outputs to have certain maximum rated wattages. (section 321(a)(3) of EISA 2007 amending section 325(i) of EPCA) EPCA does not, however, define ''rated wattage.'' Therefore, DOE adopted a definition of ''rated wattage'' for 4-foot medium bipin T8, T10, and T12 fluorescent lamps when it established test procedures for fluorescent and incandescent lamps in 1997. 62 FR 29222 (May 29, 1997). This definition, located in 10 CFR 430.2, references an ANSI guide from 1991, specifically ANSI Standard C78.1–1991, ''for Fluorescent Lamps—Rapid-Start Types—Dimensional and Electrical Characteristics.'' Although EPCA also

[18] At CSLs four and five, some T8 systems are more efficacious than their T5 counterparts. However, DOE notes that the average cost of a T5 system is more expensive than a T8 system. The fact that T5 lamps are less efficacious and more expensive at these standard levels indicates that there is little or no incentive for stakeholders to migrate to T5 lamps from T8 or T12 lamps in an effort to avoid the fluorescent lamp standard.

uses the term ''rated wattage'' when referring to ''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 ''incandescent lamps'' (i.e., the portion of that definition pertaining to IRL) (42 U.S.C. 6291(30)(C)), DOE did not define ''rated wattage'' for these lamps in 1997. In this rulemaking, DOE plans to update its existing definition of ''rated wattage'' to cite the current version of ANSI Standard C78.1–1991, and to apply this definition to those lamps where rated wattage is a key characteristic but is not currently defined.

DOE's current definition of ''rated wattage'' for 4-foot medium bipin T8, T10, or T12 lamps, in effect, contains three definitions of ''rated wattage'': One for those lamps listed in the ANSI Standard C78.1–1991 standard; another for residential straight-shaped lamps; and a third for all other lamps. The definition of ''rated wattage'' currently contained in DOE regulations is as follows:

Rated wattage, with respect to 4-foot medium bi-pin T8, T10 or T12 lamps, means:

(1) If the lamp is listed in ANSI C78.1–1991, the nominal wattage of a lamp determined by the lamp designation in Annex A.2 of ANSI C78.1–1991; or

(2) If the lamp is a residential straight-shaped lamp, the wattage a lamp consumes when operated on a reference ballast for which the lamp is designed; or

(3) If the lamp is neither listed in ANSI C78.1–1991 nor a residential straight-shaped lamp, the wattage a lamp consumes when using reference ballast characteristics of 236 volts, 0.43 amps and 439 ohms for T10 or T12 lamps or reference ballast characteristics of 300 volts, 0.265 amps and 910 ohms for T8 lamps. (10 CFR 430.2)

Annex A.2 of ANSI Standard C78.1–1991, referenced in the first part of the definition, discusses how to designate lamps according to industry procedure. It indicates that the lamp abbreviation may include either the rated wattage or nominal wattage for a particular lamp. The most current equivalent industry standard corresponding to ANSI Standard C78.1–1991 is ANSI Standard C78.81–2005, which also includes an equivalent section on lamp abbreviations. However, this equivalent section specifies that lamp abbreviations are to incorporate only the nominal wattage. DOE believes that a different section of ANSI Standard C78.81–2005 more appropriately defines ''rated wattage.'' Specifically, Clause 11.1 of ANSI Standard C78.81–2005 deals more directly with rated wattage when it refers to rated values in the lamp data sheets of Part IV of the standard and notes the margin that manufacturer's average values must maintain from rated values. In relevant part, Clause 11.1 of ANSI Standard C78.81–2005 states: The values of lamp voltage, current and wattage shown on the individual lamp data sheets in Part IV are rated values that apply after the lamps have been aged for 100 hours. These values were chosen by consensus to represent the industry average at the time of publication. No manufacturer's average wattage shall exceed the rated value by more than 5% plus 0.5 watts * * * Therefore, DOE tentatively plans to update the ''rated wattage'' definition's reference to ANSI Standard C78.81–2005 and to reference Clause 11.1 of that ANSI standard in place of Annex A.2 of ANSI Standard C78.1–1991.

The second part of the ''rated wattage'' definition addresses residential straight-shaped lamps. DOE adopted a definition for ''residential straight-shaped lamp'' in 10 CFR 430.2 at the same time it defined ''rated wattage'' and established the applicable test procedures. 62 FR 29222 (May 29, 1997). This definition applies only to 4-foot medium bipin lamps. The provisions on residential straight-shaped lamps reflect DOE's understanding that lamp wattage differs when a lamp operates on a low-power-factor ballast (typically residential applications) versus a high-power-factor ballast (typically commercial applications). (The measured wattage of a residential straight-shaped lamp could be different depending on the ballast on which it is operated.)[19] Thus, these provisions effectively ensure that lamps designed for residential applications are tested on ballasts typically used for residential applications. Defining ''rated wattage'' for these lamps is significant, as it clarifies whether DOE's standards are applicable to them. DOE believes that the clarification is still relevant. However, DOE notes that ANSI Standard C78.81–2005 lists a rated wattage value for a 25-Watt, 4-foot T12 rapid start medium bipin fluorescent lamp, operating on a low-power-factor ballast. Thus, it appears that some lamps which could be classified as a residential straight-shaped lamp have rated wattage values listed in ANSI Standard C78.81–2005. Therefore, DOE intends to update the second portion of the definition to state that if a residential straight-shaped lamp is not listed in ANSI, then rated wattage should be based on the wattage a lamp consumes when operated on a reference ballast for which the lamp is designed.

The third part of the definition for ''rated wattage'' (applicable if neither of the first two parts applies) states that the rated wattage is that which results when the lamp is tested under specified testing conditions. DOE is updating the test procedures for fluorescent and incandescent lamps in a concurrent test procedures rulemaking. The NOPR for that rulemaking is published in today's **Federal Register**. As part of the test procedures rulemaking, DOE is also developing testing methods for lamps not currently listed in ANSI standards which will be included as part of the DOE test procedure. DOE believes that it is preferable to reference these more detailed test procedures, rather than the current approach of specifying testing conditions in the definitions section of 10 CFR 430.2. Therefore, DOE intends to replace the third part of the ''rated wattage'' definition with a reference to the test procedures that will be set forth in 10 CFR Part 430, Subpart B, Appendix R.

EPCA's definition of ''fluorescent lamp'' uses the term ''rated wattage'' not only in describing 4-foot medium bipin lamps, but also in describing 2-foot U-shaped and 8-foot single pin slimline lamps. (42 U.S.C. 6291(30)(A)(ii) and (iv)) To clarify rated wattage for 2-foot U-shaped, and 8-foot single pin slimline lamps, DOE has tentatively decided to utilize the same framework to define ''rated wattage'' as was used for 4-foot medium bipin lamps. In particular, DOE plans to reference ANSI industry standards where they have defined the rated wattage for particular lamps, and to reference DOE's test procedures (as amended) where ANSI has not defined the rated wattage for particular lamps. Thus, DOE intends to modify the current definition of ''rated wattage'' that applies to 4-foot medium bipin lamps and make it applicable to all covered fluorescent lamps. Because ANSI Standard C78.81–2005 does not include ratings for U-shaped lamps, DOE plans to incorporate by reference and to cite to ANSI Standard C78.901–2005, ''for Electric Lamps—Single-Based Fluorescent Lamps—Dimensional and Electrical Characteristics'', which does. ANSI Standard C78.901–2005 also contains Clause 11.1, using text similar to that noted above.

The statutory definition for ''incandescent lamp'' also contains the term ''rated wattage,'' and the definition for ''incandescent reflector lamp'' similarly references a portion of the definition of ''incandescent lamp'' which contains that term. In addition,

[19] If a lamp is not listed in ANSI C78.1–1991, its ''rated wattage'' would depend on test measurements.

EISA 2007 set energy conservation standards for general service incandescent lamps which require the lamps to meet a maximum rated wattage for a particular lumen output. For incandescent reflector lamps and general service incandescent lamps, the rated wattage is the same as measured wattage. Therefore, DOE believes that the test procedures outlined in 10 CFR Part 430, Subpart B, Appendix R suffice for determining rated wattage for incandescent lamps.

The following summarizes the modified definition of ''rated wattage'' that DOE intends to consider making applicable to all covered lamps and updated to reference current industry standards:

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.

DOE requests comment on its above-discussed modification of the definition of ''rated wattage,'' applicable to both covered fluorescent and incandescent lamps. DOE recognizes that changes to the definition could affect coverage for fluorescent lamps. However, DOE believes that the modifications would have a relatively minor, if any, impact on the scope of coverage.

2. ''*Colored Fluorescent Lamp*''

With regard to the definition of ''colored fluorescent lamp'' that was codified in the CFR as part of the 1997 Test Procedure Final Rule, DOE is requesting comment on the definition for this type of fluorescent lamp which is excluded from energy conservation standards. The current definition of that term reads 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 (see 10 CFR 430.22), or a lamp correlated color temperature less than 2,500K or greater than 6,600K. 10 CFR 430.2.

In its market research, DOE observed that one of the major lamp manufacturers that operates in the European market recently introduced a fluorescent lamp with a correlated color temperature (CCT) of 17,000K. The product literature associated with this new lamp indicates that it is intended for general illumination applications. In the ''Product Application'' section of the literature, it suggests that this lamp be used for ''Indoor working areas (call centers, industry, schools, healthcare etc.), especially where an energizing environment needs to be created.'' [20] Even though DOE is unaware of any general purpose fluorescent lamps like this one being introduced into the U.S. market, there is the potential that the current definition of ''colored fluorescent lamp'' would provide an exclusion for new products being introduced in general illumination lighting applications. Therefore, DOE is considering revising the definition, possibly by adding a phrase such as ''and not designed or marketed for general illumination applications.'' DOE invites comment on this issue.

III. Energy Conservation Standards Analyses for Fluorescent and Incandescent Reflector Lamps

This section addresses the analyses DOE has performed and intends to perform for GSFL and IRL under consideration in this rulemaking and discusses the underlying assumptions applied to the analyses. For both GSFL and IRL, DOE will perform a set of analyses, including: (1) An engineering analysis; (2) a product price determination; (3) an energy-use determination; (4) an LCC and PBP analysis; (5) an NIA; and (6) an MIA. A full description of how these analyses are performed is contained in the TSD.[21] However, this section of the ANOPR provides an overview of these analyses, while focusing on how these analyses are being tailored to this rulemaking and on their underlying assumptions. It also discusses comments received from interested parties since DOE published the lighting products Framework Document.

A. Market and Technology Assessment

The market assessment provides an overall picture of the market for the products concerned, including the nature of the products, the industry structure, and market characteristics for the products. The technology assessment identifies available technologies for these products, which will be considered in the screening analysis. The subjects addressed in the market and technology assessment include product classes, technology options, manufacturers, quantities and types of products sold and offered for sale, retail market trends, and regulatory and non-regulatory programs. DOE considers both quantitative and qualitative information from publicly available sources and stakeholders in this assessment. The information DOE gathers for the market and technology assessment serves as resource material for use throughout the rulemaking.

1. Market Assessment

Issues addressed in the market assessment include: (1) Information about lamp manufacturers; (2) existing regulatory and non-regulatory initiatives; (3) historical shipments and (4) product classes. Each of these topics will be discussed in turn below.

NEMA is the trade association that represents many GSFL and IRL manufacturers. NEMA provides an organization framework for manufacturers of lighting products to work together on projects that affect their industry and business.

The majority of the domestic market share of GSFL and IRL is held by three manufacturers: (1) GE Lighting (General Electric, Inc.); (2) OSRAM Sylvania (Siemens AG); and (3) Philips Lighting (Royal Philips Electronics). In addition to lamps listed under this rulemaking, the lighting divisions of all three companies manufacture other products, such as lamp ballasts, high intensity discharge lamps, LED lighting, GSIL (already regulated by EISA 2007) and compact fluorescent lamps (CFL).

It is noted that DOE is required to consider whether small businesses are likely to be particularly affected by the promulgation of minimum efficacy standards for lamps. (5 U.S.C. 601 et seq.) The Small Business Administration (SBA) defines ''small business'' manufacturing enterprises for manufacturers of GSFL and IRL as ones having 1,000 or fewer employees.[22]

[20] Philips Lighting Product Specification Document, MASTER TL5 ActiViva Active 54W SLV (published June 29, 2007).

[21] Available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps.html.*

[22] Small Business Administration, Table of Small Business Size Standards: Matched to North

More specifically, SBA lists small business size standards that are matched to industries as they are described in the North American Industry Classification System (NAICS). A small business size standard is the largest that a for-profit entity can be and still qualify as a small business for Federal Government programs. These size standards are generally related to the average annual receipts or the average employment of a firm. For lamp products, the size standard is matched to NAICS code 335110, *Electric Lamp Bulb and Part Manufacturing,* which has a size standard of 1,000 employees. DOE identifies several small business manufacturers of GSFL and IRL in Chapter 3 of the TSD. DOE will study the potential impacts on small businesses in detail during the MIA, which it will conduct as a part of the analyses for the notice of proposed rulemaking.

Furthermore, DOE is aware of several Federal, State, and international regulatory programs that impact the GSFL and IRL markets. Amendments to EPCA in EPACT 1992 established Federal energy conservation standards for residential, commercial, and industrial GSFL and IRL. (42 U.S.C. 6295(i)(1)) In addition to the Federal regulations, the following States have established appliance efficiency regulations for other lamps for which there are no Federal standards (and thus are not preempted): Arizona, California, Connecticut, Maryland, Massachusetts, Minnesota, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington.

DOE also reviewed several voluntary programs promoting the use of energy-efficient GSFL in the United States, including the Federal Energy Management Program's (FEMP) program for energy-efficient lighting, the Consortium for Energy Efficiency (CEE)'s High Performance Commercial Lighting Initiative, the Energy Efficient Commercial Buildings Deduction, and various regional initiatives that work with State utilities to offer rebates for installation of higher efficacy GSFL systems. See Chapter 3 of the TSD for more information regarding regulatory and non-regulatory initiatives.

DOE received historical shipment data from NEMA for the years 2001 to 2005 for the two categories of lamps. (NEMA, No. 12 at pp. 5–6) Overall, NEMA's historical lamp shipment data that was incorporated by DOE into the analytical tools for the ANOPR had three main purposes. First, the shipment data and market trend information contributed to the shipments analysis and base-case forecast for each of the two categories of lamps (see Chapter 9 of the TSD). By using recent shipment data and expert opinion on market trends, DOE believes that the shipments model and base-case forecasts are based on a sound dataset. Second, DOE used the data to select the representative product classes and representative units for analysis. Generally, DOE selected representative product classes and units for analysis to reflect the highest volume, most common lamp types and wattages used in the U.S. today (see Chapter 3 of the TSD). And thirdly, DOE used these data to develop the market-share matrices for the NIA (see Chapter 10 of the TSD). Based on its understanding of trends in the market, DOE estimated how the market would respond to the various CSLs.

Additional detail on the market assessment can be found in Chapter 3 of the TSD.

2. Product Classes

In general, when 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. (See 42 U.S.C. 6295(q)) DOE normally establishes different energy conservation standards for different product classes based on these criteria. However, classification of lamps into product classes presents a challenge, because, for example, a fluorescent lamp is a component of a system, and the lamp's performance is directly related to the ballast on which it operates. The following section describes and discusses the product classes of lamps that DOE is considering for this rulemaking.

a. General Service Fluorescent Lamps

EPCA established eight product classes for GSFL based on the four fluorescent lamp types EPCA describes in its definition for "fluorescent lamp" and based on nominal lamp wattage. (42 U.S.C. 6295(i)(1)(B)) These product classes are outlined in Table III.1.

TABLE III.1.—EPCA PRODUCT CLASSES FOR GSFL

Lamp type	Nominal lamp wattage *W*	Min. CRI	Min. avg. efficacy *lm/W*
4-ft Medium Bipin	>35W	69	75.0
	≤35W	45	75.0
2-ft U-Shaped	>35W	69	68.0
	≤35W	45	64.0
8-ft Single Pin	>65W	69	80.0
Slimline	≤65W	45	80.0
8-ft High Output	>100W	69	80.0
	≤100W	45	80.0

In the Framework Document for this rulemaking, DOE presented a preliminary discussion of potential revisions to the prescriptive standards established by EPCA. ((42 U.S.C. 6295(i)(1)(B); see 10 CFR 430.32(n)(1)). Specifically, DOE considered subdividing the product categories in EPCA's table of efficacy requirements for fluorescent lamps, nearly doubling the number of product classes by introducing lamp tube diameter as a differentiating variable (i.e., ">T8" and "≤T8"). In presenting this potential modification, DOE used the same wattage divisions and minimum color rendering index (CRI) requirements that EPCA uses for these lamps, with T8 and T12 lamps in the same product class. Several stakeholders provided comment on the draft product classes discussed in

American Industry Classification System Codes. (Feb. 2007). Available at: *http://www.sba.gov/services/contractingopportunities/sizestandardstopics/part121sects/index.html.*

the Framework Document, as discussed below.

For 4-foot medium bipin lamps, Philips suggested combining all lamps with diameters greater than T8 into one category. Philips then suggested creating a category for T8 and smaller diameters with wattages less than or equal to 32W. (Philips, No. 11 at p. 1) GE and Osram both supported DOE's suggestion for lamps with diameters greater than T8, but they suggested that DOE should change the wattage division from 35W to 31W, and include a correlated color temperature (CCT) division for lamps with diameters less than or equal to T8. (GE, No. 13 at pp. 1–2; Osram, No. 15 at pp. 2–3) The Joint Comment recommended that DOE combine the T8 and T12 product classes, because there are few T8 lamps above 35W, and, therefore, the existing wattage bins could be analyzed by maintaining some separation of T8 and T12 lamps. (Joint Comment, No. 9 at p. 8)

For 2-foot U-shaped lamps, Philips suggested modifying the draft product classes by combining wattage ranges, and the commenter also recommended having just two product classes, based upon lamp diameter, that apply to any wattage 2-foot U-shaped lamps. GE and Osram both supported DOE's approach for considering lamps with diameters greater than T8, and these commenters suggested that DOE should change the wattage division from 35W to 31W, and include a CCT division for lamps with diameters less than or equal to T8. (GE, No. 13 at pp. 1–2; Osram, No. 15 at pp. 2–3)

For the 8-foot single pin slimline lamps, Philips suggested combining all lamps with diameters greater than T8 into one product class, and then establishing a separate product class for lamps with T8 and narrower diameters, regardless of wattage. (Philips, No. 11 at pp. 1–2) GE and Osram both suggested keeping the T12 category of high output lamps, and creating a separate class for diameters less than T12. For this new separate class, GE and Osram both proposed dividing it further into two subclasses, one including T12 8-foot single pin slimline lamps with wattages greater than 58W and another including T12 8-foot single pin lamps with wattages less than or equal to 58W. (GE, No. 13 at pp. 1–2; Osram, No. 15 at pp. 2–3)

For the 8-foot high output lamps, Philips suggested combining all lamps with diameters greater than T8 into one product class, and then establishing a separate product class for lamps with T8 and narrower diameters with a nominal lamp wattage of 86W and below. (Philips, No. 11 at pp. 1–2) GE and Osram both suggested keeping the T12 category of high output lamps, and creating a separate class for lamps with diameters less than T12. (GE, No. 13 at pp. 1–2; Osram, No. 15 at pp. 2–3) GE argued that this class of lamps with diameters less than T12 should encompass all wattages, whereas Osram recommended that the class should encompass only lamps greater than 85W. (GE, No. 13 at pp. 1–2; Osram, No. 15 at pp. 2–3)

DOE considered all these comments, and continued to research appropriate product classes for the general service fluorescent lamps being considered for coverage under this rulemaking. DOE identified differential utility and physical attributes of fluorescent lamps around which the development of separate product classes would be based on the statutory criteria. (42 U.S.C. 6295(q)) [23] In this notice, DOE is considering establishing product classes based upon the following three lamp attributes that have differential utility and impact efficacy: (1) Physical constraints of lamps (i.e., lamp shape and lamp length); (2) lumen package (i.e., regular versus high output); and (3) CCT. Following that discussion, this document also analyzes other potential factors that DOE considered as potential product class determinants (i.e., ballast interoperability, lamp wattage, lamp diameter, and color rendering index), but which were not adopted for reasons indicated below.

i. Class Setting Factors

Physical Constraints of 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. For example, a 2-foot U-shaped lamp, while having the same overall tube length, is less efficacious than a 4-foot linear lamp due in part to the fact that the electrical arc within the tube has to bend to conform to the shape of the lamp. Similarly, a 4-foot lamp has a different utility than an 8-foot lamp, as these lamps generally require different fixtures. And, efficacy tends to increase with length, such that all else being equal, 8-foot lamps generally have higher efficacy values than 4-foot lamps. Given the impact that geometry has on both utility and efficacy, DOE proposes maintaining the division of product classes by lamp geometry.

Lumen Package. In addition to the physical constraints of a lamp, DOE also recognizes that the lumen package a lamp provides to consumers is another potential differentiating factor for product classes, because it provides utility in the form of a quantity of light per unit lamp length. In this way, 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 notes, however, that efficacy decreases as a fluorescent lamp is driven harder to increase its light output. For example, the efficacy of high output 8-foot lamps are approximately 7 to 10 percent lower than that of slimline 8-foot lamps. Because 8-foot lamps are not already subdivided according to physical constraints, DOE plans to further subdivide the 8-foot linear lamps into slimline and high output.

Considering the fluorescent lamps currently covered under EPCA and the additional general service fluorescent lamps discussed in section II which DOE is considering for coverage, DOE is considering establishment of the following four differentiating categories of lamps: (a) 4-foot medium bipin; (b) 2-foot U-shaped; (c) 8-foot single pin slimline; and (d) 8-foot recessed double contact high output. DOE notes that these are the same four categories of lamps that were established by EPCA in section 325(i)(1). (42 U.S.C. 6295(i)(1)(B))

Correlated Color Temperature. Finally, within each of these four categories of fluorescent lamps, DOE

[23] (q) Special rule for certain types or classes of products

(1) A rule prescribing an energy conservation standard for a type (or class) of covered products shall specify a level of energy use or efficiency higher or lower than that which applies (or would apply) for such type (or class) for any group of covered products which have the same function or intended use, if the Secretary determines that covered 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 from that which applies (or will apply) to other products within such type (or class).

In making a determination under this paragraph concerning whether a performance-related feature justifies the establishment of a higher or lower standard, the Secretary shall consider such factors as the utility to the consumer of such a feature, and such other factors as the Secretary deems appropriate.

recognizes that the CCT of the fluorescent lamps provides a distinct utility (i.e., the light emitted by the fluorescent lamp has different qualities), which impacts the efficacy of the lamp. The CCT describes, in part, how the white light emitted from a fluorescent lamp is perceived. Lower color temperatures correspond to ''warmer'' light, with more red content in the spectrum, and higher color temperatures correspond to ''cooler'' light, with more blue content. As the spectral emission of the light radiated from the fluorescent lamp is modified to change the CCT, the light emitted may contain more red light (and less blue) or more blue light (and less red). The measured efficacy of these lamps with different CCT will be different, because efficacy is measured in lumens [24] 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 sum, the metric that DOE will establish as the minimum performance requirement for fluorescent lamps—efficacy, measured in lumens per watt—may need to be adjusted to account for differences in the CCT of light emitted from a fluorescent lamp. Today, lamps with a ''warmer'' CCT (4,100K) represent the majority of the fluorescent lamp market, and therefore this is the CCT of the lamps analyzed in this ANOPR. Fluorescent lamps having a ''cooler'' CCT (e.g., >5,000K) are growing in popularity in the market, perhaps because they have been found to allow for better color discrimination and improved visual performance.[25]

GE and Osram both requested that DOE establish separate product classes for T8 lamps with CCT above and below 4,500K. (GE, No. 13 at pp. 1–2; Osram, No. 15 at p. 1 and p. 3) Osram commented that higher CCT lamps have a lower lumen output because lamps with higher CCT contain more blue light, which causes the lumen measurement to be lower. Osram argued that it is important for DOE to differentiate certain fluorescent lamps by CCT in the analysis to account for this difference in performance. (Osram, No. 15 at p. 1) GE also stated that should DOE decide to regulate lamps with high CCT values (e.g., 5,000K), then these types of lamps would require a different and lower lumen-per-watt threshold, because of the slightly lower lumen rating due to the increased energy in the blue part of the light emission spectrum. (GE, No. 13 at p. 1) Philips commented that if DOE decides to adopt efficacy levels higher than those proposed by Philips, then DOE should place higher CCT lamps in a separate product class because they tend to have slightly lower efficacies. (Philips, No. 11 at p. 2)

In response, DOE believes that for fluorescent lamps, the differences in CCT of the light emission can be sufficiently large that they constitute a performance-related feature that affects the efficacy of the lamp. Therefore, DOE is planning to establish separate product classes for GSFL in part based upon CCT. Related to this preliminary decision are two critical, associated issues—(1) How many groups should be established? and (2) Where should the separator(s) between product classes be set? DOE's initial thoughts on this matter are set forth below.

Presently, EPCA does not cover colored fluorescent lamps (i.e., such lamps are excluded under 42 U.S.C. 6291(30)(B)(iii)) and these lamps are defined, in part by their CCT (both terms defined at 10 CFR 430.2). Lamps with a CCT less than 2,500K or greater than 6,600K are considered ''colored fluorescent lamps'' and are not subject to the minimum efficacy standards (note: See discussion in this section pertaining to a potential revision to coverage of colored fluorescent lamps). DOE is considering dividing GSFL, (with CCTs ranging from 2,500K to 6,000K) into two product classes. DOE believes that establishing two groups does not make the product classification overly complex, and yet such approach acknowledges the primary issue raised about the different utility provided by the cooler lamps. To this end, DOE is considering adoption of a CCT divider at 4,500K, as recommended by industry. (Osram, No. 15 at p. 1, GE, No. 13 at p. 2) The most common CCTs found on the market are 3,500K, 4,100K, 5,000K, and 6,500K. Thus, having a divider at 4,500K will establish separate product classes for those lamps with ''warmer'' CCTs (3,500K and 4,100K) and ''cooler'' CCTs (5,000 and 6,500K). Although in this proceeding, DOE is considering establishing two separate CCT groups for GSFL, if the trend toward much higher CCT lamps continues (discussed in section II.B.3), then DOE may need to establish multiple CCT groups, as the spectral emission (and thus, efficacy) of these general service lamps will vary as the CCT increases.

DOE is requesting comment on all aspects of this potential CCT division, but particularly: (1) Whether there should be a CCT product class divider; (2) how many groupings of CCT are appropriate; and (3) what the CCT divider or dividers should be. In addition, DOE welcomes technical perspectives on how DOE might scale the efficacy level from the representative unit of analysis of 4,100K to higher CCT product classes. In addition, DOE also notes that if comments indicate that the definition of a colored fluorescent lamp warrants some revision such that certain very high CCT lamps would be covered (e.g., over 17,000K), then perhaps it would be appropriate to consider several CCT groupings (which would manifest themselves as minimum efficacy steps). DOE requests further comment on this issue, including technical perspectives.

ii. Other Potential Class-Setting Factors Considered, But Not Adopted

As stated above, DOE did not choose to establish product classes based upon any of the following four factors: (1) Ballast interoperability; (2) lamp wattage; (3) lamp diameter (i.e., T8 vs. T12); and (4) color rendering index (CRI). Each of these factors is discussed below, along with DOE's rationale for not further considering them for class-setting purposes.

Ballast Interoperability. DOE did not consider interoperability of lamps on the same ballast system as a differentiating factor for product classes. DOE acknowledges that there is a difference between lamps and lamp-and-ballast systems, and that certain lamps may have the same form factor but may not operate on the same ballast. However, DOE treats these constraints as an economic issue in its LCC analysis, rather than a utility issue. In other words, in the LCC analysis, DOE considered a T8 lamp as a more-efficacious replacement for a T12 baseline lamp. In its economic analysis, DOE accounts for the need to install a new ballast to operate the T8 lamp by including the installed cost of a new lamp and ballast for the T8 replacement. This consideration of T8 lamps as substitutes for T12 lamps is consistent with DOE's understanding of the market, and with manufacturers' marketing literature. Had DOE elected to differentiate these lamps on ballast interoperability, or indeed, lamp diameter, this direct comparison may not have been made. DOE believes this

[24] A ''lumen'' is a measurement of the radiometric energy emission from a light source weighted by the response function of a human eye, referred to as the ''photopic spectral luminous efficiency function'' (V(λ)).

[25] ''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/claims.asp.*

approach is appropriate for this rulemaking, because there is no unique functionality or service rendered by, for example, one T8 lamp and an equivalent T12 lamp.

Lamp Wattage. With respect to lamp wattage, DOE observed in the product literature published by manufacturers that lower-wattage lamps are marketed and promoted as energy-saving versions of the more popular wattages. For example, lamps with 25W, 28W, and 30W are marketed as energy-efficient alternatives to the 32W T8. For this reason, DOE does not believe it is appropriate to establish divisions based upon wattage within the product classes, because wattage does not have utility in and of itself, but rather is a measure of energy use. For example, if a 30W T8 lamp can deliver the same (or very similar) performance as a 32W T8, then there is no reason to establish an arbitrary wattage divide at 31W, forcing these two lamps into separate product classes. If two product classes were set, the 30W T8 lamp could not be considered as an efficient alternative for the 32W T8 lamp, which conflicts with how these lamps are treated by the market. DOE understands that these reduced-wattage lamps are marketed and used by consumers as energy-efficient substitutes, and therefore, should be considered as such when DOE establishes product classes for these lamp types. Therefore, DOE plans to consider eliminating wattage-based dividers, because this attribute by itself does not provide utility. Fluorescent lamps of different wattages are generally capable of being substituted for each other, and provide the same or similar service. DOE also believes that a product classification system that eliminates wattage dividers would be more representative of how these lamps are currently being installed and used in the market.

Lamp Diameter. With respect to lamp diameter, DOE had expressed in the Framework Document its intention to consider lamps with diameters of T8 and smaller in one product class and lamps with diameters greater than T8 in a separate product class. On further consideration, DOE has tentatively decided that the lamp diameter does not provide unique utility to end-users. As an example, a consumer can choose to use a 4-foot medium bipin lamp and be able to obtain similar lumen packages from either a T12 or T8 model. The T8 lamp may need to be operated on a different ballast with a higher ballast factor (BF), but the system can be modified to account for the differences in lamp diameter, so the resultant systems are approximately equivalent. DOE recognizes that the diameter of the lamp will impact the efficacy, but the utility provided to the end-user is comparable and/or equivalent. Therefore, DOE has tentatively decided not to separate product classes by lamp diameter.

However, recognizing that both T12 and T8 lamps operate on different ballasts and in order to consider separately the impact of standards on consumers of both types of lamps, DOE structured the analytical tools (including the LCC and NIA spreadsheets) so that each consumer subgroup could be analyzed separately. Thus, for example, the LCC results are reported separately for T8 and T12 baseline lamps.

Color Rendering Index. The Color Rendering Index (CRI) is the ability of a light source to produce color in objects. The CRI is expressed on a scale from 0–100, where 100 is the best in producing vibrant color in objects. Relatively speaking, a source with a CRI of 80 will produce more vibrant color in the same object than a source with a CRI of 60. Generally, fluorescent lamps with higher efficiency phosphors exhibit both a higher efficacy and higher CRI, although this is not always the case. EPCA establishes an upper and lower bound on the CRI of GSFL. Specifically, EPCA states that lamps with a CRI equal to or greater than 87 are excluded from coverage. (42 U.S.C. 6291(30)(B)(viii)) EPCA also establishes two minimum CRI requirements for each of the four groups of fluorescent lamps, one at 69 CRI and one at 45 CRI. Within one group of fluorescent lamps (e.g., 4-foot medium bipin), EPCA requires that lamps nominally rated at greater than 35W have a minimum CRI of 69 and that lamps nominally rated at 35W or lower have a minimum CRI of 45. (42 U.S.C. 6295(i)(1)(B); see 10 CFR 430.32(n)(1))

Several manufacturers suggested that DOE should make changes to the minimum CRI required for GSFL. (Philips, No. 11 at p. 1; GE, No. 13 at p. 2; Osram, No. 15 at p. 3) These manufacturers recommended that the T8 lamp diameter product classes should have minimum CRI values of 75. Philips also recommended that DOE should adopt minimum CRI values of 75 or greater for all fluorescent lamp product classes, given today's technology. (Philips, No. 11 at p. 1)

DOE considered these comments, but believes it lacks the authority to accommodate this request to adjust minimum CRI values in this way. While 75 CRI may be a reasonable level for fluorescent lamps, DOE's mandate from Congress is to focus on advancing energy efficiency and energy conservation in the marketplace. DOE does not set standards by regulating specific performance attributes of products, such as the CRI rating of a lamp. Furthermore, if DOE were to simply adopt the higher CRI level, it might be eliminating lamps from the market without conducting a rulemaking analysis to determine whether this action was cost-justified or not. For all of these reasons, DOE is not increasing the minimum CRI requirement to 75, but is inviting further comment and rationale on possible approaches to handling the issue of CRI.

DOE recognizes that in removing the wattage distinctions for GSFL product classes, the metric that differentiated by CRI is no longer present. Therefore, some possible solutions would be to: (1) Eliminate the CRI minimum requirement for all regulated fluorescent lamps; (2) adopt the lower of the two CRI minimum requirements (i.e., 45 CRI) as applying to all regulated fluorescent lamps; (3) adopt the higher of the two CRI requirements (i.e., 69 CRI) as applying to all regulated fluorescent lamps; (4) adopt the CRI of the representative lamp that is determined to be cost-justified as the minimum CRI for that product class; and (5) maintain the CRI requirements in EPCA for the product classes established by EPACT 1992 while setting efficacy standards for the product classes established in this notice.

DOE recognizes that each of these approaches for addressing the CRI minimum requirement has its own advantages and disadvantages. The first option, eliminating the CRI requirement, risks the potential for a back-sliding in performance. That said, for the products offered in the market today, the CRI generally increases with the efficacy levels considered in this rulemaking. Thus, the CRI values of future standards-compliant lamps would naturally be higher than the two existing minimum requirements. The second option suggests that DOE simply apply the minimum 45 CRI requirement to all fluorescent lamps. This approach would not eliminate any lamps now covered between 45 and 69 CRI, however as with the first option, carries a certain risk that there may be some backsliding for lamps that previously required to meet would have had to have been 69 CRI, but which now could be as low as 45 CRI.

The third option, to simply require all lamps to have a minimum of 69 CRI, would eliminate certain lamps that are presently manufactured between 45 and 69 CRI. DOE notes that through this energy conservation standards rulemaking, it may be increasing the efficacy requirements on those lamps anyway, which may have the effect of preventing further use of those phosphors that supply light with a 45 to 69 CRI performance. However, to simply change the CRI requirement without analysis, and thereby eliminate product, appears to be in conflict with DOE's authority under EPCA. The fourth option identified above concerns DOE simply adopting the CRI requirement of the cost-justified lamp considered in the rulemaking analysis. That is to say, if DOE determines that a particular lamp with a certain efficacy is the cost-justified level at which it will set the mandatory standard for that product class, DOE would also adopt the CRI of that lamp as the minimum CRI requirement for all lamps in that product class. Finally, the fifth option maintains the current minimum requirements in EPCA for the product classes established in EPACT 1992 while setting efficacy requirements for the additional product classes established in this notice. Because this option requires no change in the CRI requirement for fluorescent lamps, there is no risk of eliminating product from the marketplace nor does it allow for backsliding in performance.

DOE requests comment on these five alternative approaches or others that would address the issue of the minimum CRI requirement for fluorescent lamps.

iii. Product Class Results

For the reasons discussed above, DOE has tentatively decided to consider the following product classes for GSFL (see Table III.2). These draft product classes are more aggregated than those originally presented in the Framework Document. For each of the eight product classes, DOE anticipates that it would develop a point efficacy value (lumens per watt), which would apply to all the lamps covered within each class.

TABLE III.2.—DOE ANOPR PRODUCT CLASSES FOR GSFL

Lamp type	For CCT ≤ 4,500K, minimum lamp efficacy *lm/W*	For CCT > 4,500K, minimum lamp efficacy *lm/W*
4-foot medium bipin	Product Class #1	Product Class #5.
2-foot U-shaped	Product Class #2	Product Class #6.
8-foot single pin slimline	Product Class #3	Product Class #7.
8-foot recessed double contact HO	Product Class #4	Product Class #8.

b. Incandescent Reflector Lamps

EPCA established minimum efficacy requirements by wattage for IRL, as presented in Table III.3. (42 U.S.C. 6295(i)(1)(B))

TABLE III.3.—EPCA PRODUCT CLASSES AND EFFICACY REQUIREMENTS FOR IRL

Wattage *W*	Min. average 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

In its Framework Document, DOE stated its preliminary intention to keep the same six product classes. DOE requested comment on this approach, including whether any modifications to the six product classes was warranted.

Several stakeholders commented that these potential product classes for IRL seemed reasonable and appropriate for this rulemaking. (NEMA, No. 4.5 at p. 75; ACEEE, No. 4.5 at p. 75; PG&E, No. 4.5 at p. 75; EEI, No. 4.5 at p. 76; NEMA, No. 8 at p. 2; Joint Comment, No. 9 at p. 5) DOE's additional research, however, has identified a problem with the potential product classes presented in the Framework Document, particularly as DOE considered standard levels with higher efficacy values. The existing wattage groups are problematic because the wattage rating of the lamp is a property about the lamp that the regulation is working to reduce, and yet it is also being used as the basis of classification. This issue is further complicated by the fact that some consumers (particularly in the residential sector) think of and purchase IRL based on the rated wattage, which is associated with an expected level of light output. The following discussion outlines DOE analyses in determining preliminary product classes for incandescent reflector lamps and the rationale therefore.

i. Class Setting Factors

Modified-Spectrum. As discussed in section I.E.2, EISA 2007 adopted a new definition for ''colored incandescent lamp'' [26] which supersedes DOE's definition previously incorporated at 10 CFR 430.2.[27] This new statutory definition effectively increases the scope of energy conservation standards coverage of IRL to include any IRL that has a lens containing five percent or more neodymium oxide or is a plant light lamp. As both of these types of IRL filter out portions of the emitted spectrum of the lamp, DOE believes that many of these lamps would fall under the definition of ''modified spectrum'' which was also adopted by the new energy legislation. The EISA 2007 definition of ''modified spectrum'' reads as follows:

''The term 'modified spectrum' means, with respect to an incandescent lamp, an incandescent lamp that—

(i) Is not a colored incandescent lamp; and

(ii) When operated at the rated voltage and wattage of the incandescent lamp—

I. Has a color point with (x,y) chromaticity coordinates on the Commission Internationale de l'Eclairage (C.I.E.) 1931 chromaticity diagram that lies below the black-body locus; and

II. has a color point (x,y) chromaticity coordinates on the C.I.E. 1931 chromaticity diagram that lies at least 4

[26] EISA 2007's definition of ''colored incandescent lamp'' reads as follows: ''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 CIE 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).''

[27] The definition of ''colored incandescent lamp'' adopted by the 1997 Lamps Test Procedure Final Rule 62 FR 29221, 29228 (May 29, 1997) reads as follows: ''Colored incandescent lamp means an incandescent lamp designated and marketed as a colored lamp that has a CRI less than 50, as determined according to the method given in CIE Publication 13.2 (see 10 CFR 430.22); has a correlated color temperature less than 2,500K or greater than 4,600K; has a lens containing 5 percent or more neodymium oxide; or contains a filter to suppress yellow and green portions of the spectrum and is specifically designed, designated and marketed as a plant light.''

MacAdam steps (as referenced in IESNA LM16) distant from the color point of a clear lamp with the same filament and bulb shape, operated at the same rated voltage and wattage.'' (42 U.S.C. 6291(30)(W))

Modified-spectrum lamps provide unique utility 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 improved visual performance.[28] In addition to providing a unique utility, DOE also understands that the technologies that modify the spectral emission from these lamps also decrease their efficacy (i.e., the ability of the lamp to convert watts of energy into lumens of visible light). This is because a portion of the light emission is absorbed by the coating. Neodymium coatings or other coatings on modified-spectrum lamps absorb some of the visible emission from the incandescent filament (usually red), creating a modified, reduced spectral emission. Since the neodymium or other coatings absorb some of the lumen output from the filament, these coatings decrease the efficacy of the lamp.

DOE is concerned that, given the newly-adopted definition of ''colored incandescent lamp,'' if DOE were to subject modified-spectrum IRL to the same standard as standard-spectrum IRL, then these IRL with modified-spectrum glass or coatings may not be able to achieve the mandatory standard, which could in turn lead to this type of product being lost from the market. Therefore, consistent with EISA 2007's approach on general service incandescent lamp standards, DOE is planning to establish separate product classes for regular IRL (i.e., those without modification to the spectral emission) and modified-spectrum IRL (i.e., ones which have some portion of the spectral emission absorbed). However, to ensure that a suitable standard level is set for these lamps (such that they are neither disadvantaged nor advantaged compared to standard-spectrum lamps), DOE plans to establish an appropriately scaled efficacy requirement for them, based on DOE's analysis of standard-spectrum IRL and then adjusted to account for the portions of the spectrum that are absorbed by the neodymium or spectrally-enhancing coating. DOE discusses how this scaling would be accomplished in the Engineering Analysis (see section III.C.6).

ii. Other Potential Class-Setting Factors Considered, but Not Adopted

Wattage. As DOE started to structure the analytical framework for the IRL analysis, DOE increasingly found that the initial approach of six wattage groups for product classes was not reasonable. Particularly as more-efficacious IRL with equivalent light output were considered, the approach presented in the Framework Document would have resulted in these replacement lamps being placed in a separate product class, and as such, would no longer be considered a ''replacement.'' For example, consider a 75W reflector lamp at 14.0 lm/W and an equivalent, more-efficacious replacement at 60W at 17.5 lm/W. These two lamps are essentially equivalent products, with equal levels of light output, operating lives, and customer utility (e.g., both operate in the same socket). However, under the Framework Document's approach for potential IRL product classes, these lamps would appear in different product classes. (42 U.S.C. 6295(i)(1)(B); see 10 CFR 430.32(n)(2)) Thus, DOE realized that wattage is not a suitable product class divider because it does not provide a unique utility; instead, it merely provides a measure of power consumption.

On further examination and consideration of the standard established by EPCA for reflector lamps, DOE is now interpreting the wattage groups in the existing standard as equivalent to a mathematical step-function equation that applies to all regulated IRL. DOE believes EPCA, in effect, establishes different minimum average lamp efficacies at each ''step'' or range of wattages for a single product class, which encompasses all IRL. This function recognizes that IRL incorporating the same technological feature, like a halogen capsule, are less efficacious at lower wattages than higher wattages. Therefore, lamps at lower wattages are subject to a lower standard than lamps at higher wattages even though lamps at all wattages are in the same product class.

As DOE considers more-efficacious substitute lamps in the analysis for this rulemaking, it must decrease the nominal lamp wattage range in order to keep the light output of the substitute lamps to within ten percent of the light output of the baseline lamp. Thus, as DOE presents the CSLs for the ANOPR, DOE plans to use a mathematical function that would establish the efficacy requirement at any wattage. Like the step function in EPCA, this mathematical function accounts for the fact that lamps at lower wattages are inherently less efficacious than lamps at higher wattages. See TSD Chapter 5 for a detailed discussion on the development of the CSLs for IRL.

Spot Versus Flood Incandescent Reflector Lamps. With respect to the issue of spot versus flood reflector lamps, several stakeholders commented that they did not believe DOE should establish separate product classes on this basis. (NEMA, No. 4.5 at p. 75; ACEEE, No. 4.5 at p. 75; PG&E, No. 4.5 at p. 75; EEI, No. 4.5 at p. 76; NEMA, No. 8 at p. 2) DOE considered these comments and reviewed technical reports on the performance of spot versus flood reflector lamps. Based upon this information, DOE has tentatively concluded that while there might be a differentiating utility afforded to consumers through the light distribution patterns of a spot reflector lamp versus a flood reflector lamp, that differentiating utility would not be expected to impact the efficacy of the lamp. Thus, DOE does not plan on creating separate product classes for spot and flood reflector lamps.

iii. Product Class Results

In sum, as discussed previously, DOE is considering all wattages of reflector lamps to be part of the same product class, with the standard level for any given lamp being a function of lamp wattage. As DOE considers more-efficacious replacement lamps, the rated wattages must decrease in order to maintain consistent levels of light output (i.e., within ten percent of the baseline lamp). Additionally, DOE is planning to consider efficacy standards for full-spectrum IRL separately from modified-spectrum IRL. Table III.4 summarizes the two product classes DOE is considering for the ANOPR. (For ease of commenting on IRL product classes, DOE has continued the product class numbering from where the GSFL classes left off.)

[28] ''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/claims.asp*.

TABLE III.4.—DOE ANOPR PRODUCT CLASSES FOR IRL

Lamp type	Standard-spectrum minimum lamp efficacy *lm/W*	Modified-spectrum minimum lamp efficacy *lm/W*
Incandescent Reflector Lamps	Product Class #9	Product Class #10.

3. Technology Assessment

In the technology assessment, DOE identifies technology options that appear to be feasible means of improving product efficacy. This assessment provides the technical background and structure on which DOE bases its screening and engineering analyses. The following discussion provides an overview of the salient aspects of the technology assessment, including issues on which DOE seeks public comment. For a more complete discussion, Chapter 3 of the TSD provides detailed descriptions of the basic construction and operation of GSFL and IRL, followed by a discussion of technology options to improve the efficacy of that lamp type.

a. General Service Fluorescent Lamps

Table III.5 lists the technology options that DOE has identified for improving the efficacy of GSFL. Table III.5 also provides TSD citations to each of the options listed, in order to enable the public to learn more about what is encompassed under each of the options.

TABLE III.5.—GENERAL SERVICE FLUORESCENT LAMP TECHNOLOGY OPTIONS

Name of technology option	Description	TSD reference
Highly Emissive Electrode Coatings	Improved electrode coatings to increase electron emission.	Chapter 3, Section 3.3.1.1.
Higher Efficiency Lamp Fill Gas Composition	Fill gas compositions to improve cathode thermionic emission or increase mobility of ions and electrons in the lamp plasma.	Chapter 3, Section 3.3.1.2.
Higher Efficiency Phosphors	Techniques to increase the conversion of ultraviolet light into visible light.	Chapter 3, Section 3.3.1.3.
Glass Coatings	Coatings that enable the phosphors to absorb more UV energy, so that they emit more visible light.	Chapter 3, Section 3.3.1.4.
Higher Efficiency Lamp Diameter	Vary the lamp diameter to improve its efficacy	Chapter 3, Section 3.3.1.5.
Multi-Photon Phosphors	Emitting more than one visible photon for each incident UV photon.	Chapter 3, Section 3.3.1.6.

Philips commented that some lamps use an extra thick layer of expensive phosphors to improve efficacy. However, Philips commented that the global supply of these high-quality phosphors is unknown, and there may be some issues associated with higher manufacturing cost if a standard level were set such that it required the use of this technology. (Philips, No. 11 at p. 2) DOE will keep this comment in mind during the manufacturer impact analysis interviews it will conduct at the NOPR stage of this rulemaking.

b. Incandescent Reflector Lamps

Table III.6 lists the technology options DOE has identified to improve the efficacy of IRL. Some of the technology options listed in Table III.6 are incorporated into commercially-available products today. For example, higher-temperature operation is utilized (usually in conjunction with halogen lamps) to improve the efficacy of the tungsten filament. Additionally, coiling of the tungsten filament is currently practiced widely by lamp manufacturers to increase its surface area, thereby improving filament efficacy.

TABLE III.6.—INCANDESCENT REFLECTOR LAMP TECHNOLOGY OPTIONS

Name of technology option	Description	TSD reference
Higher-Temperature Operation	Operating the filament at higher temperatures, the spectral output shifts to lower wavelengths, increasing its overlap with the eye sensitivity curve. This measure may shorten the operating life of the lamp.	Chapter 3, Section 3.3.2.1.
Microcavity Filaments	Texturing, surface perforations, microcavity holes with material fillings.	Chapter 3, Section 3.3.2.2.
Novel Filament Materials	More-efficacious filament alloys	Chapter 3, Section 3.3.2.3.
Thinner Filaments	Thinner filaments to increase operating temperature. This measure may shorten the operating life of the lamp.	Chapter 3, Section 3.3.2.4.
Efficient Filament Coiling	Coiling of the filament to increase surface area	Chapter 3, Section 3.3.2.5.
Crystallite Filament Coatings	Layers of micron or submicron crystallites deposited on the filament surface.	Chapter 3, Section 3.3.2.6.
Efficient Filament Orientation	Positioning the incandescent filament to increase light emission out of the lamp.	Chapter 3, Section 3.3.2.7.
Higher Efficiency Inert Fill Gas	Filling lamps with alternative gases, such as Krypton, to improve efficacy by reducing heat conduction.	Chapter 3, Section 3.3.2.8.

TABLE III.6.—INCANDESCENT REFLECTOR LAMP TECHNOLOGY OPTIONS—Continued

Name of technology option	Description	TSD reference
Luminescent Gas	Gaseous fills that react with certain wavelengths of the filament emission to generate visible light.	Chapter 3, Section 3.3.2.9.
Tungsten-Halogen Lamps	Small diameter fused quartz envelope with a halogen molecule to re-deposit tungsten on the filament. Commonly referred to as a "halogen" lamp.	Chapter 3, Section 3.3.2.10.
Higher Pressure Tungsten-Halogen Lamps	Increased pressure of the halogen capsule by increasing the density of halogen elements.	Chapter 3, Section 3.3.2.11.
Non-Tungsten Regenerative Cycles	Novel filament materials that incorporate a regenerative cycle.	Chapter 3, Section 3.3.2.12.
Infrared Glass Coatings	Infrared coatings (both phosphor and thin-film) to reflect some of the radiant energy back onto the filament. When used in conjunction with a halogen capsule, this technology option is referred to as a halogen infrared reflector (HIR) lamp.	Chapter 3, Section 3.3.2.13.
Integrally Ballasted Low Voltage Lamps	The ballast converts the operating voltage of the lamp from line voltage to a lower voltage.	Chapter 3, Section 3.3.2.14.
Higher Efficiency Reflector Coatings	Alternative internal coatings with higher reflectivity	Chapter 3, Section 3.3.2.15.
Trihedral Corner Reflectors	Individual corner reflectors in the cover glass that reflect light directly back in the direction from which it came.	Chapter 3, Section 3.3.2.16.
Efficient Filament Placement	Positioning the filament to increase light emission out of the lamp.	Chapter 3, Section 3.3.2.17.

Additional detail on the technology assessment can be found in Chapter 3 of the TSD.

In summary, DOE invites comments on all of the technology options it considered for GSFL and IRL, including any omissions or revisions necessary to have a more comprehensive technology assessment. In the context of commenting on technology options, DOE also requests information on the feasibility, performance improvement, and cost of the technology options, as well as any recent developments in their technical maturity.

B. Screening Analysis

The purpose of the screening analysis is to evaluate the technology options identified as having the potential to improve the efficiency of a product, to determine which options to consider further and which options to screen out. DOE consults with industry, technical experts, and other interested parties in developing a list of technology options for consideration. Section III.A.3 discusses the lists of identified technology options for the products being considered for coverage under this rulemaking. DOE then applies the following set of 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).

1. Technology Options Screened Out

Applying the four screening criteria discussed above to the identified technology options for GSFL and IRL, DOE developed the list of technology options shown in Table III.13 that will not be considered further in this rulemaking analysis, because they do not meet one or more of the aforementioned screening criteria. In the text following Table III.13, DOE discusses each of these technology options and provides the rationale for screening them out. Chapter 4 of the TSD provides further information on the Screening Analysis.

TABLE III.7.—SUMMARY OF TECHNOLOGY OPTIONS SCREENED OUT OF DOE'S ANALYSIS

Lamp category	Technology option	Screening criteria failed on
GSFL	Multi-Photon Phosphors	Technological feasibility; Practicability to manufacture, install, and service.
IRL	Microcavity Filaments	Product utility to consumers; Practicability to manufacture, install, and service.
IRL	Novel Filament Materials	Practicability to manufacture, install, and service; Product utility to consumers.
IRL	Crystallite Filament Coatings	Practicability to manufacture, install, and service.
IRL	Luminescent Gas	Technological feasibility.

TABLE III.7.—SUMMARY OF TECHNOLOGY OPTIONS SCREENED OUT OF DOE'S ANALYSIS—Continued

Lamp category	Technology option	Screening criteria failed on
IRL	Non-Tungsten-Halogen Regenerative Cycles.	Practicability to manufacture, install, and service; Product utility to consumers.
IRL	Infrared Phosphor Glass Coating	Practicability to manufacture, install, and service.
IRL	Integrally Ballasted Low Voltage Lamps.	Technological feasibility.
IRL	Trihedral Corner Reflectors	Practicability to manufacture, install, and service.

a. Multi-Photon Phosphors

For GSFL, DOE screened out the use of multi-photon phosphors, even though they have the potential to significantly improve lamp efficacy. By emitting more than one visible photon for each incident ultraviolet photon, a lamp employing this technology would be able to emit more light for the same amount of power. However, development of this technology remains in the research phase, and DOE is unaware of any prototypes or commercialized products that incorporate multi-photon phosphors. Thus, DOE screened out this technology option based on the first criterion, technological feasibility. Additionally, because this technology is still in the research phase, DOE believes that it would not be practicable, or even possible, to manufacture, install, and service this technology on the scale necessary to serve the relevant market at the time of the effective date of an amended standard. As discussed below in section III.C, DOE based the GSFL engineering analysis on commercially-available lamps, deriving efficacy values for these lamps from manufacturer catalogs and specifications. Therefore, DOE considered the technology options contained in Table III.5 implicitly as incorporated into commercially available lamps at the efficacy levels it evaluated.

b. Microcavity Filaments

DOE also screened out several technologies that could potentially improve the efficacy of IRL. First, DOE screened out the use of microcavity filaments. Microcavity filaments increase an incandescent lamp's efficacy by reducing the amount of energy converted to infrared light emitted by the filament while increasing the amount of energy converted to visible light. The TSD's market and technology assessment (TSD Chapter 3) notes that Sandia National Laboratories researchers examined microcavity resonance in a tungsten photonic lattice, and a literature search revealed multiple patents referencing this technology. Since research prototypes of microcavity filaments do exist, DOE determined that this technology option is technologically feasible. However, research indicates that materials patterned at the submicron level may experience problems with stability. Because such instability could negatively affect lamp function and life, DOE believes that it is not yet practicable to implement this technology in general service lamps. For this reason, DOE screened out this technology option based on the third criterion, impacts on product utility to consumers. Furthermore, DOE is unaware of any commercialized lamps that incorporate microcavity filaments, so we are concerned that mass-manufacturing techniques for this technology would be problematic. For this reason, DOE does not believe that this technology would be practicable to manufacture, install, and service. Therefore, DOE is not considering filaments with microcavities as a design option for improving the efficacy of IRL.

c. Novel Filament Materials

Second, DOE screened out the use of novel filament materials, such as nitrides and carbides, that have the potential to improve lamp efficacy by emitting more light in the visible spectrum at a given temperature than traditional tungsten filaments. Because several patents on such filaments exist, DOE believes that this technology option is technologically feasible. However, DOE is unaware of any lamps available today that use such filaments. Furthermore, DOE understands that technological barriers, such as prohibitive brittleness of the filament, limit implementation of this technology. Finding a practical way to incorporate novel filament materials into commercially-viable incandescent lamps would require further research, as would making such lamps practical for general service applications. Thus, DOE believes this option must be screened out due to its potential negative impacts on consumer utility. Furthermore, DOE believes that it would not be practicable to manufacture this technology on the scale necessary to serve the relevant market at the time of the effective date of an amended standard. Therefore, DOE is not considering novel filament materials as a design option for improving the efficacy of IRL.

d. Crystallite Filament Coatings

Third, DOE screened out crystallite filament coatings, which are oxide-covered micron or sub-micron crystallites comprised of thorium, tantalum, or niobium. These coatings can be used to increase the light emissivity of an incandescent lamp's filament. Because several patents on such filament coatings exist, DOE believes that this technology option is technologically feasible. However, DOE was unable to locate any data on the incorporation of crystallite filament coatings into prototypes or commercially available products. Using crystallite filament coatings in incandescent lamps may require additional manufacturing techniques, such as chemical vapor deposition. DOE understands that these techniques are not in use in the mass-production of incandescent lamps. In addition, DOE believes that it would not be practicable to manufacture this technology on the scale necessary to serve the relevant market of incandescent lamps before the effective date of an amended standard. Therefore, DOE is not considering crystallite filament coatings as a design option for improving the efficacy of IRL.

e. Luminescent Gases

Fourth, DOE screened out luminescent gases. These gases, placed inside the envelope of an incandescent lamp, react with certain wavelengths of the filament emission and generate visible light. DOE is unaware of any existing commercially-available products or prototypes of incandescent lamps incorporating luminescent gases. Accordingly, DOE screened out luminescent gases based on the first criterion, technological feasibility. Therefore, DOE is not considering luminescent gas fills as a design option for improving the efficacy of IRL.

f. Non-Tungsten-Halogen Regenerative Cycles

Fifth, DOE screened out non-tungsten-halogen regenerative cycles.

Regenerative cycles allow a filament to burn at a higher temperature (and thus higher efficacy) than conventional incandescent lamps, while maintaining a useful service life. Non-tungsten-halogen regenerative cycles are regenerative cycles that do not employ the use of the tungsten filament or halogen gas fill. DOE understands that regenerative cycles other than tungsten-halogen may be possible for other filament materials. However, as noted above, DOE screened out the use of novel filament materials on the basis of the second and third screening criteria. Due to the fact that use of the non-tungsten-halogen regenerative cycles would depend on the incorporation of a non-tungsten filament (already screened out), DOE is screening out such cycles from consideration based on the same two criteria. DOE believes that it would not be practicable, and maybe not even possible, to manufacture novel filament materials lamps with associated regenerative cycles on the scale necessary to serve the relevant market at the time of the effective date of an amended standard. Also, the use of other filament materials, and therefore their associated regenerative cycles, may have an adverse impact on consumer utility. Therefore, DOE is not considering non-tungsten-halogen regenerative cycles as a design option for improving the efficacy of IRL.

g. Infrared Phosphor Glass Coatings

For IRL, DOE screened out infrared phosphor glass coatings. When used as a coating on the bulb surface, infrared phosphors harvest the emitted infrared energy and convert it to visible light, thereby potentially increasing lamp efficacy. Because patents on such infrared phosphor coatings exist, DOE determined that this technology option is technologically feasible. However, DOE does not believe infrared phosphor glass coatings would be practicable to manufacture because making hundreds of millions of incandescent lamps annually with infrared phosphor coatings would require significant changes to current manufacturing processes and DOE has no data to indicate that such manufacturing processes are feasible or could be made ready to serve the relevant market at the time of the effective date of an amended standard. Therefore, DOE is not considering infrared phosphor coatings as a design option for improving the efficacy of IRL.

h. Integrally Ballasted Low Voltage Lamps

Incandescent filaments that are designed to operate at a lower voltage are both shorter in length and thicker in cross-sectional area than incandescent filaments designed to operate at a line voltage from 115 to 130V. Increasing the thickness of the filament can improve its efficacy by allowing the lamp to be operated at higher temperatures. Therefore, using an integral ballast allows one to increase the efficacy of a lamp by operating its filament at a lower voltage (e.g., 12 volts) than standard U.S. household line voltage (i.e., 120 volts). Although this technology is commercially available in Europe [29] and elsewhere in the world where the standard household line voltage is 220–240 volts, DOE is unaware of any commercially-available products or prototypes of this same technology option that operate on U.S. household line voltage of 120 volts. Accordingly, DOE is screening out integrally ballasted low voltage lamps based on the first criterion, technological feasibility. Therefore, DOE is not considering integrally ballasted low voltage lamps as a design option for improving the efficacy of IRL.

i. Trihedral Corner Reflectors

For IRL, DOE screened out trihedral corner reflectors, which could be incorporated into the cover glass of IRL and have the potential to increase lamp efficacy by redirecting infrared radiation back onto the filament. Because patents on trihedral corner reflectors exist, DOE determined that this technology option is technologically feasible. However, manufacturer data have not provided any indication as to the incorporation of this technology into prototypes or commercially-available products. Using trihedral corner reflectors, which entail an additional disc requiring external fabrication and installation in the lamp, is likely to necessitate manufacturing techniques not currently available for mass production. For this reason, DOE believes that it would not be practicable to implement this technology on the scale necessary to serve the relevant IRL market at the time of the effective date of an amended standard. Therefore, DOE is not considering trihedral corner reflectors as a design option for improving the efficacy of IRL.

2. Design Options Considered Further in Analysis

After screening out technologies in accordance with the policies set forth in 10 CFR part 430, Subpart C, Appendix A, (4)(a)(4) and 5(b), DOE is considering the technologies, or ''design options,'' listed in the table below as viable means of improving the efficacy of lamps covered under this ANOPR. The market and technology assessment (TSD Chapter 3) provides a detailed description of these design options.

TABLE III.8.—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 (thin-film).
	Higher Efficiency Reflector Coatings.
	Efficient Filament Placement.

The above listed ''design options'' will be considered by DOE in the engineering analysis. As discussed in section III.C, to the greatest extent possible, DOE based its engineering analysis on commercially-available products, which incorporate one or more of the design options listed above. In this way, DOE is better able to apply

[29] Philips Electronics Press Release (2007). Available at: *http://www.lighting.philips.com/gl_en/news/press/product_innovations/archive_2007/press_new_masterclassic_lamp.php*.

these features of more-efficacious lamps in a manner consistent with real world application. To this end, DOE has used catalog data, including price and performance information, where available.

DOE invited comment on DOE's selection of these design options. Previously, manufacturers have expressed some concern about certain technologies impacting the manufacturing of high-volume IRL. DOE understands that infrared reflective coatings require time to deposit on the capsules/lamps. While lamps with this technology option are commercially available today in small production runs, DOE is requesting comment on whether these technologies could be applied in the volumes necessary to meet the market demand for IRL in the three-year compliance period mandated under the law authorizing DOE to conduct this rulemaking. In particular, DOE requests comment on whether this technology (or other technology options listed above) indeed meet DOE's screening criterion related to whether a technology can be ''mass manufactured.''

For more detail on how DOE developed the technology options and on the process DOE used to screen these options, refer to Chapter 3 and Chapter 4 of the TSD.

C. Engineering Analysis

The engineering analysis identifies, for each product class, potential increasing efficiency levels above the level of the baseline model. As key inputs in this process, the engineering analysis considers technologies not eliminated in the screening analysis. DOE considers these technologies either explicitly as design options or implicitly as incorporated into commercially-available lamps at the efficiency levels evaluated. For more information on the technologies used in commercially-available lamps, refer to Chapter 5 of the TSD.

In the engineering analysis for this rulemaking, DOE concentrated its efforts on developing product efficacy levels associated with ''lamps designs,'' based upon commercially-available lamps that incorporate a range of design options. ''Design options'' consist of discrete technologies (e.g., infrared reflective coatings). However, where necessary, DOE supplemented commercially-available product information with an examination of the incremental costs and improved performance of discrete technologies. In this way, DOE's standards development analyses can appropriately assess the technologies identified as candidates for improving lamp efficacy.

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. Section III.E of this notice discusses the product price determination (see TSD Chapter 7 for further detail).

1. Approach

To the extent possible, DOE based the analysis on commercially-available lamps that incorporate the design options identified by the Technology Assessment and Screening Analysis. For GSFL, all lamp-and-ballast designs are commercially available and have publicly available performance and price information. The majority of the engineering analysis for IRL is also based on commercially-available lamps. However, where needed, DOE supplemented these lamps with additional model lamps which use commercially-available technologies so that a substitute lamp at each CSL was available for each baseline lamp. For both GSFL and IRL, instead of using manufacturer cost data, DOE elected to follow suggestions to derive price information using observed market prices for existing products. For more information on the rationale for this approach, refer to section III.E of this notice.

The engineering analysis follows on the same general approach for both categories of lamps analyzed in this rulemaking. The steps below more fully describe this approach:

Step 1: Select Representative Product Classes. DOE reviewed covered lamps and their associated product classes. 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. Section III.C.2 of this notice provides detail on the representative product classes selected for the analysis. Section III.C.6 of this notice provides detail on how DOE extrapolates from the representative product class to other product classes.

Step 2: Select Baseline Lamps. DOE selected baseline lamps from the representative product classes on which it conducted the engineering analysis (and subsequent analyses). These baseline lamps were selected to represent the characteristics of typical lamps in a given product class. Generally, a baseline lamp is one that just meets existing mandatory energy conservation standards or one that represents the typical lamp sold. Specific characteristics such as CCT, operating life, and light output were all selected to characterize the most common lamps purchased by consumers today. For all the representative product classes, DOE selected multiple baseline lamps, in order to ensure consideration of different high-volume lamps and associated consumer economics. Baseline lamps are discussed in section III.C.2 of this notice.

Step 3: Identify Candidate Lamp or Lamp-and-Ballast Designs. DOE selected a series of more-efficacious lamps for each of the baseline lamps considered within each representative product class. DOE considered technologies not eliminated in the screening analysis. DOE considered these technologies either explicitly as design options or implicitly as design options incorporated into commercially-available lamps at the efficiency levels evaluated. In identifying more efficacious lamp or lamp-and-ballast designs, DOE recognizes that the lumen package and performance characteristics of a system are important design criteria for consumers. For example, if consumers do not have the option to purchase substitution lamps or lamp-and-ballast systems with similar lumen packages under an energy conservations standard, consumers would need to renovate the lighting design in a particular building in order to maintain a similar light output. Therefore, lamp and lamp-and-ballast designs for the LCC analysis were established such that potential substitutions maintained light output above a maximum 10 percent decrease from the baseline lamp system's light output. In addition, substitute lamps were chosen to have performance characteristics (e.g., CCT) similar to those of the baseline lamp.

In identifying more-efficacious substitutes for GSFL, DOE utilized a database of commercially-available lamps. For the LCC, DOE developed the engineering analysis based on the two substitution scenarios where a consumer can maintain light output while decreasing energy consumption. In the first scenario, the consumer maintains light output while decreasing energy by replacing the baseline lamp with a more efficacious lower-wattage lamp that operates on the existing ballast. In the second scenario, the consumer maintains light output while decreasing energy consumption by replacing the lamp-and-ballast system with a more efficacious lamp and a different ballast. For example, a lamp-and-ballast system with a more efficacious same-wattage lamp and lower ballast factor ballast will consume less energy and maintain light output.

For IRL, DOE used some commercially-available lamps, but also developed ''model'' lamps which incorporate design options that may not be commercially available for certain lamp types and wattages but which use commercially-available technologies. For example, DOE developed efficacy estimates for reduced-wattage IRL with an improved halogen infrared (HIR) coating. For the LCC, DOE considered only one substitution scenario. In this scenario, consumers save energy and maintain light output by replacing their lamp with a lower wattage more efficacious lamp. For a more detailed discussion of lamp and ballast designs, see section III.C.3 of this notice.

Step 4: Developed Candidate Standard Levels. Having identified the more-efficacious substitutes for each of the baseline lamps (or lamp-and-ballast systems), DOE developed CSLs based on a consideration of several factors including: (1) The design options associated with the specific lamps being studied (e.g., grades of phosphor for fluorescent lamps, the use of infrared coatings for IRL); (2) the ability of lamps across wattages to comply with the standard level of a given product class;[30] and (3) the maximum technologically-feasible level. For a more detailed discussion of CSL development for each of the representative product classes analyzed, see section III.C.4 of this notice.

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 and Baseline Lamps

As discussed in section III.A.2, DOE is considering establishing eight product classes across the range of covered GSFL and two product classes for covered IRL. Due to scheduling and resource constraints, DOE was not able to analyze each and every product class. Instead DOE carefully selected certain product classes that it would analyze, and then scale its analytical findings on those representative product classes to other product classes that were not analyzed. The representative product classes are generally selected to encompass the highest volume, most commonly sold lamp types.

Once DOE identifies the representative product classes for analysis, DOE selects the representative units for analysis (i.e., baseline lamps) from within each product class. In the Framework Document, DOE identified some preliminary ideas for representative product classes and units for analysis. This section summarizes the comments received on this topic and the related decisions DOE made in conducting this portion of the ANOPR analysis.

ACEEE provided a cross-cutting comment about representative product classes and units for analysis. ACEEE expressed concern that DOE may over-simplify the analysis by analyzing lamps of a few wattages and then generalizing to lamps of other wattages, in which case the results may not scale well. (ACEEE, No. 4.5 at pp. 67 and 79–80) The Joint Comment expressed this same concern, stating that analyzing too few products risks oversimplifying the analysis and obtaining results that cannot be extended to other products. Because such an approach could result in the sacrifice of potential energy savings, the Joint Commenters urged DOE to analyze multiple lamp wattages. (Joint Comment, No. 9 at p. 2)

In response, DOE plans to establish eight product classes for GSFL. For IRL, although DOE is considering only two product classes, DOE defines CSLs with lamp efficacy requirements that vary by wattage to prevent oversimplification of the analysis. In addition, for each potential GSFL and IRL product class that is being analyzed, DOE is analyzing more than one baseline lamp to reflect the range of manufacturers' current lamp offerings. For example, for IRL, DOE recognizes that an incandescent lamp with the same basic technology exhibits higher efficacies at higher wattages. By analyzing multiple products at several different wattages, DOE was able to define a CSL that sets the same technology requirement for IRL, regardless of wattage.

a. General Service Fluorescent Lamps

As discussed in section III.A.2, DOE has tentatively decided to revise the table of product classes to reflect the utility of these products and how they are used in the market. From this new set of product classes, DOE generally selected as representative product classes those that encompassed the majority of shipments and from which efficacy values could be scaled.

DOE observed that 4-foot medium bipin lamps constitute the vast majority of GSFL sales. These are followed in order of unit sales by 8-foot single pin slimline lamps and 8-foot recessed double contact HO lamps, which together constitute less than a quarter of GSFL sales. Because 4-foot medium bipin, 8-foot single pin slimline, and 8-foot recessed double contact HO lamps are the most common GSFL, DOE has selected them as representative lamps for its analysis. Shipments of 2-foot U-shaped lamps account for less than 5 percent of GSFL unit sales historically.[31] Given the relatively small market share of U-shaped lamps, DOE did not explicitly analyze these lamps.

With regard to product class divisions by CCT, DOE recognizes that lamps whose CCT is greater than 4,500K represent a small market share of GSFL. Therefore, DOE has chosen to analyze lamps with CCT less than or equal to 4,500K.

Although DOE is not analyzing the 2-foot U-shaped lamps or lamps that have a CCT greater than 4,500K, DOE nevertheless plans to consider standards for these product classes. DOE will extend its decision for the 4-foot medium bipin product class to the 2-foot U-shaped product class. This is possible because 2-foot U-shaped lamps generally are operated in the same way and generally span the same wattages as 4-foot medium bipin lamps. For lamps whose CCT is greater than 4,500K, DOE will extrapolate its findings from the representative lamps it analyzed that are less than or equal to 4,500K. For details on how DOE intends to consider development of standards for product classes not analyzed, see section III.C.6 of this notice.

Within the representative product classes for GSFL, DOE selected as representative units for analysis those lamps with the highest volumes. Although DOE reorganized the product classes from what it presented in the Framework Document, the representative units selected for analysis are generally consistent with the comments received regarding the appropriate units for analysis. For example, several stakeholders commented that DOE should select the cool white phosphor energy-saver T12 as a baseline lamp. (NEMA, No. 8 at pp. 2–3; GE, No. 4.5 at pp. 63–65 at pp. 70–71; Philips, No. 11 at p. 1; GE, No. 13 at pp. 2–4; Osram, No. 15 at p. 3; GE, No. 4.5 at pp. 63–65). Osram commented that DOE should also

[30] Efficacy levels span multiple lamps of different wattages. In selecting CSLs, DOE considered whether these multiple lamps can meet the efficacy levels.

[31] Source: NEMA, No. 12 at p. 7.

consider a 700 series T8 as a baseline lamp. (Osram, No. 15 at p. 3). In contrast, EEI and PG&E commented that the baseline lamps should be selected in terms of when the standard will go into effect (six years from now), and the cool white lamp may not be a good representative baseline lamp at that time. (EEI, No. 4.5 at pp. 68–69, PG&E, No. 4.5 at p. 73). In addition, ACEEE commented that it may be better for DOE to analyze both the energy-saver and non-energy-saver lamps as baselines, and then later in the process DOE could decide whether one should be removed from the analysis. (ACEEE, No. 4.5 at pp. 66–67).

After consideration of the public comments, DOE selected T8 and T12 baseline lamps for analysis. For T12 lamps, DOE selected both non-energy-saver lamps (i.e., 40W T12 4-foot medium bipin GSFL) and energy-saver versions (i.e., 34W T12 4-foot medium bipin GSFL), where they were available, as baseline lamps. For non-energy-saver versions of T12 GSFL, DOE selected 700 series, non-cool-white T12 lamps. For energy-saver versions of the T12 GSFL, DOE selected cool white models as baseline lamps. For T8 lamps, DOE only selected the non-energy-saver lamp (i.e., 32W T8 4-foot medium bipin GSFL) as a baseline lamp because energy-saver versions are not prevalent in the marketplace. For the baseline 32W T8 lamp, DOE used a rare-earth phosphor 700 series non-energy-saving lamp as the baseline. In all cases, the phosphor technology employed by each of these lamps is a direct reflection of the most commonly sold lamp today. DOE also selected fluorescent lamps with a CCT of 4,100K for all the analysis (i.e., baseline lamps and standard-compliant replacement lamps). DOE selected this CCT value because it is both the most popular CCT and because it falls approximately in the middle of the range of typical GSFL, which span from 3,000K to 6,500K.

Table III.9 presents the representative product classes and baseline lamps that DOE has tentatively developed for GSFL.

TABLE III.9.—GSFL REPRESENTATIVE PRODUCT CLASSES AND BASELINE LAMPS

Lamp type	Representative product class	Baseline lamps						
		Descriptor	Nominal wattage *W*	CCT *K*	Rated efficacy* *lm/W*	Initial light output *lm*	Mean light output *lm*	Lifetime *hr*
4-foot medium bipin	CCT ≤4,500K	F40T12	40	4,100	80.0	3,200	2,880	20,000
		F34T12	34	4,100	77.9	2,650	2,300	20,000
		F32T8	32	4,100	86.2	2,800	2,520	20,000
8-foot single pin slimline.	CCT ≤4,500K	F96T12	75	4,100	85.6	6,420	5,906	12,000
		F96T12	60	4,100	87.6	5,300	4,664	12,000
		F96T8	59	4,100	94.8	5,700	5,130	15,000
8-foot recessed double contact HO.	CCT ≤4,500K	F96T12	110	4,100	80.1	9,050	8,145	12,000
		F96T12	95	4,100	82.5	8,000	6,950	12,000

*Rated efficacy is based on the rated wattage of the lamps and the initial lumen output. The rated wattage in order of baseline is 40W, 34W, 32.5W, 75W, 60.5W, 60.1W, 113W, and 97W.

As discussed in section III.C.3.a, DOE is taking a systems approach to its analysis for GSFL. In accordance with this approach, DOE selected typical ballasts to pair with the baseline lamps. DOE generally paired a ''normal'' BF ballast (i.e., with a BF typically between 0.84 and 1.0) with baseline lamp systems. These pairings are intended to characterize the typical system used in the market. For example, for installed T8, 4-foot medium bipin fluorescent systems, DOE selected an instant start electronic ballast with a BF of 0.88. In addition to ballast types, DOE also selected the number of lamps per ballast that represent a typical system. DOE is aware that 4-foot medium bipin ballasts are available in a variety of lamp-per-ballast designs. According to the 2000 rule on GSFL ballasts (hereafter ''2000 Ballast Rule''), there are on average 2.8 lamps per 4-foot medium bipin system. 62 FR 56740 (Sept. 19, 2000).[32] To accurately represent the market and to simplify the analysis, DOE has decided to use a 3-lamp system for 4-foot medium bipin lamps. For 8-foot lamps, DOE selected 2-lamp ballasts, representative of typical 8-foot systems in the market. For further detail on the lamps and lamp-and-ballast systems DOE uses in its analyses, see Chapters 5 and Appendix 5A of the TSD.

b. Incandescent Reflector Lamps

As discussed above, for the ANOPR, DOE decided to revise the table of product classes to reflect the utility of these products and how they are used in the market, including the creation of a product class for modified-spectrum lamps. Because modified-spectrum lamps currently make up only a small percentage of the market, DOE has selected the standard-spectrum IRL product class for analysis and intends to extrapolate its findings to the modified-spectrum product class. Section III.C.6 provides detail on this extrapolation.

ACEEE commented that DOE should analyze each of the six IRL wattage group product classes, rather than only two, as DOE presented in its Framework Document. Otherwise, ACEEE argued that DOE would potentially risk oversimplifying the analysis. (ACEEE, No. 4.5 at pp. 79–80) The Joint Comment also asserted that DOE should examine each product class for IRL since the appropriate substitute lamps in each of those classes can vary. (Joint Comment, No. 9 at p. 2)

Given the revisions to the product class structure for IRL (i.e., that product classes are no longer defined by wattage), DOE now recognizes that the discrete utility of IRL is based on the lumen package, not the wattage rating. For this reason, the discrete IRL representative wattage groups that were discussed in the Framework Document,

[32] 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 B. Marginal Energy Prices and National Energy Savings. Table B.6. (Jan. 2000). Available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/appendix_b.pdf.*

and upon which DOE received comment, are being merged into one product class. However, to prevent oversimplification of the analysis, DOE has chosen to analyze three different lamps of multiple wattages (and lumen packages) in the standard-spectrum product class. DOE has tentatively decided to concentrate its resources on conducting analysis of the most popular reflector lamps—in terms of lamp size, wattage, and lumen package. Accordingly, DOE examined existing products on the market at multiple wattages to select baseline lamps which it used to derive efficacy equations that span wattage. Therefore, DOE was able to apply the analysis performed on the most popular lamps to the other, less common lamps. Further detail on the CSLs DOE has developed for IRL follows in section III.C.6.

With regard to baseline lamps, NEMA commented that DOE should conduct more analysis on the 75W and the 150W parabolic aluminized reflector (PAR) lamp, and clarify whether these are ''blown PAR'' lamps. (NEMA, No. 8 at pp. 2–3) EEI commented that given the market penetration of halogen PAR lamps, DOE might consider them as some of the baseline lamps for the analyses. (EEI, No. 4.5 at p. 77) GE commented that blown PAR38 lamps are very common in the market (both 75W and 150W), and that they may represent a good baseline because they are the least efficient type of PAR technology currently sold. (GE, No. 4.5 at p. 79)

In response, DOE selected three baseline lamps of varying wattage and shapes to provide a comprehensive understanding of consumer economics. Specifically, DOE included PAR halogen baseline lamps of three different wattages: 50, 75, and 90 Watts. Average wattage information of PAR lamps acquired from NEMA and a review of manufacturer product catalogs indicate that these are the highest volume wattages. These baseline lamps are currently regulated by EPCA and, therefore, meet the EPCA standard.

DOE identified three lumen packages that are popular in the commercial and residential sectors, and then identified lamps that provided that service. These three packages are in the range of approximately 600 to 1,300 lumens. DOE analyzed PAR baseline lamps in each of the lumen packages as DOE believes that these lamps represent a good cross-section of the most common reflector lamps that will be sold and used at the effective date of the standard (the year 2012). Since these lamps capture a range of wattages and lumen packages, they cover a range of applications.

Table III.10 presents the representative product class and baseline lamps that DOE has selected for the ANOPR IRL analyses.

TABLE III.10.—IRL REPRESENTATIVE PRODUCT CLASS AND BASELINE LAMPS

Lamp category	Representative product class	Representative product class baseline lamps				
		Descriptor	Wattage *W*	Efficacy *lm/W*	Initial light output *lm*	Lifetime *hr*
IRL	IRL Standard-Spectrum	PAR30	50	11.6	580	3,000
		PAR38	75	14.0	1,050	2,500
		PAR38	90	14.6	1,310	2,500

DOE requests comment on its preliminary selection of representative product classes and baseline lamps for GSFL and IRL.

3. Lamp and Lamp-and-Ballast Designs

In the market and technology assessment (see TSD Chapter 3), DOE identifies a range of technology options that improve the efficacy of the two categories of lamps considered in this rulemaking. In the screening analysis (see TSD Chapter 4), DOE screened out certain technology options because they fail to satisfy the requirements of all four screening criteria. Those technology options not screened out by the four criteria are called ''design options,'' and DOE considered them in the engineering analysis.

The Joint Comment suggested that, when deciding how many potential standard levels to examine, DOE should look at natural divisions in the market, by product class, rather than selecting an arbitrary number of standard levels. (Joint Comment, No. 9 at p. 4)

For the lamps considered in this rulemaking, DOE's selection of design options guided its selection of CSLs. Because products spanned a large range of efficacies for GSFL and IRL, DOE looked at natural divisions in the market when selecting lamp designs. For example, for GSFL, DOE noted groupings around the types of phosphor used and the wall thickness of those phosphors. With regard to IRL, DOE identified natural ''technology-based'' divisions in the market around the type of incandescent technology used (i.e., halogen, or HIR).

DOE also took into account lumen output when it established lamp designs for its analyses. In the Framework Document, DOE stated its intention to hold the lamp lumen output constant at the level of the baseline model. Thus, as the lamps become more efficacious, they will consume less energy rather than produce more light. Holding lumen output constant across the efficacy levels is necessary to ensure that products supply equivalent service under the base-case and standards-case scenarios.

The Joint Comment agreed with DOE's intention in this regard and suggested that DOE avoid structuring the standard so that compliant lamps would noticeably reduce light output. The Joint Comment also expressed concern about a standard that might result in the use of efficiency gains to over-illuminate certain installations or to install longer-life lamps instead of capturing energy savings. (Joint Comment, No. 9 at p. 6) EEI stated that there are some energy-saving incandescent lamps that use a slightly lower wattage and produce fewer lumens, but do so at a higher efficacy. Therefore, to allow for energy savings, and as a sensitivity to the analysis, EEI recommended that DOE should evaluate a 10-percent lumen band of equivalency for incandescent lamps. (EEI, No. 4.5 at pp. 117–118)

In response, it is noted that for the LCC, DOE considered those lamps (or lamp-and-ballast systems) which: (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. Lamp or lamp-and-ballast designs that under-illuminate and over-illuminate are considered in the NIA. For the LCC, DOE also chose to consider only energy-saving options. For GSFL, energy savings can either be achieved through lamp replacements or lamp-and-ballast replacements. For GSFL, energy savings can only be achieved through lamp replacements. For the NIA, DOE analyzed a range of energy saving and non-energy-saving options. The non-energy-savings lamps, as well as more-efficient lamps that increase or decrease light output by more than 10 percent of the base case, can be found in Appendix 5A of the TSD.

a. General Service Fluorescent Lamps

EEI recommended that DOE should take a systems approach when analyzing GSFL in the NES and LCC, because the ballast is the piece of the system that determines the energy usage overall. (EEI, No. 7 at p. 1) DOE agrees with this comment and did apply 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. By using a systems approach, DOE was able to demonstrate the actual energy consumption and light output of an operating lamp in a given end-user installation. DOE is cognizant of the fact, however, that it is not regulating fluorescent lamp ballasts in this rulemaking, and, therefore, while it selected ballasts with different ballast factors (BF) [33] in order to obtain the appropriate level of system lumen output, DOE did not necessarily select the most energy-efficient versions of those ballasts with different BF. (Note: DOE is initiating a separate rulemaking on fluorescent lamp ballasts, in which it will evaluate whether new and amended efficiency standards should be applied to fluorescent lamp ballasts.[34]) So although DOE is not setting minimum performance standards for fluorescent systems in this rulemaking, DOE's analysis does consider the operation of fluorescent lamps in a lamp-and-ballast system while evaluating efficacy standards for these lamps.

This systems approach allows DOE to select a variety of energy-saving lamp-and-ballast designs that meet a given CSL. In general, 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 a variety of technologies. As discussed in the screening analysis (section III.B.2), DOE considered commercially-available GSFL that use highly emissive electrode coatings, higher efficiency lamp fill gas composition, higher efficiency phosphors, glass coatings, or higher efficiency lamp diameter to achieve a higher efficacy. After selecting these higher efficacy lamps, DOE selected lamp-ballast combinations for the LCC that both save energy and maintain comparable lumen output. For instances in which the consumer is replacing only the lamp, DOE selected a reduced-wattage, higher-efficacy lamp for use on the existing ballast. For instances in which 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.

GE argued that DOE can only control a lamp for lamp replacement in this rulemaking, and that the ballast type is not regulated as part of this rulemaking. (GE, No. 4.5 at pp. 110–111) GE also commented that an increase in lumens would suffice for the lamp replacement events. (GE, No. 4.5 at p. 122)

ACEEE and GE commented that DOE should consider replacement lamps that have the same wattage but higher efficacy coupled with a lower ballast factor (BF) ballast as energy-efficient substitutes for the baseline lamp. Similarly, ACEEE recommended that DOE should consider technology options that use a lower BF ballast with a higher-efficiency lamp to achieve energy savings. (ACEEE, No. 4.5 at p. 113) GE stated that the energy use for fluorescent lamps is driven primarily by the BF, and that this should be a part of the energy savings analysis. (GE, No. 4.5 at pp. 116–117) DOE agrees with these comments, and followed the recommendations of these stakeholders in its analysis. As the efficacies of the fluorescent lamps being considered increased, DOE selected and used ballasts with lower ballast factors, such that the system lumen output was within ten percent of the baseline system lumen output.

In this rulemaking, DOE considers reduced-wattage lamp options (i.e., ones which emit lumens equal to the lumen output of the baseline lamp, or below that lamp by no more than 10 percent, and result in energy savings). In the NIA, DOE also considers substitute lamps which produce more light but do not save energy. This reflects the fact that DOE cannot require consumers to change their ballast along with their lamps. However, in situations where a consumer has the opportunity to replace a ballast, DOE allows consumers to change both their ballast and lamp. For example, consumers can select a lamp with a higher efficacy and a ballast with a lower BF to obtain a system that would result in approximately the same system light output as the baseline system. This new lamp-and-ballast combination would have a lower-wattage consumption due to the lower BF.

In the Framework Document, DOE identified several technology options that it intended to consider analyzing in this rulemaking. In response to that list of technology options, stakeholders provided feedback on certain options. Upon reviewing some of the fluorescent lamp-and-ballast pairings, GE commented that DOE should not assume that as lamp efficacy increases, one could always reduce wattage to achieve a constant light output with fluorescent lamps. GE points out that going below the 34W energy savings lamp, for example, is not possible, because lower-wattage lamps would not work on available ballasts. (GE, No. 4.5 at pp. 106–107)

In response, DOE has sought to create lamp and lamp-and-ballast designs that are practical and realistic in this engineering analysis. For example, for the 34W 4-foot medium bipin T12 GSFL, DOE did not consider reduced-wattage substitutes. Rather, DOE paired higher efficacy 34W 4-foot medium bipin T12 GSFL with lower BFs to capture energy savings while maintaining lumen output.

GE also stated that it is not always possible to use a 28W fluorescent lamp as a replacement for a 32W lamp on all the available ballasts. GE recommends that DOE decide what an acceptable range of reduced-wattage lamps might be, given that restrictions on use increase as the wattage decreases. (GE, No. 4.5 at pp. 126–127).

DOE understands that one of the ways manufacturers build lower-wattage fluorescent lamps is through the addition of krypton gas into the mix to change the resistance of the lamp. In the manufacturer interviews DOE held to prepare for the ANOPR, DOE was told that as the proportion of krypton gas increases, the fluorescent lamp has more

[33] The ''ballast factor'' of a ballast is the ratio of the light output of a fluorescent lamp or lamps operated on a ballast to the light output of the lamp(s) operated on a standard (reference) ballast. Ballast factor depends on both the ballast and the lamp type; a single ballast can have several ballast factors depending on lamp type. The light output of a single fluorescent lamp is measured on a ballast with a ballast factor of 1.0. One can reduce the light output of a lamp-and-ballast system by operating a lamp on a ballast with a lower ballast factor.

[34] Energy efficient ballasts are characterized as having higher ballast efficacy factors (BEF). The BEF is directly related to the quotient of the BF and the power consumed by the ballast, such that a ballast maintaining BF while reducing power consumption will have a higher BEF, and be a more energy-efficient ballast. In its ANOPR analysis, DOE varied the ballast BF, not the BEF, in its assessment of standards for fluorescent lamps. DOE will be considering new and amended BEF standards in the separate fluorescent lamp ballast rulemaking.

difficulty starting, being dimmed, and operating in cold-temperature environments. However, in other manufacturer interviews, DOE was informed that technological improvements were such that 28W fluorescent lamps should no longer have problems starting nor issues with features such as dimming or frequent on-off (often caused by motion sensors). DOE also reviewed publicly-available manufacturer literature and found at least one major lamp manufacturer stating that its 28W fluorescent lamp does not have restrictions on use.[35] For these reasons, DOE did consider the 28W lamp as an energy-saving replacement for a 32W T8 baseline lamp. However, DOE is aware that consumers should not be subject to any decrease in utility and performance and that not all consumers would choose a lower-wattage lamp if DOE established standards for T8 lamps. The NIA analysis contains technology option market-share matrices which contain assumptions about the relative proportion of consumers who would elect a particular lamp (or lamp and ballast) option in response to a standard. These matrices are described in section III.H of this notice, and Chapter 9 of the TSD. DOE invites further comment on the use of 28W, as well as 25W, replacement fluorescent lamps in the analysis and the expected market share these lamps would capture at the various CSLs. DOE intends to continue the dialogue with the public on this issue to better understand the capability of these reduced-wattage fluorescent lamps.

b. Incandescent Reflector Lamps

For IRL, DOE has observed natural efficacy divisions in the marketplace which correspond to the use of halogen capsules, HIR technology, and improved reflector coatings to increase lamp efficacy. DOE considers these efficacy divisions in selecting CSLs by using the efficacy levels of commercially-available lamps as a guide. Commercially-available products do not exist at all of the CSLs for all of the baseline lamps, however. For example, the 75W PAR38 baseline lamp with 1,050 lumens has commercially-available products at all three CSLs, but the 50W PAR30 baseline lamp with 580 lumens only has commercially-available products at one of the three CSLs. Because DOE believes it is technically feasible to incorporate the commercially-available technologies in lamp types that correspond to all of the baseline lamps, and in order to have a continuous range of efficacies to analyze, DOE is developing some model IRL which it bases on lamp lumen packages which are commercially available. In particular, using efficacy information for the commercially-available lamp designs (that are substitutes for certain baseline lamps), DOE is able to develop a relationship of efficacy to wattage. This then allows DOE to develop lamp designs that are not commercially available for certain wattages, but that would be substitutes for other baseline lamps. DOE assumes that lamps of similar diameters may substitute for one another (e.g., PAR38 IRL will be substituted with another PAR38 IRL). Generally, the lamp design substitutes for baseline lamps are based around the lumen output of the baseline lamp, plus or minus 10 percent.

In reviewing published catalog data, DOE observed that higher efficacy, reduced-wattage IRL (which maintain light output within 10 percent) are available as substitutes for a number of baseline lamps. Furthermore, these reduced-wattage designs span a range of design options available for consideration in this rule. These design options, discussed in the screening analysis portion of this notice (section III.B), include the tungsten-halogen regenerative cycle (hereafter ''Halogen'') and halogen infrared technologies (hereafter ''HIR''), a technology that uses both Halogen and glass coatings that reflect infrared light. DOE observed that the commercially-available halogen IRL fall within two tiers of efficacy. To distinguish the efficacies of these halogen IRL, DOE is designating them as Halogen and Improved Halogen. DOE also observes two tiers of efficacy for HIR IRL. To distinguish the efficacies of these IRL, DOE is designating them as HIR and Improved HIR. DOE believes Improved HIR and Improved Halogen can be achieved by using the additional design options discussed in the screening analysis. These design options include higher-efficiency filaments, efficient filament coiling, filament configuration, capsule design, high pressure capsules, or higher efficiency reflector coating. DOE observed lifetime changes across these ''naturally-occurring'' reduced-wattage IRL. (That is, a halogen reduced-wattage IRL typically has a lifetime of around 2,000 to 3,000 hours, whereas an HIR IRL typically lives for 3,000 to 4,000 hours.) DOE has maintained the lifetime attributes of the commercially-available product for its analysis.

In summary, DOE seeks comment on its selection of lamp and lamp-and-ballast designs for GSFL and IRL.

4. Candidate Standard Levels

a. General Service Fluorescent Lamps

Table III.20 and Table III.22 present a summary of the candidate standard levels (CSLs) for each of the representative product classes for the lamps covered under this rulemaking. In general, the CSLs for GSFL (presented in Table III.20) follow a general trend of increasing efficacy through the use of higher-quality phosphors. The CSLs also represent a move from higher-wattage T12 technologies to lower-wattage, higher-efficacy T8 technologies. CSL5 represents the most efficacious fluorescent lamp (i.e., ''max tech''). In all product classes, fluorescent lamps that meet CSL5 are T8 lamps which use 800 series phosphors.

The following paragraph presents a detailed discussion of the design options used to meet each CSL for the 4-foot medium bipin product class. For more information on design options used to meet each CSL for the 8-foot single pin slimline product class and the 8-foot recessed double contact HO product class, refer to Chapter 5 of the TSD.

A standard at CSL1 impacts the two 4-foot medium bipin T12 baseline lamps. Because the baseline T8 lamp is above this efficacy level, consumers using the T8 lamp are not impacted. This CSL can be met with a 34W T12 lamp using 700 series rare earth phosphors or a 40W T12 lamp using improved 700 series or 800 series rare earth phosphors. A standard at CSL2 also only impacts T12 lamps. This CSL can be met by both the 34WT12 and 40W T12 lamp using an 800 series rare earth phosphor. A standard at CSL3 impacts all three baseline lamps. To meet this level, the 32W T8 lamp must use an 800 series rare earth phosphor. The T12 lamps must use an 800 series rare earth phosphor and possibly other design options such as a different gas fill or increased thickness of the bulb-wall phosphor to increase the lamp's efficacy. A standard at CSL4 also impacts all three baseline lamps. However, there are no T12 lamps commercially available that can meet this efficacy requirement. Therefore, users of T12 lamps would be forced to replace their ballasts and operate T8 lamps instead. For the T8 lamps, this level requires the use of higher-efficacy 800 series rare earth phosphor. A 30W T8 lamp that produces an equivalent amount of light as the baseline unit on a similar ballast meets this CSL. CSL5,

[35] This catalog states the following about 25W, 28W, and 30W T8 lamps: ''Operates on: Any Instant Start Ballast; Programmed Start Ballast that supplies equal to or greater than 550 starting voltage.'' Source: Philips Lamp Specification and Application Guide (2006), p. 72.

which also impacts all three baseline lamps, represents the most efficacious 4-foot medium bipin lamps. Again, there are no T12 lamps commercially available that can meet this efficacy requirement. Therefore, users of T12 lamps would be forced to replace their ballasts and operate T8 lamps instead. 32W T8 lamps which meet this efficacy level must use 800 series rare earth phosphor and may incorporate other efficacy improvements to the lamp, such as a different gas fill or increased thickness of the bulb-wall phosphor. A 28W and a 25W T8 lamp that produces an equivalent amount of light on the same ballast as the baseline unit meets this CSL.

Philips commented that there is more than one kind of reference ballast that can be used to test GSFL, and that the same lamp operated on two different ballasts can have a different efficacy. Because a given lamp can exhibit different efficacies based on the testing method use, Philips commented that DOE should use a standard test procedure based on ANSI requirements to develop lamp efficacy values. (Philips, No. 11 at p. 3)

In response, DOE's current test procedure for fluorescent lamps is based on ANSI standards and evaluates the performance of lamps on a single, low-frequency reference ballast. As noted previously, DOE is currently conducting a rulemaking on the test procedures for fluorescent and incandescent lamps in tandem to this energy standards rulemaking. In that rulemaking, DOE is proposing to continue to use low-frequency ballast testing for all GSFL except those which can only be tested on a high-frequency ballast. Further detail on the ANSI standards incorporated by reference that are used to evaluate lamps is available in 10 CFR Part 430, Subpart B, Appendix R and in the Test Procedures NOPR. DOE does note, however, that while it uses the test procedure values to set efficacy levels, it considers the operation of lamps on several different ballast types in the LCC and NIA analyses. This way, the economic evaluation of the CSLs more accurately reflects how users actually operate these lamps.[36] DOE calculated system power data using published catalog information. Further detail on this calculation is available in Chapter 5 of the TSD.

A more detailed discussion on how DOE selected these CSLs for each product class, which technologies they represent, and which design option lamps DOE used at these CSLs for each of the representative units, can be found in Chapter 5 of the TSD.

TABLE III.11.—SUMMARY OF THE CANDIDATE STANDARD LEVELS FOR FLUORESCENT LAMPS WITH CCT ≤ 4,500K

Candidate standard level	4-Foot medium bipin	8-Foot single pin slimline	8-Foot recessed double contact HO
	lm/W	lm/W	lm/W
CSL1	82.4	87.3	83.2
CSL2	85.0	92.0	86.1
CSL3	90.0	94.8	87.6
CSL4	92.3	98.2	91.9
CSL5	95.4	101.5	95.3

b. Incandescent Reflector Lamps

Table III.22 presents the CSLs for IRL. For IRL, the increasing CSLs represent shifts in technology, including shifts from halogen to HIR technology. As the baseline lamps are generally already utilizing halogen technology, CSL1 for IRL is met through improved halogen technologies which are achieved with an improved reflective coating or higher pressure halogen capsules. CSL2 for IRL can be met with HIR technology (i.e., a technology that uses a halogen capsule with an infrared reflective coating.) CSL3 for IRL can be met with improved HIR technologies; this level can be achieved with an HIR lamp that has an improved reflective coating, better HIR coatings or higher pressure halogen capsules.

The CSLs for IRL use an efficacy equation which calculates minimum average efficacy (in lumens per watt) based on the rated wattage of the lamp (denoted by the variable P in the equation). As an example, consider a baseline 50W PAR30 lamp with an efficacy of 11.6 lm/W. The minimum required efficacies of a 50W lamp under the CSLs would be 14.4 lm/W at CSL1, 15.8 lm/W at CSL2, and 17.8 lm/W at CSL3. Plots of these CSLs are presented in Chapter 5 of the TSD.

TABLE III.12.—SUMMARY OF THE CANDIDATE STANDARD LEVELS FOR STANDARD-SPECTRUM IRL

Candidate standard level	Standard-spectrum incandescent reflector lamps
	lm/W
CSL1	$5.0P^{0.27}$
CSL2	$5.5P^{0.27}$
CSL3	$6.2P^{0.27}$

A more detailed discussion on how these CSLs were derived, which technologies they represent, and which design option lamps are used at these CSLs for each of the representative units can be found in Chapter 5 of the TSD.

DOE invites comment on the CSLs for GSFL and IRL.

5. Engineering Analysis Results

The following section presents partial results from the engineering analysis for GSFL and IRL. The results include detail on the characteristics of lamp and lamp-and-ballast designs DOE used in its analyses and the CSL which they meet. The full set of results for the lamps and lamp-and-ballast systems DOE analyzed, including additional product classes and baselines, are available in Chapter 5 and Appendix 5A of the TSD. DOE is presenting the partial results here to facilitate comment on the methodology of DOE's analyses, and on the presentation of its results.

a. General Service Fluorescent Lamps

Engineering analysis results for GSFL include descriptions of the lamp-and-ballast systems DOE selected for the analyses. Because the CSLs are based on lamps, and at some CSLs DOE has analyzed multiple lamps, in some

[36] This approach is similar to other rulemakings where DOE bases product efficacy levels on the test procedure measurements, while design options analyzed in the NIA are adjusted with operating hour data to reflect energy use in the marketplace.

instances DOE presents multiple systems per CSL.

Table III.13 presents the engineering analysis results for a 34W T12 baseline lamp system. Building from the baseline system, the table presents each of the engineering analysis lamp-and-ballast designs DOE used for each of the five CSLs. At each CSL, DOE generally considered both a replacement lamp that had the same wattage as the baseline lamp and operates on a new (lower BF) ballast, and a replacement lamp that had a reduced wattage. This difference between the design lamps considered is evident in the ''rated wattage'' column. Then, for each of those design lamps, DOE provides the rated efficacy, the initial and mean light outputs, and the average operating life of the lamp. The table is sorted by efficacy, such that each lamp represents a higher efficacy, and thus constitutes a more-efficient lamp design in the engineering analysis. The table also presents the type of ballast DOE pairs with each lamp, including the BF for that ballast, the resultant system power rating of the lamp operating on that ballast, and the system initial and the system mean light outputs. The BF was selected so that the new system does not reduce light output by more than 10 percent of the baseline lamp system. The system performance of the more-efficacious lamps is utilized in the LCC, where an economic analysis is conducted to determine whether a more-efficacious lamp or lamp-and-ballast system is cost-justified. For details on the LCC, see section III.G and Chapter 8 of the TSD.

4-Foot T8 lamp and ballast replacements are considered as substitutes for the baseline lamp. The highest energy-saving system uses a 0.88 BF electronic ballast with a reduced-wattage T8 lamp and maintains lumen output within 10 percent. Additional engineering analysis results for GSFL are available in Chapter 5 and Appendix 5A of the TSD.

TABLE III.13.—LAMP-AND-BALLAST REPLACEMENT ENGINEERING ANALYSIS 4-FOOT MEDIUM BIPIN GSFL WITH A CCT ≤ 4,500K

Candidate standard level	Lamp diameter	Nominal wattage	Rated wattage	Rated efficacy	Initial light output	Mean light output	Life	Ballast type	Ballast factor	System power rating	System initial light output	System mean light output
		W	W	lm/W	lm	lm	hr			W	lm	lm
Baseline	T12	34	34	77.9	2,650	2,300	20,000	Magnetic	0.88	108.0	6,996	6,072
Baseline	T12	34	34	77.9	2,650	2,300	20,000	Electronic	0.88	91.7	6,996	6,072
CSL1	T12	34	34	82.4	2,800	2,460	20,000	Electronic	0.88	91.7	7,392	6,494
CSL1	T12	34	34	82.4	2,800	2,460	20,000	Electronic	0.86	90.3	7,224	6,347
CSL2	T12	34	34	85.3	2,900	2,610	20,000	Electronic	0.86	90.3	7,482	6,734
CSL2	T8	32	32.5	86.2	2,800	2,520	20,000	Electronic	0.88	87.5	7,392	6,653
CSL3	T8	32	32.5	90.8	2,950	2,710	20,000	Electronic	0.78	78.5	6,903	6,341
CSL3	T12	34	34	91.2	3,100	2,790	24,000	Electronic	0.86	90.3	7,998	7,198
CSL4	T8	32	32.5	92.3	3,000	2,850	24,000	Electronic	0.75	75.9	6,750	6,413
CSL4	T8	30	30	95	2,850	2,680	18,000	Electronic	0.78	72.4	6,669	6,271
CSL5	T8	32	32.5	95.4	3,100	2,915	24,000	Electronic	0.75	75.9	6,975	6,559
CSL5	T8	28	28	97.3	2,725	2,560	18,000	Electronic	0.78	63.3	6,377	5,990
CSL5	T8	25	25	96	2,400	2,280	24,000	Electronic	0.88	66.8	6,336	6,019

*This table includes the systems DOE analyzed for 3-lamp 34W T12, 4,100K systems. These lamp-and-ballast designs apply to situations where consumers purchase both a lamp and a ballast. Additional results for other baselines and purchasing events are available in Chapter 5 of the TSD.

b. Incandescent Reflector Lamps

Engineering analysis results for IRL describe the baseline lamps DOE selected for the analyses. Table III.14 presents the engineering analysis results for the 75W PAR38 IRL. This baseline lamp and its lamp design substitutes are based around a 1,050 lumen-output lamp. The max-tech option (CSL3) offers a 36 percent improvement in efficacy, with longer life. Additional engineering analysis results are available in Chapter 5 and Appendix 5A of the TSD. Discussion on the CSL efficacy values (derived from observed and extrapolated lamp efficacy values) are also available in Chapter 5 and Appendix 5A of the TSD.

TABLE III.14.—ENGINEERING ANALYSIS FOR STANDARD-SPECTRUM IRL*

Candidate standard level	Design option	Lamp descriptor	Wattage	Initial light output	Efficacy	Lamp lifetime
			W	lm	lm/W	Hr
Baseline	Halogen	PAR38	75	1050	14.0	2,500
CSL1	Improved Halogen	PAR38	66	1050	15.9	3,000
CSL2	HIR	PAR38	60	1050	17.5	3,000
CSL3	Improved HIR	PAR38	55	1050	19.1	4,000

*The results in this table are for 75W PAR38 IRL. Additional results are available in Chapter 5 of the TSD.

6. 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 intends to scale CSLs from those product classes that it analyzed to those product classes that it did not analyze.

a. General Service Fluorescent Lamps

As discussed in section III.C.2, above, DOE did not analyze GSFL with a correlated color temperature (CCT) above 4,500K and 2-foot U-shaped lamps. As discussed in section III.A, the efficacy of lamps with cooler CCTs (i.e., higher CCT values) is lower due to the quality of blue light emitted by lamps with cooler CCT. DOE compared commercially-available T8 lamps at 4,100K and 6,500K, and found that the efficacy of the 6,500K lamps was between 4 and 7 percent lower than that of the 4,100K lamps. In order not to overly penalize current product offered in the market, DOE is considering adopting the larger of the two scaling factors, namely 7 percent, when determining the minimum efficacy requirement for lamps greater than 4,500K. This would mean, for example, that if 82.4 lm/W (i.e., CSL1) were selected for the 4-foot medium bipin product class of 4,500K CCT and below, the scaled minimum efficacy requirement for the product class greater than 4,500K CCT would be 76.6 lm/W. DOE invites comment on this preliminary decision, including other approaches the public suggests, and any mathematical or other technical scaling factors that could be applied.

Similarly, DOE observed that 2-foot U-shaped lamps generally are less efficacious than 4-foot medium bipin lamps due to the bend of a 2-foot U-shaped lamp. This drop in efficacy appears to be dependent on the wattage and diameter of the lamp in question. DOE has observed that 40W T12 2-foot U-shaped lamps are on average 6 percent less efficacious than a 40W T12 medium bipin lamp of the same phosphor series and manufacturer, while 34W T12 or 32W T8 2-foot U-shaped lamps are generally 3 percent less efficacious than the 34W T12 or 32W T8 medium bipin lamp of the same phosphor series and manufacturer. In order not to overly penalize T12 lamps, DOE is considering applying a 6 percent decrease to the CSLs for 4-foot medium bipin lamps for 2-foot U-shaped lamps. DOE invites comment on this preliminary decision, including other approaches, and any mathematical or other technical scaling factors that could be applied.

b. Incandescent Reflector Lamps

DOE has analyzed standard-spectrum lamps in its analysis, but DOE intends to set separate minimum efficacy requirements for standard-spectrum and modified-spectrum IRL, utilizing the approach discussed below. Modified-spectrum IRL filter out portions of the light spectrum emitted by the filament in order to obtain a particular spectral emission. Modified-spectrum lamps achieve their particular spectral emission through either a coating applied to the outer glass of the lamp or through the incorporation of neodymium (or other additives) into the outer glass bulb. Because this filtering of light reduces the lumen output of the lamp, DOE plans to establish a separate minimum efficacy requirement, appropriately scaled, for modified-spectrum lamps. As there is considerable variability in the modification of the spectrum (i.e., with some lamp coatings or glass additives adsorbing more light, others less), DOE plans to scale standard levels based on the degree of spectral modification.

In order to scale appropriately, manufacturers would be required to measure the lumen output of both their modified-spectrum lamp, as well as the lumen output of an equivalent, standard-spectrum reference lamp (i.e., a lamp with equivalent: (1) Rated wattage; (2) rated voltage; (3) gas fill pressure and composition; (4) bulb shape and size; (5) filament type and orientation; (6) finish; and (7) other design features of the modified-spectrum lamp except for the coating or neodymium (or other additives) which produces the modified-spectrum. In order to determine the appropriate minimum efficacy requirement for the modified-spectrum lamp, manufacturers would measure the lumen output of both the modified-spectrum lamp and the equivalent standard-spectrum reference lamp, and 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 minimum efficacy requirement for the standard-spectrum reference lamp. This lumen-output-adjusted minimum efficacy requirement would be scaled appropriately for exactly the coating or neodymium (or other additives) content producing the modified spectrum. In this way, the consumer would be assured that any minimum efficacy standard the Secretary may establish for standard-spectrum lamps would also be incorporated into the covered modified-spectrum lamps. DOE invites comment on this method of establishing a lumen-output-adjusted efficacy requirement, including other approaches, and any mathematical or other scaling factors for modified-spectrum lamps.

Additional detail on the engineering analyses can be found in the Engineering Chapter (Chapter 5) of the TSD.

D. Energy-Use Characterization

The purpose of the energy-use characterization is to estimate the energy consumption of the baseline and higher efficacy lamps and lamp systems considered in this analysis. DOE determines the energy consumption of the lamps and lamp systems through the rated power (i.e., rated in watts) and the way consumers use the lamp (i.e., operating hours per year). This analysis, which is meant to represent typical energy consumption in the field, is an input to both the LCC and PBP analyses and the NIA. The energy-use characterization enables DOE to determine the LCC and the PBP of more-efficacious lamps relative to the baseline lamp.

DOE derives the annual energy consumption of lighting systems by multiplying the power rating by the number of hours of operation per year. The following sections discuss the inputs and calculations DOE used to develop annual operating hours and the energy consumptions for the various lamps and lamp systems considered in this analysis. For more information on the representative classes analyzed for these lamp and lamps systems refer to section III.C.2 of this notice. Comments provided on issues related to the energy-use characterization are also summarized in these sections.

1. Operating Hours

In the Framework Document, DOE sought data on the typical applications and end-use profiles of GSFL and IRL. EEI recommended that DOE take into account the distribution of operating hours (i.e., the number of hours a lamp is in use) by both lamp category and sector. (Public Meeting Transcript, No. 4.5 at pp. 158–159)

DOE structured the analysis in a manner consistent with this comment, developing operating hours by both lamp category and sector. In addition, for the LCC analysis, DOE accounted for variability of operating hours by developing a distribution of operating hours for the LCC spreadsheet. The operating hour distributions capture variation across census divisions, building types, and lamp categories for all sectors. Within the commercial and industrial sectors, the distributions capture variation across ''applications,'' and within the residential sector, the distribution captures variation across ''room types.'' A list of these applications and room types is available in Chapter 6 of the TSD.

EEI and the Northwest Power and Conservation Council (NWPCC) suggested several sources (such as Electric Power Research Institute, New York State Energy Research and Development Authority, California Energy Commission, CalMac, Florida Solar Energy Center) that DOE could use to obtain operating hour distribution data. (Public Meeting Transcript, No. 4.5 at pp. 158–164) NEMA recommended that DOE should use data from the 2002 study, U.S. Lighting Market Characterization Volume I (LMC). (Public Meeting Transcript, No. 4.5 at p. 160; NEMA, No. 8 at p. 3)

After reviewing other data sources, DOE selected the LMC for this analysis because it is the most complete source of operating hour data and because it is generally consistent with other sources. The LMC, which is based on thousands of building audits and surveys, provides national-level data on operating hours by building type and lamp category for all sectors. These operating hours are broken down by application for the commercial and industrial sectors, and room type for the residential sector.

EEI suggested that DOE should update the operating hour distributions to account for lighting controls in the commercial sector (Public Meeting Transcript, No. 4.5 at p. 158). EEI was not specific whether the lighting controls should encompass occupancy sensors, daylight dimming, or demand-responsive dimming systems that are activated during peak demand periods.

While DOE recognizes that there probably are more lighting controls being used today, DOE does not believe the level of penetration is likely to be significantly different from LMC, which was published in 2002. Furthermore, DOE believes the overall national level of penetration of lighting controls at the individual level (i.e., those that would respond to one individual's office) is still relatively low. Finally, DOE is unsure how it would account for lighting controls, as there is uncertainty about which control systems are being recommended and nationally-representative data sources on the impact of lighting controls were not identified. Therefore, DOE has not modified the operating hour data from LMC for the ANOPR. However, DOE invites comment on this issue. In particular, DOE invites comment on the type, prevalence, and operating hour reductions due to lighting controls used separately in the commercial, industrial, and residential sectors.

In conjunction with data from the LMC, DOE used data from the Energy Information Administration's (EIA) CBECS (2003), RECS (2001), and the MECS (2002). These EIA studies provide information on the distribution of buildings within the U.S., by building type and census division. DOE associated the LMC's operating hour data by building type with the EIA's data by building type and census division to derive operating hours by census division. This allowed DOE to correlate the electricity price distribution (see TSD Chapter 8) and sales tax distribution (see TSD Chapter 7) with the operating hour distribution by census division in the LCC spreadsheet. The following describes data sources used to develop operating hours, by sector.

For the residential sector, DOE used RECS building data and LMC residential sector operating hour data. The 2001 RECS data indicate the probability that a certain building type is within a census division. The LMC indicates the occurrence of certain room types within a given building type and the operating hour characteristics of typical lamps in these rooms. By using probabilities derived from RECS, the LCC model selects a building of a certain type and census division. The model then selects a room within that building type using LMC data and presents operating hour data for a typical lamp in that room.

DOE used a similar approach to the one described for the residential sector to develop a distribution of operating hours in the commercial sector. However, in lieu of room type, the model selects operating hours based on application. The 2003 CBECS data indicate the probability a certain building type is located in a certain census division. Once the LCC model selects a building, DOE used the LMC to indicate the probability a lamp is installed in a certain application in that building. The LMC then estimates the operating hour characteristics of a typical lamp for that application. A sample of the diversity of operating hour characteristics can be found in Chapter 6 of the TSD.

To develop a distribution of operating hours in the industrial sector, DOE used an approach similar to that used for the commercial sector. The 2002 MECS data indicate the probability a certain building type exists. Once the model selects a building, DOE uses LMC to ascertain the probability a GSFL or IRL is installed in a certain application in that building. LMC then gives the operating hour characteristics of a typical lamp for that application. Because MECS does not provide the location of industrial sector buildings, DOE used population information from the 2007 census to establish the probability that a certain industrial building exists in a certain census division. Table III.15 summarizes the weighted-average operating hours per lamp category per sector.

DOE has not developed the weighted-average operating hours for GSFL in the residential sector because shipment information and manufacturer interviews indicate that the vast majority of the GSFL market resides in the commercial and industrial sectors. However, if analysis of GSFL in the residential sector were deemed necessary, DOE could use the distribution of operating hours of IRL, as this may approximate the operating hour profile of GSFL in the residential sector. Alternatively, DOE could develop a distribution of operating hours from an alternative data source.

DOE invites comment on the average operating hours for the use of GSFL and IRL in the commercial, residential, and industrial sectors. DOE also invites comment on how DOE should develop an operating hour distribution for GSFL in the residential sector.

TABLE III.15.—AVERAGE OPERATING HOURS BY SECTOR AND LAMP CATEGORY

Sector	Lamp category	Average annual operating hours *hrs/year*
Residential	IRL	884.2
Commercial	GSFL	3435.0
	IRL	3450.0
Industrial	GSFL	4795.1
	IRL	4664.0

2. Results

For GSFL, energy consumption by sector is based on the system power rating derived by DOE and the average annual operating hours of that lamp. As an illustration of how DOE determined energy consumption, Table III.16 and Table III.17 list the system power ratings and annual energy consumption of the 4-foot medium bipin product class. Additional detail on the energy-use characterization of other GSFL can be found in Chapter 6 of the TSD.

TABLE III.16.—FOUR-FOOT MEDIUM BIPIN T8 GSFL 3-LAMP SYSTEM POWER CONSUMPTION RATING AND ANNUAL ENERGY CONSUMPTION

Lamp & ballast designs	System power rating	Annual energy consumption	
		Commercial	Industrial
	W	*kWh*	*kWh*
1.18BF32 Elec[37]	114.5	393.2	548.9
1.18BF25 Elec	93.0	319.5	446.1
1.0BF32 Elec	98.3	337.7	471.4
1.0BF30 Elec	90.2	309.8	432.5
1.0BF28 Elec	80.5	276.5	386.0
0.88BF32 Elec	87.5	300.6	419.7
0.88BF30 Elec	80.5	276.5	386.0
0.88BF28 Elec	71.1	244.2	340.9
0.88BF25 Elec	66.8	229.6	320.5
0.78BF32 Elec	78.5	269.8	376.6
0.78BF30 Elec	72.4	248.8	347.3
0.78BF28 Elec	63.3	217.3	303.3
0.75BF32 Elec	75.9	260.5	363.7

TABLE III.17.—FOUR-FOOT MEDIUM BIPIN T12 GSFL 3-LAMP SYSTEM POWER RATING AND ANNUAL ENERGY CONSUMPTION

Lamp-and-ballast designs	System power rating	Annual energy consumption	
		Commercial	Industrial
	W	*kWh*	*kWh*
0.95BF40 Mag	129.0	443.1	618.6
0.88BF34 Mag	108.0	371.0	517.9
0.88BF40 Elec	107.7	369.8	516.2
0.88BF34 Elec	91.7	314.8	439.5
0.87BF40 Elec	107.0	367.5	512.9
0.86BF40 Elec	90.3	310.2	433.0

Because the lamp system for IRL consists only of the lamp, the system's rate of energy use is simply the rated power of the lamp. Table III.18 details the lamp power rating and annual energy consumption for the 75W PAR38 reference lamp and its lamp designs. Additional detail on the energy-use characterization of IRL can be found in Chapter 6 of the TSD.

TABLE III.18.—IRL POWER RATING AND ANNUAL ENERGY CONSUMPTION, 75PAR38

Technology option	Lamp efficacy	Lamp power rating	Annual energy consumption		
			Commercial	Industrial	Residential
	lm/W	*W*	*kWh*	*kWh*	*kWh*
Baseline	14.0	75.0	258.8	349.8	66.3
CSL1	15.9	66.0	227.7	307.8	58.4
CSL2	17.5	60.0	207.0	279.8	53.1
CSL3	19.1	55.0	189.8	256.5	48.6

E. Product Price Determination

This section explains how DOE developed end-user prices for baseline products as well as higher-efficacy products, and how DOE developed the sales tax figures it used in the analyses. To derive the total, installed end-user cost of products, DOE added sales tax and installation costs, where appropriate, to end-user prices. Please see section III.G for a discussion of installation costs.

1. Introduction and Methodology

a. Overview

In the Framework Document, DOE suggested the approach of deriving end-user prices by applying distributor and contractor mark-ups to manufacturer-selling-price estimates. DOE had

[37] A notation of the form ''1.18BF32Elec'' indicates a lamp-ballast system consisting of a 32W lamp paired with an electronic ballast of a 1.18 ballast factor. ''0.95VF40 Mag'' refers to a lamp-ballast system of a 40W lamp paired with a magnetic ballast of a 0.95 ballast factor.

planned to derive manufacturer selling prices by applying manufacturer mark-ups to the manufacturer costs of production. At the Public Meeting, GE and NEMA commented that manufacturer cost data is proprietary information and is therefore unlikely to be shared by manufacturers. (Public Meeting Transcript, No. 4.5 at pp. 133–135).

As an alternative to deriving manufacturer selling price from manufacturer cost, GE suggested that DOE obtain manufacturer selling prices from distributors, State procurement contracts and other publicly-available information sources. GE further recommended that if DOE seeks to derive manufacturer costs, DOE could work backwards through the distribution chain from the publicly-available product list prices. (Public Meeting Transcript, No. 4.5 at p. 133) ACEEE and several stakeholders supported the same methodology recommended by GE. (NEMA, No. 8 at p. 3, Public Meeting Transcript, No. 4.5, p. 129 and p. 136; Joint Comment, No. 9 at p. 3).

As suggested by stakeholders, DOE obtained manufacturer's published end-user price schedules for lamps (hereafter called the manufacturer's ''blue book'' or ''lamp price schedules'') as well as information on discounts applied to those price schedules from distributors, State contracts, and other publicly-available information sources. In addition, DOE also obtained information on distributor pricing (i.e., what a distributor would pay) for commercial, industrial, and institutional consumers of lamps. Thus, in response to comments on the Framework Document, and due to the availability of pricing information, DOE revised its approach for developing lamp prices from what was presented in the Framework Document.

Starting from a consistent set of prices in the blue books, DOE looked at publicly-available prices in State procurement contracts, at large electrical supply distributors, home-improvement/hardware stores, and other sources of publicly-available end-user prices, such as Internet retailers. In its review of publicly-available market prices, DOE observed a range of end-user prices paid for a given lamp, depending on the distribution channel through which it is purchased and the volume at which it is purchased. DOE observed that State procurement contracts typically negotiated a discount of around 70 to 90 percent off the blue book. In the vast majority of instances, these discounts apply uniformly to all products on a price schedule irrespective of the volume of a particular lamp.

Internet retailers, electrical supply distributors, and home-improvement/hardware stores generally reflected prices paid by consumers in the medium-to-high range of prices. Furthermore, these channels usually apply different discounts to lamps depending on their sales volume. Since many high-efficacy lamps are ''niche'' products, DOE observed that they were generally less discounted than commodity lamps.

ACEEE commented that State procurement contracts represent prices with low mark-ups. (Public Meeting Transcript, No. 4.5 at pp. 129–130) GE and the Joint Comment stated that mark-ups vary by volume, with GE stating that higher volume lamps have lower mark-ups and lower volume lamps have higher mark-ups. (Public Meeting Transcript, No. 4.5 at p. 133; Joint Comment, No. 9 at p. 3).

In response to comments and in line with its observations of public pricing, DOE developed three sets of discounts from the blue books, representing the range of low, medium, and high lamp prices for GSFL and IRL. For IRL, commercially-available products did not span the full range of efficacies considered. For those lamps where commercial pricing was not available, DOE extrapolated pricing from available lamps. The development of the low, medium, and high prices specific to each lamp category is described below in subsection III.E.1.b.

Several stakeholders commented that the manufacturer costs DOE derives should reflect the production of commodity-type products. (Joint Comment, No. 9 at pp. 2–3). To reflect future commoditization of higher-efficacy lamps when they become the minimum complying products, the discounts DOE applied to blue books to derive the low, medium, and high prices are a constant markdown across all lamps. (Baseline incandescent lamps received a slightly larger discount, as reflected in State procurement contracts.) DOE also accounted for the future commoditization of high-efficacy residential IRL by using the incremental pricing of PAR 38 IRL. In particular, DOE notes that the market for high-efficacy PAR 38 IRL is well developed in comparison to the high-efficacy PAR 30 IRL market. Furthermore, DOE notes that the products themselves use the same fundamental technologies. Although DOE did not estimate manufacturer costs directly, DOE notes that the use of a single markdown across efficacies and types of PAR 38 IRL and the use of PAR38 IRL incremental pricing for PAR30 IRL accounts for commoditization of high-efficacy products.

Once DOE calculated end-user prices, DOE added sales tax and, if appropriate, installation costs to derive the total, installed end-user cost. Please see section III.G for a discussion of installation costs. For the reference case in the LCC, DOE used the medium lamp prices, but it also conducted analysis at the low and high lamp prices, to ascertain the impact of these other price points (see TSD Chapter 8). In the NIA, DOE used only the medium prices in that analysis because this price best represents the average purchase price for a variety of consumers nationwide (see TSD Chapter 10). DOE also developed a single average end-user price for the new and replacement ballasts used, to which it added sales tax and installation costs. DOE requests comment on the approach to developing end-user prices for GSFL and IRL considered in this rulemaking.

b. General Service Fluorescent Lamps

To develop low-range prices for GSFL, DOE calculated a discount off the blue book consistent with prices found in State procurement contracts. DOE mirrored the procurement discount schedule by using a constant discount across lamp efficacies. As noted above, DOE believes that using this discount schedule is appropriate for the rulemaking analyses, as it reflects currently-available pricing and because it takes into account commoditization of standard-compliant lamps. Consistent with State procurement contracts, DOE assumed that these low-range prices include a distributor mark-up but no contractor mark-up. As such, this is truly a lower bound of pricing which assumes the most favorable conditions.

For medium-range prices, DOE took a discount off the blue book that is consistent with the distributor pricing it received and that represents a typical discount for commercial institutions on high-volume (commodity) lamps. Again, DOE used a single discount across efficacies. DOE added a contractor mark-up of 13 percent so that the resulting price would encompass both a contractor and distributor mark-up. DOE obtained this contractor mark-up estimate from the 2000 Ballast Rule.[38]

[38] 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 (Jan. 2000). Available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/gs_fluorescent_0100_r.html*.

For the high-range prices, DOE deduced discounts on commodity lamps from blue book prices for small quantity purchasers by observing high-range pricing and obtaining distributor quotes. These prices also encompass both a contractor and a distributor mark-up. DOE was able to obtain data on actual prices for all GSFL it considered in the analyses.

For the replacement ballasts considered in the analysis, DOE gathered prices from publicly-available manufacturer price schedules and applied a uniform discount that is customary for pricing to large customers. All ballast prices represent contractor net price plus contractor mark-up for ballasts purchased from a distributor. DOE computed a simple average end-user price by applying a 50-percent mark-up above the lowest price paid in large multi-year State procurement contracts. Based on conversations with industry experts, DOE believes these prices are representative of average end-user sales prices. DOE was able to obtain data on actual prices for ballasts it considered in the analyses.

c. Incandescent Reflector Lamps

For IRL, DOE modeled PAR30 and PAR38 IRL. DOE calculated the low-range price for PAR38 IRL as it did for GSFL given their large range of higher-efficacy products commercially available. Specifically, DOE compared State procurement contracts to blue books to develop an average discount. Again, DOE mirrored State contract pricing by following the discount schedule used in State contracts. For the medium-range price, DOE took a discount off the blue book to represent shipment weighted-average prices paid by consumers for commonly available lamps. For the high-range prices, DOE took a discount off the blue book that represents prices that are higher-than-average but in line with observed high-range pricing. This medium-range price is equidistant from the low-range and high-range prices.

For PAR30 IRL, DOE used a slight variation to the methodology followed for GSFL and PAR38 IRL. In particular, to develop the PAR30 baseline lamp price, DOE used the price differential between an incandescent (non-halogen) BR40 lamp and halogen PAR38 lamp. DOE added this price differential to a incandescent (non-halogen) BR30 lamp price to obtain the baseline halogen PAR30 lamp price. By developing prices for the baseline lamps from the incandescent replacement lamps (BR30 and BR40 lamps), DOE is recognizing that the high-volume product currently being shipped may be a lower-efficacy (non-halogen) incandescent lamp.[39] Therefore, basing prices off of this lamp will most accurately represent the commoditization of the halogen PAR30 by 2012 (the effective date of the amended standard). Similarly for higher-efficacy lamp designs, DOE developed a list price to discount from based on the incremental blue book prices of PAR38 IRL. As such, DOE added the incremental end-user blue book price of PAR38 lamps to the baseline PAR30 lamp price to derive higher-efficacy PAR30 lamp list prices. DOE chose this methodology for PAR30 IRL because for PAR30 lamps, two of the standards-compliant lamps were not commercially available. In addition, PAR30 lamps use the same fundamental technologies as PAR38 lamps, which serve a more developed market.

2. End-User Price Results

The following section presents partial results from the product price determination. The tables summarize the end-user prices DOE developed through the product price determination. (The figures in the tables do not include tax or installation costs). They follow in order of lamp category. Additional results for the product price determination are available in Chapter 7 of the TSD.

a. General Service Fluorescent Lamps

Table III.19 lists the low, medium, and high end-user prices DOE used for the 4-foot medium bipin T12 GSFL considered in the analyses. Results for 4-foot medium bipin T8 GSFL and 8-foot GSFL are available in Chapter 7 of the TSD. In reviewing market prices, DOE observed that prices generally increased with increasing efficacy. However, other lamp characteristics such as lifetime, wattage, and CRI likely also affected price, but these variables cannot be completely isolated. To the extent feasible, DOE considered non-efficacy characteristics that affect installed or operating costs in the LCC.

TABLE III.19.—END-USER PRICES FOR 4-FOOT MEDIUM BIPIN GSFL*

CSL	Lamp efficacy *lm/W*	Lamp power *W*	Lamp lifetime *hr*	CRI	Mean lamp light output *lm*	Low price *$*	Medium price *$*	High price *$*
T12 40W Baseline	80.0	40	20,000	70	2,880	1.41	2.35	3.28
T12 34W Baseline	77.9	34	20,000	62	2,300	0.89	1.49	2.09
1	82.5	40	20,000	80	3,000	2.64	4.41	6.17
1	82.4	34	20,000	70	2,460	1.58	2.64	3.70
2	85.0	40	24,000	80	3,060	3.51	5.86	8.20
2	85.3	34	20,000	80	2,610	2.90	4.83	6.76
3	90.0	40	24,000	85	3,250	3.57	5.95	8.33
3	91.2	34	24,000	85	2,790	3.50	5.83	8.16

*This table presents results for T12 4-foot medium bipin GSFL. Results for additional product classes, and T8 4-foot medium bipin GSFL are available in Chapter 7 of the TSD.

As noted above, DOE derived one end-user price for the GSFL ballasts it considered in the analysis. DOE did not develop end-user prices for magnetic ballasts operating with 4-foot medium bipin lamps (rapid start magnetic ballasts), 8-foot single pin slimline lamps (instant start magnetic ballasts), and 8-foot recessed double contact high output lamps (rapid start magnetic ballasts). This is because the LCC and NIA analyses do not model any purchases of these ballasts after 2012. The energy conservation standards set by the 2000 Ballast Rule and the EPACT 2005, Pub. L. 109–58, are effective for all covered ballasts in 2010. These standards ban the sale of magnetic 4-

[39] Although currently the BR40 non-halogen IRL may be the higher-volume product, DOE expects that, with the prescription of energy conservation standards for certain ER and BR lamps by EISA 2007, by 2012 (the effective date of this rulemaking's amended standards) the PAR30 halogen baseline lamp price will reflect the effects of further commoditization.

foot medium bipin and 8-foot single pin slimline ballasts. In addition, DOE believes that sales of magnetic ballasts that operate 8-foot recessed double contact high output lamps will be minimal after 2012. Again, for all of these reasons, DOE did not consider magnetic ballasts in either the LCC or NIA analyses.

In its review of market prices for ballasts, DOE observed that prices tended to be constant within two groupings of BFs: (1) Low and normal BFs (a BF typically under 1.0); and (2) high BFs (a BF typically over 1.0). Table III.20 presents end-user prices for ballasts used in the LCC and NIA analysis.

TABLE III.20.—END-USER PRICES FOR INSTANT START ELECTRONIC FLUORESCENT LAMP BALLASTS

Lamp type	Ballast factor range		Ballast price
4-foot T8 Medium Bipin	Normal and Low BF	0.75–0.88	$18.31
4-foot T8 Medium Bipin	High BF	1.0–1.18	25.49
4-foot T12 Medium Bipin	Normal BF	0.86–0.88	24.36
8-foot T8 Single Pin Slimline	Normal and Low BF	0.78–0.88	25.86
8-foot T8 Single Pin Slimline	High BF	1.18	47.51
8-foot T12 Single Pin Slimline	Normal BF	0.85–0.88	24.73
8-foot T8 Recessed Double Contact HO	Normal BF	0.81–0.88	48.17
8-foot T12 Recessed Double Contact HO	Normal BF	0.88–0.90	30.40

b. Incandescent Reflector Lamps

For IRL, within the range of lamp wattages analyzed, DOE observed that lamp price did not vary significantly by wattage. As a result, DOE did not vary price by wattage in its analysis. However, DOE did observe price differentials between larger- and smaller-diameter IRL and, therefore, analyzed the two lamp shapes (PAR38 and PAR30) separately. Table III.21 presents the end-user price results for PAR38 IRL. Results for the PAR30 IRL are available in Chapter 7 of the TSD.

TABLE III.21.—END-USER PRICES FOR PAR38 IRL

Lamp type	Lamp shape	CSL	Lamp lifetime *hr*	Low price *$*	Medium price *$*	High price *$*
Halogen	PAR38	Baseline	2,500	3.20	4.80	6.40
Improved Halogen	PAR38	1	3,000	4.07	6.10	8.13
HIR	PAR38	2	3,000	4.18	6.26	8.35
Improved HIR	PAR38	3	4,000	5.00	7.50	10.00

DOE requests feedback on its approach to developing lamp or lamp-and-ballast prices for GSFL and IRL. Furthermore, DOE requests comment on its end-user prices results for fluorescent lamp ballasts.

3. Sales Taxes

The sales tax figure represents State and local sales taxes that are applied to the consumer product price. It is a multiplicative factor that increases the consumer product price. DOE derived State and local taxes from data provided by the Sales Tax Clearinghouse.[40] These data represent weighted averages that include county and city rates. DOE then derived population-weighted average tax values for each Census division and large State. The distribution of sales tax rates ranges from a minimum of 0 percent to a maximum of 9.4 percent, with a weighted-average value of 6.9 percent.

[40] Sales Tax Clearinghouse, Aggregate State Tax Rates (2007). Available at: *http://thestc.com/STrates.stm*. Specifically, DOE utilized the relevant material from this website as posted on May 25, 2007; that material is available in Docket #EE–2006–STD–0131.

Additional detail on the derivation of the product prices used in this analysis can be found in Chapter 7 of the TSD, product price determination.

F. Rebuttable Presumption Payback Periods

A more energy-efficient device will usually cost more to purchase than a device of standard energy efficiency. However, the more-efficient device will usually cost less to operate due to reductions in operating costs (i.e., lower energy bills). The payback period (PBP) is the time (usually expressed in years) it takes to recover the additional installed cost of the more-efficient device through energy cost savings. Section 325(o)(2)(B)(iii) of EPCA establishes a rebuttable presumption that a standard for GSFL or IRL is economically justified if the Secretary finds that ''the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy * * * savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure * * *.'' (42 U.S.C. 6295(o)(2)(B)(iii)) This rebuttable presumption test is an alternative path to establishing economic justification, as compared to consideration of the seven factors set forth in 42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII).

DOE's lamp test procedures measure the rate of light output per unit power consumption of a lamp (i.e., lumens per watt) rather than a measurement of energy consumption (i.e., a measurement over a duration or operating time period). Therefore, in order to calculate energy savings for the rebuttable presumption payback period, one would need to multiply the rate of power consumption of a lamp times the usage profile of that lamp. For IRL, energy savings calculations in the LCC and PBP analyses use both the relevant test procedures as well as the relevant usage profile. Because DOE calculates payback periods using a methodology consistent with the rebuttable presumption test for IRL in the LCC and payback period analysis, DOE is not performing a stand-alone rebuttable presumption analysis for IRL, as it is already embodied in the LCC and PBP analyses. For GSFL, DOE believes that the rate of energy consumption of the lamp-and-ballast system is a more accurate measure of real world power consumption than the rate of power consumption of the lamp as measured on a reference ballast, as specified in the test procedure.[41] Because calculations of energy savings in the LCC are based on real-world conditions, DOE will also rely on payback periods calculated in the LCC for GSFL. See section III.G of this notice or Chapter 8 of the TSD for further detail on the LCC and payback period calculation.

G. Life-Cycle Cost and Payback Period Analyses

The life-cycle cost (LCC) and payback period (PBP) analyses determine the economic impact of potential standards on consumers. The effects of standards on individual or commercial consumers include changes in operating expenses (usually lower) and changes in total installed cost (usually higher). DOE analyzed the net effect of these changes GSFL and IRL first by calculating the changes in consumers' LCCs likely to result from CSLs as compared to a base case (no new standards). The LCC calculation considers 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. DOE performed the LCC analysis from the perspective of the consumer of a lamp.

DOE also analyzed the effect of changes in operating expenses and installed costs by calculating the PBP of potential standards relative to a base case. The PBP estimates the amount of time it would take the individual or commercial consumer to recover the assumed higher purchase expense of more energy efficient product through lower operating costs. The PBP is based on the total installed cost and the operating expenses, the same approach used in calculating the LCC. However, unlike in the LCC analysis, DOE considers only the first-year operating expenses in the calculation of the PBP. Because the PBP does not account for changes in operating expense over time or the time value of money, it is also referred to as a simple PBP. Usually the consumer benefits of a regulation exceed the consumer costs of that regulation if the service life of the covered product is substantially longer than the PBP.

The following discussion provides an overview of the approach and inputs for the LCC and PBP analyses performed by DOE, as well as a summary of the preliminary results generated for the lamps under consideration in this rulemaking. However, for a more detailed discussion on the LCC and PBP analyses please refer to Chapter 8 of the ANOPR TSD.

1. Approach

The LCC analysis estimates the impact on consumers of potential energy conservation standards by calculating the net cost of a lamp (or lamp-ballast system) under two scenarios: (1) A ''base case'' of no new standard; and (2) a ''standards case'' under which lamps must comply with a new energy efficiency standard. The first step in calculating the LCC is specifying the installed costs associated with each design, which includes the lamp (or lamp-and-ballast system) price, sales taxes, and any installation cost. (The development of total installed costs is explained more fully in sections III.E of this notice and Chapters 7 and 8 of the TSD.) After developing the installed costs, DOE used operating hour data and electricity price data to develop operating costs of the base-case and standards-case lamps over the analysis period. (The development of operating costs is explained in section III.D.1. of this notice and Chapters 6 and 8 of the TSD.)

DOE calculated the LCC value for each design and each customer using a discount rate that represents the average cost of capital for that customer. After repeating the calculation for many customers and many designs,[42] DOE calculated the distribution of net LCC impacts of each design. A distinct advantage of this approach is that DOE can identify the proportion of lamp installations achieving LCC savings or attaining certain payback values due to a new energy conservation standard, in addition to the average LCC savings or average payback for that standard. Refer to Chapter 8 of the ANOPR TSD for detailed discussion of the LCC analysis method.

During the Public Meeting on the Framework Document, DOE stated its intention to use Monte Carlo analysis in the LCC to consider end-user variability and conduct sensitivity analyses. Reinforcing this decision, stakeholders commented that conducting such analyses using a Monte Carlo approach would provide useful information on the number of purchasers who benefit from or are disadvantaged by the standard, and by how much. (Joint Comment, No. 9 at p. 4) Accordingly, DOE has incorporated in its LCC and PBP spreadsheet model both Monte Carlo simulation and probability distributions by using Microsoft Excel spreadsheets with Crystal Ball (a commercially-available add-in program). DOE's Monte Carlo simulation considers variability in electricity prices, sales taxes, operating hours, and discount rates. See section III.G.2 for a discussion of LCC inputs. For a detailed discussion on the average annual energy use of lamps and the methodology used to calculate the distribution of annual energy use, please refer to section III.D of this ANOPR and Chapter 6 of the TSD.

In order to accurately compare the life cycle cost of two different products, one must evaluate the life cycle cost of each product over the same fixed period of time (i.e., the analysis period). For the life-cycle cost analysis, the analysis period is the lifetime of the covered product. For most covered products that DOE analyzes, the lifetimes of the more efficient products are the same as the lifetimes of baseline products being analyzed. For this rulemaking, given the unequal lifetimes of the baseline and higher efficacy lamp designs, DOE has chosen to establish its analysis period on the lifetime of the baseline lamp. In situations where a lamp lifetime is shorter than the analysis period, DOE assumes that the lamp is replaced during the analysis period. To account for any remaining lifetime at the end of the analysis period, DOE calculates a ''residual value'' for that lamp.[43]

$$RV = IC \cdot \left\{ \frac{SL - \left[P_{Analysis} - (n \cdot SL) \right]}{SL} \right\}$$

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

[41] For example, T8 lamps which are often operated on high-frequency electronic ballasts would be tested and measured on a line-frequency (60 Hz) reference ballast using DOE's test procedure, resulting in different performance characteristics than this lamp would exhibit in the field, operated on an electronic ballast.

[42] For each design, DOE calculated the LCC results for 1,000 consumers using Monte Carlo simulations. These results are presented in Appendix 8B of the TSD.

[43] The ''residual value'' represents the remaining value of a lamp or a ballast from the end of the period of analysis to the end of the service life of the lamp or ballast. The equation for residual value is as follows: (see equation above)

Where IC = total installed cost of the product, n = the number of replacements within the analysis period, SL = the service life of the product, and $P_{Analysis}$ = the analysis period.

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.[44] More information discussing the residual value is given in Chapter 8 of the TSD.

ACEEE commented that a residual value calculation or a 50-year analysis period would yield similar results. (Public Meeting Transcript, No. 4.5 at p. 188) DOE agrees that using a long analysis period, such as 50 years, and discounting cash flows would normalize for differences in lifetimes of different lamps. However, the statute explicitly directs DOE to consider the increased first costs and operating cost savings over ''the estimated average life of the covered product.'' (42 U.S.C. 6295(o)(2)(B)(i)(II)) The life-cycle costs over a 50 year analysis period would be significantly larger than those over a typical lamp lifetime. For this reason, DOE believes that the residual value approach is more consistent with the statute and with the concept of life-cycle costing, and elected to use the lifetime of the baseline lamp as the period of analysis. DOE invites comment on its usage of residual values in the life-cycle cost analysis as well as any other possible approaches to calculating life-cycle costs for products with different lifetimes.

2. Life-Cycle Cost Inputs

For each efficacy level analyzed, the LCC analysis requires input data for the total installed cost of the product, the operating cost, and the discount rate. Table III.22 summarizes the inputs and key assumptions DOE used to calculate the consumer economic impacts of various energy efficacy levels for each product. A more detailed discussion of the inputs follows.

TABLE III.22.—SUMMARY OF INPUTS AND KEY ASSUMPTIONS USED IN THE LCC ANALYSES

Input	Description
Consumer Equipment Price	As discussed in section III.E, DOE started with manufacturer catalog (''blue-book'') pricing, and used different discounts to represent low, medium, and high prices for all lamp categories.
Sales tax	Sales tax is then applied to convert the consumer equipment price to a final consumer price including sales tax. The sales tax mark-up is described in detail in section III.E.
Installation cost	This input represents the cost to the commercial or industrial customers of installing the lamps or lamp systems. The installation price represents all costs required to install the lamp or lamp system but does not include the customer equipment price. The installation price includes labor and overhead. Thus, the total installed cost equals the consumer equipment price including sales tax plus the installation price.
Annual operating hours	The annual operating hours are the estimated hours that a lamp is in use during the time span of one year. Section III.D, Energy-Use Characterization, details how DOE determined the lamp operating hours as a function of end-user sector, geographic region, and application.
Product energy consumption rate	The product energy consumption is the site-energy usage rate associated with operating the lamp system. Section III.D, Energy-Use Characterization, details how DOE determined the product energy consumption rate.
Electricity prices	Electricity prices used in the analysis are the average price per kilowatt-hour (i.e., $/kWh) paid by customers. DOE determined electricity prices using national average residential, commercial, and industrial electricity prices for the sample calculation, while for the Monte Carlo distribution, DOE used average residential, commercial, and industrial values for 13 regions and large States. All electricity price data are obtained from the EIA, 2005.
Electricity price trends	DOE used the EIA's *AEO2007*[45] to forecast electricity prices. For the results presented in this notice, DOE used the *AEO2007* reference case to forecast future electricity prices.
Lifetime	The total hours in operation after which the consumer retires the lamp or components of a lamp system from service.
Discount rate	The discount rate is the rate at which DOE discounts future expenditures to establish their present value.
Analysis Period	Analysis period is the time span over which DOE calculated the LCC.

a. Total Installed Cost Inputs

The following sections describe the total installed cost inputs. As described previously, to account for variability in pricing, DOE estimated three product prices per lamp design, which correspond to variation in purchasing power. DOE applied sales tax to each product price to create a set of end-user prices for these system components.

The installation cost represents all costs associated with installing the lamp or lamp-and-ballast system, other than the end-user lamp price. Thus, the total installed cost equals the consumer lamp price (which includes mark-ups and taxes) plus the installation cost. In its Framework Document, DOE noted that installation costs are negligible for the residential sector but important in the commercial and industrial sectors. NEMA commented that there are generally no repair or maintenance costs for incandescent lamps, but only installation costs. (Public Meeting Transcript, No. 4.5 at p. 174; NEMA, No. 8 at p. 3)

DOE is aware that installation costs for incandescent lamps are applicable by sector and not by lamp type. For example, consumers in the residential sector typically do not incur installation costs, as these consumers typically change their own lamps. Therefore, for IRL analyzed in the residential sector, DOE assumed no installation costs. Rather, the cost the user pays is simply that of the product. Purchasers in the commercial and industrial sectors, on the other hand, do incur installation costs because they usually employ a maintenance worker to install their incandescent lamps. Therefore, DOE applied installation costs for IRL analyzed in the commercial and industrial sectors.

DOE stated in the Framework Document that it would consider installation costs but not maintenance costs in its analysis. According to NEMA, installation costs are important

[44] National Institute of Standards and Technology Handbook 135, 1996 Edition, 210 pages (Feb. 1996), p. 4–6.

[45] 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.*

for fluorescent lamps, but there are also some maintenance costs. (Public Meeting Transcript, No. 4.5 at p. 174) DOE presumes that the maintenance costs to which NEMA referred are the costs of re-lamping a lighting system (i.e., replacing the lamp in a lighting system at end of lamp life). For GSFL, DOE assumed installation costs for lamp-and-ballast systems, and re-lamping costs for lamps.

DOE requested comment in the Framework Document on whether it should consider group and spot re-lamping practices in its analysis of installation costs. NEMA commented that, for GSFL, a small percentage of fluorescent lamps are group re-lamped rather than spot re-lamped. (Public Meeting Transcript, No. 4.5 at pp. 174–176; NEMA, No. 8 at p. 3) GE commented that group re-lamping should not be considered for incandescent or incandescent reflector lamps, but could be considered for fluorescent lamps; however, GE did not provide further explanation for its opinion. (Public Meeting Transcript, No. 4.5 at pp. 176–177)

The approach DOE is following for the ANOPR is consistent with these comments. For GSFL, DOE obtained estimates of the prevalence of group versus spot re-lamping from the 2000 Ballast Rule. DOE then weighted the spot and group re-lamping times by the percent occurrence of spot versus group re-lamping to derive weighted-averaged re-lamping times. To account for installation costs for IRL in the commercial sector, DOE used re-lamping time estimates from the *RS Means Electrical Cost Data, 2007* [46] (hereafter ''RS Means'').

For ballasts, DOE derived labor rates for electricians and helpers from RS Means. Labor rates are the sum of the wage rate, employer-paid fringe benefits (i.e., vacation pay, employer-paid health, and welfare costs), and any appropriate training and industry advancement funds costs. DOE assumed that the labor rate for installing a ballast is a composite that equals 50 percent of the electrician labor rate plus 50 percent of the electrician-helper labor rate. For re-lamping (only lamp replacement), DOE assumed that the task was performed by a general maintenance worker at a labor rate DOE obtained from the U.S. Bureau of Labor Statistics for a General Maintenance worker.[47]

Using these labor rates and labor times, DOE derived the average cost to install a lamp and the average cost to install a lamp and ballast.

DOE recognizes that labor times for replacing a ballast may change because of changes in the 2005 National Electric Code.[48] Specifically, the addition of Part XIII, Section 410.73(G) to the 2005 National Electric Code requires a means for disconnecting luminaires installed in an indoor location so that electrical contractors will not work on energized equipment while replacing or servicing ballasts. This change applies to both commercial and industrial installations.[49] This requirement goes into effect January 1, 2008, and it is expected to significantly increase the labor time required for ballast installations. Therefore, DOE is requesting comment on how labor times and related installation costs for ballasts will be affected by this change in the National Electric Code.

Additional details on the development of installation costs can be found in Chapter 8 of the ANOPR TSD.

b. Operating Cost, Replacement Cost, and Residual Value Inputs

The following sections describe additional inputs used in calculating the LCC. These include inputs used to develop operating costs, replacement costs, and residual values. The operating cost of a lamp system is a function of the annual energy consumption, energy cost, repair and maintenance costs, analysis period, and the discount rate. Annual energy consumption is the site-energy use (i.e., electricity use) associated with operating a lamp or lamp-and-ballast system. The inputs for estimating annual energy consumption are discussed in section III.D of this ANOPR. Electricity prices are the prices paid by consumers for electricity. DOE used electricity price trends to forecast electricity prices into the future. Multiplying the annual energy consumption by the electricity prices yields the annual energy cost. Because DOE assumed no repair or maintenance costs, costs associated with repairing or replacing components that have failed, the only operating costs associated with lamps are energy costs. The analysis period is the time span over which the LCC is calculated. For the purpose of this rulemaking, DOE based the analysis period on the baseline lamp's service lifetime (i.e., the lamp's operating lifetime in hours divided by annual operating hours). The discount rate is the rate at which DOE discounted future expenditures to establish their present value. The replacement cost (i.e., the costs associated with a lamp replacement) is dependent on the installed cost, discount rate, analysis period, and service life. The product service life is the age at which the product is retired from service. The residual value (also dependent on the four inputs used to develop replacement costs) is the discounted total installed cost of a lamp (or lamp and ballast) multiplied by the percentage of remaining life for that lamp (or lamp and ballast) past the analysis period.

i. Electricity Prices

With regard to electricity prices, DOE derived 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. For Census divisions containing one of these large States, DOE calculated the regional average values leaving out data for the large State—for example, the Pacific region average does not include California, and the West South Central region does not include Texas.

DOE estimated residential, industrial, and commercial electricity prices for each of the 13 geographic areas based on data garnered from EIA Form 861, Annual Electric Power Industry Report. DOE's calculation methodology uses the most recently available EIA data (2005). For further details of the methodology that DOE used for deriving energy prices, see Chapter 8 of the ANOPR TSD.

DOE stated in the Framework Document that it would use price forecasts by the EIA to estimate the trends in electricity prices. In response, ACEEE and the Joint Comment argued that current EIA energy price forecasts are too low and will likely be revised upwards over the next few years. (Joint Comment, No. 9 at p. 3; Public Meeting Transcript, No. 4.5 at p. 216) Therefore, the Joint Comment requested that DOE use the latest available price forecasts from EIA to conduct the analyses. (Joint Comment, No. 9 at p. 3) Taking into account these comments, DOE used EIA's AEO2007, containing the latest available price forecasts from EIA to estimate future energy prices. For the analyses to be conducted for the NOPR and Final Rule, DOE intends to update its energy price forecasts to be based on the latest available version of AEO.

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

[47] U.S. Department of Labor Bureau of Labor Statistics. Occupational Employment and Wage Estimates. National Cross-Industry Estimates (May 2005). Available at: *http://www.bls.gov/oes/oes_dl.htm*.

[48] National Fire Protection Association, *National Electric Code 2005*. CENGAGE Delmar Learning: 2004.

[49] Ode, Mark C., ''Unplugging Fluorescents,'' Electrical Contractor (July 2005). Available at: *www.ul.com/regulators/ode/0705.pdf*.

DOE did not explicitly discuss demand charges[50] in the Framework Document, but stakeholders identified this as an issue and submitted comments. For example, ACEEE commented that DOE should consider demand charges in its electricity pricing rather than averaging prices because lighting tends to be ''peakier'' than the average use. (Public Meeting Transcript, No. 4.5 at pp. 169–171) PG&E commented that DOE should account for the marginal consumer cost of electricity in its analysis and that the marginal cost of electricity is significantly different than the average cost of electricity in certain regions (Public Meeting Transcript, No. 4.5 at pp. 215) PG&E also commented that in addition to using a single average price, DOE should look at a range of electricity prices. EEI commented that separating out demand charges could lead to similar results, except, possibly, for the residential sector. (Public Meeting Transcript, No. 4.5 at pp. 172 and 215) The Joint Comment stated that utility rate structures have been changing over time, and it recommended that DOE conduct a sensitivity analysis to evaluate whether changes in pricing structure would significantly impact the rulemaking analyses. The Joint Comment also suggested that DOE should consider basic electricity tariff evolutions in the structure of the LCC and NIA, if the sensitivity analysis shows that expected changes to electricity price structures are influential. (Joint Comment, No. 9 at p. 4)

DOE notes that in the analysis performed for the fluorescent ballast rulemaking, DOE found that the reduction in ballast energy consumption results in a correspondingly lower reduction in peak power. In other words, the lighting load improves a building's load profile. Thus, the marginal rate of electricity for lighting was found to be slightly lower than the average utility rate. In relative terms, DOE assumed in the ballast rulemaking that the demand reduction was 80 percent of the energy savings. For the case study analyzed in the ballast rule, a 5-percent energy savings resulted in a 4-percent demand reduction of the peak kW, and at the consumption weighted mean of the differences, the electricity marginal prices were found to be 5.2 percent lower than average prices.[51]

Consistent with a number of other current DOE rulemakings, DOE has tentatively decided to use average regional electricity prices for its analyses. DOE believes that using average regional EIA prices would not underestimate operating cost savings. In addition, the approach will include the regional variations in energy prices, while reducing analytical complexity.

In addition to accounting for regional variability, DOE also addressed future variability by incorporating three separate projections from AEO2007 into the spreadsheet models for calculating LCC and PBP: (1) Reference; (2) low economic growth; and (3) high economic growth. These three cases reflect the uncertainty of economic growth in the forecast period (from 2005 to 2030). The high- and low-growth cases show the projected effects of alternative growth assumptions on energy markets. The development and use of regional average electricity prices are described below and in more detail in Chapter 8 of the TSD.

ii. Lamp Lifetime

With regard to lamp lifetime, DOE stated in the Framework Document that it would consider published catalog data, as well as literature sources and inputs from manufacturers and other stakeholders in its analysis. GE and NEMA commented that DOE should use published catalog data for lamp lifetimes. (Public Meeting Transcript, No. 4.5 at p. 176; NEMA, No. 8 at p. 3) In response, DOE did use published manufacturer literature for lamp lifetimes, where available. However, for some IRL, published manufacturer literature on lamp lifetimes is not available. Therefore, where applicable, DOE derived lamp lifetimes as part of the engineering analysis, in the manner discussed in section III.C.

For GSFL, the manufacturer literature provides lamp lifetimes for both lamps operated three hours per start and those operated 12 hours per start. Therefore, in the Framework Document, DOE invited comment as to which lifetime value is more appropriate for use in the LCC analysis. GE and EEI commented that by referencing studies on lighting controls, DOE could develop a weighted lamp lifetime by estimating the proportion of the installed base that is operated at 12 hours per start and the proportion that is operated at three hours per start. (Public Meeting Transcript, No. 4.5 at p. 179, Public Meeting Transcript, No. 4.5 at pp. 179–180) In its comments, EEI opined that using 3 hours per start in the base case and standards case would be sufficient for this analysis (Public Meeting Transcript, No. 4.5 at p. 180). After considering public comments, DOE has tentatively decided on the following approach in this area. Because published manufacturer literature on lamp lifetimes for 12 hours per start is not available for all lamps in the base case and the standards case, and because the lifetimes are shorter in three-hours-per-start data, DOE decided to base its calculation of lamp lifetimes for both base- and standards-case lamps on three hours per start data. Thus, under this approach, DOE would not risk overstating energy savings. DOE welcomes comment on this approach.

Lamp lifetime is not only affected by the number of hours per start but also by the type of relamping practiced. For example, lamps replaced through group relamping, in contrast to spot relamping, will be replaced before the end of their rated life. In the Framework Document, DOE invited comment on whether the effect on lamp lifetime of group and/or spot re-lamping practices should be taken into account. GE commented that group re-lamping practices should be taken into account for GSFL and that this practice usually occurs at 70 percent of the rated lifetime. (Public Meeting Transcript, No. 4.5 at pp. 176–177) Like the calculation of re-lamping costs, DOE averaged the group versus spot re-lamping impact on lifetime by their percent occurrence for GSFL. DOE assumed a lamp subject to group re-lamping practices operates for 75 percent of its rated life, an estimate obtained from the 2000 Ballast Rule.[52] DOE then applied this life impact factor to the rated lifetimes from the manufacturing literature for the GSFL it analyzed. For 4-foot medium bipin lamps, the average lifetime used in the analysis was 94 percent of the rated lifetime. For 8-foot single pin slimline lamps, the average lifetime was 91 percent of the rated lifetime, and for 8-foot recessed double contact HO lamps, the average lifetime was 92 percent of the rated lifetime. For the reasons discussed in section III.G.2.a, DOE

[50] Typically consumers pay a premium for electricity consumed during times in the day when the demand for electricity is at its peak. These additional charges are called ''demand charges.''

[51] 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 B, Marginal Energy Prices and National Energy Savings p. B–10 (Jan. 2000). Available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/appendix_b.pdf.*

[52] 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, p. A–19 (Jan. 2000). Available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/appendix_a.pdf.*

agrees with GE that group re-lamping should not be considered for IRL. (Public Meeting Transcript, No. 4.5 at pp. 176–177). Therefore, DOE did not assume an impact on lamp lifetime due to group re-lamping for IRL.

iii. Discount Rates

As noted in the Framework Document, DOE planned to develop an analysis on discount rates similar to prior rulemaking analyses that evaluated the impact of standards on products or equipment installed in the residential, commercial, and industrial sectors. NWPCC commented that DOE should use discount rates from prior rulemakings, because these rates do not vary appreciably over the long term. (Public Meeting Transcript, No. 4.5 at pp. 183–184) In response, DOE reviewed the discount rate analyses from several recent rulemakings, and decided to use the same residential discount rates as it did for the 2007 ANOPR for the Residential Electric and Gas Ranges and Microwave Ovens, Dishwashers, Dehumidifiers, and Commercial Clothes Washers (hereafter ''Home Appliance ANOPR''). 72 FR 64432 (November 15, 2007). For the commercial sector, DOE used the same discount rates for the categories of lamp users as it used for those same categories in the 2006 NOPR for Electrical Distribution Transformers (hereafter ''Transformer NOPR''). 71 FR 44356 (August 4, 2006). However, DOE adjusted the aggregate commercial sector discount rate to account for differences in the proportions of types of owners of each lamp type.

For residential replacement lamps, DOE identified all possible debt or asset classes that would be sources of funds used to purchase replacement lamps, including household assets that might be affected indirectly. The mean real effective rate across all types of household debt and equity, weighted by the shares of each class, is 5.6 percent.

For the commercial and industrial sectors, 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. For further details on DOE's method for estimating discount rates, see Chapter 8 of the ANOPR TSD.

iv. Analysis Period

The analysis period is the time span over which the LCC is calculated. DOE bases the analysis period on the longest baseline lamp life in a certain product class divided by the annual operating hours of that lamp. If the user chooses to run the LCC using weighted average values, then the analysis period is based on the longest baseline lamp life divided by the average annual operating hours for that lamp in a chosen sector, or a multiple thereof. For example, the longest lived baseline IRL lamp is 3,000 hrs. If the user chooses to analyze this lamp in the commercial sector, then the analysis period is the lamp lifetime of 3,000 hours divided by the average annual operating hours for IRL in the commercial sector of 3,450 hrs/yr, which yields an analysis period of 0.9 years. In order to allow users to compare the cost of IRL lamps over multiple lamp lifetimes, one can select a multiple of this analysis period (i.e., 1.8, 2.7, or 3.6 years). If the user chooses to run the LCC using Crystal Ball® software (a tool used to do the Monte Carlo analysis), the analysis period is based on the longest baseline lamp life divided by the annual operating hours chosen by Crystal Ball®. For example, the user may choose to run IRL in the commercial sector using Monte Carlo analysis. If Crystal Ball® selects a building that is used for religious worship, the analysis period for IRL for that selection will be based on a lamp lifetime of 3,000 hours divided by the annual operating hours for IRL in a building used for religious worship of 1,609 hrs/yr, which yields an analysis period of 1.9 years. However, users cannot select a multiple of this analysis period when using Crystal Ball® due to the nature of the LCC spreadsheet. For detail on additional results, please see Chapter 8 and Appendix 8B of the TSD.

v. Effective Date

For purposes of this discussion, the ''effective date'' is the future date when a new standard becomes operative (i.e., the date by and after which lamp manufacturers must manufacture products that comply with the standard). DOE publication of a final rule in this standards rulemaking is scheduled for completion in June 2009. Pursuant to sections 325(i)(3) and (5) of EPCA, the effective date of any new or amended energy conservation standards for these lamps must be three years after the final rule is published, which would be June 2012. (42 U.S.C. 6295(i)(3) and (i)(5)) DOE calculated the LCCs for all consumers, based upon an assumption that each would purchase the new product in the year the standard takes effect.

3. Payback Period Inputs

As explained above, the PBP is the amount of time it takes the consumer to recover the estimated additional installed cost of more-efficient products through energy cost savings only. Payback analysis is a technique used to obtain a rough indication of whether an investment is worthwhile. This type of calculation is known as a ''simple'' payback period because it does not take into account other changes in operating expenses over time or the time value of money.

The inputs to the calculation of the PBP are the total installed cost of the product to the customer for each efficacy level and the annual (represented by first-year) operating expenditures for each efficacy level. The PBP calculation uses the same inputs as the LCC analysis, except that energy price trends and discount rates are not needed. The calculation needs energy prices only for the year in which a new standard is expected to take effect, in this case 2012.

4. Lamp Purchasing Events

GE, ACEEE, and PG&E all recommended that DOE should divide the lamp market into three market segments: (1) New construction; (2) major retrofit; and (3) replacement lamps; such an approach would allow DOE to differentiate between the options facing consumers for those three scenarios. (GE, No. 4.5 at p. 112; ACEEE, No. 4.5 at p. 113; PG&E, No. 4.5 at p. 113) GE, for example, commented that lumens can be kept constant with the baseline system for new construction, whereas for the replacement lamp market segment, lumens may be higher than the baseline system. (GE, No. 4.5 at p. 122) In response, DOE agrees with stakeholders on this point and has broken the LCC and NIA into several market segments or ''lamp purchasing events'' to represent the lamp-and-ballast designs facing consumers under each scenario. These ''lamp purchasing events'' are described below. Although DOE considers in the LCC only those energy-saving design options which reduce lumen output by 10 percent or less, all other design options facing consumers are considered in the NIA.

To further explain, DOE designed the LCC analysis for this rulemaking around scenarios where consumers have a need to replace a lamp; these are collectively referred to as ''lamp purchasing events.'' Each of these events may present the consumer with a different set of technology options and, therefore, a different set of LCC savings for a certain CSL. For GSFL, DOE identified five possible scenarios under which consumers would purchase a lamp and potentially be affected by a minimum energy conservation standard. These scenarios are: (1) Lamp failure; (2) standards-induced retrofit; (3) ballast failure; (4) ballast retrofit; and (5) new construction/renovation. These five lamp purchasing events are described in more detail below. (It is noted that for IRL, due to the fact that there is no ballast involved, the scenario for the incandescent lamp product classes is simply a lamp failure.) In addition to the descriptions below, Table III.23 and Table III.24 summarize the lamp purchasing events considered in this analysis.

• *Lamp Failure (Event I):* This event reflects a scenario in which a lamp either fails (spot-relamping) or is about to fail (group relamping) and must be replaced. In the absence of the energy conservation standard, the analysis assumes an identical lamp would have been installed as a replacement. However, under a lamp energy conservation standards scenario, a standards-compliant lamp is required which operates on the existing ballast. Thus, the first consumer response to a lamp failure is expected to be a simple lamp replacement with the same type of lamp. A second response occurs for owners of T12 systems. Unlike T8 lamps, there are certain lamp standard levels which a T12 lamp cannot meet. These users would be required to purchase both new lamps and ballasts in order to meet the lamp energy conservation standard.

• *Standards-Induced Retrofit (Event II):* This event reflects a scenario in which an increase in the energy conservation standard for lamps prompts end-users to retrofit both lamps and ballasts, whereas, in the base case, they would otherwise have installed only a lamp due to a lamp failure. This lamp purchasing event only applies to users with T12 lamps because, unlike T8 lamps, there are certain lamp standard levels which a T12 lamp cannot meet. This event contemplates a scenario where users, under a lamp energy conservation standard, can no longer purchase a T12 replacement lamp for their T12 ballast. For this scenario, DOE assumes a uniform age distribution of T12 lamps throughout the nation. Therefore, based on this age distribution, the average T12 lamp is halfway through its lifetime. Consumers in the base case purchase only a lamp after the average T12 lamp has died (i.e., after it has lived through the second half of its lifetime). Consumers in the standards case choose to change both the lamp and the ballast early, instead of waiting for their T12 lamps to fail. Therefore, in the standards case, a lamp-and-ballast purchase would occur at the beginning of the analysis, before the average lamp being replaced has failed.

• *Ballast Failure (Event III):* This event reflects a scenario in which the installed ballast has failed. DOE recognizes that energy conservation standards for ballasts set by the 2000 Ballast Rule and EPACT 2005 are effective in 2010. These standards ban the sale of magnetic 4-foot medium bipin and 8-foot single pin slimline ballasts. In addition, DOE believes that sales of magnetic ballasts that operate 8-foot recessed double contact high output lamps will be minimal after 2012. Therefore, in the baseline, users who had a magnetic T12 ballast would be expected to replace it with an electronic T12 ballast. Users who had a T8 ballast installed would be expected to replace it with a T8 ballast. However, in the standards case, end-users would select a standards-compliant lamp-ballast combination such that the system light output never drops below 10 percent of the baseline system.

• *Ballast Retrofit (Event IV):* This event applies only to T12 users because, according to industry experts, the majority of ballasts that are retrofitted are T12 lamp-and-ballast systems. As opposed to the standards-induced retrofit event where end-users replace only their lamps in the base case, end-users under this event replace both their lamps and ballasts in the base case in order to save energy. With standards, end-users will also retrofit their old lamps and ballasts, but with standards-compliant lamps. DOE assumes that end-users continue to use the existing fixture and replace only the ballast. Because the spatial layout in the building space is constrained by the number of fixtures, light output of the replacement lamp-and-ballast system is maintained.

• *New Construction and Renovation (Event V):* This lamp purchasing event encompasses all the new fixture installations where the lighting design will be completely new or can be completely changed. This scenario is only applicable to those baseline lamps that are usually used in new construction and renovation (4-foot T8s, 8-foot single pin slimline T8s, and 8-foot recessed double contact HO T12s). In this scenario, the spatial layout of fixtures in the building space is not constrained to any previous configuration. Because new fixtures can be installed, consumers could install a lamp-and-ballast system that would not maintain the light output of the baseline system. For instance, if light output of the standards case system is lower than the base case system, consumers can increase the number of standards case lamp-and-ballast systems installed in the building by a certain percentage to maintain the light output of base case lamp-and-ballast systems.

Table III.23 and Table III.24 outline the events and actions taken by consumers in response to those events both in the base case and the standards case.

TABLE III.23.—FRAMEWORK OF EVENT-TYPE SCENARIOS FOR T12 LAMPS

Event	Base-case action	Standards-case action
Event I. Lamp Failure	(a) Installs a T12 lamp	Installs a lower-wattage, higher efficacy lamp, where the system light output never drops below 10 percent of the baseline system.
	(b) Installs a T12 lamp	Installs a T12 or T8 electronic ballast and lamp, where the system light output never drops below 10 percent of the baseline system.
Event II. Standards-Induced Retrofit.	Replace T12 lamp halfway through analysis period.[53]	Installs a new T12 or T8 electronic ballast and lamp, where the system light output never drops below 10 percent of the baseline system.
Event III. Ballast Failure	Installs a T12 electronic ballast and lamps in the existing fixture.	Installs a new T12 or T8 ballast and lamps, where the system light output never drops below 10 percent of the baseline system.

TABLE III.23.—FRAMEWORK OF EVENT-TYPE SCENARIOS FOR T12 LAMPS—Continued

Event	Base-case action	Standards-case action
Event IV. Ballast Retrofit	Installs a T8 electronic ballast and lamps in the existing fixture.	Installs a new T12 or T8 ballast and lamps, where the system light output never drops below 10 percent of the baseline system.
Event V. New Construction and Renovation.	Installs a new T12 system	Installs a new T12 or T8 system that is where the system light output never drops below 10 percent of the baseline system. Light output can be maintained through spacing.

TABLE III.24.—FRAMEWORK OF EVENT-TYPE SCENARIOS FOR T8 LAMPS

Event	Base-case action	Standards-case action
Event I. Lamp Failure	Installs a T8 lamp	Installs a lower-wattage, higher efficacy lamp, where the system light output never drops below 10 percent of the baseline system.
Event III. Ballast Failure	Installs a T8 electronic ballast and lamps in the existing fixture.	Installs a new T8 ballast and lamps, where the system light output never drops below 10 percent of the baseline system.
Event V. New Construction and Renovation.	Installs a new T8 system	Installs a new T8 system, where the system light output never drops below 10 percent of the baseline system. Light output can be maintained through spacing.

5. Life-Cycle Cost and Payback Period Results

DOE calculated the average LCC savings relative to the base-case forecast for each product class. As mentioned above, the base case consists of the projected pattern of product purchases that would occur in the absence of new energy conservation standards.

DOE did not explicitly discuss aggregating results of the LCC and PBP analyses in the Framework Document, but stakeholders identified this as a critical issue and submitted comment thereon. For example, ACEEE commented that DOE should weigh its results for the three market segments it considered—new construction, retrofit, and lamp replacement—by their percentage of sales. (Public Meeting Transcript, No. 4.5 at pp. 118–119) The Joint Comment also recommended that DOE should weigh its results by market segment. (Joint Comment, No. 9 at p. 5) In addition, ACEEE commented that some of the higher efficacy lamp substitutes could have higher wattages than their replacement. (Public Meeting Transcript, No. 4.5 at pp. 118–119)

DOE recognizes that different lamp consumers will be impacted differently by a new standard depending on the market segment to which they belong. To model these different situations, the LCC analysis is designed around scenarios—the ''lamp purchasing events''—where consumers have a need to replace a lamp. The LCC spreadsheet calculates the LCC impacts for each of these scenarios separately. Looking at the impacts on each scenario separately allows one to view the results of many subgroup populations in the LCC analyses.

For the ANOPR, DOE decided not to aggregate the results of the various event scenarios together into a single LCC at each CSL. To do so would have required too many assumptions, such as: (1) The relative occurrence of each event over time, or (2) the market share of each lamp in the base case and each standards case. Another argument against aggregating the LCC results stems from the fact that the LCC analysis only considers energy-saving lamp or lamp-and-ballast designs. As ACEEE commented, consumers may elect options that save no energy or perhaps consume more energy. (Public Meeting Transcript, No. 4.5 at pp. 118–119) Finally, aggregating the results of the LCC analysis events blurs the lines with the NIA analysis. DOE believes it is more appropriate to incorporate assumptions about consumer decisions and long-term market trends in the NIA, and leave the LCC as a direct head-to-head comparison between lamp and lamp-and-ballast designs under different scenarios or ''events.'' Note further that the LCC savings results help DOE estimate consumer behavior decisions for the NIA.

DOE recognizes that the large number of LCC and PBP results can make it difficult to draw conclusions about the cost-effectiveness of CSLs. The following presents partial results from the LCC analysis. The LCC results are presented according to the lamp purchasing events that culminate in purchase of lamp-and-ballast designs. These results are for a subset of all of the possible events, although they represent the most prevalent purchasing events (events I(b) and IV have been omitted in this notice but are presented in the TSD). A range of the LCC savings and PBP are given for each CSL. The range reflects the results of multiple systems (i.e., multiple lamp-ballast pairings) which consumers could purchase to meet a CSL. In addition, DOE has chosen not to present detailed PBP results by CSL in this ANOPR because DOE believes that, given the drawbacks to PBP discussed earlier, the short lifetime of IRL and the systems nature of GSFL, LCC results are a better measure of cost-effectiveness. However, a full set of both LCC and PBP results for the systems DOE analyzed are available in Chapter 8 of the TSD. DOE is presenting the partial results here to facilitate comment on DOE's methodology of its analyses, and on the presentation of its results.

a. General Service Fluorescent Lamps

Table III.25 through Table III.27 lists the result for one baseline lamp in each of the three product classes DOE analyzed (i.e., 4-foot medium bipin, 8-foot single pin slimline and 8-foot recessed double contact HO). Throughout this section, the terms ''positive LCC savings'' and ''negative LCC savings'' are used. When a standard results in ''positive LCC savings,'' the life cycle cost of the standards-compliant lamp is less than the life cycle cost of the baseline lamp, and therefore, the consumer benefits. A

[53] Event Type II represents a standards-induced retrofit where lamps are substituted before the end of their lifetime. DOE assumed that lamps lived to half of their average lifetime when substituted under this scenario.

consumer is adversely affected when a standard results in ''negative LCC savings'' (i.e., when the life cycle cost of the standards-compliant lamp is higher than the life cycle cost of the baseline lamp). The range of values given represents the multiple ways a consumer can meet a certain CSL under each lamp purchasing event. For example, at CSL3, a consumer in need of a lamp and ballast can either purchase a high-efficacy T12 lamp on an electronic ballast or a high-efficacy T8 lamp on an electronic ballast. While both these choices are available to the consumer, the selection of a T8 system offers positive LCC savings.

Table III.25 presents the findings of an LCC analysis on the 34W T12 4-foot medium bipin GSFL baseline operating in the commercial sector. Key inputs consist of using AEO2007 reference case electricity prices, an analysis period of 5.5 years, and medium-range lamp and ballast prices. Note that any standard level beyond CSL3 for this baseline lamp would require a lamp and ballast replacement, since no T12 lamp currently meets the efficacy requirements of CSL4. In addition, because DOE is only presenting energy-saving options in the LCC and because there are no energy-saving (or reduced wattage) lamp replacement options for the 34W T12 lamp, Event I(a) which would require only a lamp replacement is not shown. In general, one finds that consumers who do switch from T12 to T8 lamps experience positive LCC savings at all CSLs.

The positive LCC results for Event II are due to consumers that replace a functioning 34W T12 lamp on a magnetic ballast with a high efficacy T8 lamp on an electronic ballast. This situation occurs at CSLs three through five. Negative LCC savings (i.e., increases in life-cycle costs) are generally due to replacement of a functioning 34W T12 lamp on a magnetic ballast with a higher-efficacy T12 lamp on a T12 electronic ballast. This situation occurs at CSLs one through three. (Both the T12 and T8 electronic substitutions result in negative LCC savings at CSL2) These LCC results explain why consumers are electing to replace their T12 magnetic systems with T8 electronic systems instead of choosing T12 electronic ballast systems.

Event III represents consumers who are already faced with replacing both a lamp and a ballast. The baseline ballast for this event is assumed to be an electronic T12, since the ballast standards from the 2000 Ballast Rule and EPACT 2005 would be effective in 2010. Consumers prompted by this event would experience positive LCC savings if they purchase a high efficacy 4-foot T8 lamp on an electronic ballast at all CSL levels. Negative LCC savings would occur if consumers replace a functioning 34W T12 lamp on an electronic ballast with a high efficacy T12 lamp. The LCC savings of Event III are greater than those of Event II because in the base case of Event III consumers were faced with a ballast replacement cost.

PBP results for Event II and III range from zero to 37.7 years. The systems nature of the lamp LCC makes the payback period results difficult to interpret. For example, LCC savings are positive for many CSLs where the payback period exceeds the lifetime of the baseline lamp which is approximately five years. When these paybacks are compared to the lifetime of a lamp-ballast system of 15 years (spanning the life of one ballast and three lamp replacements), the payback periods appear much more acceptable. Payback periods longer than the lifetime of the system are associated with negative LCC savings. The zero-year payback (or instantaneous payback) also results from the systems nature of these LCC results. For example, zero payback periods that appear for Event III are due to the replacement of a more expensive electronic T12 ballast with a less expensive T8 electronic ballast. For more information on PBP results refer to Chapter 8 of the TSD.

TABLE III.25.—LCC RESULTS FOR A 3-LAMP 4-FOOT MEDIUM BIPIN SYSTEM OPERATING IN THE COMMERCIAL SECTOR*

Candidate standard level	Rated lamp efficacy *lm/W*	LCC savings 2006$	
		Event II: standards-induced retrofit (lamp & ballast replacement)	Event III: ballast failure (lamp & ballast replacement)
CSL1	82.4	−18.00	−2.02
CSL2	85.3 to 86.2	−23.36 to −6.31	−9.05 to 8.01
CSL3	90.8 to 91.2	−23.66 to 1.60	−9.34 to 15.92
CSL4	92.3 to 95.0	5.01 to 6.26	19.33 to 20.58
CSL5	95.4 to 97.3	4.88 to 16.96	19.19 to 31.28

*The results displayed are for the 34W T12 baseline lamp with a 5.5 yr analysis period. Additional results are available in Chapter 8 of the TSD.

Table III.26 presents the findings of an LCC analysis on the 60W T12 8-foot single pin slimline GSFL baseline lamp operating in the commercial sector. Key inputs consist of using AEO2007 reference case electricity prices, an analysis period of 4.0 years and medium-range lamp and ballast prices. Note that any standard level beyond CSL3 for this baseline lamp would require a lamp-and-ballast replacement, since no T12 lamp currently meets the efficacy requirements of CSL3. In general, consumers who do switch from a 60W T12 to a T8 lamp experience positive LCC savings only if their ballast has already failed.

Event I is not shown because there are no energy-saving lamp replacement options for a 60W T12 lamp. Event II represents consumers who respond to higher lamp standards by replacing a functioning 60W T12 system with a new lamp and ballast. For this event, consumers experience increased LCC at all CSLs. Event III represents consumers who are already faced with replacing both a lamp and a ballast. The baseline ballast for this event is assumed to be an electronic T12, since the ballast standards from the 2000 Ballast Rule and EPACT 2005 would be effective in 2010. Consumers prompted by this event would experience positive LCC savings if they purchase a high-efficacy 8-foot single pin slimline T8 lamp on an electronic ballast. Negative LCC savings would occur because some consumers who replace a functioning 60W T12 lamp on an electronic ballast with a high-efficacy T12 lamp on an electronic ballast.

PBP results for Event II and III range from 2.7 to 20.7 years. For more information on PBP results refer to Chapter 8 of the TSD.

TABLE III.26.—LCC RESULTS FOR A 2-LAMP 8-FOOT SINGLE PIN SLIMLINE SYSTEM OPERATING IN THE COMMERCIAL SECTOR*

Candidate standard level	Rated lamp efficacy *lm/W*	LCC savings 2006$	
		Event II: standards-induced retrofit (lamp & ballast replacement)	Event III: ballast failure (lamp & ballast replacement)
CSL1[54]	87.6	N/A	N/A
CSL2	92.6	−24.78	−3.04
CSL3	94.8 to 97.5	−24.31 to −23.55	−2.56
CSL4	98.2	−16.42	5.33
CSL5	101.5 to 101.8	−15.68 to −13.73	6.06 to 8.02

*The results displayed are for the 60W T12 baseline lamp with a 6.0 yr analysis period. Additional results are available in Chapter 8 of the TSD.

Table III.27 presents the findings of an LCC analysis for a 95W T12 8-foot recessed double contact GSFL baseline lamp operating in the industrial sector. Key inputs consist of using AEO2007 reference case electricity prices, an analysis period of 2.3 years, and medium-range lamp and ballast prices. Note that any standard level beyond CSL2 for this baseline lamp would require a lamp and ballast replacement, since no T12 lamp currently meets the efficacy requirements of CSL3. In general, DOE's research indicates that consumers who do switch from a 95W T12 to a T8 lamp would experience positive LCC savings only if their ballast has already failed or if they are renovating or constructing a new building.

Event I is not shown because there are no energy-saving lamp replacement options for a 95W T12 lamp. The positive LCC results for Event II occur because some consumers replace a functioning 95W T12 lamp on an electronic ballast with a high-efficacy T8 lamp on an electronic ballast. Negative LCC results are due to consumer replacement of a functioning 95W T12 lamp on a magnetic ballast with a high-efficacy T12 lamp on an electronic ballast. Events III and V represent consumers who are already faced with replacing both a lamp and a ballast. Consumers, prompted by these events, would experience positive LCC savings if they purchase a high-efficacy T8 lamp on an electronic ballast. Consumers would experience higher LCCs if they replace a functioning 95W T12 lamp on an electronic ballast with a high-efficacy T12 lamp on an electronic ballast. Under this scenario, the lowest LCC occurs at CSL4.

PBP results for Event II, III, and V range from 3.2 to 64.8 years. For more information on PBP results refer to Chapter 8 of the TSD.

TABLE III.27.—LCC RESULTS FOR A 2-LAMP 8-FOOT RECESSED DOUBLE CONTACT HO SYSTEM OPERATING IN THE INDUSTRIAL SECTOR*

Candidate standard level	Rated lamp efficacy *lm/W*	LCC savings 2006$	
		Event II: standards-induced retrofit (lamp & ballast replacement)	Event III: ballast failure and event V: new construction and renovation (lamp & ballast replacement)
CSL1	N/A[55]	N/A	N/A
CSL2	85.5 to 86.1	−36.86	−3.43
CSL3	87.6 to 88.9	−47.10 to −46.48	−13.67 to −13.05
CSL4	91.9 to 93.0	−24.12 to −21.19	9.32 to 12.25
CSL5	95.3	−20.53	12.9

*The results displayed are for the 95W T12 baseline lamp with a 2.3-yr analysis period. Additional results are available in Chapter 8 of the TSD.

Results for all GSFL events and baselines are presented in Table 8.5.1 to Table 8.5.16 of Chapter 8 in the TSD.

b. Incandescent Reflector Lamps

Table III.28 provides the LCC results for a 75W PAR38 IRL operating in the commercial sector. These results are based on the AEO2007 reference case electricity prices, an analysis period of 0.9 years,[56] and use of medium-range

[54] Because the 60W T12 baseline exceeds CSL1, there are no energy saving design options at this level. There are, however, energy saving design options at CSL1 for the 75W T12 baseline.

[55] Because the 95W T12 baseline is only slightly below CSL1, there are no energy saving design options at this level. There are, however, energy saving design options at CSL1 for the 110W T12 baseline.

[56] The service life of commercial IRL is shorter than GSFL because the longest lived baseline IRL

Continued

lamp prices. Note that the lowest LCC (and highest LCC savings) occurs at CSL3. PBP results for IRL range from 0.4 to 0.6 years. LCC and PBP results for all IRL baseline lamps are available in Chapter 8 in the TSD. More information about the lamps that meet each CSL are provided in Chapter 5 of the TSD.

TABLE III.28.—LCC RESULTS FOR A 75W PAR38 OPERATING IN THE COMMERCIAL SECTOR*

Candidate standard level	Rated lamp efficacy *lm/W*	LCC savings 2006$
CSL1	15.9	2.71
CSL2	17.5	3.92
CSL3	19.1	5.89

*These results are for the 75W PAR38 baseline lamp. Additional results are available in Chapter 8 of the TSD.

In summary, DOE presents these findings to facilitate public review of the LCC and PBP analyses for this rulemaking. DOE seeks information and comments relevant to the assumptions, methodology, and results for all of these analyses. See Chapter 8 of the TSD for additional detail on the LCC and PBP analyses and results. For results of the Monte-Carlo model and other sensitivities refer to Appendix 8B of the TSD.

H. Shipment Analysis

This section presents the shipment analysis, which is an input into the national impact analysis (NIA) (section III.I) and manufacturer impact analysis (section III.K). DOE will undertake revisions to the NIA, conduct the final manufacturer impact analysis (MIA), and then report the findings from both in the NOPR.

As indicated above and in the NIA section below, DOE developed a base-case shipment forecast for each analyzed lamp type to depict what would happen to energy use, and to consumer costs for purchase and operation of lamps, in the absence of new or revised energy conservation standards. To evaluate the impacts of such standards for these lamps, DOE compares the estimated base-case projection against forecasted estimates of what would happen if DOE were to promulgate standards for GSFL and IRL. One common element in the base-case and standards-case forecasts is product shipments. In determining the base case, DOE considered historical shipments, the mix of efficacies sold in the absence of any new standards, and how that mix might change over time.

DOE developed separate shipment models for GSFL and IRL. The GSFL shipment model projects lumen growth by forecasting lumen demand serviced by GSFL lamp type in the commercial and industrial sectors. In accordance with historical shipment data, annual shipments are forecasted for 8-foot recessed double contact HO lamps in the industrial sector, and 4-foot medium bipin and 8-foot single pin slimline lamps in the commercial sector. Due to their relatively small shipment-based market share (approximately four percent) of the total GSFL market, DOE decided—for the ANOPR only—not to forecast shipments of or analyze the national impacts of standards on 2-foot U-shaped lamps. However, for the NOPR, DOE does intend to scale the NIA results from other product classes that were analyzed to the 2-foot U-shaped lamp product classes, to develop estimates of the NES and NPV for this lamp type. DOE may base the extrapolation of NIA results on relative market shares, average incremental prices for each lamp design, or average changes in energy consumption between lamp-and-ballast designs. DOE invites comment on which of these or other scaling relationships it should use for the NOPR.

The shipment model for IRL is based on the growth in the number of sockets using these light sources in the commercial and residential sectors. Based on manufacturer interviews, DOE forecasted shipments of IRL in both the commercial and residential sectors. DOE invites comment on the various sectors used to establish shipment forecast estimates for GSFL and IRL.

DOE followed a consistent four-step process to forecast shipments for GSFL and IRL. First, DOE used NEMA's historical shipment data from 2001 to 2005 to estimate total historical (NEMA member and non-NEMA members) shipments of each analyzed lamp type in the sectors described above. Second, using these historical shipments, DOE projected shipments to 2011. Then, based on average service lifetimes, DOE estimated a stock of lamps in 2011 for each lamp type. Third, DOE forecasted lamp (and ballast for GSFL) shipments from 2012 to 2042 (the analysis period for the NIA) by modeling various events, such as lamp replacement or new construction. Because these shipments are dependent on lamp and lamp-system properties (e.g., lifetime and lumen output), as a fourth step, DOE developed base-case and standards-case market-share matrices. These market-share matrices determine the forecasted technology mixes in the lamp stock and shipments. Each of these analytical steps in the shipment analysis is discussed in further detail below.

1. Historical Shipments

GE and NEMA both commented that historical shipment data should be used as an input to the fluorescent and incandescent lamp shipment models. (Public Meeting Transcript, No. 4.5 at p. 198; NEMA, No. 12 at p. 2) NEMA provided shipment data on GSFL and IRL spanning 2001 to 2005. Recognizing that these shipment figures cover only NEMA members, based on manufacturer interviews DOE increased these estimates slightly to account for the volume of fluorescent and incandescent lamps that are imported and/or manufactured by non-NEMA lamp companies. A list of lighting-related NEMA member companies and several lists including various lighting-related non-NEMA member companies can be found in Chapter 3 of the TSD.

Because certain ER and BR shaped IRL (BR 30 and BR40 65 Watt) are statutorily exempted from energy conservation standards, DOE used manufacturer product catalogs to estimate the market share of those exempted products. As research indicated that these exempted products constitute approximately 60 percent of all incandescent (non-halogen) IRL shipments, DOE accounted for this when using the NEMA historical shipments data. In addition, to model

lamp is 3,000 hrs while the baseline lamps for GSFL vary between 12,000 and 20,000 hours. In addition, operating hours for commercial IRL are comparable to the operating hours for commercial and industrial GSFL (3,450 for commercial IRL and 3,435 for commercial GSFL or 4,795 for industrial GSFL).

IRL operated in the commercial sector separately from those operated in the residential sector, DOE used a reflector lamp study conducted by the New York State Energy Research and Development Authority[57] with additional shipment data submitted by NEMA (NEMA, No. 17 at p. 2)[58] to estimate the percentage of incandescent and halogen IRL shipments by sector.

In addition, because GSFL of different correlated color temperatures (CCTs) were not segregated in the NEMA historical shipment data, DOE decided to analyze and forecast shipments of each lamp type, aggregating across the lamps of low (less than or equal to 4,500K) and high (greater than 4,500K) CCT. Similarly, DOE forecasts IRL shipments by aggregating across the standard-spectrum and modified-spectrum lamps. In both of these cases of aggregation, DOE used a representative product class to evaluate lamp designs and believes that the national impacts will be similar for those product classes not directly analyzed. Specifically, for GSFL, DOE used lamp designs with CCT less than or equal to 4,500K to represent both low-CCT and high-CCT lamps. For IRL, DOE used standard-spectrum lamp designs to represent the markets of both standard-spectrum and modified-spectrum reflector lamps. In addition, by aggregating the previously-discussed product classes, DOE assumes that there will be no significant migration of shipments or stock between lamps of different CCTs or spectrums. DOE invites comment on this aggregation of product classes in the shipment analysis and NIA. Details regarding scaling and usage of NEMA's historical shipments can be found in Chapter 9 of the TSD.

2. Shipment Projections to 2011 and Calculations of Stock of Lamps in 2011

DOE estimated shipments to 2011 for GSFL and IRL by linearly extrapolating historical shipment data (from 2001 to 2005) of each lamp type. In addition, DOE also accounts for efficacy standards (effective in 2008) for small diameter and ER and BR shaped lamps prescribed by EISA 2007. DOE expects that the result of these standards is that by 2008, all IRL shipments covered in this rulemaking will be of products using halogen technology. Because halogen lamps generally have longer lifetimes than their incandescent counterparts, and are therefore replaced (and shipped) less often, DOE has applied a reduction to its projection of IRL shipments after 2007. DOE invites comment on the shipment projections to 2011 for GSFL and IRL.

The stock of lamps in 2011 was estimated by summing annual shipments backward from 2011. For each lamp type, DOE summed shipments for the number of years that corresponds to the average lifetime of that lamp type. For GSFL, this initial lamp stock is converted into an initial lamp-and-ballast system stock. DOE extrapolated the ballast age profile of each lamp system type by considering historical shipments from census data for electronic and magnetic ballasts and historical growth in lumen demand. Since DOE determined that the 2011 lamp stock of 8-foot T8 recessed double contact HO are a small minority of the total GSFL stock, DOE disregarded this initial lamp stock in its shipment forecast. However, as discussed later, DOE did capture future shipments of these lamps as they replace 8-foot T12 recessed double contact HO systems. DOE invites comment on the methodology and data sources used to estimate initial lamp stocks in the year 2011, in particular its treatment on 8-foot T8 recessed double contact HO lamps.

3. Base-Case and Standards-Case Shipment Forecasts to 2042

The shipment models DOE developed for the ANOPR each consider specific market segments in developing their estimate of annual shipments. For all lamp types, DOE accounts for two lamp purchase events (corresponding to those discussed in Section III.G): (1) Lamp replacement following a lamp failure (Event I); and (2) new construction (Event V). In addition, for the GSFL shipment models, DOE models two additional lamp purchase events—lamp-and-ballast systems installed following a ballast failure (Event III), and lamp-and-ballast systems installed due to lamp system retrofit (an aggregation of Events II and IV).

ACEEE and the Joint Comment recommended that DOE should weigh the analytical results for GSFL by market segment. (Public Meeting Transcript, No. 4.5 at pp. 118–119; Joint Comment, No. 9 at p. 5) In response, DOE implicitly weighs the occurrence of new construction, retrofit, and replacement lamp sales based on stock turnover in the shipment model. DOE's determination of shipments due to new construction assumes a 1.6 percent per year lumen growth rate. DOE estimated a 1.6 percent per year lumen growth rate based on the latest CBECS data on growth of building floor space. Shipments due to ballast replacement are based on a ballast inventory model with a 14-year ballast lifetime in the commercial sector and a 10-year ballast lifetime in the industrial sector. To account for consumer reactions in response to higher total installed costs of certain systems, DOE assumes that the retrofit rates (or rates of early ballast retirement) of these systems increase as the CSLs increase. Finally, DOE calculated the market share of lamp replacements in the GSFL shipment model as a function of the average lamp lifetime of the lamp designs chosen. For more information, see Chapter 9 of the TSD.

GE and NEMA both recommended that DOE should develop its lamp shipment forecast based on lamp shipments, rather than a ballast inventory model. (Public Meeting Transcript, No. 4.5 at pp. 193–194; NEMA, No. 8 at p. 3) In response, DOE did use the lamp shipment data provided by NEMA and has calibrated its shipment models using historical shipment data. However, for the fluorescent lamp shipment analysis (and NIA), based on this historical lamp shipment data and 2002 and 2005 U.S. Census Bureau data, DOE developed a ballast inventory model for several reasons. For example, DOE needs to capture and track the anticipated decline in BF that would occur in the ballast inventory (or stock) in standards cases as discussed earlier. This decline in BF is critical to tracking the NIA calculations and results. Also, by modeling the ballast stock and its turnover, DOE was able to model the occurrence of lamp-and-ballast purchase events, as described earlier.

In their comments on the Framework Document, GE and the Joint Commenter emphasized the importance of accounting for wider fixture spacing of higher-lumen-output systems in the new construction/remodeling market. (Joint Comment, No. 9 at p. 5; Public Meeting Transcript, No. 4.5 at pp. 119–120) In response, DOE notes that the fluorescent shipment model's base-case and standards-case forecasts account for this effect by allowing installed systems to have a range of light outputs. DOE then normalizes the total lumen output due to new construction by decreasing or increasing the number of shipments

[57] New York State Energy Research and Development Authority, Incandescent Reflector Lamps Study of Proposed Energy Efficiency Standards for New York State (2006). (Last accessed October 7, 2006 at: *http://www.nyserda.org/publications/Report%2006-07-Complete%20report-web.pdf*.) The October 7, 2006 material from this Web site is available in Docket #EE–2006–STD–0131.

[58] This written comment, document number 17, was submitted in response to the Energy Conservation Program for Commercial and Industrial Equipment: High-Intensity Discharge (HID) Lamps and is available in Docket #EE–DET–03–001.

based on the average lumen output per system.

For IRL, the shipment forecasts are based on a stock turnover (i.e., lamp replacements upon lamp failure) and growth in the number of sockets in use (through new construction). DOE assumed a 1.6 percent growth rate in lamp sockets per year for the commercial sector and 1.3 percent growth rate per year for the residential sector. DOE based these estimates on the latest CBECS and RECS forecasts of square footage growth in these respective sectors. The rate of stock turnover from one lamp technology to another and the total number of shipments depend upon operating hours and the lifetimes of shipped lamps.

DOE also received comments from ACEEE and NEMA remarking that DOE should be aware of any clear trends in historical shipment data and that these trends should be reflected in the base-case shipment model. (Public Meeting Transcript, No. 4.5 at p. 194; NEMA, No. 12 at p. 2) DOE took these comments into account when developing its analytical approach, using the data on market trends provided by NEMA as well as manufacturer and expert interviews to establish base-case trends. For example, for GSFL, DOE mimicked historical trends and modeled a shift from magnetic to electronic ballasts in both the 4-foot medium bipin and 8-foot single pin slimline markets. For the 8-foot T12 recessed double contact HO lamp, DOE modeled it as having no new construction, because historical shipments have indicated that its market is relatively flat. In addition, DOE incorporated historical market trends in the GSFL model by controlling the types of systems shipped to account for new construction and retrofits. DOE invites further comments on other trends that should be modeled in its shipment forecasts, particularly for GSFL.

For IRL, a significant source of uncertainty in the base-case lamp forecasts involves the potential for rapidly-emerging new lighting technologies to enter the market. For example, the residential market is already being transformed by the rapid increase in reflector CFL sales. CFL can be three to four times more efficient and last several times longer than the incandescent lamps they are replacing. Assumptions made in the base-case lamp forecast about any change in market share for CFL greatly impact the energy savings and NPV benefits that could result from standards. Yet in comparison to solid-state lighting (SSL) sources,[59] CFL are a ''mature'' technology, with relatively predictable price, efficacy, and lifetime attributes. Technology forecasts about the potential attributes of SSL sources suggest that they may achieve efficacies twice that of CFL and may last up to ten times longer. Clearly, if SSL technology achieved such promise, it would radically impact the benefits calculations from potential standards. However, in order to calculate the energy savings and NPV benefits, DOE would need to accurately forecast the anticipated price and performance points of an emerging technology such as SSL, which would be extremely difficult and speculative.

Therefore, in this rulemaking, DOE plans to account for the market impact of these emerging technologies in the NIA by deducting the anticipated emerging technology market share from the installed base. DOE would estimate the market shares of these technologies in the future (absent standards) by deducting that market share from the base case of impacted customers. This methodology would effectively reduce the size of the market impacted by energy conservation standards, without requiring DOE to prepare estimates of the price and efficacy of those emerging technologies for the NIA model. Thus, DOE could incorporate the impact of emerging technologies in the base-case and standards-case, without having to prepare uncertain forecasts for those emerging technologies. DOE believes that reducing the number of affected consumers is the most appropriate approach for this rulemaking because: (1) the efficacies of the emerging technologies are projected to be much higher than those that can be achieved by incandescent-based lamps; and (2) the emerging technology lamps are not yet subject to any DOE regulation, and, therefore, consumers would be migrating to non-covered, substitute lamps.

For the ANOPR, DOE is estimating that the market penetration of these emerging technologies (e.g., SSL, Ceramic Metal Halide, CFL) will be 50% of the IRL sockets in the installed base by the year 2042. DOE requests comment on this methodology used in the ANOPR for incorporating emerging technologies in the base-case forecasts. In addition, DOE seeks input on reasonable market-share estimates for GSFL and IRL in order to properly bound the range of potential energy savings and NPV that would result from standards.

[59] ''SSL source'' refer to a lighting technology using light-emitting diodes (LEDs).

4. Market-Share Matrices

As discussed in the engineering analysis (Section III.C) and the LCC analysis (section III.G), consumers have available to them a variety of choices in terms of lamps and lamp systems. When choosing lighting systems, consumers often make their choice after considering lamp attributes such as lifetime, efficacy, price, lumen output, rated wattage, and total system power. As discussed earlier, the shipments for GSFL and IRL depend on input assumptions, including lamp lifetime and system lumen output. In addition, other lamp or lamp-system properties such as price and energy consumption are key inputs to the NES and NPV calculations. Therefore, within each product class, DOE believes it necessary to directly account for the mix of technologies which consumers select in the base case and standards case. In order to account for the range of possible consumer choices, DOE developed and populated technology market-share matrices. These market-share matrices allocate percentage market shares to each of the lamp technologies for the base case and standards case, either by proportioning lamp shipments or lamp stocks. As discussed in the NIA (Section III.I), the base-case and standards-case efficacy forecasts are also dependent on the market-share matrices.

a. General Service Fluorescent Lamps

The GSFL shipment model incorporates several separate market-share matrices to characterize shipments of lamps and lamp-and-ballast systems at different times during the analysis period. For each analyzed system type (e.g., 4-foot T8 medium bipin), DOE defines market-share matrices for the ballasts installed before 2012 versus new ballasts installed in 2012 and later. This enables the GSFL shipment model to capture a migration to different lamp-and-ballast designs over time in both the base and standards cases.

At the Public Meeting, PG&E commented that, by the effective date of the standard, it is expected that commercial fluorescent lighting fixtures will be considerably improved. (Public Meeting Transcript, No. 4.5 at p. 113) In addition, NWPCC generally commented that typical BFs may change between the current stock and the stock in 2012. (Public Meeting Transcript, No. 4.5 at p. 175) In response, DOE recognizes that fluorescent lighting systems will likely improve and that the ballast factors (BFs) may change over time. DOE populated the 2012 base-case market-share matrix (including BFs) based on discussions with industry experts, manufacturer interviews, and a review of available products. DOE can alter the inputs into the base-case market-share matrix (the technology mix in 2012) to reflect any level of improvement in lighting fixtures by 2012. In addition, the base-case GSFL shipment forecast has the ability to model improvement in lighting systems and shifts in BFs after 2012. Furthermore, if the public were to present alternative forecast scenarios to those considered for the ANOPR, the matrices are designed such that these alternative scenarios could be modeled for the NOPR.

In addition, for the standards-case market-share matrices, DOE implemented two shipment scenarios for fluorescent lamps: (1) ''roll-up,'' and (2) ''shift.'' The ''roll-up'' scenario represents the standards case assuming all product efficacies in the base case which do not meet the standard would ''roll-up'' to meet the new standard level. Those that were above the standard level are considered unaffected and continue to purchase the same base-case lamp or lamp system. The ''roll-up'' scenario characterizes consumers primarily driven by the first-cost of the lamp, and they are restricted to replacing their base-case lamp with an equal wattage lamp when possible. The ''roll-up'' scenario, therefore, represents a lower bound of energy-savings scenario.

The ''shift'' scenario models the standards case assuming all product efficacies are affected by the standard (whether or not their base-case efficacy meets the standard). This scenario, in which consumers are driven by both lamp cost and energy savings, results in an upper bound energy-savings scenario. A detailed description of the two fluorescent standards-case scenarios can be found in Chapter 9 of the TSD. DOE invites comment on the populated GSFL market-share matrices in the base-case and both standards-case scenarios.

To illustrate the above approach, Table III.29 presents an example of a market-share matrix for the GSFL shipment model. This matrix characterizes the technology mix of new 4-foot T8 medium bipin lamp-and-ballast systems shipped in 2012 and 2042 in the base case and at CSL 3 under the shift scenario. Shipments of new systems in the intermediate years can be characterized by a linear progression from the 2012 technology mix to the 2042 technology mix. A separate market-share matrix exists for 4-foot T8 medium bipin lamp purchases on pre-existing ballasts. For this new system market-share matrix, the lamp-and-ballast designs were generated by pairing each lamp with the three ballasts with the most common BFs (0.88, 0.78, and 0.75) in the 4-foot T8 medium bipin market. This produces both energy-saving and non-energy-saving options. In the standards-case scenario shown, consumers then shift to reduced-wattage lamps and/or lower BFs.

TABLE III.29.—FOUR-FOOT T8 MEDIUM BIPIN MARKET-SHARE MATRIX UNDER THE SHIFT SCENARIO

Mix of New Lamp-and-Ballast Systems Purchased					
CSL	Lamp-and-ballast design	Base case		CSL3	
		2012 (percent)	2042 (percent)	2012 (percent)	2042 (percent)
Electronic Ballast Factor					
0.88					
2	32.5 W, 86.2 lm/W	43	8	....	....
3	32.5 W, 90.8 lm/W	29	10	0	0
4	32.5 W, 92.3 lm/W	11	14	0	0
4	30 W, 92.3 lm/W	0	3	11	14
5	32.5 W, 95.4 lm/W	7	12	7	12
5	28 W, 97.3 lm/W	0	3	0	3
5	25 W, 96 lm/W	0	4	0	0
0.78					
2	32.5 W, 86.2 lm/W	0	4	....	....
3	32.5 W, 90.8 lm/W	0	0	43	8
4	32.5 W, 92.3 lm/W	0	6	29	10
4	30 W, 92.3 lm/W	2	6	0	0
5	32.5 W, 95.4 lm/W	0	6	0	0
5	28 W, 97.3 lm/W	3	7	0	4
5	25 W, 96 lm/W	0	4	3	7
0.75					
2	32.5 W, 86.2 lm/W	0	0	....	....
3	32.5 W, 90.8 lm/W	0	0	0	10
4	32.5 W, 92.3 lm/W	0	0	0	9
4	30 W, 92.3 lm/W	2	6	0	0
5	32.5 W, 95.4 lm/W	0	0	0	0
5	28 W, 97.3 lm/W	3	7	7	19
5	25 W, 96 lm/W	0	0	0	4
Total	....	100	100	100	100

b. Incandescent Reflector Lamps

Similar to the GSFL model, the IRL shipment model use market-share matrices to project shipments. The IRL commercial and residential shipment models separately designate stock technology mixes in the years 2012 and 2042. These market-share matrices also present the available lamp designs in the standards case for which the stock technology mix is also characterized in one intermediate year. DOE developed percentage inputs for the IRL market-share matrices based on an examination of manufacturer product catalogs, historical shipment information, and interviews with manufacturers.

Table III.30 presents an example of a market-share matrix for the commercial IRL shipment model. This matrix characterizes the stock technology mix of IRL in the years 2011 and 2042 in the base case, and in the years 2013 and 2042 at CSL 2. DOE chooses to characterize the stock in 2013 because DOE projects that by then the majority of the base-case commercial IRL stock would have turned over to be standards compliant. In the base case, DOE predicts a decline in halogen technology lamps and a rise in more-efficient HIR lamps. At CSL 2, all IRL must meet an HIR standard.

TABLE III.30.—MARKET-SHARE MATRIX FOR COMMERCIAL IRL SOCKETS

Candidate standard level	Lamp design	Percentage stock in 2011 (Base case input only)	Percentage of stock in 2013 (Standards case input only)	Percentage of stock in 2042
Base Case	90 W, 14.6 lm/W, 2500 hrs, Halogen	33		21
	75 W, 14.0 lm/W, 2500 hrs, Halogen	26		16
	50 W, 11.6 lm/W, 3000 hrs, Halogen	22		14
	70 W, 18.0 lm/W, 3000 hrs, HIR	8		21
	60 W, 17.5 lm/W, 3000 hrs, HIR	6		16
	41.3 W, 15.0 m/W, 3000 hrs, HIR	5		14
	Total	100		100
CSL2	70 W, 18.0 lm/W, 3000 hrs, HIR		41	41
	60 W, 17.5 lm/W, 3000 hrs, HIR		32	32
	41.3 W, 15.0 m/W, 3000 hrs, HIR		27	27
	Total		100	100

In addition to modeling one main scenario for IRL shipments, in order to capture the range of NES and NPV results possible, DOE created two sensitivity scenarios in the IRL shipments analysis. In one sensitivity scenario (termed ''65 Watt BR lamp substitution'') in the standards case, DOE models a migration away from covered IRL toward exempted 65 Watt BR 30 and 65 Watt BR 40 lamps. As discussed earlier, EISA 2007 extended energy conservation standards coverage to certain ER and BR while exempting others. DOE believes that as the efficacy standards for IRL increase, some consumers who would normally purchase a covered IRL may instead choose to purchase a higher-wattage, lower-first-cost, exempted 65 Watt BR lamp. Although these exempted lamps do not fall under the scope of this rulemaking, DOE has included a sensitivity scenario incorporating this potential outcome, because it affects NES and NPV results. Further discussion of this 65 Watt BR lamp substitution sensitivity scenario can be found in Chapter 9 and Appendix 9A of the TSD.

Regarding the second standards-case sensitivity scenario modeled, EEI commented that consumers may choose to purchase a higher-wattage lamp rather than a reduced-wattage lamp. (EEI, No. 7 at p. 1) If this were to happen, consumers would operate lamps in the standards case that gave them more lumens than they are modeled to be using in the base case. To represent this scenario, DOE created a ''10-percent lumen increase'' sensitivity scenario, which assumes that the residential IRL market, on average, would produce ten percent more lumens under standards scenarios. To achieve this increase in lumens, DOE models a portion of IRL purchases at reduced wattages and others at constant or higher wattages. Appendix 9A of the TSD presents both the market-share matrix and results associated with this scenario.

Chapter 9 and Appendix 9A of the TSD presents all of the market-share matrices used in the shipment models for GSFL and IRL. DOE requests specific comment on the detailed matrices which represent the underlying input assumptions for each of the shipment scenarios and lamp types.

5. Shipment Forecast Results

Table III.31 and Table III.32 present the results of the base-case shipment forecasts for GSFL and IRL, respectively. In those tables, values provided for the years 2001 to 2005 present historical shipment data, whereas the 2006 to 2011 shipments are linear extrapolations from the historical shipments. The shipments estimated for 2012 to 2042 are the projected unit shipments generated by the shipment models. This section includes a general discussion of the market dynamics impacting shipments in the standards cases. Chapter 9 of the TSD provides the detailed numerical output of the standards-case shipment forecasts.

For GSFL, in accordance with historical shipment data, shipments of 4-foot T12 medium bipin and 8-foot T12 single pin slimline lamps in the base case are expected to decline as the magnetic ballasts on which those lamps are installed are no longer sold. These retired 4-foot T12 medium bipin and 8-foot T12 single pin slimline systems are expected to be replaced with 4-foot T8 medium bipin lamp-and-ballast systems, respectively. In addition, DOE forecasts that 90 percent of 8-foot T12 single pin slimline systems will be replaced with 4-foot T8 medium bipin lamp systems, and 10 percent will be replaced with 8-foot T8 single pin slimline systems. This effect, along with the 4-foot T8 systems purchased for new construction, account for the expected increase in 4-foot T8 and 8-foot T8 shipments. The base-case shipment forecasts of 8-foot T12 recessed double contact HO are depicted as constant, similar to the historical shipments.

The standards-case forecasts experience similar trends, though at modified rates. At CSL1, CSL2, and CSL3, the early retrofit rates of 4-foot T12 medium bipin and 8-foot T12 single pin slimline systems are expected to increase, thereby accelerating the reduction in those shipments while increasing shipments of 4-foot T8 medium bipin and 8-foot T8 single pin slimline shipments. Because voluntary retrofits are not incorporated in the 8-foot T12 recessed double contact HO model, the standards-case shipment forecasts of these lamps at CSL1, CSL2, and CSL3 are similar to the base-case forecast. In addition, because at CSL 4 and CSL 5, 4-foot T12 medium bipin, 8-foot T12 single pin slimline, and 8-foot T12 recessed double contact HO lamps are no longer standards-compliant, these systems are automatically retrofitted upon lamp failure.

TABLE III.31.—GSFL SHIPMENTS IN THE BASE CASE
[Millions]

Year	4-foot T12 medium bipin	4-foot T8 medium bipin	8-foot T12 single pin slimline	8-foot T8 single pin slimline	8-foot T12 recessed double contact HO
2001	236	182	48	5	27
2003	202	191	41	6	27
2005	181	240	37	6	28
2007	151	262	32	7	27
2009	122	292	26	7	27
2012	111	425	17	9	31
2015	71	479	10	9	31
2020	22	584	3	10	31
2025	....	657	....	10	31
2030	....	705	....	10	31
2035	....	775	....	10	31
2040	....	874	....	10	31
2042	....	889	....	10	31
Cumulative (2012–2042)	556	20,812	78	305	971

The forecasted shipments beyond the year 2011 of covered IRL (exempted BR and ER lamps are not included) are shown in Table III.32. As demonstrated below, the shipments shown decrease over the analysis period. There are two reasons why DOE projects shipments to decrease: (1) Increased penetration of CFL and other long-lived emerging technologies; and (2) historical growth in IRL stock (approximately 8 to 10 percent annually) which is significantly higher than the historical growth rate in building floor space (i.e., 1.6 percent annually in the commercial sector and 1.3 percent annually in the residential sector). Given this inconsistency in growth rates, DOE believes this high historical growth rate in IRL stock is unsustainable in the long term, so DOE has tentatively decided to instead base IRL socket growth after 2011 on the historical growth in building floor space. This decrease in stock growth contributes to the expected decline in IRL shipments.

In the standards case, shipments of IRL in both the commercial and residential sectors are generally expected to decrease relative to the base case, as longer-lived HIR and improved HIR lamps are incorporated into the installed stock. In addition, for the 65 Watt BR lamp substitution scenario, shipments of covered IRL decrease relative to the base case due to the migration to exempted 65 Watt BR lamps.

TABLE III.32.—IRL SHIPMENTS IN THE BASE CASE
[Millions]

Year	Commercial	Residential
2001	67	66
2003	71	70
2005	83	85
2007	89	93
2009	92	85
2012	98	99
2015	98	98
2020	96	96
2025	94	93
2030	90	88
2035	86	83
2040	80	76
2042	77	74
Cumulative (2012–2042)	2,814	2,770

Additional detail on the shipments analyses can be found in Chapter 9 of the TSD.

I. National Impact Analysis

The national impact analysis (NIA) assesses cumulative national energy savings (NES) and the cumulative national economic impacts of candidate standards levels. The analysis measures economic impacts using the net present value (NPV) metric, which represents the net present value (i.e., future amounts discounted to the present) of total customer costs and savings expected to result from new standards at specific efficacy levels. For a given CSL, DOE calculated the NPV, as well as the NES, as the difference between a base case and the standards-case forecasts. Detailed information on the national impacts analysis can be found in Chapter 10 of the TSD.

DOE determined national annual energy consumption as the product of the annual energy consumption per unit lamp system and the number of total units in the installed stock. The per-unit annual energy consumption is a function of lamp efficacy and lamp wattage (and BF in the case of the GSFL). TSD Chapter 6, *Energy-Use Characterization,* describes how the per-unit energy consumption varies as a function of efficacy for each of the considered lamps. Cumulative energy savings are the sum of the annual NES determined over a specified time period. DOE calculated net economic savings each year as the difference between total operating cost savings and increases in total installed costs. Cumulative economic savings are the sum of the annual NPVs determined over a specified time period.

1. Approach

In the standards case, more-efficacious products gradually replace less-efficacious products over time. This affects calculations of both the NES and NPV, which are both a function of the total number of units in use and their efficacies, and thus depend on annual shipments and the lifetime of a product. Both calculations start by first estimating the installed lamp stock. As discussed in section III.H (Shipments Analysis), new lamps (or, for GSFL, new lamp-and-ballast systems) shipped over time are specified by market-share matrices. These shipments are tracked through the analysis period to establish the installed stock of lamps.

In the standards case, given that most consumers are likely to install lamp systems with energy consumption less than or equal to their base-case systems, the energy consumption per unit of capacity used by the products in service gradually decreases in the standards case relative to the base case. To estimate the resulting national energy savings at each CSL, DOE followed a four-step process. First, DOE calculated the national site-energy [60] consumption for GSFL and IRL for each year, beginning with the expected effective date of the standards (2012) for the base-case forecast and each standards-case forecast. Second, DOE determined the annual site-energy savings, consisting of the difference in site-energy consumption between the base case and the standards case. DOE also estimated and reported additional heating, ventilating, and air conditioning (HVAC) interaction savings associated with increased lamp efficacy in the commercial sector. Third, DOE converted the annual site-energy savings into the annual amount of energy saved at the source of electricity generation (i.e., primary energy), using a site-to-source conversion factor that varies by year (calculated from AEO 2007 projections). Finally, DOE summed the annual source-energy savings from 2012 to 2042 to calculate the total NES for that period.

To estimate NPV, DOE calculated the net impact each year as the difference between total operating cost savings (or the electricity cost savings) and increases in total installed costs (which consist of manufacturer selling price, sales taxes, and installation cost). DOE calculated the national NPV at each CSL using a three-step process. First, DOE determined the total product costs under the standards case and the base case from the total installed cost (including product prices, installation, and replacement costs as discussed in section III.G.2.a) and shipments of lamps (or lamp-and-ballast systems). Second, DOE determined the total operating costs in the base case and standards case from electricity prices and the stock of lamps and lamp systems. Third, DOE determined the difference between the net operating cost savings and the net product cost increase to get the net savings (or expense) for each year. DOE then discounted the annual net savings (or expenses) to 2007 for lamps bought during the analysis period (2012 to 2042) and summed the discounted values to provide the NPV of a CSL. An NPV greater than zero shows net savings (i.e., the CSL would reduce customer expenditures relative to the base case in present-value terms). An NPV that is less than zero indicates that the CSL would result in a net increase in customer expenditures in present-value terms.

2. Base-Case and Standards-Case Forecasted Efficacies

A key aspect of the estimates of NES and NPV is the proportion of future lamp shipments meeting different efficacies for the base case (without new standards) and each of the standards cases (with new standards). Because key inputs to the calculation of the NES and NPV are dependent on the estimate of the efficacies shipped, it is important to know the projected efficacy-distribution of lamp shipments. However, with regard to the calculation of the NES, it is also important to note that the total energy savings per unit is not solely dependent on the lamp efficacy, but also on the lamp wattage (and BF for fluorescent lamps). Because most consumers select lamp wattage when purchasing lamps, per-unit energy consumption for a particular standards-case purchase is not necessarily less than per-unit energy consumption for the corresponding base-case purchase. For example, a higher-efficacy lamp can be purchased at the same wattage under the standards case, thereby increasing lumen output without reducing energy consumption. On the other hand, by installing an equally-efficacious fluorescent lamp on a ballast with a lower BF, the outcome can be a positive energy savings for that system. As discussed in section III.H, the lamp systems available in the shipments forecast, and ultimately in the NIA, incorporate consumer choices that encompass both energy-saving and non-energy-saving options.

Also discussed in the shipments analysis (section III.H), the base-case and standards-case forecasted efficacies are primarily determined by inputs into the market-share matrices in both the fluorescent and incandescent NIA models. As exemplified in Table III.33, the base-case efficacy forecast of 4-foot medium bipin and 8-foot single pin slimline lamps show a gradual increase in average efficacy due to both the phasing out of T12 ballasts and the penetration of higher-efficacy T8 lamps. As T12 lamps are generally less efficacious than their T8 counterparts, the market shift toward T8 lamp-and-ballast systems causes an overall increase in efficacies of shipped fluorescent lamps. In addition, as T12 magnetic ballasts generally have higher system powers than their electronic T8 counterparts, average system power decreases overall. Due to the banning of magnetic ballasts by the 2000 Fluorescent Ballast rulemaking, by the year 2025, all magnetic T12 ballasts are expected to have retired from the installed stock, and the increase in average lamp efficacy and decrease in average system power slows. Because the installed stock of the 8-foot recessed double contact HO lamp market is already predominantly operating on electronic ballasts, the increase in average lamp efficacy and decrease in average system power is solely due to the penetration of more-efficacious or reduced-wattage lamps being installed on lower ballast factor ballasts.

[60] "Site energy" is the energy consumed by the lamp systems directly as they are operated at the end-use site.

TABLE III.33.—BASE-CASE AVERAGE LAMP EFFICACY AND SYSTEM POWER OF THE GSFL STOCK

Year	4-foot medium bipin		8-foot single pin slimline		8-foot recessed double contact HO	
	Average efficacy lm/W	Average system power* W	Average efficacy lm/W	Average system power** W	Average efficacy lm/W	Average system power† W
2012	87.9	93	91.3	135	83.0	198
2015	88.9	89	92.6	129	83.0	197
2020	90.0	85	95.7	116	83.3	197
2025	90.7	84	97.5	110	83.7	196
2030	91.3	82	98.0	109	84.1	194
2035	91.9	81	98.4	108	84.5	193
2042	92.8	79	99.1	107	85.0	192

* 4-foot medium bipin systems are lamp systems composed of either one or two ballasts and three lamps.
** 8-foot single pin slimline systems are lamp systems composed of one ballast and two lamps.
† 8-foot recessed double contact systems are lamp systems composed of one ballast and two lamps.

Improvement in stock efficacy for IRL is driven by shifts to more-efficacious HIR technologies. For IRL, as discussed in the Shipments Analysis (see section III.H.3), DOE reports only the improvement in efficacy of the lamp sockets not migrating to non-IRL emerging technologies such as solid-state lighting or ceramic metal halide. As demonstrated in Table III.34 the average efficacy of the installed stock of IRL is expected to increase during the analysis period.

TABLE III.34.—BASE-CASE AVERAGE LAMP EFFICACY OF THE IRL STOCK

Year	Average efficacy lm/W
2012	13.7
2015	13.8
2020	13.8
2025	13.8
2030	13.9
2035	13.9
2042	13.9

DOE invites comment on the base-case efficacy forecasts of GSFL and IRL.

3. *National Impact Analysis Inputs*

Table III.35 summarizes the major inputs to the NES and NPV spreadsheet models. For each input, the table provides a brief description of the data source. For details on the entire national impact analysis, see Chapter 10 of the ANOPR TSD.

TABLE III.35.—NATIONAL ENERGY SAVING AND NET PRESENT VALUE INPUTS

Input data	Data description
Shipments	Annual shipments from the GSFL and IRL shipment models (see TSD Chapter 9, Shipments Analysis).
Stock of Lamps	Established based on the 2011 lamp stock, the service life of lamps and/or ballasts, and the annual shipments. The initial stock is based on historical shipments and projected shipments from 2006 to 2011. (See TSD Chapter 9, Shipments Analysis).
Effective Date of Standard	2012.
Analysis Period	2012 to 2042.
Unit Energy Consumption (kWh/yr)	Established in the Energy-Use Characterization, TSD Chapter 6, by lamp or lamp-and-ballast design and sector.
Total Installed Cost	Established in the Product Price Determination, TSD Chapter 7 and the LCC Analysis, TSD Chapter 8, by lamp-and-ballast designs.
Electricity Price Forecast	2007 EIA Annual Energy Outlook forecasts (to 2030) and extrapolation for beyond 2030 (see TSD Chapter 8).
Electricity Site-to-Source Conversion	Conversion varies yearly and is generated by 2007 EIA Annual Energy Outlook forecasts (to 2030) of electricity generation and electricity-related losses. Conversion factors for beyond 2030 are extrapolated.
HVAC Interaction Savings	6.25% of total energy savings in the commercial sector.
Rebound Effect	1% of total energy savings in the commercial sector.
	8.5% of total energy savings in the residential sector.
Discount Rate	3 and 7 percent real.
Present Year	Future costs and savings are discounted to the year 2007.

Inputs for the calculation of NES identified in Table III.35 include the analysis period, per-unit annual energy consumption, shipments, lamp stock, site-to-source conversion factors, rebound effect, and heating/ventilating/air conditioning (HVAC) interaction savings. The following discussion provides further context and information on these inputs.

One of the critical inputs to the NES and NPV calculations is the analysis period. DOE received several comments at the Framework Meeting regarding the appropriateness of 30 years as the duration of the analysis period for a fluorescent and incandescent lamp NES. Both GE and PG&E commented that because the life-cycle of fluorescent lighting systems is approximately 15 or 20 years, a 30-year analysis period is too long in the commercial sector. In addition, GE commented that although incandescent lamps are often upgraded much sooner than 20 years, a 20-year analysis period could be used for consistency with the GSFL analysis. (Public Meeting Transcript, No. 4.5 at pp.204–205) ACEEE commented that DOE should use a 30-year analysis period for consistency with other rulemaking analyses. (Public Meeting Transcript, No. 4.5 at pp. 205–206) In response, DOE recognizes that the life-cycle of GSFL systems and IRL are all estimated to be less than 30 years; however, DOE has tentatively decided to use an analysis period from 2012 to 2042 for consistency with the shipment and national impact analyses of other rulemakings.

Annual energy consumption per lamp system is used to calculate the annual national energy consumption. For IRL, the lamp system is solely composed of the incandescent lamp. For GSFL, DOE received a comment from EEI urging DOE to consider system energy consumption in the fluorescent lamp national impact analysis. EEI emphasized that the ballast determines the energy savings in many situations. (EEI, No. 7 at p. 1) DOE recognizes the significance of EEI's comment and has incorporated this approach into its analysis. Accordingly, for the ANOPR, DOE considered GSFL lamp-and-ballast pairs, or systems, in constructing its national impact analysis. Section III.D, *Energy-Use Characterization*, provides the energy consumption of each lamp-and-ballast pairing used in the national impact analysis.

The lamp stock in a given year is the number of lamps shipped from earlier years to the present and which survive in the given year. The NIA spreadsheet model keeps track of the number of units shipped each year. As discussed in Section III.H, *Shipments Analysis*, DOE develops its forecasted shipments for the base case from the initial stock of fluorescent and incandescent lamps in the year before the effective date of the standard (i.e., 2011).

For both GSFL and IRL, DOE developed market-share matrices illustrating the technology migration of the stock. The growth in stocks (either by lumen demand or by number of sockets in the field) and the average lumen output per lamp result in a forecasted lumen output for the commercial GSFL, industrial GSFL, commercial IRL, and residential IRL markets over the analysis period. If DOE receives comment that over-lighting or under-lighting in any of the markets will result in a decrease in total shipments and total stock, DOE may make such a stock adjustment for the NOPR. DOE invites comment on this issue.

The site-to-source conversion factor is the multiplicative factor DOE uses for converting site-energy consumption (the energy used at the end-use site) into primary or source energy consumption (the energy used at the source before transmission or conversion losses). For electricity, the conversion factors vary over time due to projected changes in generation sources (i.e., the power plant types projected to provide electricity to the country). For the ANOPR, DOE calculated annual average site-to-source conversion factors using EIA's AEO2007. The conversion factors were derived by dividing the total energy used to produce electricity in each forecast year in the United States, as indicated in AEO2007, by the total electricity delivered for each forecasted year. For example, the site-to-source conversion factor in 2012 is calculated to be 10,680 BTU/kWh.

DOE received multiple comments regarding the HVAC system interaction with fluorescent lighting fixtures in the commercial sector. EEI commented that DOE should account for this interaction (both the reduction of AC loads and increase in heating loads) as an effect of the standard in its national impacts analysis. (EEI, No. 7 at p. 1; Public Meeting Transcript, No. 4.5 at p. 242) In addition, EEI noted that a trend toward higher-efficacy HVAC systems may lower this HVAC interaction with lighting. (Public Meeting Transcript, No. 4.5 at pp. 159–160) Based on this comment, DOE has decided to include HVAC interaction in its calculation of the NES (but not in the NPV calculation). To account for HVAC energy savings, DOE used the analysis completed by the 2000 Fluorescent Ballast rulemaking, which calculates an HVAC interaction energy savings of 6.25 percent of total energy savings.[61] As EEI suggested, this analysis incorporates changes in both heating and cooling loads as a result of the standard. The analysis also involved calculating the lighting HVAC interaction energy savings on buildings built before 1989 (5 percent of total energy savings) and ones built from 1990 to 1995 (10 percent of total energy savings). The ballast analysis assumed that over the analysis period, the building stock would move from the 5 percent interaction factor towards the 10 percent interaction factor. Using simple scaling methods, 6.25 percent was used as an average interaction over the entire analysis period. Using this same methodology for lamps, an analysis period ranging from 2012 to 2042 would have a slightly higher HVAC energy savings. However, DOE acknowledges EEI's comment that the overall HVAC savings with lighting may also decrease due to more-efficient heating and cooling systems. Considering these competing factors, DOE believes it is reasonable to use 6.25 percent of total energy savings as the HVAC energy savings in commercial sector for both GSFL and IRL.

NWPCC commented that due to the increasing prevalence of air conditioning systems, it would be worthwhile to analyze the heating load of incandescent lamps on the HVAC systems in the residential sector. (Public Meeting Transcript, No. 4.5 at pp. 162–163) GE then responded that incandescent lamps have a minor effect on HVAC energy usage, so such an analysis is not warranted. (Public Meeting Transcript, No. 4.5 at p. 163) While DOE appreciates NWPCC's comment, DOE believes that IRL will have a minor effect on HVAC energy usage in the residential sector. Therefore, DOE has not included that interaction in the NES analysis. DOE invites further comment on the issue of HVAC interaction in both the commercial and residential sectors.

In its analysis, DOE considered the rebound effect[62] that occurs after installation of energy-efficient lighting equipment. DOE examined a summary of the literature regarding the rebound effect in relation to lighting equipment.[63] Based on four studies, the summary estimated that, for a 100 percent increase in energy efficiency, values of ''take-back'' or rebound for residential lighting are between five and twelve percent of the energy consumption savings. In addition, with regards to a firm's response to higher-efficiency lighting, the summary estimated zero to two percent for values of rebound for lighting. Therefore, in the calculation of national energy savings due to energy conservation standards on lighting, DOE used a rebound rate of 8.5 percent in the residential sector and one percent in the commercial and industrial sectors. However, DOE notes that the summary of the literature reports that the results of rebound due

[61] 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 B, pp. B–23–B–30 (Jan. 2000). Available at: *http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/appendix_b.pdf*

[62] Under economic theory, ''rebound effect'' refers to the tendency of a consumer to respond to the cost savings associated with more efficient equipment in a manner that actually leads to marginally greater product usage, thereby diminishing some portion of anticipated energy savings related to improved efficiency.

[63] Greening, L.A., D.L. Greene, and C. Difiglio, ''Energy efficiency and consumption—the rebound effect—a survey,'' 28 *Energy Policy* (2000), pp. 389–401.

to lighting are inconclusive. Thus, DOE invites comments on both the inclusion and magnitude of the rebound effect for purposes of analyzing the expected effects of this regulation.

The take-back in energy consumption associated with the rebound effect provides consumers with increased value (e.g., increased lighted hours, since the increased efficiency enables consumers to use their lighting equipment for longer periods of time). The impact on consumers is, thus, the sum of the change in the cost of owning the lighting equipment (i.e., life-cycle cost) and the increased value for the longer lit hours. However, DOE is unable to monetize this increase in consumer value in the LCC analysis. DOE believes that, if it were able to monetize the increased value to consumers added by the rebound effect, this value would be at least as great as the value of the foregone energy savings. For this analysis, DOE estimates that this value is equivalent to the monetary value of the energy savings that would have occurred without the rebound effect. Therefore, the economic impacts on consumers with or without the rebound effect, as measured in the LCC and NPV analyses, are the same.

The inputs to the NPV calculation are total installed cost per unit, annual operating cost savings per unit, total annual installed cost increases, total annual operating cost savings, discount factor, present value of increased installed costs, and present value of operating cost savings.

As discussed in section III.E, DOE has collected prices for GSFL and IRL with varying wattages, efficacies, and lifetimes. In addition, for GSFL, ballast prices are included in the analysis. The total installed cost per unit, as described in section III.G, consists of these manufacturer selling prices, labor costs, and sales tax.

The annual operating cost savings per unit incorporates changes in electricity costs due to a standard efficacy level and lower energy consumption per unit. As described previously, DOE forecasted the per-unit annual electricity consumption. DOE forecasted electricity prices based on EIA's AEO2007. By using both of these values, DOE is able to establish the annual operating cost savings per unit.

The total annual installed cost increase is equal to the annual change between the base case and standards case in the product of per-unit total installed cost multiplied by the shipments forecasted of each lamp or lamp-and-ballast design. The total annual operating cost savings are equal to the change in the product of annual operating costs per unit and the total lamp stock by lamp or lamp-and-ballast design.

DOE multiplies monetary values in future years by the discount factor to determine the present value. DOE estimated national impacts using both a three-percent and a seven-percent real discount rate as the average real rate of return on private investment in the U.S. economy. DOE uses these discount rates in accordance with Office of Management and Budget (OMB) guidance to Federal agencies on the development of regulatory analysis (OMB Circular A–4, September 17, 2003), and section E, ''Identifying and Measuring Benefits and Costs,'' therein. DOE defines the present year as 2007.

The present value of increased installed costs is the annual installed cost increase in each year (i.e., the difference between the standards case and base case), discounted to the present, and summed for the time period over which DOE is considering the installation of product (i.e., from the effective date of standards, 2012, to the year 2042). The increase in total installed cost refers to both product cost and installation cost associated with the higher energy efficacy of product purchased in the standards case compared to the base case.

The present value of operating cost savings is the annual operating cost savings (i.e., the difference between the base case and standards case) discounted to the present, and summed over the period from the effective date, 2012, to the time when the last unit installed in 2042 is retired from service. Savings are decreases in operating costs associated with the higher energy efficacy of products purchased in the standards case compared to the base case. Total annual operating cost savings is the savings per unit multiplied by the number of units surviving in a particular year.

4. National Impact Analysis Results

Tables III.36 through Table III.38 present the NES results (including rebound effect and HVAC interactions where applicable) for each CSL considered for GSFL and IRL. As mentioned in Section III.H, due to the relatively small shipments-based market share of 2-foot U-shaped lamps, national impact results for 2-foot U-shaped lamps are not presented in the ANOPR. However, DOE does intend to estimate NES and NPV results for these product classes in the NOPR. In addition, the following NES and NPV values provide results for lamps of all covered CCT for GSFL. For IRL, the results are representative for both the standard-spectrum and modified-spectrum lamps.

As mentioned earlier in sections III.H.3 and III.H.4, in the GSFL shipment model, when 8-foot T12 single pin slimline lamp-and-ballast systems are retired, consumers have the option to replace those systems with 4-foot T8 medium bipin lamp-and-ballast systems. For this reason, it is necessary that DOE considers pairs of CSLs when reporting the results for the ANOPR. For the ANOPR, when DOE reports the 4-foot medium bipin NES and NPV results, these values represent only the savings accrued from new construction and the replacements of the initial 2011 4-foot medium bipin stock. It does not include savings that may be accumulated due to the added shipments and installed stock of 4-foot medium bipin systems replacing 8-foot single pin slimline systems. In addition, DOE reports the 8-foot single pin slimline NES and NPV as the savings accrued from the replacements of the initial 2011 8-foot single pin slimline stock. This assumes that 4-foot medium bipin lamps that replace the 8-foot single pin slimline lamps are still at the base-case efficacies. However, when reporting the total NES and NPV for the entire linear GSFL market, DOE assumes that all product classes (4-foot medium bipin, 8-foot single pin slimline, and 8-foot recessed double contact HO) are at the same CSL and all savings are accounted for.

DOE invites comment on appropriate CSL pairings that should be reported as trial standard levels in the NOPR, including additional pairings not presented in this ANOPR. The NIA spreadsheet has the flexibility to compute results for all combinations of CSLs at the product class level and even at the level of baseline lamps for GSFL. For example, in the GSFL NIA model, it is possible to specify different efficacy requirements for 4-foot T12 medium bipin and 4-foot T8 medium bipin lamps. More detailed discussion regarding these CSL pairs can be found in Chapter 9 of the TSD.

Table III.36 and Table III.37 present the national energy savings for GSFL under both the ''shift'' (upper bound) and ''roll-up'' (lower bound) scenarios. The highest energy savings result from CSL 5 for both scenarios and all lamp types. In addition, note that at CSL 1 and CSL 2 (and CSL 3 for only 8-foot recessed double contact HO lamps), all energy savings originate from shifts to higher-efficacy T12 lamps and, in the 4-foot medium bipin and 8-foot single pin slimline models, early retrofits to the more-efficacious T8 systems. At these CSLs, all T8 lamps are standards-compliant and, therefore, unaffected in both scenarios. At CSL 3, a large increase in total energy savings of GSFL can be observed, stemming from the saving associated with 4-foot T8 lamps (the majority of the stock) being affected by the regulations. It is also important to note that at CSL 4 and CSL 5 for all GSFL product classes, all T12 lamp systems are automatically retrofitted to T8 lamp systems because no T12 standards-compliant lamps are available as lamp designs.

TABLE III.36.—CUMULATIVE NATIONAL ENERGY SAVINGS FOR GSFL UNDER THE SHIFT SCENARIO

[2012–2042] [quads][64]

Candidate standard level	Product class	NES *quads*		
		Undiscounted	Discounted at 7%	Discounted at 3%
1	4-foot medium bipin	0.27	0.14	0.20
	8-foot single pin slimline	0.05	0.03	0.04
	8-foot recessed double contact HO	0.48	0.15	0.27
	Total	0.80	0.31	0.51
2	4-foot medium bipin	0.45	0.24	0.34
	8-foot single pin slimline	0.09	0.05	0.06
	8-foot recessed double contact HO	0.65	0.20	0.37
	Total	1.19	0.49	0.78
3	4-foot medium bipin	6.79	1.98	3.81
	8-foot single pin slimline	0.13	0.07	0.10
	8-foot recessed double contact HO	0.67	0.20	0.38
	Total	7.94	2.35	4.49
4	4-foot medium bipin	8.17	2.54	4.72
	8-foot single pin slimline	0.41	0.15	0.25
	8-foot recessed double contact HO	2.16	0.63	1.21
	Total	11.09	3.43	6.39
5	4-foot medium bipin	12.69	3.62	7.05
	8-foot single pin slimline	0.41	0.16	0.26
	8-foot recessed double contact HO	2.19	0.64	1.23
	Total	15.86	4.59	8.86

TABLE III.37.—CUMULATIVE NATIONAL ENERGY SAVINGS FOR GSFL UNDER THE ROLL-UP SCENARIO

[2012–2042] [quads][64]

Candidate standard level	Product class	NES *quads*		
		Undiscounted	Discounted at 7%	Discounted at 3%
1	4-foot medium bipin	0.27	0.14	0.20
	8-foot single pin slimline	0.05	0.03	0.04
	8-foot recessed double contact HO	0.35	0.12	0.21
	Total	0.67	0.28	0.45
2	4-foot medium bipin	0.45	0.24	0.34
	8-foot single pin slimline	0.09	0.05	0.06
	8-foot recessed double contact HO	0.61	0.19	0.35
	Total	1.15	0.48	0.76
3	4-foot medium bipin	2.88	0.92	1.68
	8-foot single pin slimline	0.13	0.07	0.10
	8-foot recessed double contact HO	0.63	0.19	0.36
	Total	3.79	1.23	2.23
4	4-foot medium bipin	3.71	1.16	2.14
	8-foot single pin slimline	0.17	0.09	0.13
	8-foot recessed double contact HO	1.89	0.55	1.06

TABLE III.37.—CUMULATIVE NATIONAL ENERGY SAVINGS FOR GSFL UNDER THE ROLL-UP SCENARIO—Continued

[2012–2042] [quads] [64]

Candidate standard level	Product class	NES *quads*		
		Undiscounted	Discounted at 7%	Discounted at 3%
	Total	5.92	1.85	3.42
5	4-foot medium bipin	6.62	1.90	3.68
	8-foot single pin slimline	0.23	0.11	0.16
	8-foot recessed double contact HO	2.05	0.60	1.15
	Total	9.26	2.72	5.20

Table III.38 presents the national energy savings for IRL in the commercial and residential sectors. As shown in the table, energy savings for both commercial and residential IRL are greatest at CSL3. Appendix 10B of the TSD presents NES results for both the ''65 Watt BR lamp substitution'' and the ''10 percent lumen increase'' sensitivity scenarios. Because both of these scenarios involve the purchasing of either higher-wattage or same-wattage lamps, the two sensitivity scenarios generally present lower NES results than that of the main scenario presented in this notice.

TABLE III.38.—CUMULATIVE NATIONAL ENERGY SAVINGS IRL

[2012–2042] [quads]

Candidate standard level	Sector	NES *quads*		
		Undiscounted	Discounted at 7%	Discounted at 3%
1	Commercial	0.48	0.15	0.28
	Residential	0.60	0.18	0.34
	Total	1.08	0.33	0.62
2	Commercial	0.83	0.27	0.49
	Residential	1.03	0.30	0.58
	Total	1.86	0.57	1.07
3	Commercial	1.13	0.36	0.66
	Residential	1.27	0.37	0.71
	Total	2.40	0.73	1.37

Below are the NPV results for the CSLs considered for GSFL and IRL. Results are cumulative and are shown as the discounted value of these savings in dollar terms. The present value of increased total installed costs is the total installed cost increase (i.e., the difference between the standards case and base case), discounted to the present, and summed over the time period in which DOE evaluates the impact of standards (i.e., from the effective date of standards, 2012, to 2042).

Savings are decreases in operating costs associated with the higher energy efficacy of each product purchased in the standards case compared to the base case. Total operating cost savings are the savings per unit multiplied by the number of units surviving in a particular year. Each product consumes energy and must be maintained over its entire lifetime. For a unit that survives after 2042, DOE calculates a residual value in both the base case and standards case to account for its remaining life. The cost savings associated with this residual value are incorporated into the total NPV result. A detailed description of this calculation can be found in Chapter 10 of the TSD.

The NPV results for the CSLs analyzed for each of the lamp types are based on discount rates of 7 and 3 percent.

Table III.39 and Table III.40 provide the NPV for GSFL under both the shift and roll-up scenarios. As seen below, CSL 4, for 8-foot recessed double contact HO lamps and 8-foot single pin slimline lamps, and CSL 5 for 4-foot medium bipin, achieve the highest NPV for the shift scenario. For the roll-up scenario, CSL 5 achieves the highest NPV for all types of fluorescent lamps analyzed. Also, for both scenarios and at all CSLs, the 4-foot medium bipin lamp results in positive NPV, because increasingly efficacious lamp-and-ballast designs generally have higher LCC savings relative to each other and

[64] Results of 4-foot medium bipin energy savings and NPV are calculated assuming there is no 8-foot single pin slimline standard while the 8-foot single pin slimline results assume no 4-foot medium bipin standard. Total results assume 4-foot medium bipin lamps and 8-foot single pin slimline lamps are subject to the same CSL.

the base-case lamp-and-ballast designs. For all GSFL, at CSL 4 and CSL 5, large and positive NPV generally result due to the integration of more-efficacious T8 design options into both commercial and industrial lamp stocks. As 4-foot T8 medium bipin lamps are the majority of stock of all GSFL, an increase in lamp efficacy and a decrease in energy consumption result in large operating cost savings and, therefore, high NPV.

TABLE III.39.—CUMULATIVE NPV RESULTS FOR GSFL UNDER THE SHIFT SCENARIO

[Billion 2006$]

Candidate standard level	Product class	NPV *billion 2006$*	
		Discounted at 7%	Discounted at 3%
1	4-foot medium bipin	0.20	0.52
	8-foot single pin slimline	−0.03	0.02
	8-foot recessed double contact HO	0.94	1.86
	Total	1.11	2.40
2	4-foot medium bipin	0.24	0.74
	8-foot single pin slimline	0.01	0.11
	8-foot recessed double contact HO	1.42	2.73
	Total	1.67	3.58
3	4-foot medium bipin	9.33	19.92
	8-foot single pin slimline	0.13	0.31
	8-foot recessed double contact HO	0.05	0.20
	Total	10.15	21.66
4	4-foot medium bipin	13.75	27.03
	8-foot single pin slimline	0.69	1.52
	8-foot recessed double contact HO	3.64	8.08
	Total	18.78	37.92
5	4-foot medium bipin	20.37	42.62
	8-foot single pin slimline	0.68	1.51
	8-foot recessed double contact HO	3.63	8.06
	Total	25.74	54.26

TABLE III.40.—CUMULATIVE NPV RESULTS FOR GSFL UNDER THE ROLL-UP SCENARIO

[Billion 2006$]

Candidate standard level	Product class	NPV *billion 2006$*	
		Discounted at 7%	Discounted at 3%
1	4-foot medium bipin	0.20	0.52
	8-foot single pin slimline	−0.03	0.02
	8-foot recessed double contact HO	0.56	1.01
	Total	0.73	1.55
2	4-foot medium bipin	0.24	0.74
	8-foot single pin slimline	0.01	0.11
	8-foot recessed double contact HO	1.15	2.13
	Total	1.40	2.98
3	4-foot medium bipin	2.60	6.15
	8-foot single pin slimline	0.13	0.31
	8-foot recessed double contact HO	0.00	0.07
	Total	2.98	7.00
4	4-foot medium bipin	5.37	10.63
	8-foot single pin slimline	0.07	0.26
	8-foot recessed double contact HO	3.27	7.33

TABLE III.40.—CUMULATIVE NPV RESULTS FOR GSFL UNDER THE ROLL-UP SCENARIO—Continued

[Billion 2006$]

Candidate standard level	Product class	NPV billion 2006$	
		Discounted at 7%	Discounted at 3%
	Total	9.00	18.74
5	4-foot medium bipin	8.19	17.29
	8-foot single pin slimline	0.24	0.66
	8-foot recessed double contact HO	3.40	7.61
	Total	12.47	26.72

Table III.41 presents the NPV for IRL in the commercial and residential sectors. As shown in Table III.41, the NPV for IRL is greatest at CSL3, consistent with trends in LCC savings. Appendix 10B of the TSD presents NPV results for both the ''65 Watt BR lamp substitution'' and the ''10 percent lumen increase'' sensitivity scenarios.

TABLE III.41.—CUMULATIVE NPV RESULTS FOR IRL

[Billion 2006$]

Candidate standard level	Sector	NPV billion 2006$	
		Discounted at 7%	Discounted at 3%
1	Commercial	0.82	1.53
	Residential	1.20	2.47
	Total	2.02	4.00
2	Commercial	1.54	2.86
	Residential	2.31	4.64
	Total	3.85	7.50
3	Commercial	2.88	5.40
	Residential	3.34	6.76
	Total	6.22	12.16

J. Life-Cycle Cost Subgroup Analysis

The LCC subgroup analysis evaluates impacts of standards on identifiable groups of customers, such as different population groups of consumers (e.g., consumers part of low income households) or different business types (e.g., educational facilities), which may be disproportionately affected by any national energy conservation standard level. In the NOPR phase of this rulemaking, DOE will analyze the LCCs and PBPs for consumers that fall into such groups. The analysis will determine whether any particular group of consumers would be adversely affected by any of the trial standard levels.

DOE plans to examine variations in energy prices and energy use that might affect the NPV of a standard for customer subpopulations. To this end, DOE intends to perform additional analyses to consider how differences in energy use will affect subgroups of customers. DOE will determine the effect on customer subgroups using the LCC spreadsheet model. As described in Section III.G, the ANOPR LCC analysis includes various customer types that use the lamps being considered under this rulemaking. This analysis includes consumers purchasing lamps in different sectors, purchasing lamps for different building types, replacing different baseline lamps or lamp/ballast systems, and undergoing different purchasing events.

For IRL, DOE can estimate LCC savings and payback periods for consumers in the residential, commercial, and industrial sectors. For GSFL, DOE can perform an LCC analysis for consumers in the commercial and industrial sectors. A subgroup analysis for consumers of GSFL in the residential sector could also be performed if DOE assumes GSFL residential lamps have the same operating hour profile as IRL residential lamps. DOE requests comment on this assumption.

DOE can also analyze the LCC impacts on consumers living in different buildings in the commercial and residential sectors. For example, DOE can analyze the impact of standards for people running educational facilities and for those who live in a mobile home. DOE also has the ability to analyze the impacts on consumers living in different regions of the country.

For both GSFL and IRL, DOE has the ability to evaluate the LCC impacts on consumers who purchase different baseline lamps or lamp-and-ballast systems. For example, the economic impacts of a standard will be different for a consumer who owns a typical 4-foot T8 lamp-and-ballast system than for a consumer who owns a typical 4-foot T12 lamp-and-ballast system. For GSFL, DOE also has the ability to analyze the LCC impact of a standard on consumers faced with a variety of different lamp-purchasing events. The LCC impacts on a consumer who must replace a lamp for their existing system are very different from those impacts on a consumer who must purchase a lamp because they are constructing a new building.

DOE received one comment in response to the Framework Document pertaining to the LCC subgroup analysis. PG&E argued that consumers will experience differential LCCs impacts, particularly for low-income households. (PG&E, No. 4.5 at p.218) DOE will consider analyzing the impacts of candidate standards on low-income subgroups for the NOPR. DOE invites comment on these and other consumer subgroups that it should consider for the NOPR. DOE also invites comments on how LCC inputs might change for each consumer subgroup.

K. Manufacturer Impact Analysis

The purpose of the MIA is to identify the likely impacts of energy conservation standards on manufacturers. DOE has begun and will continue to conduct this analysis with input from manufacturers and other interested parties. During the MIA, DOE considers financial impacts and a wide range of other quantitative and qualitative industry impacts that might occur following the adoption of a standard. For example, if DOE adopts a particular standard level, it could require changes to manufacturing practices. DOE will identify and understand these impacts through interviews with manufacturers and other stakeholders during the NOPR stage of its analysis.

More specifically, DOE will conduct each MIA in this rulemaking in three phases, and will further tailor the analytical framework for each MIA based on comments. In Phase I, DOE creates an industry profile to characterize the industry and identify important issues that require consideration. In Phase II, DOE prepares an industry cash flow model and an interview questionnaire to guide subsequent discussions. In Phase III, DOE interviews manufacturers, and assesses the impacts of standards, both quantitatively and qualitatively. It assesses industry and sub-group cash flow and NPV through use of the Government Regulatory Impact Model (GRIM). DOE then assesses impacts on competition, manufacturing capacity, employment, and regulatory burden based on manufacturer interview feedback and discussions.

Until recently, DOE reported MIA results in its standards rulemakings only after the ANOPR phase of the rulemaking. However, DOE is now evaluating and reporting preliminary MIA information in its ANOPRs. For a detailed discussion on the MIA, refer to Chapter 12 of the ANOPR TSD.

From a comment received at the Framework Document public meeting, DOE is aware that manufacturer cost data may be difficult to obtain from industry. (Public Meeting Transcript, No. 4.5 at pp. 133–135) Therefore, as recommended, DOE may approximate manufacturer costs by working backwards through the distribution chain from publicly-available prices by using estimated manufacturer and supply chain mark-ups. (Public Meeting Transcript, No. 4.5 at pp. 129 and 133–136; NEMA, No. 8 at p. 3; Joint Comment, No. 9 at p. 3). For more information on the industry cash flow analysis, refer to Chapter 12 of the ANOPR TSD.

1. Cumulative Regulatory Burden

DOE recognizes and seeks to mitigate the overlapping effects on manufacturers of new or revised DOE standards and other regulatory actions affecting the same product. In response to the Framework Document, several stakeholders submitted comments concerning the cumulative impact of regulation on lamp manufacturers. Specifically, NEMA commented that a number of companies face regulations in other countries, and that some of these products are manufactured globally for sale around the world. Therefore, NEMA commented that there are some regulatory burdens and issues that may play a factor here. (NEMA, No. 4.5 at p. 229) EEI commented that DOE should take into account State regulations in assessing the impacts of different requirements for manufacturers. (EEI, No. 4.5 at p. 233) PG&E commented that DOE should take into account trade impacts in the industry. However, PG&E does not expect this would have a large impact for manufacturers of lighting products. (PG&E, No. 4.5 at pp. 239–240) In response, DOE recognizes that both States and foreign countries are already regulating certain lamp categories or contemplating doing so. As discussed in section III.A.1, many States are currently regulating IRL primarily used in the commercial sector, and a few are beginning to regulate lamp types used more often in the residential sector. Regulations are also pending in both Mexico and Canada.

DOE will analyze and consider the impact on manufacturers of multiple, product-specific regulatory actions in the NOPR. DOE invites comment on regulations applicable to lamp manufacturers that contribute to their cumulative regulatory burden.

2. Preliminary Results of the Manufacturer Impact Analysis

DOE conducted a series of preliminary interviews with manufacturers to assess their concerns about potential impact of changes to the requirements or coverage of the regulatory standard for fluorescent and incandescent lamps. In general, manufacturers identified the following major issues of concern: (a) Sufficient time to retool in response to the standards; (b) availability of materials to produce standards-compliant lamps; and (c) maintaining product availability and features that consumers use. Each of these concerns is discussed in further detail below.

a. Retooling Equipment To Produce Standards-Compliant Lamps

All of the manufacturers interviewed expressed concern regarding the adequacy of the time periods specified under EPCA for developing standards-compliant lamps. For GSFL, some manufacturers expressed concern about the time period necessary to retool to produce standards-compliant lamps (e.g., converting from a T12 product line to a T8 product line at certain standard levels). For IRL, manufacturers commented that, depending on the timeframe for transition, they could face production capacity problems if DOE were to raise standards such that the use of halogen capsules or infrared reflective (IR) coatings on halogen capsules were required. Manufacturers believe there could be a production capacity problem due to the process time involved in layering dozens of thin, IR-reflective film coatings on the capsule. The high volumes associated with both GSFL and IRL were cited frequently as the underlying cause for concern.

b. Availability of Materials To Produce Standards-Compliant Lamps

Manufacturers interviewed expressed concern about the availability of materials to manufacture standards-compliant lamps. More specifically, concern was expressed about potential shortages of certain materials (e.g., the phosphor that produces blue light), which could in turn drive up the production cost.

c. Maintaining Product Availability and Features

Manufacturers expressed concern to DOE about the potential impact the regulation may have on their ability to continue to supply a wide diversity of products with attributes and features that their customers require. Depending on the mandatory standard level, manufacturers expressed concern that certain lamp shapes and sizes may be eliminated from the market, or that significant market shifts could occur (e.g., from incandescent technology to compact fluorescent lamps).

As discussed above, DOE will be conducting the manufacturer impact analysis for the NOPR stage of this rulemaking. As part of this inquiry, DOE will be investigating this preliminary list of issues in more depth, as well as discussing other impacts that manufacturers may experience. DOE invites comment on these and other issues, relating to the regulatory impacts on manufacturers.

Furthermore, DOE considered the possible effect of energy conservation standards for GSFL and IRL on small businesses. At this time, DOE is not aware of any small manufacturers of the lamps being considered in this rulemaking. Should any small business manufacturers be identified, DOE will study the potential impacts in greater detail during the MIA, which DOE will conduct as a part of the NOPR analysis.

L. Utility Impact Analysis

For the NOPR, the utility impact analysis will estimate the effects on the utility industry of reduced energy consumption due to any new or amended energy conservation standards for fluorescent and incandescent lamps. For GSFL and IRL, the utility impact analysis will compare the differences between each lamp type's forecasted base and standards cases for electricity generation, installed capacity, sales, and prices.

To estimate the effects of potential standards on the electric utility industry, DOE intends to use a variant of the EIA's National Energy Modeling System (NEMS).[65] NEMS, which is available in the public domain, is a large, multi-sectoral, partial equilibrium model of the U.S. energy sector. DOE/EIA uses NEMS to produce a widely recognized baseline energy forecast for the U.S. DOE uses a variant of NEMS known as NEMS-Building Technologies (NEMS–BT) to supply key inputs to its utility impact analysis.

For electrical end uses, NEMS–BT utilizes predicted growth in demand for each end use to build up a projection of the total electric system load growth for each of fifteen electricity market module supply regions, which it uses in turn to predict necessary additions to capacity. For electrical end uses, NEMS–BT accounts for the implementation of energy conservation standards by decrementing the appropriate reference case load shape. DOE will determine the size of the decrement using the per-unit energy savings data developed in the LCC and PBP analyses (see Chapter 8 of the ANOPR TSD) and the forecast of shipments developed for the NIA (see Chapter 9 of the ANOPR TSD). For more information on the utility impact analysis, refer to Chapter 13 of the ANOPR TSD.

The use of NEMS for the utility impact analysis offers several advantages. As the official DOE energy forecasting model, NEMS relies on a set of assumptions that are transparent and have received wide exposure and commentary. NEMS allows an estimate of the interactions between the various energy supply and demand sectors and the economy as a whole. The utility impact analysis will determine the changes for electric utilities in installed capacity and in generation by fuel type produced by each CSL, as well as changes in electricity sales.

DOE plans to conduct the utility impact analysis as a variant of AEO2007, applying the same basic set of assumptions. For example, the utility impact analysis uses the operating characteristics (e.g., energy conversion efficacy, emissions rates) of future electricity generating plants.

DOE will also explore deviations from some of the reference case assumptions to represent alternative future outcomes. Two alternative scenarios use the high- and low-economic-growth cases of AEO2007. (The reference case corresponds to medium growth.) The high-economic-growth case assumes higher projected growth rates for population, labor force, and labor productivity, resulting in lower predicted inflation and interest rates relative to the reference case. The opposite is true for the low-growth case. While DOE varies supply-side growth determinants in all three of these different economic-growth cases, AEO2007 assumes the same reference case energy prices for all three economic growth cases so that the impact of differences in the three scenarios are comparable, referenced against a consistent set of energy prices. The three different economic growth cases all affect the rate of growth of electricity demand.

Since the AEO2007 version of NEMS forecasts only to the year 2030, DOE must extrapolate results to 2042. It is not feasible to extend the forecast period of NEMS–BT for the purposes of this analysis, nor does EIA have an approved method for extrapolation of many outputs beyond 2030. While it might seem reasonable in general to use simple linear extrapolations of results, in practice this is not advisable, because outputs could be contradictory. For example, changes in the fuel mix implied by extrapolations of those outputs could be inconsistent with the extrapolation of marginal emissions factors. An analysis of the various trends to a sufficiently detailed degree to guarantee consistency among the extrapolations is not conducted as part of this analysis. Further, even it were, the extrapolations would still involve a great deal of uncertainty. Therefore, for all extrapolations beyond 2030, DOE intends to simply repeat the results from the year 2030 results, until it reaches the end of the analysis period, 2042. While this simplified extrapolation technique and the resulting values may seem unreasonable in some instances, results are nevertheless guaranteed to be consistent. As with the AEO reference case in general, the implicit premise is that the regulatory environment does not deviate from the current known situation during the extrapolation period. Only changes that have been announced with date-certain introduction are included in NEMS–BT.

In comments on the Framework Document, EEI requested that DOE provide an explanation of the calculations conducted using the NEMS–BT model. EEI believes such explanation would enable the public to more easily comment on the plausibility of the output. (EEI, No. 4.5 at pp. 236–237) In response, when DOE conducts the utility impact analysis for the NOPR, it will endeavor to improve the clarity and presentation of the calculations conducted using the NEMS–BT model.

M. Employment Impact Analysis

At the NOPR stage, DOE estimates the impacts of standards on employment for equipment manufacturers, relevant service industries, energy suppliers, and the economy in general. The following discussion explains the methodology DOE plans to use in conducting the employment impact analysis for this rulemaking. Both indirect and direct employment impacts are analyzed. Direct employment impacts would

[65] For more information on NEMS, please refer to the U.S. Department of Energy, Energy Information EIA documentation; a useful summary is *National Energy Modeling System: An Overview 2003,* Report number: DOE/EIA–0581(2003), March 2003 (available at: *http://tonto.eia.doe.gov/FTPROOT/forecasting/05812003.pdf*). DOE/EIA approves use of the name ''NEMS'' to describe only an official version of the model without any modification to code or data. Because the present analysis entails some minor code modifications and the model is run under various policy scenarios that are variations on DOE/EIA assumptions, in this analysis, DOE refers to it by the name ''NEMS–BT.''

result if standards led to a change in the number of employees at manufacturing plants and related supply and service firms. Direct impact estimates are covered in the MIA.

Indirect employment impacts are impacts on the national economy other than in the manufacturing sector being regulated. Indirect impacts may result both from expenditures shifting among goods (substitution effect) and changes in income which lead to a change in overall expenditure levels (income effect). DOE defines indirect employment impacts from standards as net jobs eliminated or created in the general economy as a result of increased spending driven by the increased equipment prices and reduced spending on energy.

DOE expects new standards to increase the total installed cost of equipment (includes manufacturer's selling price, distribution channel mark-ups, sales taxes, and installation cost). DOE also expects the new standards to decrease energy consumption, and, thus, expenditures on energy. Over time, increased total installed cost is paid back through energy savings. The savings in energy expenditures may be spent on new commercial investment and other items.

Using an input/output model of the U.S. economy, this analysis seeks to estimate the effects on different sectors and the net impact on jobs. DOE will estimate national employment impacts for major sectors of the U.S. economy in the NOPR, using public and commercially available data sources and software. DOE will make all methods and documentation pertaining to the employment impact analysis available for review in the Technical Support Document published in conjunction with the NOPR.

DOE developed Impact of Sector Energy Technologies (ImSET), a spreadsheet model of the U.S. economy that focuses on 188 sectors most relevant to industrial, commercial, and residential building energy use.[66] ImSET is a special-purpose version of the U.S. Benchmark National Input-Output (I–O) model, which has been designed to estimate the national employment and income effects of energy-saving technologies that are considered by the DOE Office of Energy Efficiency and Renewable Energy. In comparison with previous versions of the model used in earlier rulemakings, the current version allows for more complete and automated analysis of the essential features of energy efficiency investments in buildings, industry, transportation, and the electric power sectors.

The ImSET software includes a personal computer-based I–O model with structural coefficients to characterize economic flows among the 188 sectors. ImSET's national economic I–O structure is based on the 1997 Benchmark U.S. table (Lawson, et al. 2002),[67] specially aggregated to 188 sectors. The time scale of the model is 50 years.

The model is a static I–O model, which means that the model is able to accommodate a great deal of flexibility concerning the types of effects the energy conservation standards can have on the national employment and income effects. For example, certain economic effects of energy-efficiency improvements require an assessment of inter-industry purchases, which is handled in the model. Some energy-efficiency investments will not only reduce the costs of energy in the economy but the costs of labor and other goods and services as well, which is accommodated through a recalculation of the I–O structure in the model. Output from the ImSET model can be used to estimate changes in employment, industry output, and wage income in the overall U.S. economy resulting from changes in expenditures in the various sectors of the economy.

Although DOE intends to use ImSET for its analysis of employment impacts, it welcomes input on other tools and factors it might consider. For more information on the employment impacts analysis, refer to Chapter 14 of the TSD.

N. Environmental Assessment

For the NOPR, DOE will assess the environmental effects of energy conservation standards for GSFL and IRL. DOE anticipates that the primary environmental effects will be reduced power plant emissions resulting from reduced electricity consumption. DOE will assess these environmental effects by using NEMS–BT to provide key inputs to the analysis. The environmental assessment produces results in a manner similar to those provided in the AEO.

The intent of the environmental assessment is to provide emissions results estimates, and to fulfill legislative requirements that DOE quantify and consider the environmental effects of all new Federal rules. The environmental assessment that will be produced by NEMS–BT considers potential environmental impacts from three pollutants (sulfur dioxide (SO_2), nitrous oxide (NO_X), mercury (Hg)) and from carbon dioxide (CO_2) emissions. For each of the trial standard levels, DOE will calculate total undiscounted and discounted power plant emissions using NEMS–BT.

DOE will conduct each portion of the environmental assessment performed for this rulemaking as an incremental policy impact (i.e., an energy conservation standard imposed on the product being evaluated, in this case general service fluorescent lamps and incandescent reflector lamps) of the AEO2007 forecast, applying the same basic set of assumptions used in AEO2007. For example, the emissions characteristics of an electricity generating plant will be exactly those used in AEO2007. Also, forecasts conducted with NEMS–BT consider the supply-side and demand-side effects on the electric utility industry. Thus, the analysis will account for any factors affecting the type of electricity generation and, in turn, the type and amount of airborne emissions generated by the utility industry.

The NEMS–BT model tracks carbon emissions with a specialized carbon emissions estimation subroutine, producing reasonably accurate results due to the broad coverage of all sectors and the inclusion of interactive effects. Past experience with carbon results from NEMS suggests that emissions estimates are somewhat lower than emissions based on simple average factors. One of the reasons for this divergence is that NEMS tends to predict that energy conservation measures will slow generating capacity growth in future years, and new generating capacity is expected to be more efficient than existing capacity. On the whole, NEMS–BT provides carbon emissions results of reasonable accuracy, at a level consistent with other Federal published results. In addition to providing estimates of the quantitative impacts of GSFL and IRL standards on carbon emissions, DOE may consider the use of monetary values to represent the potential value of such emissions reductions. DOE invites comment on how to estimate such monetary values or on any widely accepted values that might be used in DOE's analyses.

NEMS–BT also reports on SO_2 and NO_X, which DOE has reported in past analyses. The Clean Air Act

[66] Roop, J. M., M. J. Scott, and R. W. Schultz, ''ImSET: Impact of Sector Energy Technologies,'' PNNL–15273. (Pacific Northwest National Laboratory, Richland, WA)(2005).

[67] Lawson, Ann M., Kurt S. Bersani, Mahnaz Fahim-Nader, and Jiemin Guo, ''Benchmark Input-Output Accounts of the U. S. Economy, 1997,'' Survey of Current Business (Dec. 2002), pp. 19–117.

Amendments of 1990[68] set an SO_2 emissions cap on all power generation. The attainment of this target, however, is made flexible among generators through the use of emissions allowances and tradable permits. Although NEMS includes a module for SO_2 allowance trading and delivers a forecast of SO_2 allowance prices, accurate simulation of SO_2 trading implies that physical emissions effects will be zero because emissions will always be at or near the ceiling. However, there may be an SO_2 economic benefit from energy conservation in the form of a lower SO_2 allowance price. Since the impact of any one standard on the allowance price is likely small and highly uncertain, DOE does not plan to monetize the SO_2 benefit.

NEMS–BT also has an algorithm for estimating NO_X emissions from power generation. The impact of these emissions, however, will be affected by the Clean Air Interstate Rule (CAIR), which the EPA issued on March 10, 2005. 70 FR 25162 (May 12, 2005). CAIR will permanently cap emissions of NO_X in 28 eastern States and the District of Columbia. As with SO_2 emissions, a cap on NO_X emissions means that product energy conservation standards may have no physical effect on these emissions. When NO_X emissions are subject to emissions caps, DOE's emissions reduction estimate corresponds to incremental changes in the prices of emissions allowances in cap-and-trade emissions markets rather than physical emissions reductions. Therefore, while the emissions cap may mean that physical emissions reductions will not result from standards, standards could produce an environmental-related economic benefit in the form of lower prices for emissions allowance credits. However, as with SO_2 allowance prices, DOE does not plan to monetize this benefit because the impact on the NO_X allowance price from any single energy conservation standard is likely small and highly uncertain.

With regard to mercury emissions, NEMS–BT has an algorithm for estimating these emissions from power generation, and, as it has done in the past, DOE is able to report an estimate of the physical quantity of mercury emissions reductions associated with an energy conservation standard. DOE assumed that these emissions would be subject to EPA's Clean Air Mercury Rule[69] (CAMR), which would permanently cap emissions of mercury for new and existing coal-fired plants in all States by 2010. Similar to SO_2 and NO_X, DOE assumed that under such system, energy conservation standards would result in no physical effect on these emissions, but would be expected to result in an environmental-related economic benefit in the form of a lower price for emissions allowance credits. DOE's plan for addressing analysis does not include monetizing the benefits of reduced mercury emissions, because DOE considered that valuation of such impact from any single energy conservation standard would likely be small and highly uncertain.

On February 8, 2008, the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued its decision in State of *New Jersey, et al.* v. *Environmental Protection Agency,*[70] in which the Court, among other actions, vacated the CAMR referenced above. Accordingly, DOE is considering whether changes are needed to its plan for addressing the issue of mercury emissions in light of the D.C. Circuit's decision. DOE invites public comment on addressing mercury emissions in this rulemaking.

With regard to particulates, these emissions are a special case because they arise not only from direct emissions, but also from complex atmospheric chemical reactions that result from NO_X and SO_2 emissions. DOE does not intend to analyze or report on the particulate emissions from power stations because of the highly complex and uncertain relationship between particulate emissions and particulate concentrations that impact air quality. In sum, the results for the environmental assessment are similar to a complete NEMS run as published in the AEO2007. These results include power-sector emissions for SO_2, NO_X, mercury, and carbon in five-year forecasted increments extrapolated to 2042. The outcome of the analysis for each CSL is reported as a deviation from the AEO2007 reference (base) case.

The Joint Comment stated that DOE should evaluate mercury and particulate emissions as part of the environmental assessment due to their potential impacts on public health. (Joint Comment, No. 9 at p. 4) As discussed above, DOE will analyze and report on mercury emission reductions; however it does not intend to report on particulate emissions.

For more detail on the environmental assessment, refer to the environmental assessment in the ANOPR TSD.

O. Regulatory Impact Analysis

DOE will prepare a draft regulatory impact analysis in compliance with Executive Order 12866, ''Regulatory Planning and Review,'' which will be subject to review by the Office of Management and Budget's Office of Information and Regulatory Affairs (OIRA). 58 FR 51735 (Oct. 4, 1993).

As part of the regulatory impact analysis, and as discussed in Section III.K, ''Manufacturer Impact Analysis,'' DOE will identify and seek to mitigate the overlapping effects on manufacturers of new or revised DOE standards and other regulatory actions affecting the same products. Through manufacturer interviews and literature searches, DOE will compile information on burdens from existing and impending regulations affecting the lamps covered under this rulemaking. DOE also seeks input from the public about regulations whose impacts it should consider.

The regulatory impact analysis also will address the potential for non-regulatory approaches to supplant or augment energy conservation standards to improve the efficacy of GSFL and IRL. The NOPR will include a complete quantitative analysis of alternatives to the proposed conservation standards. DOE will use the NES spreadsheet model (as discussed in section III.I, ''National Impact Analysis'') to calculate the NES and NPV for the alternatives to the proposed conservation standards. For more information on the regulatory impact analysis, refer to the regulatory impact analysis report in the ANOPR TSD.

IV. Candidate Energy Conservation Standards Levels

In terms of process, DOE specifies candidate standards levels in the ANOPR, but does not propose a particular standard at this stage of the rulemaking. Table IV.1 and Table IV.2 present the CSLs that are discussed in today's ANOPR for the fluorescent and incandescent reflector lamps product classes directly analyzed. As mentioned earlier, in this ANOPR, DOE analyzes four of the ten product classes of lamps. Section III.C.6 discusses DOE's considered approach for extrapolation of CSLs to other product classes not analyzed.

[68] The Clean Air Act Amendments of 1990 were signed into law as Pub. L. 101–549 on November 15, 1990. The amendment can be viewed at: *http://www.epa.gov/air/caa/.*

[69] 70 FR 28606 (May 18, 2005).

[70] No. 05–1097, 2008 WL 341338, at *1 (D.C. Cir. Feb. 8, 2008).

TABLE IV.1.—SUMMARY OF THE CANDIDATE STANDARD LEVELS FOR GSFL

Candidate standard level	4-Foot medium bipin lamps with CCT ≤ 4,500K	8-Foot single pin slimline amps with CCT ≤ 4,500K	8-Foot recessed Double contact HO lamps with CCT ≤ 4,500K
	lm/W	lm/W	lm/W
CSL1	82.4	87.3	83.2
CSL2	85.0	92.0	86.1
CSL3	90.0	94.8	87.6
CSL4	92.3	98.2	91.9
CSL5	95.4	101.5	95.3

TABLE IV.2.—SUMMARY OF THE CANDIDATE STANDARD LEVELS FOR IRL

Candidate standard level	Standard-spectrum incandescent reflector lamps
	lm/W
CSL1	$5.0P^{0.27}$
CSL2	$5.5P^{0.27}$
CSL3	$6.2P^{0.27}$

where P = rated wattage of the incandescent lamp

DOE will review the public input it receives in response to this ANOPR and update the analyses appropriately for each product class before issuing the NOPR. DOE also will consider any comments it receives on the CSLs set forth above for GSFL and IRL, and on whether alternative levels would satisfy the EPCA criteria.

For the NOPR, DOE will develop trial standard levels (TSL) for GSFL and IRL from the above CSLs or other higher or lower levels after consideration of public comments. In previous rulemakings, DOE has considered several criteria in developing the TSLs, such as requiring that a CSL have a minimum LCC, maximum NPV, and maximum technologically-feasible efficacy. DOE invites comment on whether any of these criteria are appropriate for this rulemaking, or whether other TSLs are appropriate, perhaps based on technologies or applications that are specific to the lamps being regulated. DOE seeks feedback on the criteria it should use as the basis for the selection of TSLs. This is identified as Issue 10 under ''Issues on Which DOE Seeks Comment'' in Section 0 of this ANOPR.

V. Public Participation

DOE will make the entire record of this proposed rulemaking, including the transcript from the public meeting, available for inspection at the U.S. Department of Energy, Resource Room of the Building Technologies Program, Sixth Floor, 950 L'Enfant Plaza, SW., Washington, DC, (202) 586–2945, between 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Any person may buy a copy of the transcript from the transcribing reporter.

A. Submission of Comments

DOE began accepting comments, data, and other relevant information regarding all aspects of this ANOPR at the public meeting and will continue to accept comments until no later than April 14, 2008. Please submit comments, data, and information electronically to the following e-mail address: *fluorescent_and_incandescent_lamps.rulemaking@ee.doe.gov*. Please submit electronic comments in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format and avoid the use of special characters or any form of encryption. Comments in electronic format should be identified by the Docket Number EE–2006–STD–0131 and/or RIN number 1904–AA92, and whenever possible carry the electronic signature of the author. Absent an electronic signature, comments submitted electronically must be followed and authenticated by submitting the signed original paper document. No telefacsimiles (faxes) will be accepted.

Under 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit two copies. One copy of the document shall include all the information believed to be confidential, and the other copy of the document shall have the information believed to be confidential deleted. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors that DOE considers when evaluating requests to treat submitted information as confidential include: (1) A description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by, or available from, other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

B. Issues on Which DOE Seeks Comment

DOE is interested in receiving comments on all aspects of this ANOPR. DOE especially invites comments or data to improve the analyses, including data or information that will respond to the following questions or concerns that were addressed in this ANOPR:

1. Consideration of Additional General Service Fluorescent Lamps

EPCA directs DOE to consider additional GSFL for coverage under 42 U.S.C. 6295(i)(5). In this notice, DOE outlines its preliminary consideration of the expansion of coverage for GSFL under 42 U.S.C. 6295(i)(5), keeping in mind the express exclusions contained in the definitions of ''general service fluorescent lamp'' (42 U.S.C. 6291(30)(B)). DOE requests comment on its planned expansion of coverage. See section II for details on this issue.

2. Amended Definitions

EPCA directs DOE to consider additional GSFL for coverage under 42 U.S.C. 6295(i)(5). In the definition of ''general service fluorescent lamp,'' (42 U.S.C. 6291(30)(B)) EPCA identifies ''colored fluorescent lamps'' as expressly excluded from coverage. Although DOE defined ''colored fluorescent lamp'' in the 1997 test Procedure Final Rule, DOE believes this definition requires updating and, therefore, presents a draft amended definition for comment. DOE also invites comment on whether other exclusions are ambiguous or require modification.

One element of EPCA's definitions for ''fluorescent lamp'' and ''incandescent reflector lamp'' is a lamp's ''rated wattage,'' which helps to determine which lamps are subject to standards. (42 U.S.C. 6291(30)((A), (C)(ii) and (F), and 6295(i)(1)) In addition, energy conservation standards for general service incandescent lamps prescribed by EISA 2007 require lamps of particular lumen outputs to have certain maximum rated wattages. (42 U.S.C. 6295(i)(1)(B) In this rulemaking, DOE plans to update its definition of rated wattage to current industry references, and to apply this definition to those lamps where rated wattage is not defined (e.g., 8-foot single pin slimline lamps and incandescent lamps). DOE seeks comment on its planned modification to the definition of ''rated wattage,'' a term which applies to both covered fluorescent and incandescent lamps. See section II for details on all of these issues.

3. Product Classes

DOE requests comment on its planned revisions to the product classes for GSFL and IRL, including the use of CCT in the GSFL product classes and the separate treatment of modified-spectrum lamps for IRL. Details about DOE's planned product classes are presented in section III.A.2.

4. Scaling to Product Classes Not Analyzed

DOE is inviting comment on the selected representative product classes where it concentrates its analytical effort (see section III.C.2), and on the extrapolation of findings from the representative product classes to others that were not analyzed (see section III.C.6). DOE invites comment on appropriate scaling methods it should follow, particularly for the draft scaling factors discussed in section III.C.6 for 2-foot U-shaped GSFL, GSFL with a higher CCT, and modified-spectrum IRL.

5. Screening of Design Options

In determining which design options to consider for the engineering analysis, DOE applies four statutory screening criteria to a set of potential technologies that may improve efficacy (i.e., technology options). One of those screening criteria is ''practicability to manufacture, install, and service.'' DOE invites comment on whether certain technology options discussed in section III.B fail to meet this criterion. Some manufacturers have expressed some concern about integrating certain technology options into high-volume production lines within a limited time-frame (i.e., the statutory three-year compliance period). DOE invites comment on this issue and, if appropriate, to provide possible solutions to help resolve the issue. See section III.B and section III.K for details.

6. Operating Hours

DOE used the U.S. Lighting Market Characterization Volume I and the EIA's RECS, CBECS, and MECS to develop a national distribution of average operating hours for lamp types and end-use sectors. DOE requests comment on whether the average operating hours derived are a reasonable representation of these end-uses. See section III.D.1 for details.

7. General Service Fluorescent Energy Consumption

In today's **Federal Register**, DOE is also publishing a test procedure NOPR for fluorescent and incandescent lamps. In that NOPR, DOE proposes to continue to use low-frequency ballast testing for all GSFL except for those lamp types that can only be tested on high-frequency ballasts. While DOE uses the test procedure to confirm that manufacturers have met the minimum requirements, in this ANOPR, DOE considers the operation of fluorescent lamps on several different ballast types for the LCC and NIA analyses (i.e., DOE uses average system power ratings of GSFL operating on electronic and magnetic ballasts). This approach enables the economic evaluation of the CSLs to more accurately reflect how fluorescent lamps are operated in the field. DOE invites comment on this approach, as well as the calculated system power ratings it derived for the lamp-and-ballast combinations using published data. Detail on the system power ratings can be found in Chapter 5 of the TSD.

8. Life-Cycle Cost Calculation

In order to determine the life-cycle cost savings of lamp designs with unequal lifetimes, DOE used an analysis period corresponding to the lifetime of the baseline lamp. To account for the remaining life of the equipment at the end of the analysis period, DOE calculated a residual value by linearly prorating the initial cost of the equipment. DOE invites comment on its usage of residual values in the life-cycle cost analysis and on other possible approaches to calculating life-cycle costs for product with different lifetimes.

9. Installation Costs

In order to determine the complete installed cost for the LCC analysis, DOE developed estimates of commercial sector installation costs for IRL and GSFL. DOE seeks comment on the average labor rates and times for each lamp type. See Chapter 8 of the TSD for details.

10. Base-Case Market-Share Matrices in 2012

DOE has developed a base-case to represent the distribution of lamp systems and their efficacies currently in the marketplace, and thereby determine the proportion of consumers affected by a particular energy conservation standard level. DOE developed base-case efficacy distributions for GSFL and IRL based on a combination of interviews with lighting experts, historical shipments information, and available product data. DOE requests comment on the resultant base-case product distributions. See section III.H for details.

11. Shipment Forecasts

A key input into the shipment forecasts of GSFL and IRL is the assumed market growth. For commercial GSFL and IRL, DOE uses a growth rate of 1.6 percent based on CBECS floor space growth projections. For residential IRL, DOE uses a 1.3 percent growth rate from the RECS residential building growth projection. DOE invites comment on the data sources, estimates, and implementation of these growth rates. In addition, the shipment forecasts impact the total national lumen output of each lamp type. DOE invites comment on the national lumen output projection in both the base case and standards case. Specifically, DOE invites comment on whether any adjustments are necessary to respond to consumer actions resulting in over-lighting or under-lighting. See Chapter 9 of the TSD and section III.H for details.

12. Base-Case and Standards-Case Forecasted Efficiencies

Forecasts of average market efficacy and energy consumption, in both the base case and standards case, are fundamental inputs to the NES and NPV calculations. Estimates of the market's selection of lamp and lamp-and-ballast designs, in turn, drive the forecasts for average efficacy and energy consumption. As a sensitivity to the NES and NPV calculations, DOE developed standards-case scenarios to test the upper and lower bounds of the NES and NPV results. DOE invites comment on these standards-case scenarios it developed estimating market behavior in response to a standard, such as roll-up and shift in the GSFL market or the 65W BR lamp substitution scenario. See section III.H for details.

13. Trial Standard Levels

For the NOPR, DOE will develop trial standard levels (TSLs) based on the candidate standard levels for GSFL and IRL. DOE is considering several criteria in developing the TSLs, including, but not limited to, minimum LCC, maximum NPV, and maximum technologically-feasible efficacy. These TSLs may include combinations of CSLs and the interaction between product classes such as 4-foot medium bipin and 8-foot single pin slimline fluorescent lamps or standard-spectrum and modified-spectrum IRL. From the list of TSLs developed, DOE will select one as its proposed standard for the NOPR. DOE invites comment on the criteria it should use as the basis for the selection of TSLs. See section III.H for details.

14. Lamp Production Equipment Conversion Timeframe

Manufacturers of high-volume lamps expressed concern as to their ability to retool, invest in, or replace equipment within the statutorily-required three-year compliance period, such that they may continue to offer the volume lamps for sale at a new standard level. DOE invites comment on this issue, and welcomes recommendations on how best to mitigate any equipment conversion issues.

VI. Regulatory Review and Procedural Requirements

DOE submitted this ANOPR for review to OMB under Executive Order 12866, ''Regulatory Planning and Review.'' 58 FR 51735 (October 4, 1993). If DOE later proposes new or revised energy conservation standards for GSFL or IRL, and if the proposed rule constitutes a significant regulatory action, DOE would prepare and submit to OMB for review the assessment of costs and benefits required by section 6(a)(3) of the Executive Order. The Executive Order requires agencies to identify the specific market failure or other specific problem that it intends to address that warrants new agency action, as well as assess the significance of that problem, to enable assessment of whether any new regulation is warranted. (Executive Order 12866, § 1(b)(1)). DOE presumes that a perfectly functioning market would result in efficiency levels that maximize benefits to all affected persons. Consequently, without a market failure or other specific problem, a regulation would not be expected to result in net benefits to consumers and the nation. However, DOE also notes that whether it establishes standards for these products is determined by the statutory criteria expressed in EPCA. Even in the absence of a market failure or other specific problem, DOE nonetheless may be required to establish standards under existing law.

DOE's preliminary analysis for GSFL and IRL explicitly accounts for the percentage of consumers that already purchase more efficient equipment and takes these consumers into account when determining the national energy savings associated with various candidate standard levels. The preliminary analysis suggests that accounting for the market value of energy savings alone (i.e., excluding any possible ''externality'' benefits such as those noted below) would produce enough benefits to yield net benefits across a wide array of products and circumstances. DOE requests additional data on, and suggestions for testing the existence and extent of potential market failure to complete an assessment of the significance of these failures and, thus, the net benefits of regulation. In particular DOE seeks to verify the estimates of the percentage of consumers of all product types purchasing efficient equipment and the extent to which consumers will continue to purchase more-efficient equipment in future years.

DOE believes that there is a lack of consumer information and/or information processing capability about energy efficiency opportunities in the lighting market. If this is in fact the case, DOE would expect the efficiency for lighting products to be randomly distributed across key variables such as electricity prices and usage levels. Although DOE has already identified the percentage of consumers that already purchase more efficient lighting products, DOE does not correlate the consumer's usage pattern and electricity price with the efficiency of the purchased product. Therefore, DOE seeks data on the efficiency levels of existing lamps in use by how often it is utilized (e.g., how many hours the product is used) and its associated electricity price (and/or geographic region of the country). DOE plans to use these data to test the extent to which purchasers of this equipment behave as if they are unaware of the costs associated with their energy consumption.

Specifically, with respect to lighting products, DOE believes several factors contribute to the lack of consumer information. In the residential sector, consumer purchases are often based on wattage rather than lumen output which may result in consumers not purchasing, or rejecting higher-efficacy or energy-saving lamp designs. For example, consumers may not recognize a higher-efficacy, reduced-wattage lamp as fulfilling the same utility as their higher-wattage lamp though both lamps may have similar lumen outputs. For this reason, these higher-efficiency products may be unduly rejected in the marketplace. In addition, in the commercial and industrial sectors, the complexity of GSFL systems may introduce high information costs. GSFL systems are composed of both lamps and ballasts that may have a multitude of varying properties such as lamp wattage, lumen output, lifetime, and ballast factor. These many numerous variables impose high information costs which may prevent purchasers from selecting the most cost-effective GSFL system. DOE seeks comment on additional knowledge of the Federal Energy Star program, and the program's potential as a resource for increasing knowledge of the availability and benefits of energy-efficient lamps in the lighting consumer market.

A related issue is the problem of asymmetric information (one party to a transaction has more and better information than the other) and/or high transactions costs (costs of gathering information and effecting exchanges of goods and services). In the case of lamps, in many instances the party responsible for the lamp purchase may not be the one who pays the cost to operate it. For example, in the commercial and industrial sectors, building owners and developers may make purchase decisions about lighting fixtures which include ballasts and lamps, but it may be the tenants who pay the utility bills. Although renters often have the opportunity to purchase the replacement lamps, they are severely limited in their choices by prior fixture and ballast selections. If there were no transactions costs, it would be in the building developers' and owners' interests to install lighting fixtures that renters would choose on their own. For example, a tenant who knowingly faces higher utility bills from low-efficiency lighting would be willing to pay less in rent, and the building owner would indirectly bear the higher utility cost. However, this information is not costless, and it may not be in the interest of the renter to take the time to develop it, or, in the case of the building owner who installs the lamp system, to convey that information to the renter.

To the extent that asymmetric information and/or high transactions costs are problems, one would expect to find certain outcomes with respect to commercial and industrial lighting energy efficiency. For example, other things equal, one would not expect to see higher rents for office space with high-efficiency lighting systems. Conversely, if there were symmetric information, one would expect higher energy efficiency lighting in commercial space where the rent includes utilities, as compared to those where the tenant pays the utility bills separately.

Of course, there are likely to be certain ''external'' benefits resulting from the improved efficiency of units that are not captured by the users of such equipment. These include both environmental and energy security-related externalities that are not already reflected in energy prices, such as reduced emissions of greenhouse gases and reduced use of natural gas and oil for electricity generation. DOE invites comments on the weight that should be given to these factors in DOE's determination of the maximum efficiency level at which the total benefits are likely to exceed the total costs resulting from a DOE standard.

As previously stated, DOE generally seeks data that might enable it to conduct tests of market failure for products under consideration for standard-setting. For example, given adequate data, there are ways to test for the extent of market failure for commercial GSFL. One would expect the owners of fluorescent lamps who also pay for their electricity consumption to purchase lamps that exhibit higher energy efficiency compared to lamps whose owners do not pay for the electricity usage, other things equal. To test for this form of market failure, DOE needs data on energy efficiency of such units and whether the owner of the equipment is also the one who pays the operating costs. DOE is also interested in other potential tests of market failure and data that would enable such tests.

In addition, various other analyses and procedures may apply to such future rulemaking action, including those required by the National Environmental Policy Act (Pub. L. 91–190, 42 U.S.C. 4321 et seq.); the Unfunded Mandates Act of 1995 (Pub. L. 104–4); the Paperwork Reduction Act (44 U.S.C. 3501 et seq.); the Regulatory Flexibility Act (5 U.S.C. 601 et seq.); and certain Executive Orders.

The draft of today's action and any other documents submitted to OMB for review are part of the rulemaking record and are available for public review at the U.S. Department of Energy, Resource Room of the Building Technologies Program, Sixth Floor, 950 L'Enfant Plaza, SW., Washington, DC (202) 586–2945, between 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays.

VII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of today's advance notice of proposed rulemaking.

Issued in Washington, DC, on February 21, 2008.

Alexander A. Karsner,

Assistant Secretary, Energy Efficiency and Renewable Energy.

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