Framework Document for
High-Intensity Discharge Lamps

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Program

February 21, 2012

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LIST OF ABBREVIATIONS

ACEEE	American Council for an Energy-Efficient Economy
AEO	Annual Energy Outlook (Annual energy forecast published by EIA)
ANOPR	advance notice of proposed rulemaking
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
atm	atmosphere(s)
BOM	bill of materials
CAIR	Clean Air Interstate Rule
CAMR	Clean Air Mercury Rule
CBCP	center-beam candlepower
CBECS	Commercial Building Energy Consumption Survey by EIA
CCT	correlated color temperature
CFR	Code of Federal Regulations
CIE	Commission Internationale De L'Eclairage (int'l regulatory body)
cm^2	square centimeter(s)
CMH	ceramic pulse-start metal halide
CO_2	carbon dioxide
CRI	color rendering index
CSL	candidate standard level
D.C.	District of Columbia
DOE	U.S. Department of Energy
DOJ	U.S. Department of Justice
DSIRE	Database of State Incentives for Renewables & Efficiency
E26	Edison-base, 26 millimeters
EGU	electricity generating unit
EIA	Energy Information Administration (DOE statistical and analytical agency)
EISA 2007	Energy Independence and Security Act of 2007
EPA	U.S. Environmental Protection Agency
EPACT 1992	Energy Policy Act of 1992
EPACT 2005	Energy Policy Act of 2005
EPCA	Energy Policy and Conservation Act of 1975
ER	elliptical reflector (reflector lamp shape)
FR	Federal Register
FTC	Federal Trade Commission
GHG	greenhouse gas
GRIM	Government Regulatory Impact Model
GSFL	general service fluorescent lamp
GSIL	general service incandescent lamp
Hg	mercury
HID	high-intensity discharge
HPS	high-pressure sodium
IES	Illuminating Engineering Society of North America
ImSET	Impact of Sector Energy Technologies (PNNL-developed I/O model)
IRL	incandescent reflector lamp

K	kelvin
kWh	kilowatt-hour(s)
LCC	life-cycle cost
LE	lamp efficacy (an efficiency measure for visible light generation)
LED	light-emitting diode (a type of SSL)
LEP	light-emitting plasma
lm	lumen(s) (a measurement of light flux.)
LMC	U.S. Lighting Market Characterization
MECS	Manufacturer Energy Consumption Survey (done for EIA by the Census)
MH	metal halide
MHLF	metal halide lamp fixture
MIA	manufacturer impact analysis
MR	multi-faceted reflector
MSP	manufacturer selling price
MV	mercury vapor
NEMA	National Electrical Manufacturers Association
NEMS	National Energy Modeling System (developed and used by EIA)
NEMS-BT	National Energy Modeling System – Building Technologies
NES	national energy savings
NESHAP	national emissions standards for hazardous air pollutants
NIA	national impact analysis
NOD	notice of determination
NODA	notice of data availability
NOPD	notice of proposed determination
NOPM	notice of proposed meeting
NOPR	notice of proposed rulemaking
NO_X	nitrogen oxides
NPV	net present value
NVLAP	National Voluntary Laboratory Accreditation Program
OMB	U.S. Office of Management and Budget
Pa	pascal(s)
PAR	parabolic-aluminized reflector (reflector lamp shape)
PBP	payback period
PM	particulate matter
PMH	pulse-start metal halide
PNNL	Pacific Northwest National Laboratory
quad	quadrillion (10^{15}) British thermal units
RFI	request for information
R	reflector
SCC	Social Cost of Carbon
SDG&E	San Diego Gas & Electric
SEC	U.S. Securities and Exchange Commission
SO_2	sulfur dioxide
SSL	solid-state lighting
TSD	technical support document
TSL	trial standard level

U.S.C.	United States Code
W	watt(s)

1 INTRODUCTION

The U.S. Department of Energy (DOE) Appliances and Commercial Equipment Standards Program, within the Office of Energy Efficiency and Renewable Energy's Building Technologies Program, develops and promulgates test procedures and energy conservation standards for certain consumer products and commercial equipment. The process for developing standards involves analysis, public notice and comment, and consultation with interested parties. Interested parties include manufacturers, consumers, energy conservation and environmental advocates, State and Federal agencies, and any other groups or individuals with an interest in these standards and test procedures.

1.1 Overview of the Framework Document

The purpose of this framework document is to describe the procedural and analytical approaches DOE anticipates using to evaluate potential energy conservation standards for high-intensity discharge (HID) lamps (see section 1.2 for a discussion of the statutory authority for this rulemaking). This document is intended to inform interested parties of the process DOE will follow and to encourage and facilitate the input of interested parties during the rulemaking. This document serves as the starting point for developing energy conservation standards and is not a definitive statement on any issue to be determined in the rulemaking.

Section 1 of this document provides an overview of DOE's rulemaking process. Sections 2 through 17 discuss analyses DOE intends to conduct in determining whether to establish energy conservation standards for HID lamps, and if so at what level. DOE will maintain information about this rulemaking on its website at http://www1.eere.energy.gov/buildings/appliance_standards/commercial/high_intensity_discharge_lamps.html.

Item 1	*Although DOE invites comment on all aspects of the material presented in this document, several specific issues on which DOE seeks comment are set out in comment boxes like this one. DOE uses these comment boxes to highlight issues and ask specific questions regarding the approaches DOE plans to follow to conduct the analyses required for the energy conservation standards rulemaking. Such requests for feedback are numbered sequentially throughout the document and are repeated in appendix A.*

1.2 Authorities

Title III, Part C of the Energy Policy and Conservation Act of 1975 (EPCA), (42 U.S.C. 6291–6317), as amended, established the Energy Conservation Program for Certain Industrial Equipment, which includes the HID lamps addressed in this framework document.[1] EPCA requires DOE to prescribe testing requirements for those HID lamps for which DOE makes a determination that energy conservation standards would be technologically feasible and economically justified, and would result in significant energy savings. 42 U.S.C. 6317(a)(1).

[1] For editorial reasons, upon codification in the U.S. Code, Part C was re-designated Part A-1.

EPCA further requires DOE, within 18 months of prescribing any testing requirements for HID lamps, to prescribe energy conservation standards for those lamps. 42 U.S.C. 6317(a)(2). Any standards would apply to lamps manufactured 36 months after the date the standards rule is published. 42 U.S.C. 6317(a)(3).

DOE published a positive final determination[2] that standards for certain HID lamps are technologically feasible, economically justified, and would result in a significant energy savings, estimated at 11.4 quadrillion British thermal units (quads) of cumulative energy savings over 30 years. 75 FR 37975 (July 1, 2010). As a result of this determination, DOE is currently conducting a test procedure rulemaking for the specified lamps.[3] In this framework document, DOE is considering standards for these HID lamps. During the standards rulemaking, DOE will decide whether and at what level(s) to promulgate energy conservation standards. The decision, which will incorporate public participation, will be based on the technological feasibility, economic justification, and energy savings of specific potential standard levels pursuant to the requirements of EPCA. (*See, e.g.*, 42 U.S.C. 6295(o)-(p) and 6316(a)) DOE's consideration of standby mode and off mode energy use for these standards is discussed in detail in section 1.5.3.

DOE received comments on the proposed determination (NOPD) for HID lamps from two interested parties: the American Council for an Energy-Efficient Economy (ACEEE) and San Diego Gas & Electric (SDG&E). These commenters encouraged DOE to hasten the issuance of an HID lamps energy conservation standards rulemaking and to combine a possible HID lamps energy conservation standards rulemaking with the ongoing metal halide lamp fixtures (MHLF) energy conservation standards rulemaking, or at least with the analysis. (Docket No. EERE-2006-DET-0112-001, ACEEE, No. 22 at p. 1; SDG&E, No. 23 at p. 2)[4] DOE addresses this issue in section 1.3.

1.3 Coordinated Development of HID Lamps and MHLF Rulemakings

Based on feedback from interested parties, DOE intends, to the extent feasible, to coordinate the development of its energy conservation standard rulemakings for HID lamps and metal halide lamp fixtures (MHLFs). DOE received comments on this subject in response to both its HID lamps final determination and MHLF framework document and preliminary analysis, with recommendations ranging from analyzing the equipment separately but including discussion of both in the same rulemaking document to regulating metal halide (MH) lamps and metal halide lamp fixtures collectively using a single system-based metric. This system-based metric would assess the performance of the lamp and fixture collectively, instead of separate metrics for each component. DOE has decided to develop the NOPRs for each rule separately because DOE is considering separate metrics for HID lamps and metal halide lamp fixtures. However, because

[2] The 2010 HID lamps final determination is available at www1.eere.energy.gov/buildings/appliance_standards/commercial/high_intensity_discharge_lamps.html.
[3] DOE published a proposed test procedure NOPR on December 15, 2011 (76 FR 77914) and expects to publish any final test procedures within 30 months of issuing the determination, or January 1, 2013.
[4] A notation in the form "ACEEE, No. 22 at p. 1" refers to (1) a statement that was submitted by the American Council for an Energy-Efficient Economy and is recorded in the docket "Energy Conservation Program for Commercial and Industrial Equipment: High-Intensity Discharge (HID) Lamps," Docket Number EERE-2006–DET–0112 as comment number 22; and (2) a passage that appears on page 2 of that document.

data sources for the two rules are similar or the same (e.g., lamp lifetimes, electricity price data, etc.), they will be shared, as appropriate, between the rules. Following the NOPR stage, DOE will evaluate comments from interested parties and consider how best to coordinate the two final rules.

Item 2	*DOE welcomes comments on how it should coordinate development of the final rules for HID lamps and metal halide lamp fixtures.*

1.4 Overview of the Rulemaking Process

1.4.1 Rulemaking Process and Participation of Interested Parties

EPCA specifies that any standard DOE prescribes for commercial equipment shall be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A); 6316(a)) Moreover, EPCA states that the Secretary may not establish an amended or new standard if such standard would not result in a significant conservation of energy or is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(B); 6316(a)) When DOE evaluates any new or amended energy conservation standard for covered equipment under EPCA, DOE considers to the greatest extent practicable the following seven factors to determine whether a standard is economically justified:

(1) the economic effect of the standard on the manufacturers and on the consumers of the equipment subject to such standard;
(2) the savings in operating costs throughout the estimated average life of the covered equipment in the type (or class) compared to any increase in the price, or in the initial charges for, or maintenance of the covered equipment which are likely to result from the imposition of the standard;
(3) the total projected amount of energy (or as applicable, water) savings likely to result directly from the imposition of the standard;
(4) any lessening of the utility or the performance of the covered products likely to result from the imposition of the standard;
(5) the effect of any lessening of competition, as determined in writing by the U.S. Attorney General (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)(I)-(VII))

Additional statutory requirements of general applicability for prescribing new or amended standards are set forth in 42 U.S.C. 6295(o)(1), (2)(B)(ii)-(iii), and (3)–(5), 42 U.S.C. 6316(a), and other relevant sections of EPCA.

The process for developing energy conservation standards involves input from the public. Interested parties generally include manufacturers, end users, environmental advocates, State and Federal agencies, and other groups and individuals with an interest in energy conservation standards and test procedures. DOE considers the participation of interested parties to be a very

important part of the rulemaking process. Accordingly, DOE encourages the participation of all interested parties during the comment period provided at each stage of the rulemaking. The broad array of interested parties who provide comments promotes a balanced discussion of critical information required to conduct the standards rulemaking, beginning with public comments on the framework document.

In conducting energy conservation standards rulemakings, DOE involves interested parties through various means. As discussed in further detail below, the standards rulemaking process involves four public notices, published in the *Federal Register*, and three public meetings (including the public notice and meeting associated with this framework document). This framework document provides details of the following stages of the rulemaking process:

- *Interim Analyses* (section 1.4.2). DOE plans to publish interim analyses to publicly vet the data, models, and tools that DOE expects to use in the rulemaking, and to facilitate public participation in developing the proposed rule. These data will include proposed equipment classes and candidate standard levels (CSLs), which span the range of efficacies from baseline equipment[5] to the most efficacious technology. DOE will hold a public meeting and webcast related to the interim analyses and will seek public comment.
- *Notice of Proposed Rulemaking* (section 1.4.3). The NOPR will present a discussion of comments received in response to the framework document and interim analyses; DOE's analysis of the effects of potential standards on consumers, manufacturers, and the nation; DOE's weighting of these effects; and the proposed standard levels for public comment. DOE will hold a public meeting and webcast related to the NOPR and will again seek public comment.
- *Final Rule* (section 1.4.4). The final rule presents a discussion of comments received in response to the NOPR, the revised analysis of the effects of standards, DOE's weighting of the effects, and any standard levels DOE is adopting. The final rule also establishes the compliance date of any standards.

DOE has prepared the following projected schedule shown in Table 1.1 for the HID lamps rulemaking.

[5] Within the broad equipment categories, DOE selected baseline lamps as representative equipment. Generally, a baseline lamp is one that represents the typical lamp sold. DOE selected specific characteristics such as certain CRIs, operating lifetimes, and light outputs to characterize the most common lamps consumers purchase. DOE selected multiple baseline lamps to ensure consideration of different high-volume lamps and their associated consumer economics.

Table 1.1 Energy Conservation Standards Rulemaking Schedule for HID Lamps

Rulemaking Notice	Publication Date
Framework Document	February 2012
Interim Analyses (projected)	August 2012
NOPR (projected)	June 2013
Final Rule (projected)	July 2014

EPCA provides that any energy conservation standard for HID lamps will apply to products manufactured on or after 36 months from publication of the final rule. (42 U.S.C 6317(a)(3))

1.4.2 **Interim Analyses**

As part of its initial rulemaking activity, DOE typically identifies technology options for improving lamp efficacy and makes a preliminary determination regarding whether to retain each option for detailed analysis or to eliminate it from further consideration. This process includes a market and technology assessment (section 3) and a screening analysis (section 4). DOE applies four screening criteria in the screening analysis to determine which technology options to eliminate. These four criteria are: (1) technological feasibility; (2) practicability to manufacture, install, and service; (3) adverse impacts on product utility or availability; and (4) adverse impacts on health or safety. Technologies that meet the screening criteria are referred to as design options in the engineering analysis.

In preparing its interim analyses, DOE will consider CSLs for each equipment class in the engineering analysis (section 5).[6] When developing CSLs, DOE generally considers efficacy levels or design options that span the full range of technologically achievable efficiencies. The range of levels DOE typically analyzes includes:

- the baseline efficacy level (*i.e.*, the minimum level), which is defined by the type of equipment with the lowest efficacy level currently sold on the market for a given category;
- levels that incorporate noteworthy technology design options or fill in large gaps between other efficacy levels considered;
- the level with the minimum LCC or greatest LCC savings; (or mean savings); and
- the highest efficacy level or lowest energy use level that is technologically feasible (*i.e.*, maximum technologically feasible, or “max tech”).

DOE collects end-user price data, historical shipment data, shipment-weighted average efficacy data, and preliminary manufacturer impact data (*e.g.*, capital conversion expenditures, marketing costs, and research and development costs) based on these CSLs. DOE will also conduct other analyses, including: (1) the consumer life-cycle cost (LCC) and payback period (PBP) analyses (section 8); (2) the national impact analysis (NIA), which considers national energy savings (NES) and consumer net present value (NPV) (section 10); and (3) a preliminary

[6] CSLs are a set of efficacy levels considered in the interim analysis that would span the range of lamp efficiencies from baseline equipment to maximum technologically feasible equipment.

manufacturer impact analysis (MIA) (section 6). DOE will use analytical models and tools to assess the different equipment classes at each CSL analyzed. Many of these analytical models and tools used to conduct the LCC and PBP analyses and to determine the NES and NPV of prospective standards are in the form of spreadsheets.

In preparing the interim analyses, DOE will consider comments received in response to the framework document.[7] The interim analysis will include an executive summary that provides an overview of the interim decisions, approaches, and results. This executive summary will also outline the issues on which DOE seeks comment. In addition to the executive summary, DOE will provide a technical support document (TSD) and analytical models to aid in review of the interim results. After publishing a notice of availability, DOE will provide a public comment period and hold a public meeting and webcast. DOE also encourages interested parties to develop joint recommendations for proposed standard levels.

DOE will post data and interim analytical results to its standards rulemaking website for review and comment. Posting interim results will enable interested parties to review the data and spreadsheet models that underpin the analyses, and can facilitate discussions among interested parties on potential joint recommendations for standard levels. DOE will use interested parties' comments to refine the models for the next stage of the rulemaking analyses, in which DOE will propose specific efficacy levels for adoption.

1.4.3 **Notice of Proposed Rulemaking**

In developing the NOPR, DOE will consider and respond to all the comments received on the framework document and interim analysis. This process may result in revisions to the interim analysis, including the engineering and LCC analyses. At that point, DOE will conduct additional economic and environmental impact analyses. These analyses generally include a consumer LCC subgroup analysis (section 11), a complete MIA (section 12), a utility impact analysis (section 13), an employment impact analysis (section 14), an emissions analysis (section 15), an analysis monetizing carbon dioxide and other emissions reductions (section 16) and a regulatory impact analysis (section 17).

DOE will describe the methodology used and make the results of all the analyses available on its website for review. Based on comments from interested parties, the analysis may be revised further. This analytical process concludes with the selection of proposed standard levels (if any) in the NOPR. DOE selects the proposed standard levels from the trial standard levels (TSLs) analyzed during the NOPR phase of the rulemaking. The NOPR, published in the *Federal Register*, will document the evaluation and selection of any proposed standard levels, along with a discussion of other TSLs considered but not selected (and the reasons DOE did not select them).

For each equipment class, DOE will identify the max tech efficacy level. If DOE proposes a level lower than max tech, it will sequentially explain the reasons for eliminating higher levels, beginning with the highest level considered. DOE will present the analytical results in the NOPR and provide the details of the analysis in an accompanying TSD.

[7] As stated in section 1.4.3, DOE will provide written responses to these comments in the NOPR.

DOE considers many factors in selecting proposed standards, as discussed in section 1.4.1. These factors are established in EPCA and take into consideration the benefits and costs of energy conservation standards. Additionally, DOE encourages interested parties to develop joint recommendations for standard levels. DOE will carefully consider any such recommendations in its decision process.

When DOE publishes the NOPR, it will provide the U.S. Department of Justice (DOJ) with copies of the NOPR and TSD to solicit feedback on the impact of the proposed standard levels on competition in the lighting industry. DOJ will review these standard levels to determine whether any lessening of competition is likely to result from the imposition of new standards. (42 U.S.C. 6295(o)(2)(B)(i)(V) and (B)(ii)) Publication of the NOPR will be followed by a 60-day public comment period that includes a public meeting.

1.4.4 **Final Rule**

After publication of the NOPR, DOE will consider public comments it receives on the proposal and accompanying analyses. DOE will review the engineering and economic impact analyses and proposed standards in light of these comments and consider modifications where necessary. Before the final rule is issued, DOE will also consider any DOJ comments on the NOPR relating to the impacts of the proposed standard levels on competition to determine whether changes to these standard levels are needed. DOE will publish all DOJ comments and DOE's responses as part of the final rule.

The standards rulemaking will conclude with publication of the final rule establishing any energy conservation standards for HID lamps. DOE will select any final standards level based on the complete record of the standards rulemaking. The final rule will promulgate any final standard levels and associated compliance date and explain the basis for their selection. The final rule will be accompanied by a final TSD.

1.5 **Scope of Coverage**

As previously mentioned, DOE is conducting this rulemaking to evaluate energy conservation standards for certain HID lamps for which DOE determined that energy conservation standards would be technologically feasible and economically justified, and would result in a significant conservation of energy.

High-intensity discharge is the generic name for a family of lamps including mercury vapor, MH, and high-pressure sodium (HPS) lamps. Although low-pressure sodium lamps are often included in the family, they are not included in the definition set forth in EPCA, and are therefore not considered in this rulemaking. The definition for HID lamp, MV lamp, and MH lamp are defined by EPCA as follows:

> *High intensity discharge lamp* means an electric-discharge lamp in which –
> 1. the light-producing arc is stabilized by the arc tube wall temperature; and
> 2. the arc tube wall loading is in excess of 3 watts/cm^2
>
> High intensity discharge lamps include mercury vapor, metal halide, and high-pressure sodium lamps.

42 U.S.C. 6291(46)).

Mercury vapor lamp means a high-intensity discharge lamp in which the major portion of the light is produced by radiation from mercury typically operating at a partial vapor pressure in excess of 100,000 Pa (approximately 1 atm). Mercury vapor lamps include clear, phosphor-coated, and self-ballasted screw base lamps.

42 U.S.C. 6291(47).

Metal halide lamp is a high-intensity discharge lamp in which the major portion of the light is produced by radiation of metal halides and their products of dissociation, possibly in combination with metallic vapors.

42 U.S.C. 6291(63).

HPS lamps are not defined in EPCA. DOE proposed a definition for these lamps in the HID lamp test procedure NOPR published on December 15, 2011 (hereafter the "test procedure NOPR"). 76 FR 77914. In this framework document, DOE is considering using the same definition for HPS lamp:

High-pressure sodium lamp is a high-intensity discharge lamp in which the major portion of the light is produced by radiation from sodium vapor operating at a partial pressure of about 6.67×10^3 pascals (approximately 0.066 atmospheres or 50 torr) or greater."

76 FR 77914, 77917 (December 15, 2011).

DOE notes that manufacturers offer "electrodeless" HID lamps, which are also referred to as light-emitting plasma lamps. These lamps emit light in a related process, and may be a subcategory of MV, HPS, or MH lamps. Initial research indicates that the gas composition of electrodeless lamps might be most similar to MH lamps. DOE is seeking more information on whether electrodeless HID lamps are a subcategory of MV, HPS, or MH lamps.

1.5.1 Specific Lamp Categories under Consideration for the Scope of Coverage

DOE assessed the potential energy savings for the lamps identified in the final coverage determination by analyzing product availability, potential lamp designs that improve efficacy, and other factors (such as the potential to serve as a substitute for other regulated lamp types). For product availability, DOE obtained quantitative information from catalogs for 14 different manufacturers.

HID lamps can differ from each other based on a variety of characteristics, such as input wattage, light output, directionality, ballast location, ballast type, lamp color, bulb shape, and base type. The following subsections provide a discussion of these features and describe the lamps DOE is considering including in the scope of coverage for this rulemaking.

1.5.1.1 **Wattage**

In examining manufacturer catalogs, DOE found that HID lamps span wattages from 15 watts (W) to 18,000 W, though these wattages varied according to lamp technology. Rated wattages range from 15 W to 18,000 W for MH lamps, from 35 W to 1,000 W for HPS lamps, and from 40 W to 2,000 W for MV lamps. DOE is considering covering a subset of the available wattages, as explained in the following paragraphs.

For MH lamps, DOE is considering covering lamps with rated wattages between 50 W and 2,000 W. Based on entries in manufacturer catalogs, less than eight percent of MH lamps available have rated wattages less than 50 W. Similarly, DOE found only 2.3 percent of MH lamps to have rated wattages that exceed 2,000 W. The small number of product offerings in both these wattage ranges does not reflect significant potential energy savings. For this reason, DOE is considering including only MH lamps with rated wattages between 50 to 2,000 W in the scope of coverage. This is consistent with the preliminary scope of coverage in the energy conservation standards rulemaking for MHLFs.[8]

For HPS and MV lamps, DOE is considering covering lamps with rated wattages between 50 W and 1,000 W. In its review of HPS and MV lamp catalogs, DOE found that less than five percent of the HPS catalog offerings and less than one percent of the MV catalog offerings had rated wattages less than 50 W. Similarly, DOE found only two MV lamps with rated wattages higher than 1000 W and no HPS lamps in this range. Given the small number of available products, DOE believes these lamps do not reflect significant potential energy savings. Therefore, DOE is considering including only HPS and MV lamps with rated wattages between 50 W and 1,000 W in the scope of coverage.

DOE acknowledges that lumen output is closely related to wattage. Although DOE used wattage to define coverage in this section, DOE requests comments on the appropriateness of using lumen output to define the lamps included in coverage. If lumen output is preferred, DOE welcomes suggestions on the appropriate ranges for coverage.

1.5.1.2 **Directionality of Lamps**

Lamp light distribution is typically categorized as omni-directional or directional. Omni-directional lamps emit light in all directions with approximately equal intensity, whereas directional lamps use a secondary optical element (*e.g.*, reflector, lens, refractor, light guide) or a combination of elements to shape the light distribution into a particular pattern. In the test procedure NOPR, DOE proposed "directional lamp" be defined as a lamp emitting at least 80 percent light output within a solid angle of π (pi) steradians (corresponding to a cone with an angle of 120 degrees). 76 FR 77914, 77917 (December 15, 2011).

DOE found that manufacturers offer both directional and omni-directional products for each of the three HID lamp types. By analyzing manufacturer catalogs, DOE found that slightly more than 10 percent of available HID lamps are directional. DOE believes, however, that the actual market share of directional HID lamps is much smaller. Because each lamp provides a

[8] The metal halide lamp fixture preliminary TSD is available at www1.eere.energy.gov/buildings/appliance_standards/commercial/metal_halide_fixtures_prelim_tsd.html.

specific beam pattern, more product offerings exist for directional lamps than for omni-directional lamps. Because DOE uses catalogs to determine market presence, the number of available directional lamps likely indicates a stronger presence than shipment data would indicate. Given the small market share, DOE does not believe these lamps represent significant potential energy savings. Therefore, DOE is considering not including directional lamps in the scope of coverage. DOE does not believe these lamps are suitable replacements for omni-directional lamps due to their pattern of light distribution.

1.5.1.3 **Ballast Location**

HID lamps can be categorized by their ballast location (*i.e.*, externally ballasted or self-ballasted lamps). The vast majority of HID lamps are operated with an external ballast—meaning that the ballast is not located within the lamp body (socket and envelope). An external ballast can be located within the fixture or installed remotely from the fixture. If the ballast is integrated into the lamp, however, DOE refers to that configuration as a self-ballasted HID lamp. In the test procedure NOPR, DOE proposed to define self-ballasted lamps as a lamp unit that incorporates all elements that are necessary for the starting and stable operation of the lamp in a permanent enclosure, and that does not include any replaceable or interchangeable parts. 76 FR 77914, 77918 (December 18, 2011).

DOE found self-ballasted lamps for MH and MV lamp types, but not for HPS technology. In reviewing catalogs, DOE found less than one percent of MH lamps were self-ballasted, whereas about 17 percent of MV lamps were self-ballasted. Self-ballasted HID lamps are often used in applications that compete with incandescent technology. These lamps have the advantage of increased efficacy and longer lifetimes relative to incandescent lamps, thereby decreasing maintenance costs. Given the small number of available self-ballasted HID lamps and the fact that consumers would likely choose incandescent technology if self-ballasted HID lamps were unavailable or more expensive, DOE does not believe there is significant potential for energy savings by regulating these products. Therefore, DOE is considering not including self-ballasted lamps in the scope of coverage for this rulemaking.

1.5.1.4 **Lamps Operated on Electronic Ballasts Only**

In its market research, DOE found catalogs indicated that some HID lamps could be operated only by an electronic ballast. These lamps used MH technology only and accounted for 1.5 percent of MH lamps overall. With such a small number of available products, DOE does not anticipate significant potential energy savings.

DOE also notes that there is no industry consensus test method for lamps that are operated only by an electronic ballast. The test procedure NOPR specifies a magnetic reference ballast, but not an electronic reference ballast. For these reasons, DOE is considering not including lamps designed and labeled for use with electronic ballasts only in the scope of coverage for this rulemaking.

1.5.1.5 **Correlated Color Temperature**

Another defining characteristic of an HID lamp is the correlated color temperature (CCT). In general terms, the CCT is a measure of the perceived color of the white light emitted

from the lamp. In the test procedure NOPR, DOE proposes to define CCT as the absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source. 76 FR 77914, 77930 (December 15, 2011)

HID lamps are available with a variety of CCTs, depending on lamp type and design. For example, HPS lamps range in CCT from 1900 K to 2700 K, and MV lamps range in CCT from 3200 K to 6800 K. In reviewing HID lamp catalogs, however, DOE found a much larger range for MH lamps, with products ranging in CCT from 2500 K to 50,000 K.

DOE found that higher CCT lamps tend to be advertised for a specific application. For example, DOE found that all MH lamps with a CCT between 10,000 K and 50,000 K were advertised as aquarium lamps whereas MH lamps with a CCT between 7200 K and 9000 K were advertised as stage and studio lighting. In addition, DOE identified lamps with a CCT of 7000 K to be horticulture lamps.

Overall, lamps with a CCT greater than or equal to 7000 K represent about two percent of all available MH lamps. Given the small number of available products, DOE does not believe these lamps represent significant potential energy savings. Therefore, DOE is considering not including high CCT lamps (with a CCT greater than or equal to 7000 K) in the scope of coverage.

1.5.1.6 **Colored Lamps**

DOE found a small number of HID lamps that were advertised as colored lamps (*e.g.*, blue, green, orange, and magenta). DOE found these lamps only in the MH market, and they represented about one percent of MH product offerings. This small market share indicates a lack of potential for significant energy savings. DOE believes some of these lamps could be excluded from the scope of coverage based on the CCT criteria discussed in the previous section, but requests comments on this conclusion and further input on a definition for these lamp types.

1.5.1.7 **Specialty Applications**

The Energy Policy Act of 2005 banned the sale of MV lamp ballasts, but exempted ballasts for certain specialty applications, such as quality inspection, industrial processing, or scientific use. DOE is considering excluding MV lamps operated by these ballasts from the scope of coverage. DOE requests comments on whether lamps for specialty applications have defining characteristics that differentiate them from lamps used for general illumination purposes. In addition, DOE welcomes comments on whether specialty applications relevant to MV technology can be served by HPS or MH technology.

1.5.2 **Summary of the Scope of Coverage**

In summary, DOE is considering including MH lamps with a rated wattage between 50 W and 2,000 W, and MV and HPS lamps with a rated wattage between 50 W and 1,000 W in the scope of coverage. Within those wattage ranges, DOE is considering including MH lamps with CCTs between 2500 K and 6999 K, MV lamps with CCTs between 3200 K and 6800 K, and HPS lamps with CCTs between 1900 K and 2700 K in coverage.

DOE is considering excluding HID lamps designed and labeled for use with electronic ballasts only, directional HID lamps, self-ballasted HID lamps, and high CCT lamps from the scope of coverage.

1.5.3 **Standby Mode and Off Mode Standards**

DOE has conducted an analysis of the potential for energy savings associated with the regulation of standby mode and off mode energy use in HID lamps. Similar to DOE's conclusion in the July 2009 GSFL/IRL final rule (74 FR 34080, 34094 (July 14, 2009)), DOE has preliminarily determined that HID lamps that are subject of this rulemaking do not operate in standby mode or off mode.

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

To satisfy the EPCA definitions of standby mode and off mode (42 U.S.C. 6295(gg)(1)), the lamp must not be providing any active mode function (*i.e.*, emitting light). However, to reach such a state, the lamp must be entirely disconnected from the main power source (*i.e.*, switched off), thereby not satisfying the requirements of operating in off mode. In addition, DOE believes that all covered equipment that meets the definition of HID lamp are single-function products and do not offer any secondary user-oriented or protective functions or continuous standby mode functions. Thus, HID lamps do not satisfy the EPCA definition of standby mode. While EPCA allows DOE to amend the mode definitions (42 U.S.C. 6295(gg)(1)(B)), DOE believes that the energy use of HID lamps is accounted for entirely in the active mode. Therefore, DOE is not considering addressing lamp operation in the standby and off modes in this rulemaking. DOE requests comments on this tentative conclusion.

Item 3	*DOE welcomes comment on whether electrodeless HID lamps (also referred to as light-emitting plasma) are a subcategory of MV, HPS, or MH lamps.*
Item 4	*DOE welcomes comments on its decision to define the scope of coverage using rated wattage instead of lumen output and the range of wattages included in coverage.*
Item 5	*DOE welcomes comments on its decision to exclude HID lamps designed and labeled for use with electronic ballasts only, directional HID lamps, self-ballasted HID lamps, and high CCT lamps from the scope of coverage. DOE also requests comments on the unique characteristics of colored HID lamps.*
Item 6	*DOE welcomes comments on whether lamps for specialty applications have defining characteristics that differentiate them from lamps used for general illumination purposes. In addition, DOE welcomes comments on whether specialty applications relevant to MV technology can also be served by HPS or MH technology.*
Item 7	*DOE welcomes comment on any additional lamps that should be excluded from the scope of coverage.DOE welcomes comments on the tentative decision to not include standby and off modes in the energy conservation standard.*

1.6 **Test Procedures**

EPCA directs DOE to establish test procedures for HID lamps. DOE has proposed a test procedure through another rulemaking, the HID lamps test procedure (RIN: 1904-AC37), and is considering basing the test procedure on ANSI,[9] Commission Internationale De L'Eclairage (CIE),[10] and IES[11] documents, including the following:

- ANSI C78.389-2004, *HID Methods of Measuring Characteristics*
- ANSI C78.379-2006, *Classification of the Beam Patterns of Reflector Lamps*
- CIE 13.3-1995, *Method of Measuring and Specifying Colour Rendering Properties of Light Sources (E)*
- CIE 15:2004, *Colorimetry*
- IESNA LM-47-01, *Approved Method for Life-Testing of HID Lamps*
- IESNA, LM-51-00, *Approved Method for the Electrical and Photometric Measurements of High-intensity Discharge Lamps*

If these ANSI, CIE, or IES test procedures are updated during the course of the test procedure rulemaking, DOE will consider updating its test procedure for HID lamps based on consideration of any such updates. As a result of discussion during the HID lamps test procedures public meeting (Docket No. EERE–2010-BT-TP-0044, Public Meeting Transcript, No. 5 at p. 121), DOE contacted the IES and found out that revisions of both IESNA LM-47 and

[9] www.ansi.org/
[10] www.cie.co.at/
[11] www.iesna.org/

LM-51 are nearing completion. As these documents are published, DOE will review and consider them in the context of its test procedure and standards rulemakings for HID lamps.

During the HID lamps test procedure public meeting, NEMA requested more specific guidance regarding integrating sphere diameter for photometric testing. (Docket No. EERE–2010-BT-TP-0044, Public Meeting Transcript, No. 5 at p. 77) DOE has reviewed LM-78-07, *Approved Method for Total Luminous Flux Measurement of Lamps Using an Integrating Sphere Photometer* and is considering including in the final rule. DOE seeks comments on integrating sphere specificity and elements of LM-78.

1.6.1 **Statistical Values**

During the HID lamps test procedure NOPR public meeting, GE, NEMA, OSRAM SYLVANIA, and Philips commented about the proposed statistical values related to HID lamps. NEMA and Philips also made mention of the European Union HID lamp standards. (Docket No. EERE-2010-BT-TP-0044, NEMA, Public Meeting Transcript, No. 5 at p. 80; OSRAM SYLVANIA, Public Meeting Transcript, No. 4 at p. 31; Philips, Public Meeting Transcript, No. 5 at p. 110;) In response to these comments, DOE reviewed the sample size of HID lamps in other standards.

The European Union requires that member state authorities shall test a sample batch of minimum 20 lamps of the same model from the same manufacturer, randomly selected. The European Union requirement states that the batch shall comply with the regulation if the average results of the batch do not vary from the limit, threshold or declared values by more than 10 percent.

ENERGY STAR® is currently developing a lamp specification. However, HID lamps are part of the ENERGY STAR luminaire (light fixtures) requirements. For the source efficacy (initial) and minimum light output (lumens) requirements of ENERGY STAR luminaires the sample size is a minimum of three lamp-and-ballast models. ENERGY STAR requires ten samples for both lumen maintenance and CCT requirements in the luminaire specification. ENERGY STAR's luminaire tolerance requirements vary according to the metric being used. For the source efficacy (initial) and minimum light output (lumens) requirements of ENERGY STAR luminaires, all of the samples tested must pass the efficacy and minimum light output. For both lumen maintenance and CCT, ENERGY STAR's requirement is that at least 80 percent of the samples achieve the requirement.

DOE notes that in 2010, NEMA provided comments regarding the appropriate sampling plan and certification requirements. NEMA stated that industry recommended using NEMA standard LSD-26 (Docket No. EERE-2010-BT-CE-0014, NEMA, No. 85 at p. 32). DOE was unable to find a copy of LSD-26 and seeks more information related to this standard.

1.6.2 **National Voluntary Laboratory Accreditation Program (NVLAP)**

During the HID lamps test procedure public meeting, NVLAP certification was discussed. NEMA commented that most testing is completed at the lamp factories and that the factories are not NVLAP certified. (Docket No. EERE-2010-BT-TP-0044, NEMA, No. 4 at p.

16) Philips stated that they currently do testing, but not always in a NVLAP approved facility. (Docket No. EERE-2010-BT-TP-0044, Philips, No. 4 at p. 93) Finally, GE and NEMA commented on the differences between the same gear being tested in round-robin fashion between NVLAP laboratories and there could be a tolerance of four percent or more. (Docket No. EERE-2010-BT-TP-0044, GE, No. 4 at p. 101; NEMA, No. 4 at p. 1010) DOE researched comments submitted on NVLAP certification during its compliance, certification and enforcement rulemaking. DOE notes that NEMA stated that NVLAP had sufficient checks and balances and made the use of the most knowledgeable testing resources. (Docket No. EERE-2010-BT-CE-0014, NEMA, No. 26 at p. 8) NEMA also stated that testing should take place at a NVLAP accredited laboratory and that measurement parameters should be limited to those explicitly identified in the statute using lamps (lumens per watt) as an example. (Docket No. EERE-2010-BT-CE-0014, NEMA, No. 85 at p. 30) DOE seeks clarification of these comments and additional information related to NVLAP certification.

Item 8	*DOE welcomes additional comments related to the test procedure.*
Item 9	*DOE requests information related to NEMA Standard LSD-26.*
Item 10	*DOE seeks comment related to NVLAP accredited testing facilities.*
Item 11	*DOE seeks comment on the sample size proposed in the HID lamps test procedures and whether sample sizes in other standards would be more appropriate.*
Item 12	*DOE seeks comment on the tolerance values proposed in the HID lamps test procedures and whether tolerance values in other standards would be more appropriate.*

1.7 **Metrics**

To develop energy conservation standards related to HID lamps, DOE must select a metric for rating the performance of the lamps. Sections 1.7.1 through 1.7.4 discuss the different metrics DOE is considering for energy conservation standards for HID lamps. Because dimming is uncommon for HID lamps, DOE plans to assess products while operating at full light output, not at a reduced light output or dimmed state.

1.7.1 **Lamp Efficacy**

DOE is considering using initial lamp efficacy as the metric for potentially setting standards for HID lamps. Initial lamp efficacy is the ratio of light output divided by lamp input power at the beginning of the life of the lamp. DOE would establish a minimum lamp efficacy requirement for HID lamps.

DOE received comments on the HID lamps NOPD from NEMA stating that lamp efficacy is not an appropriate metric for directional lamps. (Docket No. EERE-2006-DET-0112, NEMA, No. 21 at p. 2) DOE acknowledges that lamp efficacy does not fully characterize the

efficacy of directional lamps, and, if necessary, will investigate a metric based on beam angle and intensity for these lamps.

1.7.2 **Input Wattage**

DOE is also considering using input wattage as the metric for setting standards for HID lamps. With this approach, DOE would require lamps of a particular light output to not exceed a maximum input wattage requirement. Because this metric focuses on energy consumption, it allows flexibility when selecting the individual system components.

1.7.3 **Center-Beam Candlepower (Intensity)**

Directional lamps are typically characterized by beam angle. Center-beam candlepower (CBCP) is correlated to beam angle; as beam angle increases, CBCP decreases. Should DOE decide to include directional lamps within the scope of coverage, an efficacy metric for directional HID lamps would need to capture this relationship.

In researching a possible directional lamp metric, DOE found that ANSI and IES have slightly different approaches to defining beam angle. ANSI defines beam angle as 50 percent of the CBCP, whereas IES defines beam angle as 50 percent of maximum intensity in that for some lamps the maximum intensity is not at nadir.[12] Because CBCP is correlated to beam angle, it may be better than the metric developed by IES for assessing efficacy of directional lamps.

DOE notes that the ENERGY STAR specifications for SSL replacement lamps set a minimum intensity in CBCP at lamp nadir related to the beam angle of the lamp. For HID directional lamps, an appropriate metric could require a minimum CBCP related to the beam angle of the lamp for a given lamp shape and diameter. The methodology could include a scaling factor for different wattage lamps of the same shape and diameter.

1.7.4 **Beam Lumens Per Watt**

Directional lamps can also be characterized by beam (or zonal) lumens. Beam lumens are defined as the light output cast within the region outlined by the beam angle. Lumens cast outside the beam angle region are not counted toward the beam lumen metric, and beam lumens can be thought of as "useful lumens." Lamps that concentrate a higher percentage of total lumens inside the beam angle zone per input watt would generally be preferred by the consumer, because the lamp would better create a region of higher illumination to provide contrast against the background lighting. However, while beam lumens provide information about the average illumination within the region of interest, CBCP gives specific information about intensity at nadir. In addition, DOE notes that catalogs of directional HID lamps more frequently provide center-beam intensity than beam lumens.

[12] Nadir is the angle pointing directly downward from the lamp or luminaire, or 0°.

Item 13	*DOE welcomes comments related to the appropriateness of lamp efficacy as one of the potential metrics in HID lamp energy conservation standards.*
Item 14	*DOE welcomes comments on developing a center-beam intensity metric related to directional lamps. DOE requests information on other possible metrics in development or other metrics that DOE should consider, including beam lumens per watt. DOE requests comments on the appropriate definition of beam angle.*

2 OVERVIEW OF ANALYSES FOR RULEMAKING

The purpose of the analyses conducted in support of the standards rulemaking is to ensure that DOE selects energy conservation standards that achieve the maximum improvement in efficacy that is technologically feasible and economically justified, and will result in significant energy savings. Economic justification includes the consideration of economic impacts on domestic manufacturers and consumers, national benefits including environmental impacts, issues of consumer utility, and impacts from any lessening of competition. DOE expects the selection of such standards to achieve the maximum energy savings that are technologically feasible and economically justified without imposing an excessive financial burden on any particular party.

The figure below summarizes the analytical components of the DOE standards-setting process. The analyses are presented in the center column. Each analysis has a set of key inputs, which are data and information required for the analysis. The identified approaches are the methods that DOE will use to obtain key inputs, which may vary depending on the information in question. For example, some key inputs exist in public databases; in support of this rulemaking, DOE will also develop relevant information or collect such information from interested parties or experts with special knowledge. Key outputs from each analysis feed directly into the rulemaking. Arrows indicate the flow of information among the various analyses. DOE ensures a consistent approach to its analyses throughout the rulemaking by considering each analysis as a part of the overall standards-setting framework.

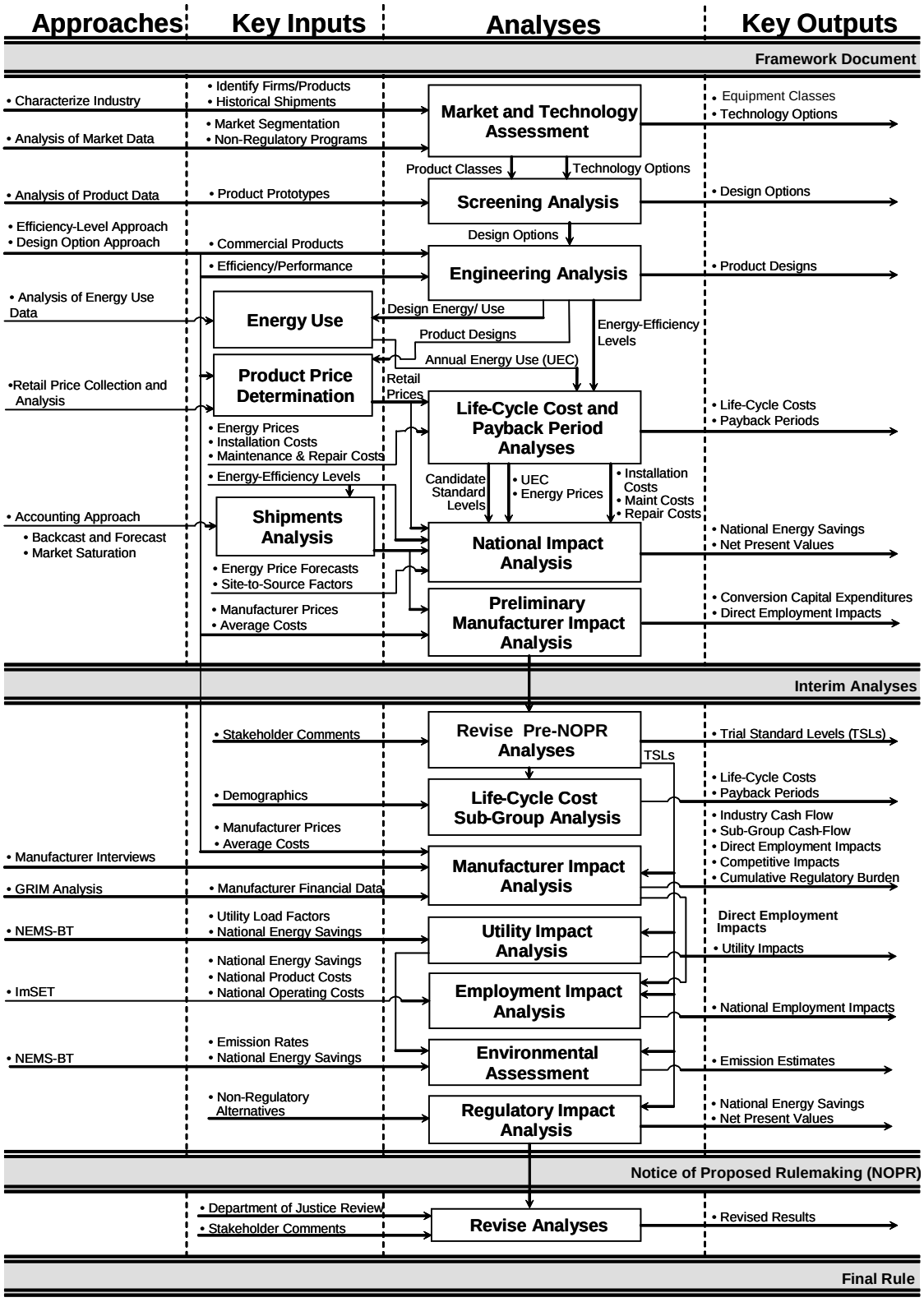

Figure 2.1 Flow Diagram of Analyses Conducted for an Energy Conservation Standards Rulemaking

3 MARKET AND TECHNOLOGY ASSESSMENT

The market and technology assessment will provide information about the manufacturers and performance attributes of HID lamps (and ballasts and fixtures where applicable). This assessment is particularly important at the outset of the rulemaking for developing equipment classes and for identifying technology options that improve efficacy for each of the three lamp types.

3.1 Market Assessment

DOE will qualitatively and quantitatively characterize the structure of the market for HID lamps. In the market assessment, DOE will identify and characterize the manufacturers of this equipment; estimate market shares and trends; address regulatory and non-regulatory initiatives intended to improve the efficacy or reduce the energy use of covered lamps; and explore the potential for technological improvements in the design and manufacturing of such equipment.

The market assessment will establish the context for this rulemaking and serve as a resource to guide the analyses that follow. For example, DOE may use historical shipments and prices as indicators of future shipments and prices. Similarly, DOE plans to use market structure data for the MIA, data that will be particularly useful for assessing competitive effects. This phase also allows DOE to start researching design options by reviewing equipment literature and industry publications.

DOE recognizes that there may be limited publicly available information on national shipments, manufacturing costs, channels of distribution, and manufacturer market shares of HID lamps. This type of data is an important input for analyses that determine if energy conservation standards are economically justified and capable of achieving significant energy savings. Therefore, DOE encourages interested parties to submit data that will improve DOE's understanding of the HID lamp market.

Interested parties may submit confidential data to DOE, indicating in writing which data should remain confidential. Interested parties must submit confidential information to DOE according to the procedures outlined in 10 CFR 1004.11. 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 must include all the information believed to be confidential, and the other copy must have the information believed to be confidential deleted. DOE will make its own determination about the confidential status of the information and treat it accordingly.[13]

[13] 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 public 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) a date after which such information might lose its confidential character; and (7) why disclosure of the information would be contrary to the public interest. 10 CFR 1004.11

DOE also works with confidential data provided by manufacturers and other organizations to prepare aggregated results for DOE's analysis. These aggregated results do not divulge individual raw data, but enable other interested parties to comment on the aggregated dataset. NEMA is the trade association for manufacturers of HID lamps; DOE expects that NEMA will play an important role in providing market information, including information on manufacturers, market shares, and trends in the market.

DOE is creating a data set of commonly available HID equipment based on recent catalogs from small and large HID lamp manufacturers. DOE will use the resulting knowledge about equipment availability to evaluate how the market may respond to various standard levels (*e.g.*, consumers substituting fixtures with pulse-start MH lamps over fixtures with probe-start MH lamps), and to gain insight on the performance attributes of various commercially available lamp technologies.

Item 15	*DOE welcomes input on disaggregated market share and shipment data based on input wattage for each HID lamp technology.*

3.1.1 **Equipment Classes**

When necessary, DOE divides covered equipment into classes by (a) the type of energy used; (b) the capacity of the equipment; or (c) any other performance-related feature that justifies different standard levels, such as features affecting consumer utility. (42 U.S.C. 6295(q)) DOE then conducts its analyses and considers establishing standards to provide separate standard levels for each equipment class.

For HID lamps, DOE examined several possible characteristics or features that could warrant separation of covered equipment into different equipment classes, including:

- directionality;
- ballast location;
- CCT; and
- light output in lumens.

Each of the listed characteristics or features is discussed below. DOE seeks feedback on these product class divisions, as well as further subdivision of equipment classes by features that are not discussed in this document such as lamp orientation, base type, CRI,[14] coating, and safety rating (open versus enclosed). In addition, if DOE determines to include directional lamps within the scope of coverage, DOE would consider beam angle and lamp diameter as class-setting factors to further subdivide the directional lamp category discussed below. DOE is not considering lamp technology (MV, HPS, MH) to be a class-setting factor as CCT more directly accounts for the differences in consumer utility among the three lamp types.

[14] The test procedure NOPR has proposed to adopt the definition for CRI in 10 CFR 430.2, as "the measured degree of color shift objects undergo when illuminated by a light source as compared with the color of those same objects when illuminated by a reference source of comparable color temperature." 76 FR 77914, 77930 (December 15, 2011)

Directionality

The direction in which the light leaves the lamp can be separated into two main categories: directional and omni-directional. The directionality of the light requires different metrics to assess efficacy and thus creates a major distinction between HID lamps. Should DOE determine to include directional lamps within the scope of coverage, DOE would consider separating equipment classes based on this characteristic.

Ballast Location

Ballasts are typically located externally to HID lamps. However, some directional and omni-directional HID lamps are self-ballasted. These self-ballasted lamps typically have lower efficacies and (or less intensity in the case of directional lamps) than externally ballasted lamps. Self-ballasted HID lamps often compete with incandescent, halogen, and compact fluorescent lamps and cannot be used as direct substitutes for externally ballasted lamps. Although the self-ballasted HID lamps have lower performance compared to typical HID lamps, substituting them for alternative technologies can yield energy savings or cost savings through the increased lifetime of HID lamps relative to incandescent alternatives. Therefore, should DOE determine to include self-ballasted lamps within the scope of coverage, DOE would consider separate equipment classes for self-ballasted HID lamps, given their difference in efficacy and unique consumer utility.

CCT

HID lamps are available with different CCT values[15] depending on lamp type and design. DOE reviewed lamp catalogs and found that CCT is related to lamp efficacy (*i.e.*, higher CCT lamps generally have lower efficacy). Product usage indicates that some consumers specify lamps of a particular color temperature for certain applications, indicating CCT may provide utility to the consumer. For example, MH lamps (higher CCT) are typically specified rather than HPS lamps (lower CCT) for indoor commercial areas due to the whiter color temperature (and also higher CRI). Using CCT as a class-setting factor rather than lamp technology would allow for different lamp types to be subject to the same energy conservation standard as long as they display the same CCT. Based on the difference in efficacy and consumer utility, DOE is considering separating equipment classes by CCT. Should DOE determine to include high CCT lamps in this rulemaking, DOE would consider separate equipment classes for these lamps.

Light Output

HID lamps are available with a variety of light outputs and input powers. DOE's review of catalog data indicates that lamps of increased light output (or input power) are generally more efficacious. In addition, consumers require more or less light output from a lamp depending on the intended use for the lamp, indicating a consumer utility from this feature. Light output and input power are highly correlated (increased input power typically leads to increased light

[15] The test procedure NOPR has proposed to adopt the definition for CCT in 10 CFR 430.2, as "the absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source." 76 FR 77914, 77930 (December 15, 2011)

output), but DOE's view is that light output more directly addresses the feature valued by consumers. Therefore, based on the difference in lamp efficacy and consumer utility, DOE is considering establishing separate equipment classes on the basis of light output.

Table 3.1 presents DOE's initial proposed equipment class structure.

Table 3.1 Initial Proposed Equipment Classes

Directionality	Ballast Location	CCT Range	Lumen Range	Equipment Class ID
Directional	Self-Ballasted	All	All	1
	Externally Ballasted	All	All	2
Omni-directional	Self-Ballasted	All	All	3
	Externally Ballasted	1,900-2,500 K	1–3,000 lm	4A
			3,001–5,000 lm	4B
			5,001–8,000 lm	4C
			8,001–11,000 lm	4D
			11,001–20,000 lm	4E
			20,001–40,000 lm	4F
			40,001–100,000 lm	4G
			>100,001 lm	4H
		2,501-5,000 K	1–3,000 lm	5A
			3,001–5,000 lm	5B
			5,001–8,000 lm	5C
			8,001–12,000 lm	5D
			12,001–20,000 lm	5E
			20,001–50,000 lm	5F
			>50,001 lm	5G
		5,001-6,999 K	1–3,000 lm	6A
			3,001–5,000 lm	6B
			5,001–8,000 lm	6C
			8,001–12,000 lm	6D
			12,001–20,000 lm	6E
			20,001–50,000 lm	6F
			>50,001 lm	6G

Item 16	*DOE welcomes comments on the proposed equipment classes for HID lamps and additional approaches to defining classes in accordance with the requirements of 42 U.S.C. 6295(q). Specifically, DOE seeks input on its proposal to establish equipment classes based on lumen output (rather than rated wattage) and CCT, and the appropriateness of the lumen output and CCT ranges selected.*
Item 17	*DOE seeks comment on whether the proposed equipment classes should be further subdivided by lamp orientation (also known as operating or burn position and typically includes vertical, horizontal, universal) or by other lamp characteristics (e.g., enclosed or open fixture rating, CRI, base type, coated or clear envelope). DOE also seeks comment on whether equipment classes should be separated based on lamp technology.*

3.2 Technology Assessment

The technology assessment centers on understanding how equipment uses energy and on identifying measures that would improve the efficacy of HID lamps. Measures that improve equipment efficacy are called technology options, and they are based on existing technologies as well as working prototypes. In consultation with interested parties, DOE will create a list of technology options for consideration in this rulemaking. Following research into this list of technology options, DOE will consider each option in light of four screening criteria: (1) technological feasibility; (2) practicability to manufacture, install, and service; (3) adverse impacts on equipment utility or availability; and (4) adverse impacts on health or safety (see section 4). Those technology options that meet the four screening criteria are called design options; these options will be considered appropriate ways to improve the efficacy of the equipment in the engineering analysis, and will assist DOE in determining the max tech design.

DOE identifies technology options by reviewing manufacturer catalogs, recent trade publications, technical journals, and patent filings. DOE will also draw from a NEMA white paper, NEMA LSD 54-2010, *The Strengths and Potentials of Metal Halide Lighting Systems,*[16] and a 2005 report from a DOE workshop that was widely attended by HID lamp manufacturers, lamp materials suppliers, and NEMA members. The report, *High-intensity Discharge Lighting Technology Workshop Report,*[17] was also recommended by NEMA in its comments provided in response to the 2010 HID lamps NOPD (Docket No. EERE-2006-DET-0112, NEMA, No. 21 at p. 4).

The following sections provide DOE's initial assessment of technologies that improve the efficacy of HID lamps.

[16] National Electrical Manufacturers Association, Lighting Systems Division. *The Strengths and Potentials of Metal Halide Lighting Systems*. Rosslyn, VA. Document LSD 54-2010. www.nema.org/stds/lsd54.cfm.

[17] U.S. Department of Energy--Office of Energy Efficiency and Renewable Energy. *High-intensity Discharge Lighting Technology Workshop Report*. November 15, 2005. Washington, D.C. apps1.eere.energy.gov/buildings/publications/pdfs/corporate/hid_workshop-report.pdf.

3.2.1 **Mercury Vapor Lamps**

MV ballasts, other than specialty application MV ballasts, have been banned from import or production since January 1, 2008 (42 U.S.C. 6295 (ee)). This ban effectively limits the installation of new MV fixtures and ballasts, meaning the only MV lamps currently being sold are replacement lamps. DOE understands there is limited industry design emphasis on MV lamps, there are limited methods to improving efficacy of MV lamps, and that the more common pathway to increased efficacy is a change of technology to MH or HPS lamps.

3.2.2 **High-Pressure Sodium Lamps**

HPS lamps are very efficacious (up to 150 lumens per watt), but have intrinsically poor color quality. HID lamp catalogs do indicate that a range of HPS lamp efficacies are available, but at this time, DOE is not aware of the specific technology options that are used achieve different lamp efficacies.

3.2.3 **Metal Halide Lamps**

DOE is aware of a limited set of technology options that could improve MH lamp efficacy. For this rulemaking, DOE intends to evaluate the following technology options:

- *Pulse-Start Technology*. Pulse-start lamps are typically more efficacious than probe-start lamps.

- *Arc Tube Design*. The arc tube generates the light for the lamp. Potential improvement options include changing the material of the arc tube from quartz to ceramic and changing the size and shape of the arc tube. Some of these options may not, however, be compatible with all MH systems. For example, ceramic arc tubes are only used with low-frequency pulse-start MH systems.

    - *Ceramic Arc Tubes.* The 2005 HID workshop report estimated that the potential energy savings from ceramic arc tubes was 1.2 quads.[18] In the years since that workshop, significant industry research and development has been devoted to ceramic arc tube design. Manufacturers have introduced commercial ceramic pulse-start metal halide (CMH) lamps with higher efficacy and better color characteristics than quartz pulse-start MH lamps. CMH technology is not, as of 2012, made in lamp wattages above 400 W, so it will not be a technology option available for all equipment classes.

    - *Arc Tube Shape.* The shape of the HID lamp arc tube relates to the efficacy of the lamp. Certain arc tube shapes (like formed or offset electrode) can be more efficacious than others for horizontal operating orientations. These arc tube shapes help position the lamp arc in a way that increases MH vapor pressure, leading to increased light output.

[18] *High-intensity Discharge Lighting Technology Workshop Report*, Nov. 15, 2005 at p. 6

- *Novel Fill Gas*. The 2005 HID workshop report estimated that the potential energy savings from using novel gases as arc tube fill gases in HID lamps is 0.7 quads.[19]

- *Lamp Electrodes*. As presented in chapter 3 of the 2010 HID lamps final determination TSD, lamp electrodes represent roughly 10 percent of a lamp's power loss (*e.g.*, for a lamp rated at 400 W, nearly 40 W of that power is not generating light but is directed to the electrodes). Different electrode materials or designs could reduce these power losses. The 2005 HID workshop report estimated that the potential energy savings of improved electrode design or electrodeless lamps are 0.2 and 0.6 quads, respectively.[20]

Item 18	*DOE welcomes comments on the preliminary technology options identified in this section, and on whether there are additional technology options it should consider.*

4 SCREENING ANALYSIS

The purpose of the screening analysis is to screen out technology options that DOE will not analyze further in the engineering analysis. DOE will follow the process set forth below. DOE will develop a list of technology options (through its own research and in consultation with interested parties) as part of the technology assessment. The identified candidate technology options will encompass all those technologies that may improve the efficacy of HID lamps. Thereafter, DOE will review each technology option in light of the following four criteria:[21]

1. *Technological feasibility.* DOE will screen out technologies that are not incorporated in commercially available products or working prototypes.

2. *Practicability to manufacture, install, and service.* If DOE determines that mass production of a technology in commercial equipment and reliable installation and servicing of the technology cannot be achieved on the scale necessary to serve the relevant market by the time of the compliance date of the standard, it will not consider that technology further.

3. *Adverse impact on equipment utility or availability.* If DOE determines that a technology will have a significant adverse impact on the utility of the relevant equipment for significant consumer subgroups, or will result in the unavailability of any covered equipment type with performance characteristics (including reliability), features, size, capacities, and volumes that are substantially the same as equipment generally available in the United States at the time, it will not consider that 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 that technology further.

[19] *High-intensity Discharge Lighting Technology Workshop Report*, Nov. 15, 2005 at p. 6
[20] *High-intensity Discharge Lighting Technology Workshop Report*, Nov. 15, 2005 at p. 6
[21] DOE's Process Rule establishes procedures, interpretations, and policies to guide DOE in the consideration and promulgation of new or amended energy conservation standards under EPCA, including the four screening criteria. The Process Rule can be found at 10 CFR Part 430, subpart C, appendix A.

DOE will fully document its reasons for eliminating any technology options during the screening analysis, and will publish this documentation for interested parties to review as part of the interim analysis. Those technology options that meet the above screening criteria will be considered design options in the engineering analysis.

Item 19	*DOE welcomes comments on how the above four screening criteria might apply to technology options under consideration by DOE, and how the screening criteria apply to any additional technology option(s) that an interested party recommends to DOE.*

5 ENGINEERING ANALYSIS

After conducting the screening analysis described in section 4, DOE will perform an engineering analysis based on the remaining design options that are available to improve lamp efficacy. The engineering analysis consists of estimating the energy use and cost of equipment at various levels of increased efficacy. Section 5.1 provides an overview of the engineering analysis; section 5.2 discusses representative equipment classes; section 5.3 discusses baseline models; section 5.4 discusses identification of higher-efficacy substitutes; section 5.5 describes efficacy levels; section 5.6 describes the scaling approach; section 5.7 describes the product price determination; section 5.8 discusses proprietary designs; and section 5.9 discusses cumulative regulatory burdens that might affect the engineering analysis.

5.1 Engineering Analysis Overview

The purpose of the engineering analysis is to determine the relationship between efficacy and end-user price. This relationship between price and efficacy serves as the basis for cost/benefit calculations to individual consumers in the LCC analysis and to the nation in the NIA.

The engineering analysis will focus on selecting commercially available lamps that incorporate design options that improve efficacy. The engineering analysis will also identify the highest efficacy that is technologically feasible within each equipment class. DOE may determine the max tech model by investigating the existence of any HID lamp prototypes with higher efficacy than that present in commercially available models. The following is a summary of primary steps in the engineering analysis:

1. Select Representative Equipment Classes
2. Select Baseline Models
3. Identify More Efficacious Substitutes
4. Develop CSLs
5. Determine Lamp Price

5.2 Representative Equipment Classes

When a type of equipment is proposed to be divided into multiple equipment classes, DOE selects certain classes as representative and concentrates its analytical effort on these classes. Generally, DOE selects representative equipment classes based on the highest shipment

volumes, although it will also consider unique performance characteristics as appropriate. The representative equipment classes are identified with gray shading in Table 5.1. For those equipment classes that are not analyzed, DOE scales CSLs from representative equipment classes through a process described in section 5.6.

Item 20 *DOE welcomes comments on the selection of representative equipment classes for HID lamps.*

5.3 Baseline Models

Once representative equipment classes are established, DOE identifies baseline models that serve as reference points against which DOE can measure changes resulting from potential energy conservation standards. DOE will create a separate engineering analysis for each baseline model selected.

The baseline model is typically the most common, least efficacious equipment sold in a given equipment class. In cases where a large portion of the market has already adopted a more efficacious lamp, DOE is considering analyzing two baseline models. For example, MV lamps are the least efficacious lamp option for some equipment classes; however, MV lamps represent a very small portion of the market because many consumers have already transitioned to MH lamp technology. For this reason, DOE will select the both a MV lamp and MH lamp as baselines for most 2501–5000 K omni-directional lamp equipment classes.

Table 5.1 shows the equipment classes that DOE has tentatively identified as representative equipment classes (indicated with gray shading) and related baseline models.

Table 5.1 Representative Equipment Classes and Provisional Baseline Models

Directionality	Ballast Location	CCT Range	Lumen Range	Baseline Model(s)	Equipment Class ID
Directional	Self-Ballasted	All	All	--	1
	Externally Ballasted	All	All	--	2
Omni-directional	Self-ballasted	All	All	--	3
	Externally Ballasted	1,500-2,500K	1–3,000 lm	--	4A
			3,001–5,000 lm	**50 W HPS**	4B
			5,001–8,000 lm	--	4C
			8,001–11,000 lm	**100 W HPS**	4D
			11,001–20,000 lm	--	4E
			20,001–40,000 lm	**250 W HPS**	4F
			40,001–100,000 lm	**400 W HPS**	4G
			>100,001 lm	--	4H
		2,501-5,000K	1–3,000 lm	--	5A
			3,001–5,000 lm	**100 W MV** **70 W Pulse-Start MH**	5B
			5,001–8,000 lm	--	5C
			8,001–12,000 lm	**175 W MV** **150 W Probe-Start MH**	5D

Directionality	Ballast Location	CCT Range	Lumen Range	Baseline Model(s)	Equipment Class ID
			12,001–20,000 lm	**250 W MV** **175 W Probe-Start MH**	5E
			20,001–50,000 lm	**400 W MV** **400 W Probe-Start MH**	5F
			>50,001 lm	**1000 W Probe-Start MH**	5G
		5,001-6,999K	1–3,000 lm	--	6A
			3,001–5,000 lm	--	6B
			5,001–8,000 lm	--	6C
			8,001–12,000 lm	--	6D
			12,001–20,000 lm	--	6E
			20,001–50,000 lm	--	6F
			>50,001 lm	--	6G
Note: Gray shaded equipment classes are representative equipment classes.					

Item 21 *DOE welcomes comments on the selection of baseline models for the proposed representative equipment classes.*

5.4 Identify Higher-Efficacy Lamp Replacements

DOE selects more efficacious lamps for each baseline lamp by considering technologies not eliminated in the screening analysis. DOE considers these technologies in the engineering analysis by analyzing commercially available lamps in which the design options are already incorporated. In identifying more efficacious lamp-and-ballast designs, DOE recognizes that a lamp's lumen package and performance characteristics are important design criteria for consumers. DOE chooses more efficacious substitute lamps with performance characteristics similar to those of the baseline lamps.

DOE notes that its analysis of energy consumption will be based on a lamp-and-ballast system because the lamp and ballast operate together in practice. DOE will consider the power losses of the ballast in addition to the lamp wattage to accurately model the impact of lamp efficacy standards.

In identifying more efficacious lamps, DOE will use a database of HID lamp catalog information, supplementing with test data when possible. DOE is considering selecting HID lamps for the analysis such that potential substitutions maintain light output of the lamp-and-ballast system within 10 percent of the mean lumens of the baseline system.[22] This approach will accurately characterize the cost-effectiveness of a particular efficacy level if a consumer makes an informed decision that maintains light output.

One challenge in considering efficacy levels for HID lamps is ensuring that increased efficacy leads to reduced energy consumption rather than increased light output. Energy consumption can be reduced with increased efficacy though several pathways including:

[22] Because HID lamps (other than self-ballasted lamps) require a ballast to operate, DOE will pair a representative ballast with representative HID lamps to develop representative lamp-and-ballast systems. DOE's analyses will use a representative input power for the entire lamp-and-ballast system.

1. A shift to reduced wattage lamps in response to the increased efficacy required by standards.

2. Respacing and reducing the number of fixtures to take into account the increased light output from each fixture.

DOE understands that respacing and reducing the number of fixtures is not always an option, even for a renovation or new construction purchasing event. DOE also recognizes that a reduced wattage lamp alternative may not be available for every lamp currently on the market. As a result, DOE may consider consumer behaviors resulting in under-illumination, over-illumination, or no energy savings in the NIA.

Item 22	*DOE welcomes comments on more efficacious (and equal lumen output) substitutes for each proposed baseline model, up to and including the max tech lamp that would result in reduced energy consumption.*
Item 23	*DOE welcomes comment on the current and future availability of reduced wattage lamps and the practicality of reducing and respacing fixtures. DOE also invites comment on whether barriers exist to developing new lamps that would provide reduced wattage alternatives to today's lamps.*

5.5 **Efficacy Levels**

After identifying more efficacious substitutes for each baseline lamp-and-ballast system, DOE will develop CSLs, a set of efficacy levels considered in the interim analyses that spans the range of lamp efficacies from baseline equipment to equipment at the maximum technologically feasible level. Each CSL is analyzed in the LCC and NIA analyses. At the NOPR stage of the rulemaking process, DOE will propose energy conservation standard levels for each equipment class and invite public comment.

Efficacy levels are generally based on consideration of several factors, including (1) design options associated with the specific lamps being studied; and (2) the maximum technologically feasible efficacy level. Furthermore, DOE will consider the impact of energy conservation standards on the overall efficiency of lighting systems. Lighting systems could exist whose optimal performance is achieved using a lamp that does not meet a high lamp efficacy requirement. DOE does not intend for a standard to eliminate lighting systems that save more energy than the savings due to increased lamp efficacy.

Finally, the equipment class structure described in section 3.1.1 reflects a "binned" efficacy level approach. In this approach, DOE would establish a constant lamp efficacy requirement for particular ranges of light output. Although a constant efficacy requirement simplifies standards for manufacturers, this approach would subject all lamps in a particular light output range to the same standard, which could encourage the market towards the higher light output (and higher input power) end of the bin. This could potentially negate energy savings associated with increasing lamp efficacy. Therefore, DOE is also considering an equation-based approach. An equation-based approach would establish lamp efficacy requirements as a function

of light output, thus eliminating the need for equipment classes based on lumen output. As described in section 3.1.1, lamp efficacy tends to increase for lamps with higher light output, and an equation-based approach would allow DOE to account for this trend with a continuous relationship.

Item 24	*DOE welcomes comments on the use of an equation-based versus binned efficacy level approach for HID lamps.*
Item 25	*DOE welcomes input on whether highly efficacious lighting systems could be eliminated given a particular lamp efficacy requirement.*

5.6 **Scaling Method**

For the equipment classes not analyzed directly, DOE plans to scale the engineering results and CSLs from the representative equipment classes based on efficacy ratios observed in catalog data or by extrapolation across lumen output using regression equations. For example, DOE might calculate an average percent difference in efficacy between lamps in equipment class 4A and 4B (representative class) and use this percent difference to scale the engineering results from equipment class 4B to 4A.

Item 26	*DOE welcomes comments on its proposed approach to scale from representative equipment classes to classes not directly analyzed in the engineering analysis.*

5.7 **Product Price Determination**

In this rulemaking, DOE plans to estimate end-user price directly, rather than develop manufacturer selling prices (MSP) from a bill of materials and manufacturer markup analysis. DOE selected this methodology because it is difficult to reverse-engineer an HID lamp; they are not easily disassembled, and fill gas composition and partial pressures are difficult to assess.

DOE is considering collecting manufacturer suggested price lists (hereafter "blue-book") and applying a discount based on the distribution channel through which the lamp is purchased. DOE will gather price information from State procurement contracts, large electrical supply distributors, home-improvement/hardware stores, and other sources of publicly available end-user prices such as Internet retailers, to estimate the appropriate discounts. DOE will also add an estimate of sales tax to the end-user price estimates as necessary based on tax information provided by the Sales Tax Clearinghouse[23]

DOE seeks feedback on the sales distribution channels of HID lamps, as well as the allocation of market share between these channels. DOE also encourages interested parties to submit any relevant data that would improve DOE's understanding of the cost-efficacy relationship of HID lamps. As discussed previously, DOE will present aggregated results in future stages of the rulemaking rather than confidential data received from interested parties.

[23] Sales Tax Clearinghouse, Aggregate State Tax Rates. Available at: thestc.com/STrates.stm.

Item 27 *DOE seeks comment on its end-user price approach for calculating the cost-efficacy relationship for HID lamps. In particular, DOE seeks comment on typical distribution channels for HID lamps, as well as the allocation of market share between these channels.*

5.8 Proprietary Designs

In its engineering and economic analyses, DOE will consider all design options that are commercially available or present in a working prototype, including proprietary designs. However, if a proprietary design is the only approach available to achieve a given efficacy level, then DOE will eliminate the efficacy level from further analysis. DOE will reject a standard level that can be met only with a single proprietary technology because it could result in an anti-competitive market, a principle consistently applied in past DOE rulemakings as economically unjustifiable. However, if a given energy efficacy level can be achieved by a number of design approaches, including a proprietary design, DOE will continue to examine the given efficacy level, in spite of the proprietary nature of a particular design.

DOE is aware of manufacturer concerns about proprietary designs and will take steps to maintain the confidentiality of any proprietary data provided by manufacturers. This information will provide input to the competitive impacts assessment and other economic analyses.

Item 28 *DOE seeks information regarding the existence of relevant proprietary designs for the HID lamps under consideration in this rulemaking. DOE also seeks comment on whether these proprietary designs are the only pathway to increase lamp efficacy.*

5.9 Outside Regulatory Changes Affecting the Engineering Analysis

In conducting an engineering analysis, DOE considers the impacts of regulatory burdens outside of DOE's energy conservation standards rulemaking process that can affect manufacturers of the covered equipment. Some regulatory requirements can also affect the efficacy or energy use of the HID lamps covered under this rulemaking. DOE will consider non-lamp (*e.g.*, ballast, fixture, luminaire) regulatory requirements related to HID lamps, and attempt to identify all outside regulatory requirements that could affect the engineering analysis. The consideration of these requirements is closely related to the cumulative regulatory burden assessment that DOE will conduct as part of the MIA. Based on consideration of the comments received on the engineering analysis, DOE will make any necessary changes to its analysis.

Item 29 *DOE welcomes comments on regulatory burdens and changes directly or indirectly related to HID lamps that should be considered in the engineering analysis.*

Item 30 *DOE welcomes comments on other engineering issues that could affect the engineering analysis.*

6 ENERGY-USE CHARACTERIZATION

The purpose of the energy-use characterization is to estimate the energy usage in the baseline and higher-efficacy lamps considered in this rulemaking. This analysis, which is meant to represent typical energy usage 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 in relation to the baseline lamp.

For HID lamps, energy use is derived by multiplying the system input power rating by the annual operating hours. System power is defined as the total input power to the lamp-and-ballast system. Due to ballast inefficiencies, HID ballasts typically add between 8 percent and 27 percent (the higher percentages are associated with the lower rated power lamps) of the lamp rated power to the system. For the LCC and PBP analyses in the 2010 HID lamps final determination, DOE surveyed the commercially available ballast input power ratings for given lamps, and used the median ballast input power for each type of lamp in the energy-use characterization. DOE proposes to review manufacturer catalogs for HPS and MV ballast input power values as it did for the determination. For MH ballast input power, DOE will review catalogs as well as ongoing analyses for the concurrent MHLF rulemaking.

DOE plans to use data from the 2010 U.S. Lighting Market Characterization,[24] the Energy Information Administration's (EIA's) 2003 Commercial Building Energy Consumption Survey (CBECS),[25] and EIA's 2006 Manufacturer Energy Consumption Survey (MECS)[26] to estimate a distribution of operating hours for the different HID lamps by sector and census division. While the 2010 MECS data collection has started (four year cycle), these data are not yet available. The EIA studies provide information on the distribution of buildings within the United States by building type and census division. The LMC, which is based on thousands of building audits and surveys, provides national data on annual operating hours by building and lamp type for all sectors. These operating hours are further broken down by application for the commercial and industrial sectors. By comparing the LMC data with the EIA data, DOE will derive annual operating hours for census divisions and selected large states. This approach allows DOE to correlate the electricity price and sales tax distributions with the operating hours distributions of census divisions and selected large states in the LCC spreadsheet.

For the NOPR stage of this rulemaking, DOE will conduct a sensitivity analysis to determine how high and low estimates of energy use might affect the economic feasibility of any proposed energy conservation standards. DOE will also be able to correlate regional electricity prices and sales tax data to develop a more accurate distribution of the variability in consumer effects in the LCC analysis.

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[24] U.S. Department of Energy--Office of Energy Efficiency and Renewable Energy. *Final Report: 2010 U.S. Lighting Market Characterization.* 2012. Washington, D.C. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.

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

[26] U.S. Department of Energy-Energy Information Administration. *Manufacturing Energy Consumption Survey*, Table 1.4: Number of Establishments by First Use of Energy for All Purposes. 2006. Washington, D.C. www.eia.doe.gov/emeu/mecs/mecs2006/2006tables.html.

Item 31	*DOE welcomes comments on whether median system input power is appropriate for characterizing lamp energy use.*
Item 32	*DOE welcomes comments on its proposed methodology to determine annual operating hours for covered HID lamps in the commercial and industrial sectors, and how operating hours may vary by lamp type and application.*

7 MARKUP ANALYSIS

In its markup analysis, DOE will evaluate distribution channels for HID lamps to help develop end-user equipment prices for the LCC analysis and NIA. To relate end-user prices to MSPs used in the MIA, DOE will also estimate the price markups occurring in the identified distribution channels.

Although HID lamps are the covered equipment in this rulemaking, DOE must also consider the prices of ballasts and fixtures related to HID lamps because ballast and fixture prices can vary with lighting application (*e.g.*, indoor versus outdoor). Some options considered in the proposed efficacy levels will require a new ballast, or possibly a new fixture (with a new ballast). Therefore, DOE must also consider the distribution channels for lamps, ballasts, and fixtures in determining equipment prices.

MSPs are inputs to the MIA (section 12). Because DOE is developing end-user prices from price schedules, it will need to derive MSPs for the MIA from end-user prices using manufacturer-to-consumer markups.

7.1 Distribution Channels

In generating end-user price inputs for the LCC analysis and NIA, DOE must identify distribution channels (*i.e.*, how the equipment is distributed from the manufacturer to the consumer), and estimate relative sales volumes through each channel. DOE has identified the two primary distribution channels for HID lamps as follows:

Lamp Distribution Channel 1:
Lamp Manufacturer → Electrical Wholesaler (Distributor) → Contractor → End-User of Lighting System

Lamp Distribution Channel 2:
Lamp Manufacturer → Electrical Wholesaler (Distributor) → End-User of Lighting System

For replacement HID ballasts, DOE assumes the following primary distribution channel:

Replacement Ballast Distribution Channel:
Ballast Manufacturer → Electrical Wholesaler (Distributor) → Contractor → End-User of Lighting System

In 2009, DOE published the MHLF framework document[27] that included a distribution channel for MH lamp fixtures. Because MH lamps are a subset of HID lamps, DOE assumes the same channel for HID fixtures:

HID Fixture Distribution Channel:
Fixture Manufacturer → Electrical Wholesaler (Distributor) → Contractor → End-User of Lighting System

7.2 Markups

To help derive MSPs for the MIA, DOE will rely on economic data from public sources and industry input to determine the extent to which equipment is marked up from the manufacturer to the consumer. Publicly owned companies are required to disclose financial information on a regular basis by filing various forms with the U.S. Securities and Exchange Commission (SEC). Filed annually, SEC Form 10-K provides a comprehensive overview of the company's business and financial conditions. To estimate manufacturer markups, DOE will use financial data from available 10-K reports from publicly owned lighting equipment manufacturers.[28]

Item 33	*DOE welcomes suggestions and comments concerning its proposed approach for estimating consumer prices for HID lamps, ballasts, and fixtures.*
Item 34	*DOE welcomes comments on typical manufacturer, wholesaler, and contractor markups associated with HID lamps, ballasts, and fixtures.*

8 LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSES

The effects of new or amended energy conservation standards on consumers include a change in operating expense (usually decreased) and a change in purchase price (usually increased). The LCC of equipment is the cost it incurs over its lifetime, taking into account both purchase price and operating expenses. The PBP represents the time it takes to recover the additional installed cost of the more-efficient equipment through annual operating-cost savings. DOE analyzes the net effect on consumers by calculating the LCC and PBP using the engineering performance data (section 5), the energy-use characterization data (section 5), and the markups analysis (section 7). Inputs to the LCC calculation include the installed cost to the consumer (purchase price plus installation cost), operating expenses, the lifetime of the equipment or another defined period of analysis, and a discount rate (see section 8.2, Life-Cycle Cost Discount Rates). Inputs to the PBP calculation include the installed cost to the consumer and annual operating costs.

In addition to the LCC and PBP calculations, DOE will also conduct a rebuttable presumption analysis for HID lamps. Under 42 U.S.C. 6295(o)(2)(B)(iii), EPCA establishes a

[27] The framework document for the 2009 MHLF (RIN: 1904-AC00) is available at www1.eere.energy.gov/buildings/appliance_standards/commercial/metal_halide_ecs_framework_pub_mtg.html.
[28] 10-K reports are filed with the U.S. Securities and Exchange Commission and are available at www.sec.gov/index.htm.

rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing equipment complying with an energy conservation standard level will be less than three times the value of the consumer's first year of energy savings due to the standard as calculated under the applicable test procedure. DOE plans to use the average annual operating hours of the most common end-use application. Although the rebuttable presumption calculation is helpful in understanding that certain standard levels have shorter payback periods, DOE routinely conducts a full economic analysis that considers the full range of effects, including those to the consumer, manufacturer, nation, and environment, as required under 42 U.S.C. 6295(o)(2)(B)(i). The results of this more comprehensive analysis serve as the basis for DOE to evaluate the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). Economic justification is based on a weighing of the seven statutory factors described in section 1.4.1. As part of its interim analyses, DOE will conduct the LCC and PBP analyses using typical values to reflect conditions in the field for equipment retail price and life, energy costs, energy usage, and discount rates. If DOE determines that there is significant variability in any of these inputs, it will conduct sensitivity analyses to determine how high and low estimates for each input affect the LCC and PBP. For any sensitivity analyses that it conducts, DOE will account for correlations that may exist between inputs (*e.g.*, energy usage may be correlated to energy prices). The detailed impact calculation, which DOE will conduct for the NOPR, may include an assessment of effects on consumer subgroups, as described in section 11.

For the NOPR, DOE will carefully review all of the comments it receives on the LCC analysis, may evaluate additional parameters not included in the interim analyses, and will make any necessary revisions.

The following sections discuss the methodologies DOE plans to use to estimate energy prices; discount rates; maintenance, repair, and installation costs; and lifetimes for HID lamps. Table 8.1 lists some of the major inputs DOE anticipates it will use for the LCC and PBP analyses.

Table 8.1 Input to the Life-Cycle Cost and Payback Period Analyses

Input	Description
Equipment Price	The price of certain HID lamps will be established as described in section 7, Markups Analysis. DOE will also consider price trends, as appropriate, in this rulemaking.
Sales Tax	Sales tax is applied to convert the product price to a final consumer price. Sales tax markups will be estimated as described in section 7, Markups Analysis.
Installation, Maintenance, and Repair Costs	These inputs represent the representative cost to consumers of installing HID lamps and (if required) replacing ballasts, and fixtures. DOE assumes that HID lamps will not require maintenance or repair during their service lifetimes.
Annual Operating Hours	The annual operating hours are the estimated hours that HID lamps are in use over 1 year. Operating hours will be estimated as described in section 5, Energy-Use Characterization.
Equipment Energy Consumption Rate	The product energy consumption rate is the site-energy usage rate associated with operating the lamp system. This rate will be estimated as described in section 5, Energy-Use Characterization.
Electricity Prices	Electricity prices used in the analysis are the national average price per kilowatt-hour (*i.e.*, dollars/kilowatt-hour ($/kWh)) for that commercial and industrial applications pay.
Electricity Price Trends	Electricity price trends estimate the future cost of electricity.
Lamp Lifetime	Lamp lifetime is the number of hours a lamp is expected to be in operation before the lamp fails.
Discount Rate	The discount rate is the rate at which DOE discounts future expenditures to establish their present value (3% or 7%).
Analysis Period	The 30-year analysis period is the time span over which DOE calculates the LCC.

8.1 Electricity Prices

DOE will survey residential, commercial, and industrial energy tariffs[29] as a means for establishing marginal electricity prices for consumers of HID lamps. DOE will also use data from CBECS[30] to estimate building energy-use characteristics that affect electricity prices. DOE received comments during the HID lamp determination rulemaking that energy tariffs vary greatly even within a given state. (Docket No. EE-DET-03-001, PennDOT, No. 5 at p.1) If the tariff survey and EIA data demonstrate a large variability in electricity prices, DOE will conduct a sensitivity analysis to determine how high and low electricity price estimates might affect the economic feasibility of any energy conservation standards. DOE will use projections of national average energy prices—principally from the most recent EIA *Annual Energy Outlook* (*AEO*)[31]—as inputs for future energy prices in the LCC analysis.

[29] Energy tariffs (utility industry term for the price of electricity calculated based on the type and market price of the fuel used, government subsidies, government and industry regulation, and even local weather patterns) vary widely from country to country, and may vary significantly from locality to locality within a particular country. DOE contractors maintain a database of hundreds of tariffs that can be used to calculate incremental energy bill impacts for a given utility from energy savings at tariffs.lbl.gov.

[30] *See* www.eia.doe.gov/emeu/cbecs.

[31] *See* www.eia.doe.gov/oiaf/aeo/.

Item 35 *DOE welcomes input on its proposed approach for estimating electricity prices in this analysis.*

8.2 Life-Cycle Cost Discount Rates

Calculation of consumer LCC requires use of an appropriate discount rate. DOE uses the discount rate to determine the present value of lifetime operating expenses. Because consumers of HID lamps are typically commercial, industrial, and municipal entities, DOE will derive the discount rates for consumers of HID lamps by estimating the capital cost to companies that purchase related lighting equipment. The cost of capital is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so the cost of capital is the weighted-average cost of equity and debt financing. This corporate finance approach is referred to as the "weighted-average cost of capital." However, because the set of commercial or industrial companies purchasing HID lamps may differ from those that purchase other equipment such as distribution transformers, each rulemaking requires development of its own targeted discount rates.

DOE will publish the discount rates and documentation on the derivation of these discount rates in the interim analyses and will invite interested parties to comment on consumer discount rates during the associated comment period. DOE will make necessary changes to the interim analyses based on the comments it receives on the LCC and PBP analyses, and will reflect those changes in the NOPR.

Item 36 *DOE welcomes input on the planned approaches for estimating discount rates for consumers of the HID lamps covered under this rulemaking.*

8.3 Installation, Maintenance, and Repair Costs

DOE typically considers expected changes to installation, maintenance, and repair costs for covered equipment due to new or amended standards. Often, small incremental changes in equipment efficiency would incur little or no change in installation, maintenance, and repair costs over baseline equipment. For equipment with significant efficacy improvements over the baseline, there may be increased installation, maintenance, and repair costs because such equipment is more likely to incorporate technologies that are not widely available or used.

DOE intends to consider each of these costs in its LCC analysis of HID lamps, ballasts and fixtures as follows:

- *Installation costs*—DOE considers the total installed cost of a lamp to be the consumer product price (including sales taxes) plus the installation cost. This was the methodology used in the 2009 GSFL/IRL final rule (74 FR 34080, 34108 (July 14, 2009)) and the ER/BR framework document.[32] For the commercial, industrial, and municipal sectors,

[32] DOE's framework document is available at: www1.eere.energy.gov/buildings/appliance_standards/residential/er_br_framework_public_meeting.html

DOE assumes an installation cost that is the product of the average labor rate and the time needed to install a lamp.

DOE is aware that the costs for commercial and industrial sector lamp installations would vary depending on whether the relamping practices are based on group relamping (*i.e.*, changing multiple lamps together, before the end of the average lamp lifetime) or spot relamping (*i.e.*, changing only those lamps that have failed). However, DOE does not believe that existing relamping practices would necessarily change under an energy conservation standard.

Although the equipment under this rulemaking is a lamp, DOE is considering ballast and fixture replacement costs in its analysis. HID lamps are functionally related to specific ballast types, and fewer ballasts are interchangeable. Further, ballast replacement provides the consumer with a broader selection of efficacious HID lamps for a given lighting application.

In the 2009 GSFL/IRL final rule and ER/BR lamps framework document, DOE derived costs using *RSMeans Electrical Cost Data*,[33] a reference book with extensive cost data, to obtain average labor times for installation as well as labor rates for electricians and helpers based on wage rates, benefits, and training costs. DOE proposes to use the most current version available of *RSMeans Electrical Cost Data* for the HID lamps rulemaking. DOE will also review industry literature for other installation cost data.

- *Maintenance and repair costs*—DOE did not include maintenance costs in the LCC analysis for the 2010 HID lamps final determination because DOE assumed HID lamps require no maintenance during their operational lifetime and are replaced upon failure (or dimming below acceptable levels) instead of repaired.

Item 37	*DOE welcomes comments on how to estimate installation costs for HID lamps. DOE specifically seeks comment on the availability and value of sources other than RSMeans Electrical Cost Data to consider in estimating installation costs.*
Item 38	*DOE welcomes comments on whether relamping practices (i.e., group or spot relamping) would change if HID lamp life is affected by new energy conservation standards.*
Item 39	*DOE welcomes comments on whether maintenance or repair costs for HID lamps, ballasts or fixtures should be considered in this analysis.*

8.4 **HID Lamp Lifetimes**

DOE will use information from manufacturer product catalogs, literature sources such as technical reports and conference proceedings, and input from manufacturers and other interested parties to establish HID lamp lifetimes for use in the LCC and subsequent analyses.

[33] RSMeans Company, Inc., *RSMeans Electrical Cost Data*, Kingston, MA.

In the 2009 GSFL/IRL final rule, DOE adjusted rated lamp lifetimes to account for the effects of group relamping, effectively lowering the lifetime to approximately 91–94 percent of rated lifetime, depending on lamp type Chapter 8 of the TSD for the 2009 GSFL/IRL final rule[34]. DOE intends to investigate the prevalence of group and spot relamping of HID lamps by sector, and assess the practical effects of relamping practices on lamp lifetime.

Item 40	*DOE welcomes comments on appropriate lifetimes for the HID lamps covered in this rulemaking, and how lamp life should be adjusted to reflect group relamping practices by lamp type and sector.*

9 SHIPMENTS ANALYSIS

DOE forecasts shipments of equipment to calculate the national effects of standards on energy use, NPV, and future manufacturer cash flows. DOE plans to develop shipments forecasts based on an analysis of key market drivers for HID lamps.

9.1 Baseline Forecast

To evaluate the various effects of new or amended standards, DOE develops a baseline shipments forecast against which to compare standards-case shipments forecasts at higher efficacy levels (based on the CSLs). DOE will design the baseline forecast to project what might happen to energy use and energy costs over time if energy conservation standards for the HID lamps under this rulemaking are not adopted. In determining the baseline forecast, DOE will consider historical shipments, the mix of efficacies currently sold in the absence of regulation, and how that mix might change over time. For these purposes, DOE seeks data on historical equipment shipments and the market shares of the different efficacy levels offered in each proposed equipment class.

Item 41	*DOE welcomes recommendations on sources of data for shipments of HID lamps by proposed equipment class. In addition, DOE welcomes comments on future long-term trends in HID lamp efficacy (e.g., market share of probe-start quartz MH versus pulse-start quartz and/or pulse-start ceramic MH) for the baseline shipments forecast.*

9.2 Accounting Methodology

DOE plans to determine annual shipments in the base case by accounting for new building construction, lamp replacements due to failure, and fixture retrofits (*i.e.*, major remodeling where the fixture is replaced). Each of these three effects on the accounting methodology is discussed below:

- *New construction* applies to HID lamps in new fixtures that are installed each year due to floor space growth in a particular sector. DOE proposes to determine this by using the

[34] *See* www1.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps.html

National Energy Modeling System (NEMS) growth projection for the commercial and industrial sectors.

- *Replacements* apply to lamps that have failed or are retired from service via group relamping. DOE plans to base this calculation on lamp shipments and retirement rates over the analysis period of 30 years.
- *Retrofits* apply to HID lamps and fixtures that are installed to replace existing lamps and fixtures during renovation or remodeling. This replacement generally occurs before a lamp has failed.

DOE intends to use an accounting model to prepare shipment scenarios for the baseline and the standards-level cases. The model will keep track of the aging and replacement of HID lamps given a projection of future HID lamp sales growth.

Item 42	*DOE welcomes comments on the accounting methodology described above for each type of HID lamp covered in this rulemaking.*

9.3 Standards' Effect on HID Lamp Shipments

DOE will develop a set of shipment forecasts for covered lamps in each efficiency level analyzed, and will then use these standards-case forecasts to evaluate the effects of new standards on lamp shipments. DOE derives standards-case forecasts from the same data sets it uses for baseline forecasts. However, because the standards-case forecasts take into account the increase in purchase price and the decrease in operating costs caused by new or amended standards, forecasted shipments typically deviate from the baseline. The magnitude of the difference between the standards-case and baseline shipment forecasts depends on the estimated purchase price increase, as well as the operating-cost savings from the new or amended standard.

Market-pull programs, such as consumer rebate programs that encourage the purchase of more-efficient HID lamps, ballasts, or fixtures, also affect standards-case shipment forecasts. In the TSD for the 2010 HID lamps determination, DOE examined non-regulatory incentive programs (Appendix A of the TSD for the 2010 HID lamp determination). The review of programs started with an online search using the DOE-funded Database of State Incentives for Renewables & Efficiency (DSIRE).[35] DOE found programs in 23 states that specifically focus on HID lighting technology. Incentives exist for either installing new HID lamps or replacing HID lamps with non-HID lamps.

Federal, State, and local regulatory efforts addressing HID lamps, ballasts, and fixtures can also affect lamp shipment forecasts. Effective 2010, the State of California had requirements for MH luminaires (MH lamp fixtures) that addressed not only ballast efficiency, but also elements of lumen maintenance of the lamp. Furthermore, between 2008 and 2010, 10 states and the District of Columbia prohibited the sale of certain probe-start MH lamp fixtures between 150 and 500 W: Arizona, New York, Oregon, Rhode Island (effective 2008); District of Columbia, Maryland, Massachusetts, Vermont, and Washington (effective 2009); and California and Connecticut (effective 2010). Although these prohibitions pertain to the fixture and its installed

[35] *See* www.dsireusa.org/.

ballast, the probe-start lamp used in these fixtures would also be significantly affected. To the extent that such State regulatory requirements exist, DOE will consider their effects on the forecast of both standards-case and baseline shipments.

Item 43	*DOE welcomes comments on how proposed energy conservation standards might affect shipments of HID lamps. DOE also requests information on the HID lamp impact of existing market-pull programs, such as consumer rebate programs, to promote the adoption of more efficacious lamps.*

10 NATIONAL IMPACT ANALYSIS

The NIA assesses cumulative NES and the cumulative national economic impacts of efficacy levels. The analysis measures economic impacts using the 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 efficacy level, DOE calculates the NPV, as well as the NES, as the difference between a baseline forecast and the standards-case forecasts.

10.1 Inputs to NES and NPV Forecasts

Analyzing effects of Federal energy conservation standards for HID lamps requires comparing projected energy use in the United States with and without energy conservation standards. The forecasts contain projections of unit energy use of new lamps, annual equipment shipments, the price of purchased equipment, and baseline and standards-case efficiencies. Derivations of the baseline shipment forecasts are discussed in section 9. Approaches to determine retail prices for equipment are described in section 7. Approaches to determine unit energy use are described in section 5.

The rebound effect is another input to the NIA. Consumers that encounter lower operating costs associated with more energy-efficient products may use that product more often than the less-efficient product. DOE's rebound effect analysis accounts for any increase in consumer use. As in the 2009 GSFL/IRL Lamps Rule, DOE plans to incorporate the rebound effect that occurs after installation of energy-efficient lighting equipment. 74 FR 34080, 34115 (July 14, 2009) In the 2009 GSFL/IRL Lamps Rule, DOE examined a summary of the literature regarding the rebound effect in relation to lighting equipment. 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 were between 5 and 12 percent of the energy consumption savings. In addition, with regards to a commercial firm's response to higher-efficiency lighting, the summary estimated 0 to 2 percent for values of rebound for lighting. Therefore, in the calculation of NES due to energy conservation standards on lighting, DOE plans to use the rebound rate of 1 percent in the commercial sector estimated in the 2009 GSFL/IRL Lamps Rule. See chapter 11 of the TSD for the 2009 GSFL/IRL Lamps Rule for a more complete discussion on the rebound effect.

Table 10.1 describes some of the major inputs DOE anticipates it will develop for the NIA.

Table 10.1 Input Data, Factor, and Forecasts for the National Impact Analysis

Input	Description of Data Sources
Shipments	Annual shipments are developed as described in section 9, Shipment Analysis.
Stock of HID Lamps	Calculated from the service life of lamps developed as described in section 8, Life-Cycle Cost and Payback Period Analyses, and annual shipments from HID lamps developed as described in section 9, Shipment Analysis.
Compliance Date of Standard	3 years after publication of final rule, assumed to be June 15, 2017.
Analysis Period	2017–2046 (30 years).
Base-Case Forecasted Efficiency	Distribution of baseline shipments by efficacy level over time developed as described in section 9, Shipment Analysis.
Standards-Case Forecasted Efficiency	Distribution of shipments by efficacy level for each standards case over time as described in section 9, Shipment Analysis.
Unit Energy Consumption (kWh/yr)	Average energy use of HID lamps established as described in section 5, Energy-Use Characterization.
Total Installed Cost	Described in section 7, Markups Analysis, and section 8, Life-Cycle Cost and Payback Period Analyses.
Electricity Price Forecast	Established using *AEO2011* forecasts as described in section 8, Life-Cycle Cost and Payback Period Analyses.
Electricity Site-to-Source Conversion	Varies yearly and is obtained from EIA *AEO* forecasts of electricity generation and electricity-related losses.
Discount Rate	The rate at which DOE discounts future expenditures to establish their value in the present year. DOE will use 3- and 7-percent (real) discount rates.
Present Year	The year 2012.
Rebound Effect	1% of total energy savings in the commercial and industrial sectors.

Item 44 *DOE welcomes comments on the proposed data, factor and forecast sources it anticipates using to develop inputs for the national impact analysis.*

Item 45 *DOE welcomes comments as to whether more efficacious HID lamp designs would be operated more as a result of their increased efficacy (i.e., whether a positive rebound effect would be expected for this equipment) and if so how much longer would they be operated.*

10.2 Calculation of National Energy Savings

DOE intends to calculate national energy use for each year beginning with the expected compliance date of the standards, estimating national electricity use for the base case and each potential standard level analyzed. To account for the stock of equipment affected by new standards, DOE plans to use a spreadsheet model that effectively multiplies annual shipment forecasts by unit energy savings.

In response to past comments from interested parties who asked for a simple, transparent model, DOE developed NIA spreadsheet models for its standards rulemakings starting in 1996.

These models project energy savings and demonstrate how to account for the growth in efficacy over time.[36] Although these models are specific to each piece of equipment analyzed, their general framework is applicable to the entire HID lamp market. DOE expects that the NIA spreadsheet model will provide a stand-alone forecast of NES and NPV for HID lamps. DOE will make any necessary changes to the interim analyses based on the comments it receives, and incorporate those changes in the NOPR.

Item 46	*DOE welcomes comments from interested parties on the NES spreadsheet models it plans to use for estimating national effects of new energy conservation standards for HID lamps.*

10.3 Net Present Value of Consumer Savings

DOE calculates the national NPV of the consumer savings resulting from energy conservation standards in conjunction with the NES. It calculates annual energy expenditures from annual energy use by incorporating forecasted energy prices, using the shipment and average energy efficiency forecasts described in section 9, Shipment Analysis. DOE calculates annual equipment expenditures by multiplying the price per lamp by the forecasted shipments. The difference between a baseline and a standards-case scenario gives the national energy bill savings and increased equipment expenditure in dollars. For the HID lamp rulemaking, this differential will likely result in an NES offset against increased expenditures. The difference each year between projected energy bill savings and increased equipment expenditures is the net savings (if positive) or net costs (if negative). DOE will discount these annual values to the present time and sum them to provide a NPV. Because the national cost of capital may differ from the consumer cost of capital, the discount rate used in the NIA can be different from the rate used in the LCC. The national average aggregates the different costs of capital while the consumer cost of capital is more applicable to subsets of consumers. According to U.S. Office of Management and Budget (OMB) guidance, DOE will conduct two NPV calculations, one using a real discount rate of 3 percent and another using a real discount rate of 7 percent.[37] DOE will make any necessary changes to the analysis based on the comments it receives on the interim analyses.

11 LIFE-CYCLE COST SUBGROUP ANALYSIS

At the NOPR stage of this rulemaking, DOE will conduct an LCC subgroup analysis. In this analysis, DOE assesses consumer effects by dividing consumers into subgroups and accounting for variations in key inputs to the LCC analysis. A consumer subgroup comprises a subset of the population more likely to be affected disproportionately by new or amended energy conservation standards (*e.g.*, small businesses, minorities, low-income consumers, or seniors). The purpose of a subgroup analysis is to determine the extent of any such disproportionate effect. DOE will work with industry and other interested parties early in the rulemaking process to identify any subgroups for consideration.

[36] Examples of NES spreadsheet models from previous rulemakings can be found on DOE's website at www.eere.energy.gov/buildings/appliance_standards.
[37] OMB, Circular A-4: Regulatory Analysis (Sept. 17, 2003).

In comparing potential effects on the different consumer subgroups, DOE will evaluate variations in regional electricity prices, usage profiles, and installation costs that might affect the NPV of an energy conservation standard to certain consumer subgroups. To the extent possible, DOE will obtain estimates of the variability in each input and consider this variability when calculating consumer effects. DOE will discuss this variability with interested parties and likely sources of information.

Item 47	*DOE welcomes comments from interested parties on which, if any, consumer subgroups should be considered when developing standards for HID lamps.*

12 MANUFACTURER IMPACT ANALYSIS

The purpose of the MIA is to identify and quantify the likely economic and employment impacts of new energy conservation standards on manufacturers of HID lamps. For the interim analyses, DOE will collect, evaluate, and report preliminary information on manufacturer impacts; this will include anticipated capital conversion costs, by efficacy level, and the corresponding anticipated effects on employment. DOE will invite further input on these issues during manufacturer interviews for the NOPR analysis.

DOE intends to conduct a separate MIA for each of three types of HID lamp covered under this rulemaking; however, DOE may combine all covered lamp types into a single MIA if it is determined that this approach is the most appropriate. In addition to financial effects, a wide range of quantitative and qualitative effects may occur following adoption of a new or amended standard, which may require changes to manufacturing practices. DOE will identify these potential effects through manufacturer interviews.

For the NOPR, DOE will supplement the results of the preliminary MIA with more detailed analyses (sections 12.1 through 12.5). DOE will conduct an industry-wide cash-flow analysis using the Government Regulatory Impact Model (GRIM – see section 12.2), identify and analyze subgroups of manufacturers whose businesses vary significantly from the industry as a whole, perform a competitive impacts assessment, and review the cumulative regulatory burden for the industry.

12.1 Sources of Information for the Manufacturer Impact Analysis

Many of the analyses described previously provide important information that DOE will use as inputs for the MIA. Such information includes end-user prices (section 5) marked down to MSPs using distribution channel information from the markup analysis (section 7) and shipment forecasts (section 9). DOE will supplement this information with information gathered during manufacturer interviews.

DOE will conduct interviews with manufacturers to gain insight into the range of potential effects from new standards. The interview process provides an opportunity for directly affected parties to express their views on important issues. During the interviews, DOE will solicit detailed information on the possible effects of new standards on manufacturing costs, equipment prices, sales, direct employment, capital assets, and industry competitiveness. Both qualitative and quantitative information are valuable in this analysis.

DOE will ask interview participants to identify confidential information, and DOE will determine whether the information submitted is entitled to confidential treatment. 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 public 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 that would result from public disclosure; (6) a date after which such information might lose its confidential character; and (7) why disclosure of the information would be contrary to the public interest. DOE will then consider the information gathered, as appropriate, in the energy conservation standard decision-making process.

DOE will collate the interview results and prepare a summary of the major issues and outcomes. This summary will become part of the TSD for this rulemaking.

12.2 **Industry Cash-Flow Analysis**

The industry cash-flow analysis will rely primarily on the GRIM. DOE uses the GRIM to analyze the financial effects of new or amended energy conservation standards on the industry that produces the equipment covered by the standard.

The GRIM uses a number of factors—annual expected revenues; manufacturer costs such as costs of goods sold; selling, general, and administrative costs; taxes; and capital expenditures (both ordinary capital expenditures and those related to standards)—to determine annual cash flows associated with a new standard, beginning with the announcement of the standard and continuing for several years after its implementation. DOE compares the results against baseline projections that involve no new or amended standards.

The financial effect of new or amended standards is the difference between the two sets of discounted annual cash flows. Other performance metrics, such as return on invested capital, are also available from the GRIM.

DOE will gather the inputs needed for the GRIM from two primary sources: (1) the analyses conducted to this point; and (2) interviews with manufacturers and other interested parties. Information gathered from previous analyses will include financial parameters, manufacturing costs, price forecasts, and shipment forecasts. Interviews with manufacturers and other interested parties will be essential in supplementing this information.

12.3 **Manufacturer Subgroup Analysis**

Average industry cost values may not reveal differential effects among HID lamp manufacturer subgroups. Smaller manufacturers, niche players, and manufacturers exhibiting a cost structure that differs significantly from the industry average may be affected differently by standards. Ideally, DOE would consider the effect on every firm individually. In highly concentrated industries, this may be possible. In industries having numerous participants, however, DOE uses the results of the market and technology assessment to combine manufacturers into subgroups, as appropriate. For HID lamps, DOE is interested in feedback

about potential subgroups. The detailed manufacturer subgroup effect analysis will calculate cash flows separately for each class of manufacturer.

Item 48	*DOE seeks comments on the subgroups of HID lamp manufacturers that it should consider in a manufacturer subgroup analysis.*

12.4 **Competitive Impacts Analysis**

EPCA directs DOE to consider any lessening of competition likely to result from the imposition of new or amended standards. (42 U.S.C. 6295(o)(2)(B)(i)(V)) It further directs the Attorney General to determine in writing the effects, if any, of any lessening of competition. (42 U.S.C. 6295(o)(2)(B)(ii))

DOE will make a determined effort to gather firm-specific financial information and effects, and to report the aggregated effect of the new standard on manufacturers. The competitive impacts analysis will assess the effects on smaller manufacturers. DOE will base the assessment on manufacturing cost data and information collected from interviews with manufacturers. These interviews will focus on gathering information that will be helpful in assessing asymmetrical cost increases to some manufacturers; increased proportions of fixed costs; potentially increasing business risks; and potential barriers to market entry (*e.g.*, proprietary technologies). DOE will provide the Attorney General with a copy of the NOPR for consideration in his evaluation of the effect of new standards on the lessening of competition. DOE will publish the Attorney General's letter and address any related comments in the final rule.

12.5 **Cumulative Regulatory Burden**

Other regulations may apply to the HID lamps covered under this rulemaking, and to other equipment produced by HID lamp manufacturers. Multiple regulations may result in a significant, cumulative regulatory burden on these manufacturers. DOE will consider the effects of multiple, equipment-specific regulatory actions on these manufacturers.

Regulations that could also affect the industry subject to this rulemaking include the following:

- Ongoing energy conservation standards rulemaking for MHLF;
- Amended energy conservation standards for GSFL and IRL established by DOE on July 14, 2009 (74 FR 34080);
- New EPCA standards for medium-base compact fluorescent lamps and MV lamp ballasts (42 U.S.C 6295(bb)(1) and (ee));
- New EPCA standards for GSILs (42 U.S.C 6295(i)(1));
- New EPCA standards for MHLF (42 U.S.C. 6295 (hh));

- Existing and/or proposed State standards related to HID technology including lamps, ballast, and fixtures (*e.g.*, California's Metal Halide Luminaire Appliance Standards[38]), established consistent with 42 U.S.C. 6297(b)-(e); and
- State building energy codes lighting requirements (*e.g.*, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1[39]) established consistent with 42 U.S.C. 6297(f).

Item 49	*DOE welcomes comments on other regulations or pending regulations it should consider in its examination of cumulative regulatory burden.*

13 UTILITY IMPACT ANALYSIS

To estimate the effects of new energy conservation standards for HID lamps on the electric utility industry, DOE will use a variant of the EIA's National Energy Modeling System named NEMS-BT.[40] NEMS is a large, multi-sector, partial-equilibrium model of the U.S. energy sector that EIA has developed over several years, primarily for preparing the *AEO*. NEMS produces a widely recognized, reference-case forecast for the United States through 2030 and is available to the public.

The utility impact analysis is a comparison between the NEMS-BT model results for the base case and standard cases. Outputs of the utility impact analysis usually parallel results that appear in the latest *AEO*, with some additions. Typical outputs of the utility impact analysis include forecasts of electricity sales, price, and avoided capacity. DOE plans to conduct the utility impact analysis as a scenario departing from the latest *AEO* Reference Case. In other words, DOE will model the anticipated energy savings effects from new energy conservation standards using NEMS-BT to generate forecasts that deviate from the *AEO* Reference Case.[41]

Item 50	*DOE seeks input on its plans to use NEMS-BT to conduct the utility impact analysis on the equipment covered under this rulemaking.*

14 EMPLOYMENT IMPACT ANALYSIS

DOE estimates the effects of new or amended standards on employment for equipment manufacturers, relevant service industries, energy suppliers, and the economy in general. This

[38] California Code of Regulations, Title 20, Section 1605.3(n)(2).
[39] ASHRAE Standard 90.1-2007 is the current version of the standard. Section 9 of ASHRAE 90.1-2007 deals with lighting requirements. Available at www.ashrae.org.
[40] For more information on NEMS, please refer to the U.S. Department of Energy, Energy Information Administration documentation. A useful summary is *National Energy Modeling System: An Overview 2000*, DOE/EIA-0581 (March 2000), available at tonto.eia.doe.gov/ftproot/forecasting/05812000.pdf. EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because this analysis entails some minor code modifications and the model is run under various policy scenarios that are variations on EIA assumptions, DOE refers to the model by the name NEMS-BT. ("BT" refers to DOE's Building Technologies Program, under whose aegis this work is performed.)
[41] Several descriptions of NEMS-BT models from previous rulemakings, including general service fluorescent residential lamps and incandescent reflector lamps, can be found on DOE's website at www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/ch_14_lamps_standards_final_tsd.pdf.

analysis covers both direct and indirect employment effects. Direct employment effects are changes in the number of employees at the plants that produce the covered equipment, along with the affiliated distribution and service companies. DOE will evaluate direct employment effects in the MIA (section 6).

Indirect employment effects may result from expenditures shifting between goods (the substitution effect) and changes in income and overall expenditure levels (the income effect) that occur due to new or amended standards. DOE defines indirect employment effects from new or amended standards as net jobs eliminated or created in the general economy as a result of increased spending driven by increased equipment prices and reduced spending on energy.

The combined direct and indirect employment effects will be investigated in the employment impact analysis using the PNNL Impact of Sector Energy Technologies (ImSET) model.[42] The ImSET model was developed for DOE's Office of Planning, Budget, and Analysis to estimate the employment and income effects of energy-saving technologies in buildings, industry, and transportation. Compared with simple economic multiplier approaches, ImSET allows for more complete and automated analysis of the economic impacts of energy conservation investments.

DOE notes that ImSET is not a general equilibrium forecasting model, and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET would over-estimate the magnitude of actual job impacts over the long run for this rule. Since input/output models do not allow prices to bring markets into equilibrium, they are best used for short-run analysis. DOE will therefore include a qualitative discussion of how labor markets are likely to respond in the longer term. In future rulemakings, DOE may consider the use other modeling approaches for examining long-run employment impacts.

DOE also notes that the employment impacts estimated with ImSET for the entire economy will differ from the employment impacts in the lighting manufacturing sector estimated in the MIA using the GRIM model. The methodologies used and the sectors analyzed in the ImSET and GRIM models are different.

Item 51	*DOE requests feedback on its approach to assessing employment impacts on the equipment covered under this rulemaking.*

15 **EMISSIONS ANALYSIS**

In the emissions analysis, DOE estimated the reduction in power sector emissions of carbon dioxide (CO_2), nitrogen oxides (NO_x), and mercury (Hg) using the NEMS-BT computer model. In the emissions analysis, NEMS-BT is run similarly to the AEO NEMS, except that HID lamps energy use is reduced by the amount of energy saved (by fuel type) due to each considered standard level. The inputs of NES come from the NIA spreadsheet model, while the output is the

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

forecasted physical emissions. The net benefit of each considered standard level is the difference between the forecasted emissions estimated by NEMS-BT at that level and the AEO 2011 Reference Case.

15.1 **Carbon Dioxide**

In the absence of any Federal emissions control regulation of power plant emissions of CO_2, a DOE standard is likely to result in reductions of these emissions. The CO_2 emission reductions likely to result from a standard will be estimated using NEMS-BT and NES estimates drawn from the NIA spreadsheet model. The net benefit of the standard is the difference between emissions estimated by NEMS-BT at each standard level considered and the *AEO* Reference Case. NEMS-BT tracks CO_2 emissions using a detailed module that provides results with broad coverage of all sectors and inclusion of interactive effects.

15.2 **Sulfur Dioxide**

SO_2 emissions from affected electric generating units (EGUs) are subject to nationwide and regional emissions cap and trading programs, and DOE has preliminarily determined that these programs create uncertainty about the potential standards' impact on SO_2 emissions. Title IV of the Clean Air Act sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous states and the District of Columbia (D.C.). SO_2 emissions from 28 eastern states and D.C. were also limited under the Clean Air Interstate Rule (CAIR, 70 Fed. Reg. 25162 (May 12, 2005)), which created an allowance-based trading program. Although CAIR has been remanded to EPA by the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit), see *North Carolina v. EPA*, 550 F.3d 1176 (D.C. Cir. 2008), it remained in effect temporarily, consistent with the D.C. Circuit's earlier opinion in *North Carolina v. EPA*, 531 F.3d 896 (D.C. Cir. 2008). On July 6, 2011 EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule. 76 FR 48208 (August 8, 2011). (See http://www.epa.gov/crossstaterule/). On December 30, 2011, however, the D.C. Circuit stayed the new rules while a panel of judges reviews them, and told EPA to continue enforcing CAIR (see *EME Homer City Generation v. EPA*, No. 11-1302, Order at *2 (D.C. Cir. Dec. 30, 2011)).

The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. Under existing U.S. Environmental Protection Agency (EPA) regulations, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the imposition of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by any regulated EGU. However, if the standard resulted in a permanent increase in the quantity of unused emissions allowances, there would be an overall reduction in SO_2 emissions from the standards. While there remains some uncertainty about the ultimate effects of efficiency standards on SO_2 emissions covered by the existing cap and trade system, the NEMS-BT modeling system that DOE uses to forecast emissions reductions currently indicates that no physical reductions in power sector emissions would occur for SO_2.

15.3 **Nitrogen Oxides**

Under CAIR, there is a cap on NOx emissions in 28 eastern states and the District of Columbia. All these states and D.C. have elected to reduce their NOx emissions by participating in cap and trade programs for EGUs. Therefore, energy conservation standards for HID lamps may have little or no physical effect on these emissions in the 28 eastern states and the D.C. for the same reasons that they may have little or no physical effect on NOX emissions. DOE is using the NEMS-BT to estimate NOx emissions reductions from possible standards in the states where emissions are not capped.

15.4 **Mercury**

In the absence of caps, a DOE energy conservation standard could reduce Hg emissions and DOE plans to use NEMS-BT to estimate these emission reductions. On December 21, 2011, EPA announced national emissions standards for hazardous air pollutants (NESHAPs) for mercury and certain other pollutants emitted from coal and oil-fired EGUs. (http://epa.gov/mats/pdfs/20111216MATSfinal.pdf) The NESHAPs do not include a trading program and, as such, DOE's energy conservation standards would likely reduce Hg emissions. For the emissions analysis for this rulemaking, DOE plans to estimate mercury emissions reductions using NEMS-BT based on *AEO2011,* which does not incorporate the NESHAPs. DOE expects that future versions of the NEMS-BT model will reflect the implementation of the NESHAPs.

15.5 **Particulate Matter**

DOE acknowledges that particulate matter (PM) exposure can impact human health. Power plant emissions can have either direct or indirect impacts on PM. A portion of the pollutants emitted by a power plant are in the form of particulates as they leave the smoke stack. These are direct, or primary, PM emissions. However, the great majority of PM emissions associated with power plants are in the form of secondary sulfates, which are produced at a significant distance from power plants by complex atmospheric chemical reactions that often involve the gaseous (non-particulate) emissions of power plants, mainly SO_2 and NO_x. The quantity of the secondary sulfates produced is determined by a very complex set of factors including the atmospheric quantities of SO_2 and NO_x, and other atmospheric constituents and conditions. Because these highly complex chemical reactions produce PM comprised of different constituents from different sources, EPA does not distinguish direct PM emissions from power plants from the secondary sulfate particulates in its ambient air quality requirements, PM monitoring of ambient air quality, or PM emissions inventories. For these reasons, it is not currently possible to determine how the new standards impact either direct or indirect PM emissions. Therefore, DOE is not planning to assess the impact of these standards on PM emissions. Further, as described previously, it is uncertain whether efficiency standards will result in a net decrease in power plant emissions of SO_2, which are now largely regulated by cap and trade systems.

Item 52	*DOE seeks input on its plans to use NEMS-BT to conduct the environmental assessment for the equipment covered by this rulemaking.*

16 **MONETIZING CARBON DIOXIDE AND OTHER EMISSIONS REDUCTIONS**

DOE plans to consider the estimated monetary benefits likely to result from the reduced emissions of CO_2 and NO_X that are expected to result from each of the standard levels considered.

In order to estimate the monetary value of benefits resulting from reduced emissions of CO_2, DOE plans to use the most current Social Cost of Carbon (SCC) values developed and/or agreed to by an interagency process. The SCC is intended to be a monetary measure of the incremental damage resulting from greenhouse gas (GHG) emissions, including, but not limited to, net agricultural productivity loss, human health effects, property damage from sea level rise, and changes in ecosystem services. Any effort to quantify and to monetize the harms associated with climate change will raise serious questions of science, economics, and ethics. But with full regard for the limits of both quantification and monetization, the SCC can be used to provide estimates of the social benefits of reductions in GHG emissions.

At the time of this notice, the most recent interagency estimates of the potential global benefits resulting from reduced CO_2 emissions in 2010, expressed in 2010$, were $4.9, $22.3, $36.5, and $67.6 per metric ton avoided. For emissions reductions that occur in later years, these values grow in real terms over time. Additionally, the interagency group determined that a range of values from 7 percent to 23 percent should be used to adjust the global SCC to calculate domestic effects, although DOE will give preference to consideration of the global benefits of reducing CO_2 emissions. To calculate a present value of the stream of monetary values, DOE will discount the values in each of the four cases using the discount rates that had been used to obtain the SCC values in each case.

DOE recognizes that scientific and economic knowledge continues to evolve rapidly as to the contribution of CO_2 and other GHG to changes in the future global climate and the potential resulting damages to the world economy. Thus, these values are subject to change.

DOE also intends to estimate the potential monetary benefit of reduced NO_X emissions resulting from the standard levels it considers. For NO_x emissions, available estimates suggest a very wide range of monetary values for NO_X emissions, ranging from $450 to $4,623 per ton in 2010$).[43] In accordance with OMB guidance, DOE will conduct two calculations of the monetary benefits derived using each of the economic values used for NO_x, one using a real discount rate of 3 percent and another using a real discount rate of 7 percent.[44]

DOE does not plan to monetize estimates of Hg in this rulemaking. DOE is aware of multiple agency efforts to determine the appropriate range of values used in evaluating the potential economic benefits of reduced Hg emissions. DOE has decided to await further guidance regarding consistent valuation and reporting of Hg emissions before it once again monetizes Hg in its rulemakings.

17 REGULATORY IMPACT ANALYSIS

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

[44] OMB, Circular A-4: Regulatory Analysis (Sept. 17, 2003).

DOE will prepare a regulatory impact analysis in the NOPR and final rule stages of this rulemaking. This analysis will address the potential for non-regulatory approaches to supplant or augment new energy conservation standards to improve the efficacy of HID lamps on the market. DOE recognizes that voluntary and other non-regulatory efforts by manufacturers, utilities, and other interested parties can result in substantial energy efficiency improvements. DOE intends to analyze the likely impacts of non-regulatory initiatives on national energy savings. DOE intends to base its assessment on the actual impacts of any such initiatives to date, but also will consider information presented on the impacts that any existing initiative might have in the future.

DOE will prepare and submit to OMB the assessment of costs and benefits required under section 6(a)(3) of Executive Order 12866, “Regulatory Planning and Review,” 58 FR 51735 (Oct. 4, 1993).

APPENDIX A – LIST OF ITEMS FOR COMMENT

This appendix lists all the items for comment contained in this framework document, and the page numbers on which those items can be found.